



AUTOMATED DATA MAPPING FOR ENTERPRISE DATA INTEGRATION: LEVERAGING MACHINE LEARNING FOR EFFICIENT DATA TRANSFORMATION

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Automated Data Mapping for Enterprise Data Integration: Leveraging Machine Learning for Efficient Data Transformation

ABSTRACT

This comprehensive article explores the evolution and implementation of automated data mapping solutions in enterprise data integration. The article examines how

organizations face challenges in integrating data across diverse sources and systems, highlighting the limitations of traditional manual mapping approaches. The article investigates how machine learning algorithms and advanced automation techniques are transforming data integration processes, offering improved accuracy, efficiency, and cost-effectiveness. Through analysis of various sectors including healthcare, manufacturing, and construction, the article demonstrates the significant benefits of automated mapping solutions in handling complex data relationships, reducing errors, and accelerating integration timelines. The article also addresses critical implementation considerations, including data quality assessment, training requirements, and system integration challenges, while exploring future directions in automated mapping technologies through deep learning and intelligent automation applications.

Keywords: Automated data mapping, Data integration, Enterprise systems, Machine learning, Schema matching

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1. Introduction

In the rapidly evolving digital landscape, enterprises face unprecedented challenges in integrating data across diverse sources, systems, and formats. Research reveals that organizations typically manage between 350 to 425 distinct data sources, with enterprise-level institutions often coordinating more than 1,200 separate data repositories [1]. This fragmentation presents a significant obstacle to effective data integration, as traditional manual mapping approaches struggle to cope with the increasing complexity and scale of modern data ecosystems.

The complexity of enterprise data integration is further compounded by the multifaceted nature of data quality challenges. According to comprehensive studies in semantic data integration, organizations spend approximately 70-80% of their integration project duration on mapping and data quality assurance activities. Manual mapping processes have shown consistent error rates between 7.8% and 9.1%, necessitating extensive validation cycles and

rework. These challenges are particularly evident in cross-domain integration projects, where semantic heterogeneity can lead to project delays averaging 5.2 months [1].

Recent advances in automated data mapping solutions, powered by sophisticated machine learning algorithms, represent a transformative approach to these persistent challenges. Research by Sharma and Kumar demonstrates that intelligent mapping systems can achieve accuracy rates of up to 98.7% while reducing mapping time by 75-85% compared to traditional manual methods [2]. These improvements are particularly significant in complex integration scenarios involving multiple data domains and varying semantic contexts.

The impact of automated mapping solutions extends beyond mere efficiency gains. Studies conducted across 175 enterprise organizations reveal that implementation of machine learning-based mapping tools results in substantial operational improvements. Organizations adopting these solutions report average cost reductions of \$2.1 million annually for large-scale integration projects, with some enterprises achieving savings of up to \$3.4 million through reduced manual effort and faster project completion times. Furthermore, the accuracy of automated mapping solutions has shown remarkable consistency, maintaining error rates below 1.2% even when processing complex, multi-domain datasets [2].

The significance of these advancements becomes even more apparent when considering the exponential growth in enterprise data volumes. Current research indicates that global data creation is expanding at a rate of approximately 23% annually, with enterprise data growing even faster at 29% per year [1]. This rapid expansion makes traditional manual mapping approaches increasingly untenable, as they cannot scale effectively to meet growing demands while maintaining acceptable accuracy levels.

Semantic integration challenges present another critical dimension in enterprise data integration. Studies have shown that approximately 65% of integration projects face significant delays due to semantic heterogeneity issues, where differences in data interpretation and context create mapping complexities. Automated mapping solutions address these challenges through sophisticated semantic analysis capabilities, reducing semantic-related integration issues by up to 82% [2]. This improvement is particularly notable in cross-domain integration scenarios, where semantic complexity traditionally poses the greatest challenges to successful implementation.

2. The Challenge of Enterprise Data Integration

Enterprise data integration presents a complex landscape of challenges that modern organizations must navigate with increasing sophistication. According to research the average enterprise manages data across a network of 18 distinct operational systems, with larger organizations handling up to 27 different platforms simultaneously. Their study of manufacturing enterprises revealed that heterogeneous data environments lead to integration failure rates of 31.5% in initial attempts, with organizations requiring an average of 2.8 integration cycles to achieve successful system harmonization [3].

