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Importance and challenges of Maintenance Service Logistics

Bedeutung und Herausforderungen der Instandhaltungs-Service-Logistik

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Maintenance and service logistics are relevant to capital goods supply such as manufacturing equipment, industrial equipment or primary equipment used for processes of users. The study classifies the significance of maintenance service logistics (MSL) and investigates the challenges the organization faces in maintenance service logistics based on previous research work on the subject. A variable number of opinions have been presented by previous authors showing that maintenance operations in different industries vary according to organizational requirements, which is also a critical task. It has been identified in this study that MSL plays an important role in the overall maintenance management systems since it ensures the availability of resources and timely delivery of finished products throughout the product life cycle. There are limited empirical studies that are relevant to the topic of maintenance services-based logistics, and different studies provide terrible implications about maintenance service requirements in different industries. In future, the research can be broadened with the inclusion of a larger number of research articles or implementation of other methodologies such as primary data analysis methodology.

[Keywords: Maintenance logistics, maintenance services, service logistics]

1 INTRODUCTION

The concept of maintenance service logistics incorporates all types of processes related to resource requirements to maintain all services. It also includes planning and design for maintenance activities. Maintenance services logistics are either unconsciously or actively connected to different activities such as buying and selling communicating and dealing with certain situations. Relations in the services sector exist between the provider and the user of a particular service, and other factors such as ownership or interpersonal connections cancel act as important factors [Jur16]. The maintenance service sector is characterised by different features such as un-storability, inseparability, variability and complexity. According to the studies of [Jur16], the concept of service logistics and its maintenance stand on different pillars including banking and financials, industrial conditions, welfare services, culture, transport and telecommunications. Businesses must try and understand the potential challenges and risks in maintenance services logistics in order to mitigate effectively are we ready for the consequences. Maintenance service logistics disruptions can directly impact selling volumes, profitability and brand image of companies that are service-oriented. There are many publications that have been based on research work related to services sector logistics, and these studies can help in understanding better about the different types of issues and challenges that are faced in maintenance services logistics.

Maintenance and service logistics are useful in ensuring reliability and high availability of capital goods. In most cases, maintenance service logistics tend to represent a significant part of the overall operating costs within capital intensive industries. Maintenance and service logistics are relevant to capital goods supply such as manufacturing equipment, industrial equipment or primary equipment used for processes of users [ETV17]. Therefore, such equipment's availability is of key importance and these types of materials also require maintenance throughout their long lives. In this study, the applicability of maintenance service logistics is to be discussed identifying the different classifications of maintenance service logistics through a detailed review of the literature. The different existing research works about maintenance service logistics applications along with shortcomings of existing works have to be evaluated in this study. Potential future directions of research in maintenance service logistics application are also to be evaluated in the context of relevant functional industries such as automotive, defence, aerospace or maritime sector.

Previous studies have focused on identifying the different influencing factors on maintenance service logistics and the different challenges stakeholders face in this field. However, there has been an evolution of technology and innovation which has required adaptation of maintenance services logistics practises little environmental changes [OHH18]. This study will help examine the relevance of previously published articles in the modern context. It can also shed light on the innovation adoption literature in maintenance services and pinpointing current emerging

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themes and challenges in maintenance services logistics. The area of maintenance services logistics mostly involves activities of sourcing equipment or parts of equipment in factories across different sectors.

There are limited empirical studies that are relevant to the topic of maintenance services-based logistics, and different studies provide terrible implications about maintenance service requirements in different industries. Divergence in collective opinions among the previous research works requires further comprehension. In previous studies such as in the studies of [MSI19], existing challenges in the maintenance services sector include distribution-based issues existing in the systems, agreement failures with clients and time-based delivery issues. The present study the different identifiable research gaps in the previous studies. The conceptual framework developed in this study can help future researchers to understand the different logistics challenges in this sector and in after-sales service for equipment maintenance.

The main aim of the study is to identify the importance of maintenance service logistics and analyse the challenges faced by maintenance service logistics based on previous research work on the subject. The relatable future research issues in this topic have also been evaluated in this paper.

