



Demystifying mainframe modernization: What does it really mean?

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Abstract

This article demystifies mainframe modernization by exploring its essential components, approaches, and business imperatives. Mainframes continue to power critical enterprise systems across banking, insurance, healthcare, government, and retail sectors while organizations increasingly seek to modernize these systems for improved agility, cost-efficiency, and integration capabilities. The discussion examines the complex mainframe legacy environment, outlines modernization strategies ranging from rehosting to complete replacement, and explains key technical concepts including the transition from Mainframe (COBOL, JCL, Db2, IMS applications) to Distributed (Java, C#, SQL) architectures, as well as VSAM-to-relational mapping. The article further explores Azure-native migration services and highlights business drivers beyond technology considerations, including cost reduction, innovation acceleration, talent availability, integration capabilities, business continuity, and enhanced analytics. By understanding these aspects, organizations can develop effective modernization strategies that align technical approaches with business outcomes, ensuring transformations deliver tangible value beyond infrastructure changes. Through detailed examination of real-world implementation metrics and performance outcomes, the article provides decision-makers with practical insights for navigating the complex modernization landscape while balancing technical requirements, business priorities, and risk management considerations to achieve sustainable digital transformation of legacy mainframe systems.

Keywords: Mainframe Modernization; COBOL Transformation; Cloud Migration; Legacy Systems; Digital Transformation

1. Introduction

In the digital landscape of enterprise computing, mainframes have stood as pillars of reliability for over half a century. These powerful systems continue to process millions of transactions daily across banking, insurance, healthcare, government, and retail sectors. However, as organizations increasingly embrace cloud computing and seek greater agility, cost-efficiency, and integration capabilities, mainframe modernization has emerged as a critical strategic initiative. Despite its importance, the concept of "mainframe modernization" often remains shrouded in technical jargon and complexity.

The mainframe market reached a valuation of \$4.5 billion in 2023 and is projected to grow to \$7.35 billion by 2032, registering a compound annual growth rate of 5.6% from 2023 to 2032 according to Allied Market Research's latest report. The z17 systems, IBM's latest mainframe offering released in 2023, have demonstrated unprecedented capabilities with 40% more computing capacity and 45% higher throughput than previous generations, enabling organizations to process up to 1.7 trillion web transactions daily while reducing energy consumption by up to 25%. Financial services remain the dominant vertical, accounting for 42.6% of the global mainframe market share in 2023, with these institutions relying on mainframes to process 92% of all credit card transactions and manage 95% of all ATM transactions worldwide [1].

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Despite their continued relevance, mainframe modernization has become imperative as organizations seek to address mounting challenges. According to MLogica's comprehensive assessment framework, organizations typically discover that 72% of their mainframe applications contain undocumented business rules, with the average mainframe environment housing 8.2 million lines of code across 2,600 programs that have been maintained for 24.7 years. Their data indicates that comprehensive pre-migration assessments reduce project timelines by 37% and lower migration costs by 42% compared to organizations that proceed without thorough evaluation. These assessments typically identify an average of 847 integration points between mainframe applications and surrounding systems, 1,236 potential data quality issues, and 3,914 business rules that require preservation during modernization efforts [2].

This article aims to demystify the modernization process, breaking down the essential components, approaches, and considerations that define successful transformation journeys. By understanding the fundamental aspects of mainframe migration from rehosting applications to rearchitecting systems and transitioning data—organizations can make informed decisions about their modernization strategies, particularly when leveraging cloud platforms like Azure for their future-state architecture. Allied Market Research highlights that Z/OS continues to dominate the mainframe operating system landscape with 71.3% market share in 2019, while MLogica's assessment methodology has demonstrated that enterprises typically achieve ROI within 14-18 months of completing modernization initiatives when following structured, assessment-driven approaches to transformation [1][2].

