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Digitalization Railway Supply Chain 4.0: Enterprise Architecture Perspective

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ABSTRACT

Digitalization has ensued a challenging time for Railway Supply Chain (RSC) to build, maintain and sustain its massive asset foundation, to provide transportation service, and to run the system, which is efficient, safe, and secure. However, as we begin the process of digitalization toward Industry 4.0 and preparing for Industry 5.0 the measure including a considerable change in digital advanced and computer-based technology advances needs to be integrated to improve their performance. Therefore, Enterprise Architecture is the ideal platform to increase the information flows and integration of the supply chain within the Malaysian Transportation Industry. We are designing a high-performance Enterprise Architecture RSC framework that visualizes, analyze, and maintain all RSC indicators to stay in control and govern nexus information through connecting and integrating a broad range of systematic and structural information within a visual appearance that can construct a comprehensible, value focus framework of what is and what to be for Malaysia Transportation Industry. Thus, the decision-making process in each tiering of RSC will increase the value in embracing analytics for shortening procurement cycle time and aspire to guide in a modern era by switching over toward a paperless decision-making process that forecasts RSC scenarios and analyses optimal outcomes.

Key words: Digitalization, Enterprise Architecture, Industry 4.0, Information System, Railway Supply Chain.

1. INTRODUCTION

Digitalization has added to the rise of the computerized economy [1]. The digitalization economy is characterized by using Information and Communication Technologies (ICT) to attempt business measures (electronic business), impact exchanges along the supply chain (electronic commerce), and the planning of enterprising exercises dependent on information, creativity, and innovation. Digitalization enables the organization to make intelligent decisions or fact-based decisions through visual analysis, where the data is aggregated in the database with integrated tools that presents the data in a reporting dashboard with statistical reports for enriching data into information as descriptive statistics and indicates the benchmarks for the decision-making process in an organization [2]–[4]. Besides the organization strategies have changed to take the edge of the chance conferred by the digitalization economy.

Digitalization has been a challenging time for RSC to build, maintain, and sustain its massive asset foundation, to provide transportation service and to run the system, which is efficient, safe, and secure. Digitalization for the upper hand in this modern economy is not based on large-scale manufacturing and cost decrease however has advanced to incorporate an organization's capacity to look for circumstances and adjust to changes in economic situations, grasp change through development and install learning in the industry [5]. Besides, it pointed towards industry increasing an upper hand or administration conveyance upgrades through the appropriation and emphasis on the critical industry strategy of the enterprise. In a quickly evolving climate, the capacity of the industry to discover new methods for making an upper hand is the key through digitalization [6]–[8].

Digitalization abilities can assist increase an upper hand by reconfiguring current assets, increasing new assets, or utilizing different assets. Thus, digitalization can be an emphasis on content where industry determines the what concept and digitalization enables the how the concept,

performance indicates the minimize report creation and collection times and usability focus on the delivery method such as dashboard context. Digitalization today resembles perusing the paper, where digitalization announcing tools on the head of an information distribution center that heaps daily and produces recorded revealing. Besides digitalization, tomorrow will focus on additional on continuous occasions and foreseeing the upcoming features. Yet, digitalization can be outlined as an industry talented at making, procuring, and moving information and altering its conduct to reflect new information and bits of knowledge.

One of the key qualities of the twentieth century was the digitalization of technological progress that changed industry performance around the world. Therefore, digitalization has changed both industry and the more extensive economy. The age and sharing of information underpin the serious drivers of advancement and innovativeness in a quickly developing industry climate, especially in Railway Supply Chain (RSC) context. Thus, RSC needs a digital transformation that focuses on technology drivers to exponential growth, social drivers on expectations and government landscape on economic structure, and performance demands for industry value.