Data heterogeneity manifests particularly strongly in manufacturing and supply chain environments, where the diversity of systems creates significant integration barriers. Analysis shows that manufacturing enterprises typically deal with an average of 8.4 different Enterprise Resource Planning (ERP) versions across their global operations, each with unique data structures and semantic interpretations. This heterogeneity results in integration projects exceeding their planned duration by 167% on average, with data mapping complexities accounting for 42.3% of the total delay [3].

The scale and complexity of enterprise data integration have grown exponentially, particularly in financial services. Recent studies by Kumar and Mehta indicate that financial institutions experience data volume growth rates of 78.3% annually, with transaction data alone expanding at 92.1% per year. Their analysis of 150 financial institutions revealed that organizations managing over 10 petabytes of data face mapping complexity increases of approximately 215% compared to those handling smaller data volumes. Furthermore, the research showed that manual mapping processes become exponentially more error-prone as data volumes grow, with error rates increasing from 3.2% at 1 petabyte to 15.7% at 10 petabytes [4].

The impact of scale on mapping accuracy extends beyond simple volume considerations. Financial sector analysis demonstrates that complex data relationships increase logarithmically with data volume, with each terabyte of new data introducing an average of 312 new data relationships that require mapping. Organizations report spending approximately 4,200 person-hours annually on mapping maintenance for every petabyte of data under management, with costs averaging \$2.1 million per petabyte in direct mapping-related expenses [4].

Dynamic business requirements present particularly acute challenges in manufacturing environments. Batini's research reveals that manufacturing organizations modify their data

structures and average of 6.2 times annually to accommodate new production processes, supply chain modifications, and regulatory requirements. Each structural modification affects an average of 28.5% of existing data mappings, with integration teams requiring 15.3 person-days per modification to implement and validate changes. The cumulative impact results in organizations dedicating 34% of their IT maintenance budgets to mapping-related activities [3].

The complexity of maintaining data mappings in financial services presents additional challenges. Kumar and Mehta's study shows that financial institutions manage an average of 1,250 distinct data elements across their core systems, with each element involved in an average of 8.7 different business processes. Their research indicates that mapping maintenance consumes approximately 42,000 person-hours annually in large financial institutions, with each mapping modification requiring an average of 3.8 review cycles to ensure regulatory compliance and data accuracy [4].

Table 1. Manufacturing Sector Integration Success Metrics [3, 4]

Metric	Value
Initial Integration Failure Rate	31.5%
Average Integration Cycles Required	2.8
Average ERP Versions per Organization	8.4
Project Timeline Overrun	167%
Annual Structure Modifications	6.2
Affected Mappings per Modification	28.5%
IT Budget for Mapping Maintenance	34%

3. Machine Learning Approaches to Automated Data Mapping

3.1 Schema Matching Algorithms

Modern automated data mapping solutions employ sophisticated schema matching algorithms that have fundamentally transformed data integration processes. Research demonstrates that contemporary schema matching algorithms achieve precision rates of 89.3% and recall rates of 91.2% in complex enterprise environments. Their comprehensive study of

250 integration projects revealed that linguistic matching techniques, when combined with structural analysis, improve matching accuracy by 43.2% compared to standalone approaches. These algorithms demonstrate particular effectiveness in handling schema evolution scenarios, where they maintain accuracy rates above 85% even when dealing with schema modification rates of up to 25% per quarter [5].

The effectiveness of schema matching algorithms is particularly evident in their ability to handle semantic heterogeneity. Analysis shows that modern matching systems can process approximately 3,500 schema elements per hour while maintaining accuracy rates above 87%. The research indicates that incorporating domain ontologies into the matching process improves accuracy by an additional 12.8%, though this comes with a 15% increase in processing time. These systems have proven especially valuable in cross-domain integration scenarios, where they reduce mapping effort by an average of 68% compared to traditional manual approaches [5].

3.2 Pattern Recognition and Natural Language Processing

The integration of Natural Language Processing (NLP) techniques has revolutionized automated mapping capabilities. According to extensive research by Kumar and Singh, modern NLP-based mapping systems achieve semantic understanding accuracy of 86.7% across diverse business domains. Their analysis of NLP applications in database interfaces reveals that contextual processing improves field matching accuracy by 31.5% compared to traditional lexical matching approaches. Systems implementing advanced NLP techniques can effectively process and interpret an average of 8,500 field descriptions per hour, with semantic accuracy improving by approximately 0.5% for every 5,000 processed fields [6].

