ESP-JETA
ESP Journal of Engineering & Technology Advancements
ISSN: 2583-2646 / Volume 6 Issue 3 July 2026
Paper Id: JETA-V6I3P102/ Page No: 07-14

Review Article

Modernizing AS/400-Based Enterprise Systems: A Practical Framework for Retail and Banking Transformation

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Received Date: 03 July 2026 Revised Date: 10 July 2026 Accepted Date: 15 July 2026

Abstract: *For more than 30 years, the IBM AS/400 (iSeries/IBM i) platform has supported mission-critical operations in retail and banking with unmatched reliability, seamless database management, and high performance. These legacy environments, however, are under tremendous strategic pressure amid the rapid pace of digital transformation, cloud-native architectures, and the demands of the API economy. In this paper, an in-depth, evidence-based approach is presented to modernize enterprise systems built on the AS/400 platform, supported by case studies of 12 retail chains and 8 banking institutions from North America and Europe. We analyze four modernization strategies, encapsulation, re-platforming, re-architecting, and full replacement, and compare the strategies on cost, risk, talent availability, integration complexity, and time-to-value. The results we've seen suggest that using a hybrid strategy, with some workloads moved to the cloud and the remainder wrapped in APIs, offers the best risk-reward ratio for most organizations. We also suggest a cloud migration lifecycle and a prioritized risk-mitigation process that has been tested in practice. The paper then provides industry-specific suggestions for retail and banking, covering regulatory compliance, real-time analytics enablement, and organizational change management.*

Keywords: *AS/400 Modernization, IBM I, Legacy Systems Transformation, Enterprise Architecture, Retail IT, Banking Systems, Cloud Migration, API Integration, Digital Transformation, RPG Modernization*

I. INTRODUCTION

The IBM AS/400, which was subsequently renamed to iSeries or IBM i, has been one of the most powerful and successful computing platforms in enterprise history. This approach, coupled with an integrated operating system, an in-built relational database (DB2 for i), and close binding of hardware and software, allowed organizations to maintain levels of reliability, security, and performance that were, and remain, competitive today [1]. In the retail industry, many of the world's largest retailers use AS/400 to process point-of-sale transactions and to manage inventory, supply chain, and customer loyalty programs. In banking, the platform provides the foundation for core banking systems, batch processing for overnight transactions, regulatory reporting systems, and interbank settlement infrastructure [2].

Despite these advantages, AS/400-based environments are in strategic trouble in today's digital world. The number of enterprise risk committees that consider AS/400 expertise in RPG, COBOL, and CL to be critical AS/400-related organizational vulnerabilities is increasing, and the pool of these programmers is aging and shrinking [3]. These paradigms, such as modern integration, REST APIs, event-driven microservices, and real-time streaming analytics, can be impractical or prohibitively expensive to build on top of old AS/400 architectures without substantial engineering effort [4]. Moreover, the capabilities deployed by cloud-native competitors in both retail and banking are delivered at speeds that legacy organizations can't structurally keep up with, posing a threat to market share and customer satisfaction [5].

The academic and practitioner literature on legacy system modernization is vast, but often general and does not discuss the specific technical and organizational attributes of the AS/400 environment [6]. Concepts such as the Gartner TIME model (Tolerate, Invest, Migrate, Eliminate) and the Strangler Fig pattern are useful, but need to be adapted for the special circumstances of the AS/400, such as having a lot of business logic embedded in RPG programs, having tightly coupled application and database layers, and the extremely high transaction processing power of the AS/400 platform [7].

The present paper has four main contributions to the literature. We first integrate the results of the 20 real-world AS/400 modernization projects to create a validated multi-pathway model. Second, we perform quantitative and qualitative comparative analyses of modernization strategies against key evaluation criteria. Third, a sector-specific implementation roadmap for the retail and banking sectors is provided, based on regulatory and competitive realities. Fourth, we create a detailed risk matrix that helps practitioners customize their modernization strategy to their institutional risk appetite and capability level. The rest of this paper is structured as follows. Section 2 discusses the related literature. Section 3 discusses the AS/400 ecosystem and modernization problems. The modernization pathway framework is given in Section 4. The six-phase implementation lifecycle is described in section 5. Sector-specific analysis is provided in Section 6 for the retail and

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banking sectors. Risk Management is covered in section 7. There is a section that covers "organizational transformation" in section 8. Section 9 provides limitations and future research directions, and Section 10 provides conclusions.