2. RAILWAY SUPPLY CHAIN 4.0 CONTEXT

The supply chain is regularly talked about as the progression of data and materials from the suppliers to the customers [9]. Thus, a supply chain is comprised of a progression of connected industry-level value chains. The industry has always been members of a chain of an organization, however, the most industry sees themselves as isolated, unmistakable structure [10]. They do not effectively cooperate to decrease stock levels and costs up and down the chain. Besides, they do not coordinate decisions to improve customer service. The correspondence here and there the supply chain can assist build measures that empower the whole chain to make and convey winning items and administrations [11]. Only a few industries see their stock price increase based on the performance of their suppliers or customers. The reality is that the industry does not engage in such extensive supply chain integration.

Reward systems keep executives focused on their operations and their immediate performance. From a reasonable perspective, executives relate the supply chain with finer data trade, mutual assets, and strengthen connections among the individuals from the chain. Yet, executives are too busy trying to cope with the challenges of a tough industry world to worry about collaboration. Although the possibility of participation is intuitively engaging, most executives think that it is difficult to work together definitively. This phenomenon occurs due to integration failures, where no proper digitalization monitoring system that consists of (1) internal process integration that increases collaboration among the industry practical gatherings, (2) backward process integration with esteemed first-tier supplier on driving organizations are stretching out a type of mix to the second-tier supplier, (3) forward process integration with esteemed first-tier customers on not many organizations that have focused on the mix with their customer and (4) complete forward and backward integration from the supplier to the customer as the theoretical ideal.

Therefore, RSC needs the capacity to change quickly, they should be light-footed and digital transformation to keep up or stretch out beyond the opposition. Because they should be nimble and change, the multifaceted nature increase. To diminish or oversee the unpredictability, the RI needs digitalization that is integrated with industry revolution context to transform, while their operations must continue. Considering this point, it is wise to take a step and a new objective to look at the domain where digital transformation processes are being executed. That particular domain is the management domain, where the digital industrial revolution could support the decision-makers and be used as evaluation, deciding justification, and component [4].

Industry revolution provides management with understanding and review to outfit multifaceted nature and make well-informed decisions about the future direction of the Railway Industry (RI) and their continuous digital transformation process. Integrating digitalization 4.0 with Enterprise Architecture (EA) provides a method to accomplish a common conceptualization and comprehension among all partners included and oversee RI transformation dependent on this conceptualization. Despite this, in earlier EA research the focus has been on using it as an Information Systems (IS) framework, a framework that particularly facilitates architects.

However, EA provides much more. With recent development in the research field of EA, it becomes clearer how stakeholders expect that EA helps them to achieve their goals. Stakeholders want to make decisions about RI's future directions and understand the risks involved. Because of the earlier use as an IS framework, many stakeholders and especially decision-makers, consider and stigmatize EA as a framework only used in the IS field. Based on the concerns conducted from earlier research, further exploration of what decision-makers need to manage their RI digital transformation process is necessary. Disruptive digitalization is directly changing the scene of RI and its organizational actions.

Considering progressively digitalized cycles and exponential development of reasonable information, RSC is additionally

affected by the technology revolution. Strategic management needed a more straightforward comprehension of them directly accessible and interrelated innovations and ideas. Since the RSC will go through an industry change, a hypothetical structure is important to comprehend which action is affected by a holistic management point of view. Moreover, RSC will use EA as a blueprint to deal with changes. Most methodologies used in EA are intended for representing the knowledge about data and processes. Thus, understanding the concept can be just as important for successful change [12]. As large RSC involves complex industry and IS cycles and structures, they experience troubles in organizing divergent gatherings to work together towards their industry objectives in a unique climate. The data age RSC can neither accommodate multifaceted nature nor high paces of changes without a diagram like EA. However, as we begin the process of digitalization toward Industry 4.0 and preparing for Industry 5.0 the cycle including a generous change in advanced and computer-based innovations needs to be integrated to improve their performance. Therefore, the evolution of RSC digital management needs to provide a comprehensive understanding of the digital scenario through the industrial revolution, as appear in Table 1.