2. The mainframe legacy: understanding what we're modernizing

Mainframes represent more than just hardware; they embody entire ecosystems of business logic, data structures, and operational processes that have evolved over decades. According to BMC's 15th annual mainframe survey, 93% of executives identify the mainframe as a platform for long-term growth and new workloads, with 68% expecting MIPS (million instructions per second) consumption to grow and 53% of respondents increasing their mainframe footprint. The survey revealed that 92% of organizations have implemented DevOps practices for their mainframe environment, with 63% reporting successful cost reduction through these modernization approaches. Security and compliance remain critical concerns, with 77% of respondents citing data protection as their top priority and 67% implementing automated enforcement of security policies across their mainframe infrastructure [3].

Table 1 Mainframe Environment Current State [3][4]

Component	Characteristics
Business Perception	Platform for long-term growth and new workloads
Operational Trajectory	Increasing MIPS consumption and footprint
Development Practices	DevOps implementation for the mainframe environment
Security Focus	Data protection priority with automated policy enforcement
Application Composition	COBOL dominance with substantial code volumes
Data Storage	Relational approach with DB2, VSAM, and IMS usage
Transaction Processing	CICS, IMS DC environments with high-volume processing
Batch Operations	JCL dependence for orchestrating data operations
Security Implementation	RACF predominance with ACF2 and TopSecret alternatives
Integration Landscape	Cross-platform connections with cloud, distributed, and mobile

The typical mainframe environment encompasses complex, interconnected components that present significant modernization challenges. Kyndryl's State of Mainframe Modernization report found that applications written in COBOL represent 67% of mainframe workloads, with 43% of organizations maintaining between 1-10 million lines of code and 28% managing over 10 million lines. Data storage remains predominantly relational, with 72% of surveyed organizations using DB2, 56% utilizing VSAM, and 32% maintaining IMS databases. Transaction processing complexity is substantial, with 87% of enterprises running CICS environments that process an average of 30,000 transactions per second during peak operations. The report identified that 64% of organizations rely on JCL for batch processing, with the average mainframe environment containing 7,800 JCL scripts that orchestrate 65% of all data-intensive operations. Security systems present particular challenges, with 58% of respondents using RACF, 23% implementing ACF2, and 19% utilizing Top Secret to manage an average of 8,500 user profiles per organization [4].

The fundamental modernization challenge extends beyond individual components to their interdependencies. BMC's survey highlights that 83% of respondents have integrated their mainframes with other platforms, including cloud (46%), distributed systems (42%), and mobile applications (38%), creating complex networks of dependencies that must be preserved during modernization [3]. Kyndryl's analysis reveals that large enterprises typically maintain 145-220 integration points between mainframe applications and surrounding systems, with each integration point representing a critical dependency requiring preservation. Organizations reported that these tightly coupled architectures contain an average of 18,500 implicit dependencies, with 74% of respondents identifying dependency mapping as a "high" or "critical" challenge during modernization initiatives [4].

3. Modernization Approaches: From Lift-and-Shift to Complete Transformation

Mainframe modernization exists on a spectrum of approaches, each with varying degrees of change, risk, cost, and business value. According to Futurum Group's "Mainframe Modernization 2023: A Year in Review," organizations are increasingly implementing multi-faceted strategies tailored to their specific business needs. Their analysis of 300+ modernization initiatives revealed that 47% of enterprises prioritized rehosting strategies, 38% focused on refactoring, 32% pursued replatforming, 27% implemented rearchitecting approaches, and 21% chose replacement options. The research indicates that 74% of successful modernization programs employed at least two distinct approaches simultaneously, with enterprises averaging 2.4 different strategies across their application portfolios. Notably, organizations reported an average 31% reduction in operating costs following modernization, with implementation timelines ranging from 8 months for rehosting to 26 months for complete replacement initiatives [5].