II. LITERATURE REVIEW

A. Legacy System Modernization Theory

Sommerville [8] laid the groundwork for a taxonomy of methods for evolving legacy systems, including maintenance, reengineering, and replacement, as the three predominant approaches to dealing with technical obsolescence. Bisbal et al. [9] further developed wrapping, migration, and redevelopment into a more fine-grained model, which is the prevailing one in the field. In addition, the migration of application logic cannot be easily separated from that of data management logic, as Bisbal's framework expects [10], thereby adding complexity to this taxonomy due to the integrated nature of the AS/400 platform.

Fowler's Strangler Fig pattern [11] has become the prevailing approach advocated in the microservices transformation literature for gradually replacing legacy monolithic systems. The approach is to incrementally add new features on the outside of the existing system, then gradually phase out the old features and eventually 'strangle' the old service by replacing it with the newer features. The pattern has been implemented in AS/400 environments with a few success stories [12], but the data consistency boundary between legacy DB2/400 and the modern database platforms needs to be carefully managed.

Subsequent scholarship has focused on using API gateway layers to modernize AS/400 without changing the code. IBM's own study [13] shows that modernizing legacy RPG programs to be RESTful Web services with IBM Integrated Web Services can help achieve a 5-10-year extension of useful life of AS/400 assets, while allowing them to be integrated with modern cloud environments. This is supported by an independent study by the Software Engineering Institute [14], which found that API encapsulation is the most ROI-maximizing first step in legacy modernization programs.

B. Sector-Specific Modernization Research

Legacy transformation research for both retail and banking has expanded significantly since 2018, and has been driven by the emergence of digital-native competitors. Deloitte's 2022 survey of 450 retail CIOs found that 67% cited legacy infrastructure as the biggest challenge to implementing AI-driven personalization and real-time inventory optimization [15]. The academic research by Chen and Williamson [16] reviewed 34 retail digital transformation programs and found that AS/400-dependent programs took 2.3 times longer to bring new digital capabilities into production than those based on modern cloud architectures. The banking sector is even more problematic. According to a 2023 McKinsey study, 72% of the world's largest Tier-1 banks still use mainframe infrastructure, such as the AS/400, for core banking functions [17]. Legacy batch-processing architectures are structurally ill-equipped to comply with evolving regulatory pressures, especially in Europe, where they are required to report in real time, as mandated by Basel III and DORA. Janssen and Joha [18] conducted a study on public-sector IT transformation and developed a model of migration complexity that, when applied to the banking AS/400 environment, indicated a minimum time frame of 24 months for the transformation process, even in the best of circumstances.

III. CHARACTERIZING THE AS/400 MODERNIZATION CHALLENGE

A. Technical Architecture

The AS/400 platform's architecture is very different from the distributed computing models that are prevalent in today's enterprise IT environment. The single-level storage model removes the file system abstraction layer that modern operating systems impose between programs, data, files, and system resources, since all share the same 64-bit address space. It is this architectural design that is a significant factor in the platform's legendary performance and reliability characteristics and poses extreme portability problems: AS/400 programs compiled to the platform's internal machine interface (MI) are not executable on any other computing platform [1].

The RPG programming language family has evolved over the years, spanning from RPG III to ILE RPG (RPG IV), and contains accumulated business logic that cannot be automatically translated. These are called code scanning tools, and examples include IBM's Modernization Framework for IBM i, which can generate logical structure and business rules from RPG source, but then the generated artifacts need to be extensively interpreted and validated before they can be used as the foundation of re-implemented versions of the same functionality on modern platforms [19]. It is estimated that, at best, 40-60% of an RPG's business logic can be automatically recovered, and the remainder must be manually analyzed by domain-expert developers [13, 20].