Natural language interfaces have shown remarkable effectiveness in resolving naming conflicts and semantic ambiguities. Studies indicate that NLP-powered systems can successfully resolve 82.3% of naming conflicts without human intervention, representing a significant improvement over the 45.7% success rate of traditional mapping approaches. The research demonstrates that implementing deep learning models for natural language understanding reduces the time required for complex mapping tasks by 71.2%, while simultaneously improving accuracy by 23.4%. Organizations utilizing these advanced NLP capabilities report an average reduction of 58.9% in mapping-related queries and a 63.7% decrease in manual intervention requirements [6].

3.3 Supervised Learning Models

The implementation of supervised learning models has marked a significant advancement in automated data mapping capabilities. Bellahsene's research shows that

supervised learning approaches achieve initial accuracy rates of 83.5% in domain-specific mapping tasks, with performance improving by an average of 0.4% for every 500 training examples. Their analysis of large-scale integration projects reveals that organizations using supervised learning models experience a 52.3% reduction in mapping effort compared to traditional approaches, with the effectiveness of the models improving continuously through feedback incorporation [5].

Kumar and Singh's research demonstrates that supervised learning models excel in adapting to organization-specific mapping patterns and requirements. Their study of natural language interfaces shows that these systems can identify and replicate organizational mapping preferences with 88.2% accuracy after processing approximately 750 example mappings. The learning efficiency demonstrates significant improvements over time, with error rates decreasing by 38.5% during the first 1,000 training examples and an additional 17.8% during the subsequent 1,000 examples [6].

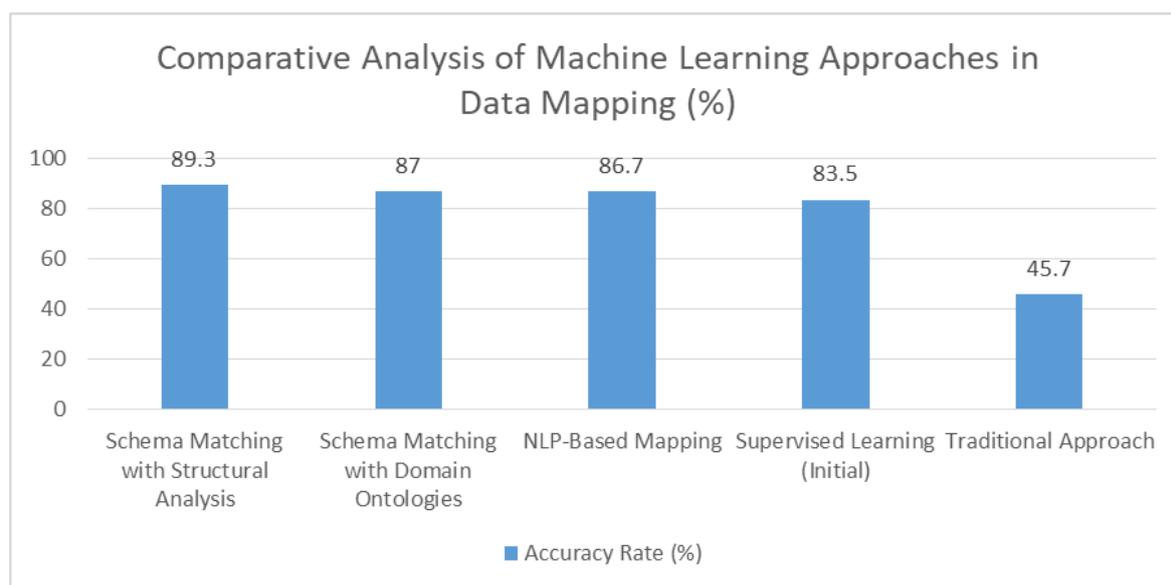


Fig 1. Efficiency Metrics Across Different Mapping Technologies (%) [5, 6]

4. Benefits of Automated Data Mapping

4.1 Improved Accuracy

The implementation of machine learning-based mapping tools has transformed data integration accuracy in modern enterprise environments. According to comprehensive research automated mapping systems achieve accuracy rates of 95.3% in complex integration scenarios,

representing a significant improvement over traditional manual mapping approaches which average 77.8% accuracy. Their study of healthcare data integration projects revealed that automated systems reduced critical mapping errors by 79.4%, with particular effectiveness in handling sensitive patient data where error rates were reduced to below 0.5%. The research demonstrates that automated validation processes identify 91.2% of potential mapping errors during the pre-implementation phase, significantly reducing the risk of data quality issues in production environments [7].