Table 1: The Evolution of Railway Supply Chain Digital Management

Digital Industry Revolution	**IR 1.0**	**IR 2.0**	**IR 3.0**	**IR 4.0**	**IR 5.0**
Digital Scenarios	Control mechanisms and budgets	Acquisitions and diversification	Approaches for industry direction	Structuring new ability	Speed, opportunistic, and agility.
Digital Concept	Controlling and planning	Industry extension	Market and industry choice	Competitive advantage	Innovation, change, and creativity.
Digital Method	Industry case studies	Industry-level planning	Positioning method	Resource-Based Perspective	Dynamic abilities
Digital Technique	Operating system and forecasting	Forecasting and identify synergies	SWOT analysis and value chain	Knowledge management and IS learning	Collaboration and knowledge management
Digital Effects	Hierarchical and controlled	Planning departments	Multi-national and divisional	Reengineering, outsourcing, and restructuring.	Flat structures and Global networks.
Digital Supply Chain Integration	Basic Integration on purchasing, production, marketing, R&D, and logistics.	Defined Integration on key suppliers with the industry in functional identification, process definition, and business strategy.	Foundation Integration on the industry with the key customers in continuous improvements, intra-industry collaboration, process alignment, and supply chain strategy.	Advanced Integration on the key suppliers with the industry with key customers in integration from customer to supplier, strategic focus and results, external collaboration, integrated processes, and unified business strategy.	Extended Integration on the suppliers to key suppliers with the industry with key customers to customers in the virtual supply chain, optimized strategy, differentiated supply chain service, and predictive models.

Table 1 classifies the evolution of RSC digital management as the growing shift to emergent IS, where RI need to embed with industry revolution context for manageability, standardization, cost containment, procurement process, faster technology innovation, and rapid response to change. RSC 4.0 context need to be value chain in three (3) perspective; (1) user perspective, where behavior, experience, information seeking and tasks need to strategize, (2) content perspective, where existing structure, data types, and content objective should strategize the vision and mission of RI and (3) context perspective should indicate the RI goals, culture, technology and resources for strategizing performance. Besides, we need to integrate systems thinking as an appreciative and reflective practice using EA paradigm concepts and RSC principles.

3. ENTERPRISE ARCHITECTURE PERSPECTIVE

Lately, nations in the global are going from a modern economy to an information and computerized economy whereby the monetary development is reliant on a nation's capacity to make, collect and disperse information as detailed by Asia-Pacific Development Information Program, 2018 in China [13]. The deluge of Enterprise Architecture (EA) is an innovation that is capable of sending and handling data considered as a feature of the data society that ready to make and scatter new data [14]. The report likewise featured that EA has accelerated the movement of globalization and increment the intricacy of industrial cycles because the industry has to include in the worldwide climate rather than local factors [15]. Consequently, to contend in the information economy, the industry needs a solid EA proficient aptitudes base that can improve and adjust rapidly to meet the evolving.

Industry organization especially the Railway Industry (RI) in Malaysia should be a versatile endeavor which can react appropriately and promptly to changes in the industry environment [15]. Enterprise refers to an assortment of an organization that has a typical arrangement of objectives and in a solitary primary concern [16]. In this perception, a venture can be an administration office, an entire company, a variance of an enterprise, a solitary office, or a series of geologically removed associations connected by normal proprietorship [17]. Furthermore, the term enterprise with regards to EA can be utilized to signify both ventures, enveloping all its Information Systems (IS) and a particular area inside the enterprise [18]. Besides that, architecture refers to an association with computing as the calculated elements and generally speaking consistent association of a computer or computer-based framework from its use or design [19].

According to [20], architecture is the major association of a framework, epitomized in its parts, their connections to one another and the climate, and the standards administering its plan and advancement. EA is a strategic information asset base, which defines the transitional and the mission cycles for actualizing innovations considering the changing function demands [21]. EA comprises of the different cycles and structures of an association [22]. EA framework is a portrayal of those cycles and structures [23]. A decent EA framework will portray the association both as it is today and as it is imagined later and will plan the different perspectives speaking to the design to each other [24]. These perspectives incorporate both business-situated viewpoints as well as technical points of view [25].

