# A Review of Enterprise Architecture for Strategic Performance Management in the Transportation Sector Digital Transformation

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***Abstract***

*This paper reviews the use of Enterprise Architecture (EA) for strategic performance management in the transport sector's digital transformation, focusing on the Balanced Scorecard (BSC) theory. EA is essential for strategic planning and performance management in the transport industry, which is vital to the economy. The study analyses academic publications, industry reports, and case studies to assess EA's benefits, drawbacks, and novel solutions in transportation. The Balanced Scorecard framework, which measures and manages performance holistically, should be used to align EA projects. EA and the Balanced Scorecard theory may provide a solid foundation for strategic performance management in the transportation sector's digital transition. It aligns goals, objectives, and KPIs with strategic vision and mission. EA also helps identify important capabilities, processes, and IT systems to accomplish desired results. It also improves decision-making by offering an integrated perspective of the organisation's resources, capabilities, and dependencies. In the transportation industry, EA for strategic performance management faces obstacles, including imprecise communication, insufficient governance, and limited planning. Innovative solutions, including improved communication channels, stronger governance systems, and enhanced planning techniques, are recommended to tackle these issues. This review analysis sheds light on the transport sector's digital transition using EA and the Balanced Scorecard theory. It advises researchers, practitioners, and policymakers to use EA to improve performance management and maintain transportation industry growth.*

***Keywords:*** *Enterprise Architecture, Intelligence Transportation System, Review Paper, Transportation*

## 1. Introduction

Enterprise Architecture (EA) is a hierarchical method for aligning Information Technology (IT) and business. In addition, it is a comprehensive plan that requires meticulous planning, documentation, and analysis of an organisation's operation [1]. It aims to document the current condition of an organisation's business architecture, information resources, information systems, and technologies to identify gaps and vulnerabilities in its processes and infrastructures and plan for future expansion [2]. It is assumed that using EA will create value for organisations.

The transportation system is an integrated complex infrastructure of businesses that provides product and passenger transportation, storage, and

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commodity movement and ensures the correct operation of the transport complex's auxiliary equipment [3, 4]. Transport industries are progressively adopting digital transformation. Consequently, adopting EA to manage complexity and lead digitalisation capabilities. A successful EA implementation in the transport industry should result in numerous benefits for decision-making, resource optimisation, and the capacity to respond quickly to disruptive trends and technologies[5, 6].

Therefore, this paper will review using EA for strategic performance management in the transport sector's digital transformation based on the Balanced Scorecard (BSC) theory. This paper thoroughly analyses EA implementation, focusing on its benefits, widely accepted frameworks, and essential elements for successful adoption. This study emphasises the increasing demand for EA skills and their potential to improve organisational performance based on empirical evidence and industry insights. Real-world illustrations demonstrate the practical implementation of EA in various industries. In addition, this paper discusses the difficult perspectives that any business may face and how to overcome them to have a stimulating work environment and the ability to compete.

## 2. Literature Review

### 2.1. Enterprise Architecture Overview

EA has emerged as a crucial field of study in organisational transformation since the pioneering work of John Zachman and subsequent studies conducted in the late 1980s [7]. According to a survey conducted in 2017, the demand for EA skills has increased by a remarkable 26%, making it the fastest-growing and most in-demand skill set in the technology industry[8, 9]. A notable automobile manufacturer, for instance, utilised EA to address the increasing complexity of the transportation industry brought on by the introduction of electric vehicle infrastructures[5, 10]. The business increased productivity, agility, and on-time product delivery by utilising EA best practices, such as aligning systems and applications, instituting intelligent electricity infrastructure, and establishing charging stations[9, 11]. This example illustrates the transformative potential of EA in addressing industry-specific obstacles and achieving organisational objectives.

Several widely recognised EA frameworks have assisted organisations in navigating the complexity of implementation. The Zachman Framework, commonly regarded as the cornerstone of EA, provides a descriptive representation necessary for comprehending and designing the enterprise's multiple dimensions[12]. For instance, a multinational conglomerate streamlined its operations by aligning strategic principles with organisational capacities and responsibilities using the Zachman Framework[13]. This allowed the organisation to develop a coherent strategy that directed EA efforts and aligned stakeholders, resulting in improved organisational performance and value creation.