Precisely's comprehensive research outlined in "Best Practices for Mainframe Modernization" provides detailed insights into the effectiveness of various approaches. Their analysis of 175 completed modernization projects demonstrates that rehosting initiatives typically achieve 42% improvements in operational efficiency while preserving 96% of existing functionality, with average implementation costs of \$215-380 per function point. Refactoring approaches yield 38% improvements in maintainability scores and reduce defect rates by 29%, though requiring significant technical expertise with 68% of organizations citing skills availability as a primary challenge. Replatforming strategies deliver 44% reductions in batch processing windows and improve scalability by 63% on average, with organizations typically converting to Java (56%), C# (27%), or distributed COBOL (17%). Rearchitecting approaches produce the most substantial transformation, with organizations reporting 76% improvements in application flexibility and 58% reductions in time-to-market for new features, though requiring investments averaging \$450-720 per function point. Replacement strategies demonstrate the highest risk profile, with 45% of projects exceeding budgets by more than 30%, but deliver comprehensive modernization with 85% improvements in user experience metrics for successful implementations. Their research emphasizes that application portfolio segmentation is critical for approach selection, with enterprises typically categorizing applications based on business value and technical complexity metrics, directing 72% of rehosting initiatives toward moderate-value applications and 81% of replacement strategies toward systems with high technical debt but limited business differentiation [6].

Table 2 Modernization Approach Comparison [5][6]

Approach	Key Characteristics	Primary Benefits
Rehosting	Highest adoption rate	Operational efficiency with functional preservation
Refactoring	Strong adoption with technical expertise requirements	Maintainability improvement and defect reduction
Replatforming	Moderate adoption with language conversion	Batch processing and scalability enhancement
Rearchitecting	Selective implementation with higher investment	Application flexibility and time-to-market acceleration
Replacement	Limited deployment with the highest risk profile	User experience transformation
Strategy Selection	Value-complexity-based targeting	Portfolio-specific approach to diversification

4. Technical Foundations: Key Concepts in Mainframe-to-Cloud Migration

Understanding several technical concepts is crucial for successful mainframe modernization. According to OpenLegacy's comprehensive assessment of mainframe modernization challenges, monolith COBOL, JCL Db2, IMS applications to Distributed Java/C# SQL conversion represents a fundamental technical hurdle in modernization initiatives. Their analysis of 50+ enterprise projects revealed that typical mainframe applications contain 40-60% of their codebase dedicated to data access logic, with each application averaging 420 unique data access patterns that require transformation. COBOL's procedural data manipulation differs significantly from SQL's set-based operations (client -server architecture), requiring careful mapping that preserves business logic while optimizing performance. The conversion process typically achieves 75% automation through pattern recognition tools, with the remaining 25% requiring manual intervention due to custom access patterns or complex business rules. Organizations implementing these conversions report average performance improvements of 37% for online transactions and 42% for batch processes, though initial development cycles typically extend 28-35% longer than anticipated due to conversion complexities [7].

The migration from VSAM to relational database structures presents distinct technical challenges that impact modernization success. According to Royal Cyber's analysis of mainframe migration initiatives, organizations typically maintain between 1,500-3,000 VSAM files in their mainframe environments, with these structures containing an average of 850 million records across a mid-sized enterprise. The conversion process requires extensive data analysis and transformation, with organizations reporting that they develop an average of 2.3 database tables for each VSAM file during normalization. This transformation process necessitates careful handling of VSAM-specific features, including alternate indexes (present in 62% of files), relative record structures (used in 38% of environments), and fixed-length record formats (implemented in 76% of VSAM datasets). Royal Cyber notes that post-migration performance optimization represents a significant effort, with organizations implementing an average of 175 database indexes to maintain equivalent performance. Their research indicates that 57% of organizations experience performance degradation of 15-20% immediately following migration, requiring an average of 3-4 tuning cycles to achieve performance parity with original VSAM implementations [8].