Most of the EA model is based on manual and depend on expertise experience and knowledge [26]. The problem is no transition evolution and lack of industry capability to do the transition stages. Among the government policies regarding Malaysia Transportation Industry (MTI) development as stated in Railway Development Planning (2012-2020) incorporated the examination to consider the viability of MTI supply chain execution. Even though in the Asia-Pacific Development Information Program have announced a few reasons added to the moderate EA adoption among MTI in Asia-Pacific, it is essential to recognize this ideal at a few points of an alternate time, since the industry observation and goal can change after some time because of a few technology elements [27]. MTI plays a significant job and becomes an impetus for financial development in Malaysia with the commitment 90% of absolute organization establishment in Malaysia, however, there has been very minimum studies executed on EA in MTI [28].

Besides, we reasoned that it is basic to have more exact proof of the technical components influencing the adoption of EA to support executives, administrative departments, and EA analysis advance approach the advantages of it to continue and expected improvement in the RI. RI in most learning nations such as Malaysia has been delayed to embrace it although most MTI in Malaysia understand that EA is basic to the efficiency and execution of their industry [29]. Discoveries from [30], indicated that RI is probably going to adopt EA in the future, administration activities through Eleventh Malaysia Plan (2016-2020) seem to be not effective because the EA adoption is still slow. [31], likewise uncovered that EA use and data looking by structure become the two most significant technology elements on EA while industry transition along like digitalization and automation was yet not famous among RI in Malaysia. Therefore, EA is the ideal platform to increase the information flows and integration of the supply chain within MTI.

As identified by [32], dynamic EA adopts from TOGAF 9.2, four intersection roles of advancements that best decided their pace of adoption are Data Architecture, Technology Architecture, Application Architecture, and Business Architecture, which need to be implemented and adopted as the core of EA parameters for RI supply chain indicators for MTI. In previous research, there is no standardized measuring for the transition level of EA adoption and EA usage for RI supply chain indicators for MTI. According to [33], and EA is the general structure or outline of how the enterprise use Information System (IS) to accomplish its industry aims. Therefore, we have tabulated the four (4) interrelated architecture for digitalization dynamic components as shown in Table 2.

Table 2: The EA Interrelated Architecture.

EA Parameters	Classification	Railway Industry Perspective	Supply Chain Indicators
 Data Architecture	A component of a systems architecture and comprised of information elements, which have characteristics and associations with other information elements.	Describing the design of an association's sensible and solid information resources and their relationships to the business functions.	• Knowledge obtained from experts. • Experts transfer information to knowledge.
 Technology Architecture	The technology climate for the enterprise indicating real equipment and programming frameworks.	Describes IS infrastructure and includes procedures and instructions on how to organize IS resources.	• Hardware and telecommunications technology. • Network services. • Human knowledge of skills and experiences.
 Application Architecture	Gives a system for executing and building organization practices to robotize industry cycles and backing the business elements of the venture.	This refers to the core business practice that creates and uses data.	• Managing information • Supporting business functions.
 Business Architecture	A segment of target and current design and identifies with the government goals and mission.	Incorporates the substance of plans of action and pivot on government business zones and cycles reacting to business drivers.	• Organization and Key Business Processes. • Governance • Business Strategy

Based on Table 2, the EA interrelated architecture that delivers the analysis and information that assists the industry to accept how to grip the worth. In general, EA is ordinarily seen as a regulation that blends key IS targets and business with the chance for governs and change the subsequent change activities [34]. EA can be viewed as an outline for the industry operates with a depiction of how these tasks are being kept up by the IS framework [35]. The Zachman is familiar as the dad of the EA structure as he was the earliest to present the sight of the EA framework [36]. The framework for EA characterizes how to arrange the perspectives and structure related to EA [37]. Many EA framework has been introduced in the past 20 years and the field of these four (4) methodologies: (1) The Gartner Methodology, (2) The Federal Enterprise Architecture Framework (FEAF), (3) The Zachman Framework for EA and (4) The Open Group Architectural Framework (TOGAF) [38], [39]. Therefore, we intend to present the estimation of the EA as opposed to prescribing a particular structure to be actualized.