The Department of Defence Architecture Framework (DoDAF) is an additional influential framework that addresses the unique requirements of the defence industry. A defence contractor integrated and compared families of

systems, systems of systems, and interoperating architectures using the DoDAF framework [14]. Employing the framework's operational, system, and technical standards, the company attained a common comprehension of architectural components and successfully delivered complex defence projects. This example illustrates the efficacy of the DoDAF framework in fostering collaboration, standardisation, and interoperability within the defence industry.

To ensure a successful EA implementation, organisations must emphasise the foundational elements of the EA methodology. A global financial institution, for instance, employed an architecture management strategy to optimise its work processes and increase operational efficiencies[15]. The organisation achieved seamless departmental integration by implementing an architecture framework that specified the business strategy and IT infrastructure and optimised its resources. The project's successful completion was facilitated by applying an implementation methodology, resulting in a successful EA implementation with measurable outcomes[16]. This real-world example illustrates the significance of aligning organisational objectives with EA implementation strategies using fundamental elements.

EA has emerged as an indispensable discipline for organisations seeking to transform their operations and attain their strategic goals. By adopting EA best practices and leveraging frameworks such as the Zachman Framework, DoDAF, and core elements of architecture management and implementation methodology, organisations can effectively navigate the complexities of EA implementation, thereby driving organisational transformation and optimising performance in a rapidly evolving business environment.

### 2.3 Digitalisation Challenges in the Transportation Sector

The pervasive influence of computers, the Internet, and mobile technology has reshaped multiple industries, including transportation. The transformative potential of information and communication technology (ICT) solutions, such as Intelligent Transport Systems (ITS) and Transport Management Systems (TMS), in enabling businesses to maintain market positions and obtain competitive advantages[17, 18]. Real-world instances are provided to illustrate the opportunities and challenges presented by innovative solutions. In addition, the impact of ICT on addressing pressing issues such as congestion, energy consumption, and environmental sustainability is examined, focusing on the significance of aligning industry standards and fostering interoperability[6]. In its conclusion, the study highlights the importance of strategic decision-making supported by integrated data and information systems for advancement in the Industry Revolution 4.0 (IR 4.0) era.

Mobile technology and social media proliferation have created new business opportunities to optimise processes and strengthen consumer connections. However, due to the rapid evolution of information and telecommunication technology, businesses frequently fail to maximise the potential of innovative solutions like ITS and TMS [4, 6, 17]. Intelligent Transport Systems are

underutilised in the transport industry, despite their potential to enhance road efficiency and safety. By effectively integrating these systems and fostering interoperability, the organisations can lay the groundwork for intelligent mobility and unleash benefits for travellers and the transportation ecosystem.

The need for industry-wide standards and collaboration becomes even more pressing when addressing congestion, energy consumption, and environmental sustainability issues. Traditional measures alone are insufficient to transform the transport industry; sophisticated applications such as ITS play a crucial role[19, 20]. Consider implementing intelligent traffic management systems in a major metropolitan area, utilising real-time data and predictive analytics to optimise traffic flow and reduce congestion[21]. Such examples highlight the significance of shared objectives, mutual comprehension, and standardised procedures for maximising the potential of ICT solutions and fostering positive social and environmental outcomes.

Effective strategic decision-making significantly depends on integrating and analysing data and information in the current business environment. Nonetheless, many organisations contend with data deluge and fragmented systems, which impede their ability to derive actionable insights[22]. To surmount these obstacles, a paradigm shift is necessary to establish a framework for strategic performance management that incorporates operational data analysis and presents strategic decisions as performance benchmarks[22]. By implementing this strategy, organisations can improve the quality of their decision-making processes, modernise their management practices, and take advantage of the opportunities presented by Industry Revolution 4.0.