Table 3 Technical Conversion Challenges [7][8]

Conversion Area	Key Challenges	Migration Considerations
COBOL-to-Java/C#	Paradigm shift from procedural to object-oriented programming.	High automation potential with necessary manual intervention
Db2/IMS to SQL	Transitioning from monolithic architectures to set-based, distributed SQL operations requires rethinking data access patterns and application logic	High automation potential with necessary manual intervention
Data Access	Significant codebase dedicated to data access	Numerous unique patterns requiring transformation
Performance	Extended initial development with eventual improvements	Enhanced transaction and batch efficiency
VSAM Structure	Thousands of files with massive record counts. Data modelling for Non-relational VSAM to Relational SQL	Multiple relational tables per VSAM file
Data Organization	Alternative indexes and record structure diversity	Fixed-length formats predominance
Performance Tuning	Initial performance degradation	Multiple optimization cycles are required

Data tier decoupling enables more flexible and maintainable application architectures. Open Legacy reports that mainframe applications typically intertwine data access and business logic across 65-80% of their codebase, creating significant maintenance and flexibility challenges. Successful modernization initiatives implement separation of concerns through layered architectures, with organizations developing an average of 840 data access methods per application suite to abstract approximately 2,300 distinct data operations. This architectural transformation delivers substantial benefits, with organizations reporting 43% reductions in code maintenance costs and 56% improvements

in development velocity for new features. However, the refactoring process requires extensive code analysis and restructuring, with organizations typically allocating 22-28% of their modernization budget specifically to this architectural transformation [7].

5. Azure-Native Migration: Leveraging Microsoft's Cloud for Mainframe Workloads

When targeting Microsoft Azure as the destination platform, organizations can leverage several services specifically designed to facilitate mainframe modernization. According to LTI's comprehensive whitepaper on mainframe migration to Azure, organizations implementing Azure-based modernization strategies achieve average total cost of ownership reductions of 35-50% over a five-year period. Their analysis of 50+ migration initiatives revealed that enterprises typically realize infrastructure cost reductions of 60-70%, while development productivity improves by 25-30% and time-to-market for new features accelerates by 30-40%. The migration journey follows a structured approach, with organizations spending an average of 4-6 weeks on initial assessment and discovery, 6-8 weeks on strategy development, 8-10 weeks on proof-of-concept implementation, and 6-18 months on full migration execution, depending on portfolio complexity. LTI's research indicates that Azure SQL Database and Managed Instance implementations demonstrate particular value for DB2 migrations, with organizations reporting 30-40% query performance improvements and data compression ratios averaging 3:1. Azure Synapse Analytics deployments achieve data processing improvements of 50-60% compared to mainframe equivalents, while Azure Functions implementations replacing batch workloads reduce processing windows by 40-60% and enable near-real-time operations that deliver significant business benefits [9].

The Forrester Total Economic Impact study commissioned by Microsoft provides detailed financial analysis of mainframe-to-Azure migrations, reporting a 302% return on investment with payback periods averaging 14 months. Organizations participating in the study achieved average annual cost savings of \$10.5 million, including \$3.2 million in infrastructure cost reductions, \$4.1 million in operational efficiency improvements, and \$3.2 million in licensing cost savings. The study found that Azure SQL implementations support 50% more concurrent users while delivering 60% faster transaction processing compared to mainframe database environments. Azure API Management deployments enable organizations to expose an average of 65 business-critical APIs with 99.95% availability, processing 2.5 million daily requests with average response times of 120ms compared to 2.2 seconds for equivalent mainframe transactions. The research highlighted that Microsoft Fabric implementations reduce data integration development time by 65% while improving refresh cycles from daily to hourly intervals. Organizations report significant risk reductions through improved disaster recovery capabilities, with recovery time objectives improving from 24-48 hours to 1-4 hours and recovery point objectives reducing from 24 hours to 15 minutes, delivering an annual risk-adjusted value of \$1.7 million through improved business continuity [10].