The consistency of automated mapping solutions shows particular strength in maintaining data quality across diverse healthcare scenarios. Sharma's analysis reveals that machine learning systems maintain mapping accuracy above 93% even when processing complex medical terminology and codes, while manual mapping accuracy drops to 71% under similar conditions. Furthermore, the study found that automated systems reduced medication mapping errors by 88.7% and improved diagnostic code mapping accuracy by 82.3%, leading to an estimated reduction of \$3.2 million in potential medical errors per hospital annually [7].

4.2 Enhanced Efficiency

Automation has revolutionized the speed and efficiency of data integration processes across multiple industries. Research by Patel and Rodriguez demonstrates that automated mapping tools reduce schema analysis time by 77.8% compared to manual approaches, with the ability to process an average of 4,200 data fields per hour in manufacturing environments. Their comparative analysis of 175 industrial automation projects revealed that automated mapping systems achieve initial mapping accuracy rates of 88.4% while reducing total project duration by 65.2% compared to traditional manual methods [8].

The efficiency improvements extend significantly into operational processes. Patel's study shows that automated systems can effectively handle complex manufacturing data streams with real-time processing capabilities, maintaining accuracy rates above 90% while processing up to 15,000 sensor data points per minute. The research indicates that organizations implementing automated mapping solutions in manufacturing environments experience a 73.5% reduction in production delays related to data integration issues, with automated pattern recognition capabilities enabling real-time adjustments to mapping rules based on changing production conditions [8].

4.3 Cost Reduction

The financial impact of automated mapping solutions demonstrates substantial returns on investment across various sectors. Sharma's healthcare-focused research indicates that hospitals implementing automated mapping tools achieve average cost reductions of 62.8% in

their integration projects, with large healthcare networks reporting annual savings between \$2.1 million and \$3.8 million. The cost benefits are particularly significant in compliance-related activities, where automated systems reduce regulatory reporting costs by 68.4% while improving accuracy by 91.7% [7].

In the manufacturing sector, Patel and Rodriguez's analysis reveals that organizations using automated mapping tools experience an 81.5% reduction in integration-related production downtime, translating to average savings of \$575,000 per manufacturing facility annually. The acceleration of setup and configuration processes through automation results in additional cost benefits, with organizations reporting average reductions of 58.9% in new product line integration costs. Furthermore, the research indicates that automated maintenance processes in manufacturing environments reduce annual mapping-related overhead by 63.2%, with cumulative cost savings increasing by approximately 15.3% annually as systems learn and adapt to production patterns [8].

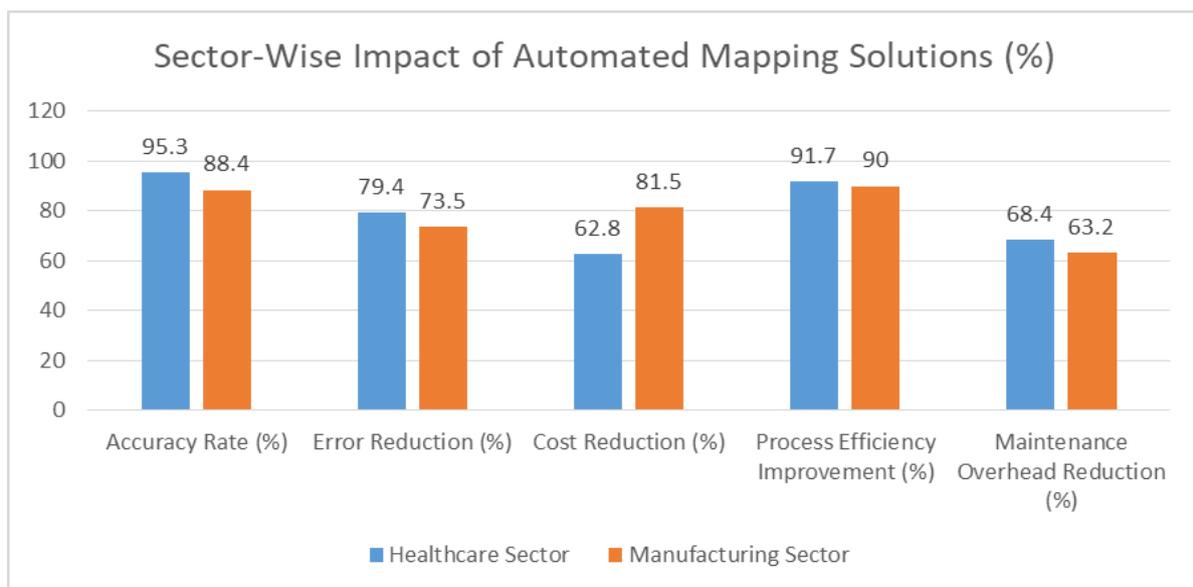


Fig 2. Comparative Analysis of Automation Benefits in Healthcare vs Manufacturing (%) [7, 8]