## 2.2 Enterprise Architecture Best Practices in Transportation Sector

Various factors, including the incorporation of electric vehicle infrastructures, have contributed to the complexity of the transportation industry. Companies such as Tesla, for instance, have effectively implemented EA frameworks and methodologies to support their electric vehicle charging network[23]. By adopting an EA framework and employing an EA methodology, Tesla was able to strategically plan and execute the expansion of their Supercharger network, ensuring customers' seamless connectivity and optimal charging experiences. Governance is crucial for leveraging EA to accomplish organisational strategy and objectives. In order to assure the safety and efficacy of the national airspace system, the Federal Aviation Administration (FAA) in the United States has implemented EA governance practices. By utilising EA, the FAA has been able to integrate resources, technologies, and operational processes to meet regulatory requirements and improve air traffic management, thereby contributing to the safety and dependability of air transportation as a whole[24].

Transportation organisations have reaped benefits from implementing business processes within an EA framework. The implementation of EA by the Port of Rotterdam in the Netherlands is notable. The Port of Rotterdam has refined

logistics operations, optimised cargo handling, and enhanced supply chain management by incorporating essential business processes into its EA framework[25]. This has increased efficiency, decreased costs, and improved the global maritime industry's competitiveness. In the transportation industry, cloud repositories have played a significant role in preserving vital information and documentation. For instance, the National Highway Traffic Safety Administration (NHTSA) in the United States uses cloud-based repositories to store and manage vital information regarding vehicle safety recalls and compliance. By employing an EA architecture for their information management systems, the NHTSA ensures secure, centralised access to vital data, facilitating effective decision-making and prompt actions to improve road safety[26].

Utilising technological skills has allowed transportation organisations to monitor and optimise resource utilisation. By implementing smart traffic management systems, cities like Singapore have optimised traffic flow and reduced congestion using advanced sensors, data analytics, and real-time monitoring. Singapore has significantly improved traffic efficacy by integrating technology competencies into its EA strategy, thereby enhancing the transportation experiences of its residents and visitors [27]. By examining these real-world examples, it is clear that the implementation of EA best practices has proven useful in addressing the complexity and challenges of the transportation industry. These examples demonstrate the importance of EA in guiding strategic planning, promoting effective governance, streamlining business processes, leveraging technology, and facilitating information management. By employing and adapting these best practices, transportation organisations can navigate an ever-changing environment, foster innovation, and achieve sustainable development.

### 2.4 Embrace Enterprise Architecture as an Optimum Solution

In the digital era, the transportation industry's complexity and competitiveness necessitate decision-making processes supported by comprehensive information systems. EA provides a structured framework for comprehending the intricate relationships between various organisational components. EA enables transportation organisations to define their information models, align business processes with strategic objectives, and address the perspectives of all stakeholders by perceiving the enterprise as a complex system [18, 28]. Transportation organisations can improve performance and preserve competitive advantage by incorporating diverse business processes and systems.

The ITS design framework emphasises the significance of shared vision and objectives as foundational elements in creating ITS architectures. The Open Group Architecture Framework (TOGAF) is widely acknowledged as a suitable guide and instrument for ITS, allowing transportation organisations to evaluate and incorporate various organisational, functional, and technological factors[5, 20]. Consider a city implementing an intelligent transportation system that combines real-time traffic data, public transportation schedules, and intelligent parking solutions. The city can construct an interoperable ITS architecture that improves

traffic flow, enhances passenger experiences, and promotes sustainable urban mobility by employing an EA-based strategy and leveraging TOGAF.

EA is critical in supporting strategic performance management as the transport industry embraces the digital revolution. EA facilitates potent visualisation and collaboration by incorporating technology with the industry context, enabling stakeholders to develop Industry Revolution 4.0 (IR 4.0) technology plans and implement digital strategies[4]. This comprehensive approach assists transportation organisations in improving manual and automated processes, fostering skill development, and establishing a change-responsive ecosystem. Consider, for example, an airline adopting an EA-driven digital transformation strategy. The business can improve operational efficiency, optimise resource allocation, and enhance customer experiences by aligning technology initiatives with the organisation's strategic objectives and leveraging EA principles.

EA provides a useful framework for strategic performance management in the transportation industry. EA's methodical approach to aligning business objectives, processes, and technology enables transportation organisations to navigate complex industry challenges and drive digital transformation. Examples, such as logistics companies, intelligent transportation systems, and airlines, illustrate the practical advantages of adopting an EA framework. By adopting ITS and IR 4.0 technologies, transportation organisations can improve decision-making processes, streamline operations, and achieve sustainable growth in the digital age.