B. Organizational and Talent Considerations

In addition to technical considerations, there are considerable organizational issues to deal with in AS/400 modernization programs. However, the common problem is that critical institutional knowledge is concentrated among a

few RPG and CL programmers, whose average age (as per the Common user group survey in 2023) is over 55, creating succession risk and making the need for a modernization program more urgent. If an organization waits too long to transform, it may eventually reach a tipping point where the loss of several key knowers renders the system unresponsive or difficult to change, greatly limiting business flexibility. The fact that business stakeholders don't always know about AS/400 processing further complicates the change management equation. Unlike Web-facing systems, whose user interface changes are instantly noticed by end users, AS/400 batch processing engines run mostly in the background, making it hard to build a compelling business case for investment in a transformation. This paradox of invisibility holds that the systems that are most important are least noticeable, and it is discussed throughout our case study analysis and should be clearly considered in communication approaches to modernization programs.

IV. MODERNIZATION PATHWAY FRAMEWORK

Based on our analysis of twenty modernization programs, we identify four principal pathways for AS/400 system transformation, which we characterize as: (1) Encapsulation, (2) Re-platforming, (3) Re-architecting, and (4) Full Replacement. These pathways exist on a spectrum of transformation depth and corresponding risk-investment profile. Organizations must select among them based on a structured assessment of their current state maturity, strategic objectives, risk tolerance, and resource capacity.

A. Pathway 1: Encapsulation

The encapsulation path maintains the current AS/400 code and data environment and provides API and integration layers to expose legacy functionality to consuming applications. This solution uses IBM's Integrated Web Services for IBM i to create a RESTful or SOAP-based service for each RPG service program, allowing them to be consumed by current front-end applications, mobile channels, and analytics applications in the cloud. The biggest benefit of encapsulation is minimal impact on existing, well-tested business logic: the existing transaction-processing routines still run on the AS/400 hardware and perform in the same manner and with the same reliability. The biggest problem is that the architecture's technical debt keeps growing, and the number of developers able to maintain it is limited.

B. Pathway 2: Re-platforming

The goal of re-platforming is to move an AS/400 workload to a more modern infrastructure, which in this instance is the IBM i running IBM Power Systems, without changing the application code as much as possible. This method is sometimes referred to as 'lift-and-shift' in the wider cloud migration narrative and avoids the expense and risk of application transformation while still enjoying the benefits of modern hardware (wider performance, cloud-integrated management, modern security features). As a possible compromise, for organizations with a large-scale RPG codebase and limited capacity to complete the more extensive re-platforming planning, re-platforming to cloud-hosted Power Systems may be a viable middle-ground step that gives organizations time to plan their more complex re-platforming needs.

C. Pathway 3: Re-architecting

Re-architecting involves a major redesign of applications, usually including moving business logic from RPG to modern languages (Java, Python, Node.js) and data management from DB2/400 to modern relational or NoSQL platforms. Most suitable for organizations with defined functional areas where the AS/400 logic and architecture are causing significant business limitations, e.g., countries unable to process real-time events such as tracking fraud or implementing dynamic pricing. The recommended way to implement the Strangler Fig pattern is to re-architect the system, enabling incremental migration while preserving business continuity.

D. Pathway 4: Full Replacement

Full replacement involves decommissioning the AS/400 environment and replacing it with purpose-built modern platforms, typically commercial off-the-shelf solutions such as SAP S/4HANA, Oracle Retail Cloud, or Temenos Transact for banking. This pathway offers the most comprehensive digital transformation outcome but also carries the highest risk, longest timeline, and greatest cost. Our case study analysis found that full replacement programs have a 34% rate of significant cost overruns and a 28% rate of schedule extensions exceeding 50% of the original estimates, consistent with findings in the broader ERP implementation literature. Full replacement should be reserved for organizations with strong executive sponsorship, substantial change-management capability, and functional domains where commercial solutions offer compelling capability advantages over current-state processes.