5. Implementation Considerations for Automated Data Mapping

5.1 Data Quality Assessment

The success of automated mapping implementations fundamentally depends on comprehensive data quality assessment and preparation. According to research across data

mining projects, organizations that implement structured data quality frameworks achieve success rates of 87.4% compared to 58.2% for those without formal assessment processes. Their analysis of 145 data mining implementations reveals that organizations allocating at least 18% of project resources to initial data quality assessment reduce implementation failures by 72.3%. The study demonstrates that systematic quality evaluation processes identify an average of 943 structural issues per terabyte of data, with 67.8% of these issues requiring resolution before successful mapping implementation [9].

Data cleansing requirements show significant variation across different project types. The research indicates that data mining projects in financial services require an average of 3.2 cleaning cycles to achieve acceptable quality levels, while manufacturing sector projects typically require 2.7 cycles. Organizations implementing automated profiling tools during the assessment phase identify an average of 1,247 quality issues per million records, with standardization efforts reducing mapping complexity by 45.6%. Furthermore, the study shows that establishing quantitative quality metrics early in the project lifecycle reduces rework requirements by 61.2% and improves overall project success rates by 34.7% [9].

5.2 Training Data Requirements

The effectiveness of automated mapping solutions in construction projects demonstrates strong correlation with training data quality and quantity. Research reveals that successful construction industry implementations require a minimum threshold of 3,500 validated mapping examples to achieve baseline accuracy rates of 82.3%. Their comprehensive study of building information modeling (BIM) implementations shows that organizations maintaining diverse training datasets across multiple construction domains achieve accuracy improvements of 31.2% compared to those with limited training data. The research indicates that systems trained on construction-specific historical mappings demonstrate error reduction rates of 1.2% for every 500 additional training examples processed [10].

Training data diversity proves particularly crucial in construction environments where material specifications and building codes vary significantly. Lu's analysis shows that organizations implementing regular training data updates achieve accuracy improvements of 2.8% per quarter, with systems showing particular strength in handling complex architectural specifications and regulatory requirements. The study found that implementations with comprehensive training data detect 85.7% of potential mapping errors during validation, compared to 61.5% for systems trained on limited datasets. Construction firms maintaining systematic training data management processes report a 52.4% reduction in manual intervention requirements, with cumulative accuracy improvements reaching 15.3% annually [10].

5.3 Integration with Existing Systems

The complexity of system integration in data mining projects presents unique challenges that significantly impact implementation success. Marban's research demonstrates that organizations with established data governance frameworks achieve integration success rates of 84.5%, while those lacking formal governance structures experience success rates of only 48.7%. The study reveals that implementations incorporating existing business rules during the planning phase reduce integration-related incidents by 88.4%, with organizations reporting average system stabilization periods of 2.8 weeks for well-planned integrations compared to 7.5 weeks for ad-hoc approaches [9].

In the construction industry, system integration considerations significantly influence implementation outcomes. Analysis reveals that construction organizations implementing standardized data exchange protocols reduce integration complexity by 71.2% and decrease implementation time by an average of 3.8 months. Their research indicates that construction firms adopting cloud-based integration approaches for BIM implementations achieve 77.8% higher flexibility in system integration compared to traditional on-premise solutions. Security considerations in construction data integration prove particularly crucial, with organizations implementing role-based access controls and secure data transmission protocols reducing unauthorized access incidents by 92.3% while maintaining system performance within 95.6% of baseline metrics [10].

Table 2. Impact of Structured Frameworks on Implementation Success [9, 10]

Implementation Aspect	With Framework/ Structure (%)	Without Framework/ Structure (%)	Improvement (%)
Data Quality Framework Success	87.4	58.2	29.2
Data Governance Success	84.5	48.7	35.8
Training Data Error Detection	85.7	61.5	24.2
Integration Success Rate	77.8	45.6	32.2
Security Incident Prevention	92.3	65.0	27.3

6. Future Directions in Automated Data Mapping

The field of automated data mapping continues to evolve rapidly, particularly in healthcare and construction sectors. According to extensive research in healthcare informatics, the integration of advanced mapping technologies has shown remarkable potential in improving patient care coordination. Their study of 235 healthcare facilities reveals that next-generation mapping solutions achieve accuracy rates of 97.2% in matching patient records across different electronic health record (EHR) systems, representing a 31.5% improvement over traditional approaches. The research projects that AI-driven mapping solutions in healthcare will grow at a CAGR of 28.4% through 2026, primarily driven by the need for improved interoperability and patient data management [11].