### 2.5 A Balanced Scorecard Approach to Improving EA Implementation in the Transportation Sector

The Balanced Scorecard theory provides organisations with an established framework for aligning their strategic goals, objectives, and performance measures across multiple perspectives[29]. By employing this framework to the obstacles encountered during EA implementation in the transportation industry, organisations can effectively resolve these obstacles and drive digital transformation success. The successful implementation of EA in the transportation industry necessitates addressing multiple challenges from multiple perspectives. Within the Balanced Scorecard (BSC) theory framework, this paper seeks to examine these challenges and propose innovative solutions. Organisations can employ a comprehensive strategy to surmount obstacles and improve EA implementation by aligning challenges with BSC perspectives. This approach provides a comprehensive strategy for addressing challenges in the internal process, learning and development, authority support, cost, technology, and talent management perspectives, ultimately resulting in the transportation industry's successful digital transformation.

## 3. Methodology

Integrating data and information systems is a critical factor for effective strategic decision-making and success for the transportation industry in the era of Industry Revolution 4.0. By aligning industry standards, fostering interoperability, and instituting frameworks for strategic performance management, the transportation industry can unlock information technology's full potential and drive

sustainable industry advancements. The steps outlined below were implemented to conduct a thorough review in this area.

**Defined the Review's Purpose and Research Questions**: The first stage involved clearly defining the paper review's objective and research queries. The purpose of the evaluation was to evaluate the application of enterprise architecture (EA) for strategic performance management in the digital transformation of the transport sector. The research questions included investigating the benefits of EA in enhancing strategic performance management, identifying the challenges and limitations in its implementation, and evaluating the overall impact of digital transformation in the transportation sector.

**Conducted Literature Search and Article Selection**: An exhaustive search was conducted to identify articles pertinent to enterprise architecture, strategic performance management, and digital transformation in the transportation sector. Many publications were gathered using academic databases such as Scopus or IEEE Xplore in conjunction with targeted keyword searches. The inclusion criteria included selecting peer-reviewed articles published within a specific timeframe that focused on the digital transformation of the transport sector and the role of enterprise architecture in strategic performance management.

**Data Extracted and Analysed:** Pertinent data from each paper was extracted after selecting the articles. The authors' names, publication year, research methodology, conceptual framework, case studies or empirical evidence, and key findings of the application of enterprise architecture for strategic performance management in the digital transformation of the transportation sector were systematically organised and documented for further analysis.

**Quality and Relevance Evaluated:** The quality and relevance of the reviewed articles were evaluated. The quality evaluation evaluated the methodological rigour, the findings' validity, and the sources' credibility. In addition, the relevance of each article to the research questions was determined to ensure that it contributed to the comprehension of the application of enterprise architecture in strategic performance management within the digital transformation of the transportation sector. This step ensured that the review included only high-quality, relevant literature.

**Synthesised and Reported Findings:** The extracted data and findings from the reviewed articles were synthesised to address the research questions. We identified and analysed themes, patterns, and trends associated with using enterprise architecture in strategic performance management. The analysis highlighted the advantages, challenges, and limitations of enterprise architecture in the digital transformation of the transportation industry. Finally, a coherent, well-structured report was compiled, presenting the synthesised findings and their ramifications for future research and practice.