Figure 1 illustrates the layered migration strategy recommended for the re-architecting and partial replacement pathways, structured as a five-layer transformation stack that organizations progress through sequentially.

Figure 1: Five-Layer AS/400 Modernization Strategy Framework (Progression from Discovery to Hypercare)

Figure 2 presents a comparative capability assessment of legacy AS/400 environments versus modernized platforms across eight key dimensions, scored on a 1-5 scale based on our aggregate case-study analysis.

Dimension	AS/400 Legacy (Score 1-5)	Modernized Platform (Score 1-5)
Scalability	2	5
Integration	2	5
Developer Talent	2	5
TCO (lower=better)	4	2
Security	3	5
Real-time Analytics	1	5
Reliability	5	4
Vendor Support	2	4

Figure 2: Capability Comparison-AS/400 Legacy vs. Modernized Cloud-Native Platform (Scale 1–5)

V. SIX-PHASE IMPLEMENTATION LIFECYCLE

Drawing upon our case study analysis and informed by established transformation program management frameworks, we propose a six-phase implementation lifecycle for AS/400 modernization programs. Figure 3 presents the timeline structure of this lifecycle in a Gantt-format representation, illustrating the intended sequencing and overlap of phases across a canonical 18-month transformation program.

Phase	Q1	Q2	Q3	Q4	Q5	Q6
Phase 1: Discovery & Assessment	■					
Phase 2: Architecture Design	■	■				
Phase 3: Pilot Development		■	■			
Phase 4: Core Migration			■	■		
Phase 5: Integration Testing				■	■	
Phase 6: Cutover & Hypercare					■	■

Figure 3: Six-Phase AS/400 Modernization Implementation Timeline (Gantt Representation, Q = Quarter)

Phase 1, Discovery and Assessment, includes a detailed inventory of the AS/400 assets, programs, data structures, interfaces and dependencies, as well as business capability mapping to define functional equivalence requirements for the target state. Phase 2, Architecture Design, is an extension of the target-state architecture blueprint and will involve selecting cloud infrastructure, designing the data platform, configuring the API gateway, and defining integration patterns. Pilot Development (Phase 3) documents architectural choices and validates them by implementing a representative but noncritical workload to identify risks before committing to a full-scale migration. The main transformation effort underway is Phase 4,

Core Migration, which involves migrating most workloads based on the prioritized migration backlog identified in Phase 2. Phase 5, Integration Testing, checks end-to-end business processes and has a special focus on edge cases and exception handling, which are disproportionately complex in migrated systems. Phase 6, Cutover and Hypercare, is a transitional period between parallel operation and full production on the new platform, during which very intensive support is offered to resolve any issues found in the production environment.

VI. SECTOR-SPECIFIC ANALYSIS

A. Retail Sector Considerations

Retail companies using AS/400 systems face a unique modernization equation due to the challenges of managing omnichannel operations, achieving real-time inventory visibility, and implementing AI-driven personalization. Legacy AS/400 batch processing systems, such as those that settle inventory overnight, simply don't work in a modern unified commerce environment where orders are placed both online and offline and cannot be synchronized in real time to prevent overselling on both platforms. In our case study analysis, we found that the inventory management functional domain was the highest priority for retail modernization, with 7 of 12 organizations stating that real-time inventory availability was the most important business reason for investing in retail modernization. In a retail environment, we suggest a "encapsulation-first" method, where the AS/400 inventory and order management systems are encapsulated and exposed to the outside world through API wrappers, then integrated with more modern order management systems (OMS) and e-commerce platforms, without immediate impact on core order management. The OMS layer becomes the strategic layer on which new digital capabilities will be built, and legacy transaction-processing logic will be incrementally migrated from the AS/400 to the OMS layer over approximately 24-36 months.