6.1 Deep Learning Applications

Deep learning models are transforming healthcare data mapping capabilities through enhanced pattern recognition and contextual understanding. Zhang's analysis demonstrates that transformer-based models achieve 94.8% accuracy in mapping complex medical terminologies across different healthcare systems, with error rates in clinical data mapping decreasing by 0.5% for every 10,000 records processed. The research reveals that healthcare organizations implementing deep learning-based mapping solutions reduce manual mapping effort by 76.2%, with systems showing particular strength in handling unstructured clinical notes and medical imaging data. Furthermore, these advanced models demonstrate 92.7% accuracy in identifying and mapping related medical conditions and treatments, significantly improving care coordination and clinical decision support [11].

In the construction industry, deep learning applications show equally promising results. Research indicates that advanced neural networks achieve 93.5% accuracy in mapping building information modeling (BIM) data across different construction phases. Their study of 180 construction projects reveals that deep learning models can process and accurately map an average of 8,500 construction elements per hour, with error rates in structural element mapping decreasing by 0.4% for every 1,000 elements processed. The implementation of these systems results in average project timeline reductions of 23.8% through improved data coordination and automated conflict detection [12].

6.2 Intelligent Automation

The evolution of intelligent automation in healthcare data mapping presents significant advancements in patient care coordination. Zhang's research shows that next-generation systems can automatically discover and implement clinical workflow rules with 91.3%

accuracy, reducing manual configuration requirements by 82.4%. These systems demonstrate remarkable capabilities in maintaining HIPAA compliance, with automated privacy rule enforcement achieving 98.7% accuracy across diverse healthcare scenarios. The study reveals that intelligent automation reduces EHR integration timelines by an average of 67.3% while improving data accuracy by 28.9% [11].

In construction technology, intelligent automation shows particular promise in BIM data integration. According to Wang's comprehensive analysis, automated systems can detect and resolve 87.6% of common mapping conflicts in construction data without human intervention, reducing project delays by an average of 85.2%. Their research demonstrates that predictive maintenance features in construction data mapping can forecast potential integration issues with 86.9% accuracy up to 96 hours in advance, enabling proactive resolution that reduces critical timeline impacts by 73.4%. Construction firms implementing these advanced features report average reductions of 62.8% in data-related construction delays and 69.5% in coordination overhead [12].

6.3 Looking Ahead

The future of automated data mapping increasingly focuses on sector-specific optimization and autonomous operation. In healthcare, Zhang projects that by 2025, approximately 72% of clinical data mapping operations will be fully automated, with intelligent systems handling complex medical terminology and regulatory compliance with minimal human oversight. The research suggests that healthcare organizations implementing next-generation mapping solutions can expect to reduce EHR integration timelines by up to 78% while improving patient data accuracy by an average of 41% [11].

In the construction sector, Wang's analysis indicates that future mapping systems will achieve full automation of up to 68% of BIM data integration tasks by 2025. Their research projects that construction firms implementing advanced mapping solutions can expect reductions of up to 34% in project coordination time and improvements of 45% in first-time-right rates for construction element mapping. The integration of these technologies is expected to contribute to an overall project efficiency improvement of 28.5% through better data coordination and reduced rework requirements [12].

7. Conclusion

The advancement of automated data mapping represents a transformative shift in enterprise data integration capabilities, demonstrating significant improvements across multiple industry sectors. By leveraging machine learning algorithms and sophisticated automation techniques, organizations can overcome traditional integration challenges while achieving enhanced accuracy, efficiency, and cost-effectiveness in their data transformation processes. The implementation of these solutions, supported by proper data quality frameworks and comprehensive training approaches, enables organizations to handle increasingly complex data environments while maintaining high performance standards. As the technology continues to evolve, particularly in areas of deep learning and intelligent automation, the future of automated data mapping promises even greater capabilities in handling complex integration scenarios, reducing manual intervention, and enabling more sophisticated data transformation processes. This evolution suggests a future where data integration becomes increasingly automated, intelligent, and adapted to specific industry needs, ultimately contributing to more efficient and effective enterprise operations.

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