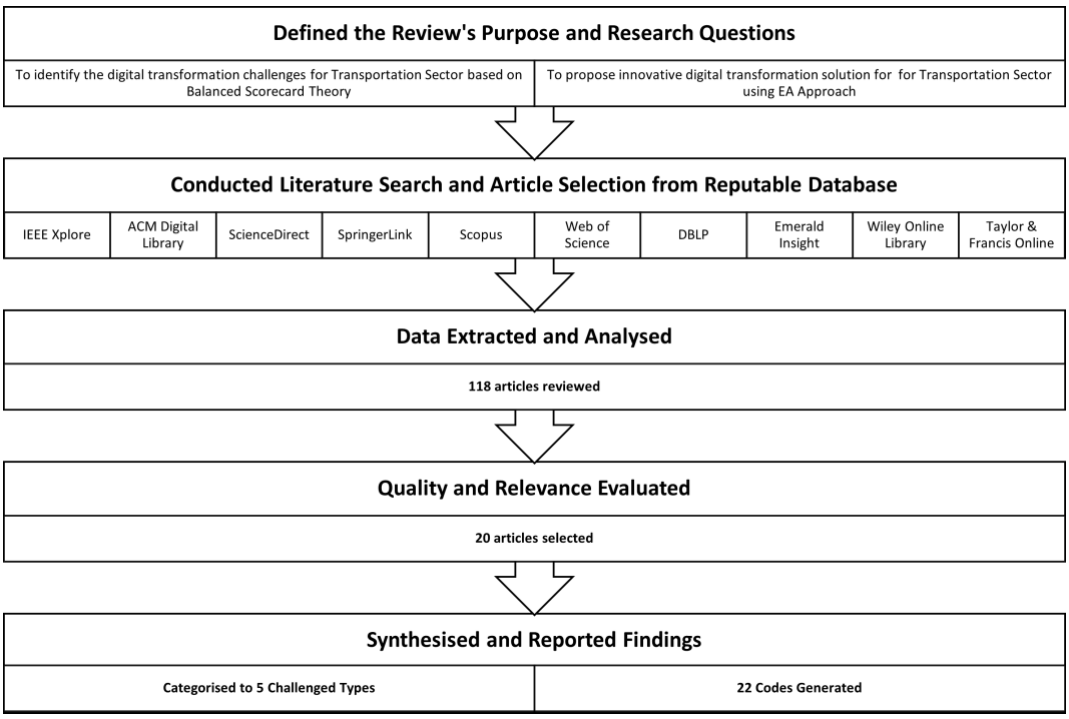


**Figure 1: Review Methodology Steps for this Study**

The analysis offered valuable insights into the application of enterprise architecture in enhancing strategic performance management and promoting digital transformation in the transportation industry. The review's findings can contribute to advancing knowledge in the field and guide future research and practical applications in this domain.

## 4. Result and Discussion

Following is the analysis from the review, which comprises 5 challenge types.

### 4.1 Internal Process Challenges

First, unclear communication prevents EA stakeholders from working together. Misunderstandings, delays, and misaligned goals might result[3, 4]. Second, poor governance such as lack of supervision and decision-making authority—can hinder EA implementation and management[5, 6]. Clear governance structures and roles are necessary for EA alignment, accountability, and effective decision-making. Another issue is misunderstanding an organisation's internal processes[6, 30]. Finding ways to improve processes and connect EA efforts with strategic goals is hard without completely understanding them. Limited resource allocation, timetables, and milestones can also slow EA initiatives. EA implementation requires a detailed plan with processes, deliverables, and dates. EA coverage and scope can also be problematic[3, 17]. If the scope is too limited or

the coverage is insufficient, crucial aspects of the organisation may be missed, leading to a flawed EA implementation.

Organisations must ensure that EA includes all essential parts and stakeholders to solve this[18, 21, 31]. Finally, a lack of standardised business standards can limit EA alignment and integration with the organisation's practises and procedures. Inconsistencies and disputes can make EA difficult to implement without explicit principles and norms. Standardised business rules and processes that follow industry best practices can assist in overcoming this obstacle and lay the groundwork for EA's success [6, 32, 33]. Organisations must improve communication, governance, internal process understanding, planning, EA scope and coverage, and business rules to overcome these problems. By doing so, organisations can overcome these challenges and apply EA more successfully and effectively.

### 4.2 Learning and Growth Challenges

EA implementation involves acculturation, assessment, skills, training, and expertise retention issues[1]. EA acculturation in the organisation is problematic as employees' lack of awareness and acceptance of EA principles might limit EA integration into decision-making and organisational culture[34, 35]. Another issue is the lack of an EA assessment system. Organisations may struggle to identify areas for development, monitor EA's impact, and connect it with strategic objectives without a systematic strategy to assess EA maturity and effectiveness[5, 10, 36]. EA practises must be assessed often to track progress and improve. Skilled architects are few[8, 37, 38]. Professionals with EA methodology, frameworks, and technology are needed to deploy EA successfully. However, the market's lack of competent architects can make it hard for organisations to find and keep EA expertise.