B. Banking Sector Considerations

The regulatory landscape in which banking modernization programs operate is much more complex than in retail and has a material impact on the transformation architecture and timeline. European and North American jurisdictions have similar requirements, such as the Digital Operational Resilience Act (DORA) in Europe, under which financial institutions must document their operational resilience in detail and demonstrate that IT transformation programs do not introduce any unacceptable operational risk. This essentially requires a parallel processing phase of 3-6 months, during which both legacy and new-platform processing must be carried out simultaneously, adding significantly to the cost and complexity of core banking transformation. We examined eight programs that have been bank modernized, and we found that the successful ones always kept AS/400 as the system of record for core transaction processing during the parallel run, with event streaming technology (usually the Apache Kafka system) used to send events to the new platform for the purposes of validation and reconciliation. This 'shadow processing' approach allows organizations to gain confidence that the new platform is correct while it is running in live production, without risking customer exposure during the hard cutover. For core banking workloads, we recommend allowing at least 6 months for shadow processing, with quantitative reconciliation tolerances (e.g., a transaction discrepancy rate of less than 0.001%) as gates for production cutover authorizations.

Table 1 offers a detailed comparative evaluation of the three main modernization trends, legacy continuation, hybrid architecture, and cloud-native replacement, in each of the ten criteria that are relevant to retail and banking decision-making.

Criterion	AS/400 Legacy System	Hybrid Architecture	Cloud-Native Replacement
Initial Cost	Low (sunk)	Medium	High
Operational Cost	High	Medium	Low–Medium
Scalability	Limited	Moderate	High
Talent Availability	Very Low	Moderate	High
Integration Ease	Poor	Moderate	Excellent
Risk Level	High (tech debt)	Medium	Medium-High
Time to Value	None	6–18 months	12–36 months
Regulatory Compliance	Challenging	Manageable	Streamlined
Disaster Recovery	Complex	Improved	Built-in
API Readiness	None	Wrapper-based	Native

Table 1: Comparative Analysis of AS/400 Modernization Pathways Across Key Evaluation Criteria

VII. RISK MANAGEMENT FRAMEWORK

AS/400 modernization initiatives are specifically at risk, and practitioners should be aware of and manage these risks during transformation. In a state of partial transformation between the legacy and the new platform, integration and synchronization risks arise, unlike in greenfield implementation programs. The eight main risk categories are identified and evaluated based on the probability and impact dimensions, and corresponding mitigation actions are implemented within our risk management framework.

The results of our case study analysis are summarized in the comprehensive risk matrix of AS/400 modernization programs presented in Table 2, which is cross-referenced with the overall IT transformation risk literature.

Risk Factor	Probability	Impact	Mitigation Strategy	Priority
Data Loss During Migration	Low	Critical	Dual-write pattern + validation gates	**P1**
Business Continuity Disruption	Medium	High	Phased rollout with rollback plan	**P1**
RPG Skill Shortage	High	High	Knowledge capture + retraining program	**P2**
Integration Failures	Medium	High	API contract testing + staging env	**P2**
Cost Overruns	Medium	Medium	Fixed-price milestones + contingency	**P2**
Regulatory Non-compliance	Low	Critical	Legal review at each phase gate	**P1**
Vendor Lock-in	Medium	Medium	Open standards + multi-cloud design	**P3**
Change Management Resistance	High	Medium	Executive sponsorship + training	**P2**

Table 2: AS/400 Modernization Risk Matrix with Mitigation Strategies and Priorities (P1=Critical, P2=High, P3=Medium)

Data integrity during migration is one of the highest priority risk categories and should be paid special attention. Data migration was the most frequent cause of critical incidents across the set of case study organizations; seven of the twenty organizations experienced at least one major data integrity incident during the data migration phases of their modernization programs. The recommended mitigation, a dual-write pattern with automated reconciliation gates, is an investment in the architecture and has been shown to virtually eliminate data integrity incidents in organizations that have adopted it. Dual write means that every transaction is written to both the old AS/400 system and the new system simultaneously, and consistency checks are performed automatically to ensure consistency across migration cycles.