Table 4 Azure Migration Benefits [9][10]

Benefit Category	Azure Services	Key Advantages
Cost Efficiency	Overall, Azure platform	TCO reduction with rapid ROI and payback
Database Migration	Azure SQL Database and Managed Instance	Query optimization with effective data compression
Data Warehousing	Azure Synapse Analytics	Enhanced processing with accelerated analytics
Process Automation	Azure Functions	Reduced batch windows with near real-time processing
Integration	API Management	Business-critical interface creation with improved latency
Data Integration	Microsoft Fabric	Reduced development time with improved refresh cycles
Business Continuity	Azure disaster recovery services	Enhanced recovery objectives with risk mitigation

6. Business imperatives: Why modernization matters beyond technology

While technical considerations dominate discussions about mainframe modernization, the business imperatives driving these initiatives are equally important. According to the International Journal of Research in Advanced Science and Engineering Technology's comprehensive analysis, cost reduction represents a primary modernization driver, with organizations achieving average total cost of ownership reductions of 37.8% over five years. Their research across 85 modernization initiatives revealed that mainframe environments typically consume 43% of IT budgets while supporting only 26% of business applications. The study found that organizations spend an average of \$4,650 per MIPS annually on mainframe operations, with these costs increasing at 4.7% annually compared to 1.9% for cloud platforms. Migration initiatives deliver substantial financial benefits, with organizations reducing annual operating costs by 39-54% through infrastructure savings (31%), licensing reductions (47%), and staff optimization (22%). The transition from capital-intensive mainframe models to consumption-based cloud approaches transforms financial structures, with fixed costs decreasing from 78% to 41% of total IT expenditures. IJRASET's research indicates that organizations typically achieve positive ROI within 12-18 months, with an average five-year ROI of 237% and cumulative savings between \$8.7-\$23.5 million for mid-sized implementations [11].

CIO Magazine's survey of executive perspectives highlights additional business imperatives driving modernization decisions. Their analysis of 400 CIO respondents found that 72% identify talent constraints as a critical factor, with organizations reporting that mainframe positions remain vacant for an average of 6.2 months compared to 2.3 months for cloud roles. Respondents indicated that 67% of their mainframe workforce will reach retirement age within five years, creating substantial operational risk. Beyond talent concerns, 83% of CIOs cited business agility as a primary modernization driver, with organizations reducing time-to-market for new features from 8.7 weeks to 2.8 weeks following modernization. Integration capabilities represented another critical factor, with 79% of respondents reporting implementation of an average of 47 new APIs connecting core systems to digital channels following modernization. These integrations delivered significant business outcomes, with organizations reporting customer engagement improvements of 34% and transaction volume increases of 28% through new channels. The research further indicated that enhanced data accessibility enables organizations to implement an average of 18 new analytical use cases within six months of modernization completion, delivering annual business value of \$2.7 million through improved decision-making capabilities [12].

7. Conclusion

Mainframe modernization represents a journey beyond technical migration, delivering transformative business outcomes through the strategic implementation of appropriate approaches. Organizations that successfully navigate this path achieve substantial cost reductions while simultaneously enhancing business agility, expanding talent accessibility, improving integration capabilities, strengthening business continuity, and unlocking valuable data insights. The modernization spectrum offers multiple pathways tailored to specific application characteristics, from low-risk rehosting to comprehensive re-architecting or replacement strategies. The Azure platform provides specialized services supporting this transition, enabling organizations to leverage cloud advantages while preserving critical business logic. As mainframes continue supporting essential business functions, modernization initiatives allow enterprises to balance maintaining operational stability with embracing innovation opportunities. The most successful transformations align technical implementation with clear business objectives, ensuring modernization investments deliver measurable benefits across operational efficiency, customer experience, and competitive differentiation. Through thoughtful planning, comprehensive assessment, and phased execution, organizations can transform their mainframe legacy from potential constraint to strategic advantage in the digital economy. Furthermore, the evolution of modernization approaches continues to accelerate, with emerging technologies like artificial intelligence and machine learning enhancing migration automation, reducing conversion complexities, and improving outcome predictability. Organizations embracing modernization as a strategic initiative rather than a technical project achieve substantially greater business impact, creating technology foundations that support ongoing innovation rather than simply replacing legacy infrastructure. The integration of DevOps practices, agile methodologies, and cloud-native architectures throughout the modernization journey establishes new operational paradigms that extend well beyond initial migration benefits, positioning enterprises to respond more effectively to evolving market conditions, customer expectations, and competitive pressures in an increasingly digital business landscape.

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