Limited EA training might also be difficult. EA staff may struggle to receive proper training[8, 39, 40]. This might create a knowledge gap and limit EA adoption and implementation in the organisation. Expertise retention is another issue. Skilled architects and EA professionals may leave if there are few incentives or career growth prospects[5, 41]. These professionals and their insights must be retained for EA projects to succeed. Lastly, creating centralised EA specialist teams might be difficult. Organisations may struggle to build specialised teams of EA professionals to advise, support, and collaborate across business divisions and projects[8, 42]. Without centralised knowledge, EA initiatives can be inconsistent, redundant, and hard to coordinate.

To overcome these issues, organisations must promote EA acculturation via effective communication and training. They should build strong evaluation systems to monitor and quantify EA's effect, invest in attracting and keeping talented architects, provide comprehensive EA training programmes, and create incentives and career development opportunities to maintain expertise. Establishing centralised EA expert teams can improve information exchange, cooperation, and consistency in EA practices.

### 4.3 Authority Support Challenges

Support, recognition, and stakeholder participation might impede EA projects. Lack of top corporate backing is a major issue. Without persistent leadership, EA initiatives may struggle with resource allocation, prioritisation, and organisational commitment[8, 10, 39]. EA regulations and processes are also lacking. Organisations may struggle to standardise EA installation and administration without explicit rules. Inconsistencies, inefficiencies, and challenges connecting EA activities with strategic objectives might ensue. EA's underappreciation as a crucial discipline is another issue[9, 43]. When an organisation does not recognise or understand EA, it might hinder investment, resource allocation, and commitment. EA's ability to alter organisations and make strategic decisions may suffer.

The political influence can hinder EA implementation. Politics and power dynamics in an organisation can affect decision-making, resource allocation, and EA support[8, 39, 44]. This can lead to conflict, resistance to change, and EA incoherence. Finally, stakeholder engagement may greatly affect EA programmes. EA projects can fail without active stakeholder participation[1, 8, 45]. To shape and link the EA strategy with organisational goals, stakeholders across levels and departments must understand, buy-in, and collaborate.

Organisations must create a culture of EA support, enforce norms and processes, raise knowledge of EA's usefulness, handle political pressures, and encourage stakeholder engagement to overcome these hurdles. Leadership commitment, good communication, and clear governance structures are needed to integrate EA into the organisation successfully.

### 4.4 Cost Challenges

Cost and resource constraints might hinder Enterprise Architecture (EA) project execution. First, due to economic pressure, organisations may have limited financial resources for EA activities[20, 46]. Budget limits and organisational agendas may limit EA investments. EA initiatives may suffer from this. Second, a lack of resources, such as experienced staff and technology infrastructure, might hinder EA projects[5, 9, 39]. The project must have enough EA-trained employees. Software tools and infrastructure are also needed to deploy and administer EA.

Insufficient cost allocation occurs when organisations underestimate EA project costs. Insufficient cost assessment and planning can lead to budget shortfalls and resource constraints during implementation[5, 9, 39]. Inadequate cost allocation can damage project outcomes, delay completion, or collapse. These problems demand that organisations carefully examine their financial capacities, assign suitable resources, and make accurate cost predictions throughout the development of the EA project. Financial backing, competent personnel, and appropriate technology are needed to implement EA successfully. By solving these difficulties, organisations may overcome economic pressure, limited resource availability, and poor cost allocation and smoothly execute their EA efforts.

### 4.5 Technology Challenges

There are two significant technological challenges associated with the introduction of EA. To begin, the tools of enterprise architecture are difficult to use. EA technologies are notoriously difficult to learn because of their inherent complexity, making it challenging for enterprises to implement them[47, 48]. This issue may be remedied with inventive solutions that streamline functionality while streamlining the user interface, making using EA goods more straightforward.