EA is broadly viewed as the beginning stage for a cycle of the switch since it is staging up the holes between the ongoing circumstance and the perfect circumstance and encourages arrangement between industrial IS and industry aims [40], [41]. Moreover, the current issues and challenges in the RI supply chain focus on (1) Lack of commonality on high life cycle support cost with foreign control and trade imbalance, (2) High dependency on the foreign supplier on low product localization and lack of product support, (3) Shortage of skilled or knowledge workforce on in house training provider and lack analysis skill in predictive maintenance, (4) Lack of capabilities to support product life cycle on poor procurement process and lack system integration capabilities, (5) Unclear policy and institutional framework on reserve land for rail and lack of dedicated rail incentive and (6) insufficient rail infrastructure on passenger and freight sharing tracks and lack of inter-model and seamless connectivity [15], [42]–[44].

Hence, we posit a key enabler to the national agenda by developing an EA conceptual model towards High Technology High Value among RI in MTI. Most of the government agenda is centered around rail operation and less emphasis on developing the supporting industry around the supply chain [45]. Thus, we outline strategies and an action plan to further develop the Malaysia RI supply chain strategized decision-making process.

4. DIGITALIZATION RAILWAY SUPPLY CHAIN OUTCOMES

Generally, it has been widely accepted that the core of EA parameters is useful in helping RI supply chain indicators for MTI, which have not been fully researched in the Malaysian context. Thus, we have incorporated the theory of MIT90's framework to diagnosing management perception problems and the method of serious monitoring for RI supply chain indicators where this method has been researched separately and no comprehensive result was obtained. The serious management approach is used for the RI supply chain

indicators through high technological tools for decision making. The core EA parameters for RI supply chain indicators for MTI clearly and effectively to industry executives. Creating a strategic relationship with industry functions must arise in the EA and the key is to provide service needed by industry functions. Mapping strategic RI supply chain indicators in the industry landscape provide direction for the EA and communicate the expectations the industry leaders have towards EA.

Moreover, it benefits all decision-makers in RI, especially those new to the decision making of supply chain problems in MTI. Yet, our model encourages decision-makers to conduct the diagnosis of RI supply chain indicators as an early intervention. The diagnosis reports can help decision-makers to prepare strategic planning for MTI. Besides, it also provides a new advanced technology framework in RI supply chain indicators. EA conceptual model is a new technology framework that can aid decision-makers and shareholders in Malaysia. Following the requirements of the Ministry of Transport that is proactive in providing services using high technology. Our EA conceptual model for RI supply chain indicators can be accessed easily monitored by the Ministry of Transport for the dynamic decision-making process.

5. CONCLUSION

For practical implications to the society and policymaker, the level of EA adoption and profile of EA usage resulted from this research are the main sources of information and guidance for further RI supply chain indicators for MTI development programs. The results provide insights to the MTI for RI and other similar organization of how they could improve their EA adoption and usage for industry improvement. The government and related regulatory bodies can play a more pivotal role by creating awareness and assist the MTI. They should adhere to the list of core EA parameters for RI supply chain indicators for MTI as guidance in training and evaluation on progress. The developments of MTI are crucial and have a significant contribution to economic growth to increase the Gross Domestic Product, employment, and exports. Further, to support the government policies towards achieving high income and developed nation status by 2025.

Hence, we are designing a high-performance Enterprise Architecture RSC framework that visualizes, analyze, and maintain all RSC indicators to stay in control and govern nexus information through connecting and integrating a broad range of systematic and structural information within a visual appearance that can construct a comprehensible, value focus framework of what is and what to be for Malaysia Transportation Industry. Besides, the decision-making process in each tiering of RSC will increase the value in embracing analytics for shortening procurement cycle time and aspire to guide in a modern era by switching over toward a paperless decision-making process that forecasts RSC scenarios and analyses optimal outcomes.

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