In this study, relatable literature regarding the maintenance services logistics and different influencing factors on the maintenance management system is to be evaluated. This study will be helpful in providing knowledge about the existing and emerging challenges in maintenance services logistics across various types of industries in the global market. The major areas identified in previous studies and implications about the future changes in maintenance service requirements and logistics can be obtained from the findings and results of the study, which might help contribute positively to the existing literature framework. Maintenance service logistics incorporates different aspects of maintenance support systems end is also inclusive of other practises in the management of organizations. This study can also be helpful in providing guidance to future organisations on the effective strategies of maintenance logistics.

2 Maintenance Service Areas Of Research

Maintenance service logistics in organisations are mostly related to different activities in supply chain management that are service-oriented and require regular maintenance such as equipment maintenance, spare parts replacement, management of maintenance staff and engineers and other factors. Many different resources are required to perform maintenance, such as spare parts, service engineers, and tools [ABH18]. To ensure it, the resources are required on time at the right place and time. To accomplish it, a service supply chain or network used and which involves an operational expenditure. In most cases, maintenance service logistics tend to represent a significant part of the overall operating costs within capital intensive industries.

Different theories and models such as the balanced scorecard model for the development of effective management strategy in maintenance logistics have been used in previous studies have which directly linked the performance results with the drivers of performance in organization's and maintenance value or costs. As mentioned in the studies [RPG+18] a conceptual balanced scorecard model can be used to understand that strategy themes and justify the strategies that can be most appropriate for successful outcomes. Similar to its application in common logistics contexts, the balanced scorecard framework is efficiently applicable in maintenance services logistics as well. The consequent steps of developing a balanced scorecard model include three steps that can lead to better decision-making in logistics management. Strategic objectives in this model are implemented for the decomposition of actionable components [RPG+18]. On the other hand, the balance scorecard model has also been recognised as one of the most advanced and technologically improved approaches that coordinate well with the information diffusion theory [WC12].

It can apparently seem that there are no prominent relationships between logistics and maintenance services and identification of individual areas is much more challenging since logistics has one of the youngest philosophical directions. In the initial stages, literature only connected logistics to directional flows within factories and automation. The literature related to logistics and maintenance has been continuously evolving and exploring new areas and previous studies have significant gaps. Majority of logistics-based studies are related to automotive transport and manufacturing or delivery processes. However, services logistics is not much explored throughout previous studies, and yet it is necessary that everyday usage and implementation of service logistics is evaluated and recognised positively [Jur16].

Service logistics can consist of different service-oriented activities broadcasting that is important for sustaining regular Operations and economic processes. Different types of processes are also included in maintenance services logistics, such as transportation, storage, manipulation, supply, and technical maintenance. It has been mentioned in the studies of [MSI19] that historical literature related to maintenance services logistics Furthermore include classifications of different maintenance parts stock-keeping units, types of demand forecasting models utilised in maintenance services logistics and flexibility of time-based logistics along with their importance and network design.

Maintenance service areas have been explored in quite a number of previous studies that outline both the existing

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challenges and processes caught and the future perspectives of maintenance service development and logistics related issues. The research work of [Sha15] pointed out that maintenance management differs across industries and it is a very critical task to manage the supply chain and logistics in maintenance services. The authors also mentioned that maintenance logistics in any organisation have operations that directly impact the availability and profitability of the firm. [CP10],on the other hand, have used previous literature review followed by a strategic approach while investigating the impacts of maintenance or humanitarian logistics chains. The findings in this study indicated that attributes such as optimisation of transportation processes, management of inventories in local or regional warehouses as well as other functionality did maintenance services are required to be coordinated with a collective strategy that integrates and pre-positions supplies and efforts [CP10]. Alternatively, the studies of [DM12]focuses on maintenance service areas such as facilities management particularly in industrial facilities and operational performance-based impacts in warehouses. Previous studies have also followed different structures while exploring the maintenance service areas which also identify particularly important areas such as performance measurement, facilities management, maintenance service contracts, logistics operations, warehouse maintenance and other similar research directions. Many previous studies such as [DPZ+13]have conducted research in areas of demand for maintenance services considering historical data available and providing futuristic forecasts based on such patterns in data. Similarly, the opinion of [Jur16] also outlines the different areas in service logistics across various industries such as the construction industry, education industry, financial services industry and manufacturing industries as well as multiple other industries. Information channelling occurs in maintenance service management through maintenance service contracts. According to most previous studies, most previous researchers have recognised that search contracts in logistics of maintenance services are between the suppliers, customers, and organisation managers.