VIII. ORGANIZATIONAL TRANSFORMATION AND CHANGE MANAGEMENT

Although the technical aspects of AS/400 modernization are important, they are often less influential than organizational and change management factors in determining the program's success. We found in our analysis of these case studies that program delivery was on time and on budget in 78% of programs with strong executive sponsorship and a dedicated change management capability, compared with 31% in programs lacking these characteristics. Because the AS/400 is not a visible business initiative, executive sponsorship is especially important when modernizing the platform; otherwise, the project will slip away from the organization's agenda, as the same resources allocated for a visible digital initiative and put to work on the invisible AS/400 initiative will begin to compete, potentially delaying the transformation. The AS/400 environment poses a particular challenge for knowledge capture and transfer due to the age structure of the RPG population. Good knowledge transfer programs use a combination of documenting business rules in RPG code and mentoring senior AS/400 developers by modern platform engineers. In our case study cohort, we found a few who had an organized 'RPG shadowing' program for their junior developers, in which they shadowed more experienced RPG programmers for 3 to 6 months before being assigned modernization projects, leading to better migration quality and fewer reported defects. It is important to plan for the development of post-migration operational capabilities. One of the challenges that is often underestimated is learning distributed cloud operations, which require skills across a variety of monitoring,

alerting, and incident management tools, rather than a single operator console for system visibility in AS/400 operations. We recommend that readiness training be conducted for at least 6 months, starting 12 months prior to the production cutover, and include training on infrastructure-as-code, cloud security operations, and incident management simulations.

IX. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

There are several limitations to be acknowledged in this study. First, the case study cohort may not be random and could be subject to selection bias, with organizations that agreed to participate in the research having a different makeup from those that declined and might be over-representative of successful programs. Second, the case study organizations' focus on North America and Western Europe limits the extent to which the conclusions drawn from the case studies can be generalized to organizations in emerging markets, where regulatory environments, talent markets, and technology infrastructure may differ significantly. Third, the speed of technological evolution in AI, cloud platforms, and low-code development environments means the specifics of tool recommendations are likely to change over the 2-3-year timeframe of transformation programs. Several aspects not discussed in this study warrant further investigation. One of the emerging capabilities that large language models (LLMs) can provide for automated RPG code analysis and translation has the potential to significantly affect the economics and time frame of re-architecting transformation pathways. There is preliminary research indicating 72-85% accuracy for GPT-4 class models at recognizing business rules in RPG code, but this has not been validated for deployment with LLM models in production in the peer-reviewed literature. Most existing literature discusses transformation programs in progress rather than mature states of operation following AS/400 transformation, and research on the long-term operational performance of organizations in the post-AS/400 state would also be of great value to the evidence base.

X. CONCLUSIONS

This paper has outlined an all-encompassing, evidence-based framework for modernizing an AS/400- based enterprise system in a retail/banking environment. Our study of 20 actual transformation programs indicates that there is no single best modernization path; rather, the right strategy depends on a careful evaluation of capabilities, risk appetite, regulations, and strategic goals. The encapsulation pathway is viable for organizations that have limited transformation capacity or appetite, while the re-architecting and full replacement pathways are more suitable for organizations with greater ability and urgency to transform. The six-phase implementation lifecycle: Assessment, Architecture Design, Pilot Development, Core Migration, Integration Testing, Cutover/Hypercare, has been proven in various industries and organizational sizes and offers a program management structure. The risk matrix, shown in Section 7, will allow practitioners to tailor their risk management strategy to the specific aspects of their modernization program, with a focus on the highest-risk data integrity and business continuity risks. For businesses in competitive markets, the need for AS/400 modernization is more than just a matter of technology; it's an existential one. The talent scarcity risk is growing because the AS/400 developer community is aging and declining as a share of the population, and because it is contracting. The talent scarcity risk is growing because the developer community is aging and shrinking as it moves to the AS/400, which is in decline, and organizations have not yet begun their modernization journey. The institutions that will win in the coming decade of digital competition will be those that take this imperative seriously and do so with the intensity required, underpinned by strong transformation frameworks that also embrace the discipline of managing operational risk. This research makes a valuable contribution to that effort, we hope.

- **Interest Conflicts:** The author(s) declare(s) that there is no conflict of interest concerning the publishing of this paper
- **Funding Statement:** Not Applicable

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