The use of industry-standard EA tools constitutes the second obstacle. Standardised tools are necessary for businesses that intend to implement Environmental Assessment frameworks and methodologies. Tools considered industry standards provide compatibility between different corporate systems[47, 48]. This issue may be remedied by using standardised EA tools, increased industry cooperation, and the formulation of recommendations. Standard tools can increase the efficacy and efficiency of EA activities by fostering seamless integration and best practices. This can lead to an overall improvement in the effectiveness of EA operations.

By employing the theory of the Balanced Scorecard to the challenges of implementing EA in the transportation sector, organisations can adopt a comprehensive and strategic approach to addressing obstacles from multiple perspectives. The innovative solutions proposed within each perspective enable organisations to improve their internal processes, nurture learning and development, obtain support from an authority, optimise costs, and leverage technology and talent management. This comprehensive strategy will facilitate the successful implementation of EA and pave the way for digital transformation in the transport industry, ensuring sustainable development and enhanced performance. Table 1 summarises all of the findings.

**Table 1. Summary of Existing Challenges in previous studies**

| Challenge Types | Codes Emerged | References |
|---|---|---|
| Internal Process | 1. Unclear communication | [3, 4] |
| | 2. Weak governance | [5, 6] |
| | 3. Lack of understanding of the internal process | [6, 30] |
| | 4. Limited planning | [3, 17] |
| | 5. Scope and Coverage | [18, 21, 31] |
| | 6. No standardised business rules | [6, 32, 33] |
| Learning and Growth | 7. Lack of EA acculturation | [34, 35] |
| | 8. No EA assessment mechanism | [5, 10, 36] |
| | 9. Lack of skilled architects | [8, 37, 38] |
| | 10. Limited EA Training | [8, 39, 40] |

| Challenge Types | Codes Emerged | References |
|---|---|---|
| | 11. Retention of expertise | [5, 41] |
| | 12. Centralised EA experts teams | [8, 42] |
| Authority Support | 13. Lack of continuous support | [8, 10, 39] |
| | 14. No mandated EA rules and processes | [9, 43] |
| | 15. EA is under recognition. | [9, 43] |
| | 16. Political Influence | [8, 39, 44] |
| | 17. Stakeholder Participation | [1, 8, 45] |
| Cost | 18. Economic pressure | [20, 46] |
| | 19. Insufficient supply of resources | [5, 9, 39] |
| | 20. Insufficient cost | [5, 9, 39] |
| Technology | 21. Complicated EA Tools | [47, 48] |
| | 22. Usage of Standard Tools | [47, 48] |

According to this, most present-day institutions are engaged in a competitive effort to supply online services based on a dynamic mechanism to make it possible for them to be readily adjusted as required. In order to properly implement an EA project, organisations operating in the transport industry need to strike an appropriate balance between the obstacles right from the start.

## 5. Conclusion and Future Work

This study has reviewed the challenge and proposed the possible applicability of the EA approach to the transport sector, recognising its significance as a vital element of the economy and daily life. Despite the challenges described in this study, instituting EA has numerous advantages, serving as a foundation for organisational development and goal attainment. Although this study has shed light on the potential benefits and drawbacks of implementing EA in the transportation industry, several limitations must be acknowledged. First, the results and proposed solutions are based on available research and may not account for all conceivable challenges specific to individual transportation companies. In addition, additional empirical validation and practical application of the new methods proposed in this study may be necessary to evaluate their efficacy and viability fully. Future research should resolve these limitations to provide a more comprehensive picture of the complexity of implementing EA in the transportation sector.

To further advance the application of EA in the transportation industry, future research can examine numerous avenues for progress. To begin, it is possible to investigate the integration of emergent technologies and trends such as big data analytics, artificial intelligence, and the Internet of Things (IoT) to determine their potential impact on EA deployment in transportation systems. Future work that

investigates the interoperability and scalability of EA frameworks across other modalities of conveyance and their associated ecosystems may prove fruitful.

In addition, case studies and practical evaluations of the novel solutions presented in this study would shed light on their efficacy and practical application. In addition, investigating stakeholders' roles and participation in the EA implementation process can contribute to a deeper understanding of the sociotechnical factors at play. Future research may advance the topic of EA in transportation by addressing these areas, enabling organisations to achieve greater efficiency, sustainability, and resilience in a constantly changing context.

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