3 Challenges In Maintenance Service Logistics

Logistics services have become a critical issue for 'companies' performance [DM12]. Logistics services improvement is one of the important factors to provide first-class customer service. The highly competitive environment, along with 'customers' demand, has forced companies to continuously evaluate, improve and reengineer their logistics operations [GLV10]. Maintenance or facilities management is concerned with the movement of products development of supply chain strategy and differentiation of offered facilities from competitors. There are other issues related to maintenance services logistics, such as providing services to clients and customers on time, minimising costs, and improving profitability[MD14]. There is utmost important of prompt repairs, tracking of the demand for these maintenance parts. This can also lead to undesired outcomes and failures in service levels. Absence of well-designed distribution networks can also be a significant issue in case of maintenance services logistics management, which indirectly affects organisations organisations' desired service levels [Hui10]. As mentioned in the studies of [MSI19], the challenges related to Maintenance services logistics also include distribution-based issues in the existing systems, agreement failures with clients and time-based delivery issues. In practice, there are also many issues in maintenance services logistics such as application of general inventory management principles in the maintenance of inventories and enough attention is not paid for gaining effective control over the maintenance management system practices.High system availability is critical for advanced technical systems such as aircraft engines and medical devices [KKN20]. Any disruptions are generally very costly and need a responsive logistics network to replace the failed item by a functional one promptly [KKN20]. On the contrary, the late delivery of such equipment to the customer can lead to increased system downtime and consequently, a significant profit loss [KKN20].

A study performed by [NVT21]on service operation vessels for offshore wind farm maintenance pointed that to minimize turbine downtime, it is essential to bring the right components to the maintenance of offshore wind farms, while budget and volume constraints prohibit having excess inventories on board. Routing and scheduling offshore wind farm maintenance services generally map into difficult decision optimization problems that require advanced solution methods for solving them [NVT21].According to [Mun17]the operational costs, especially logistics costs, have a great potential for cost reduction in the offshore wind power plants. More than 50% of the operating costs consist of direct maintenance measures (logistics, personnel and material [Mun17].This cost to be reduced to make it more attractive this renewable energy production sector. Here we can observe the organizational performance has a relation with the maintenance service logistics challenges. Hence it could be hypothesized that,

H1: Maintenance service logistics positively influences organizational performance.

Different types of challenges have been identified in previous journals and articles that are to be explored in detail in this research. Fundamentally the major issues identifiable from available sources include the design-based issues in distribution networks, agreement failures among different parties in maintenance services as well as time-based delivery issues [MSI19].[DPZ+13] have also pointed out that the current maintenance service logistics issues incorporate unsatisfactory reliability levels in forecasting, which time series forecasting methods cannot mediate. There has been observable lack of demand data in this sector, and the most important underlying cause of such lack

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of data is intermittent demand. Demand-based changes overtime also result in changes in product life cycles and problems in coordination in between tasks in maintenance services control, resulting in financial consequences and problems in supply stock situations and delivery. Strategic asset management issues are also relevant to maintenance service logistics in many organisations, and disruptions in contract terms often result in disputes and delays [DM12]. Therefore, establishing successful partnerships is crucial for avoiding facilities management and environmental issues in logistics and warehousing of maintenance services. [MKA15]have mentioned that the majority of previous studies view maintenance tasks to be carried out by technicians end most of the required data collected is cost-related. Existing data and information-related issues are commonly identified in previous studies to be a significant challenge in maintenance service logistics. These authors have also identified this to be a significant challenge. Decision-making in maintenance management is highly dependent on the effectiveness of maintenance management logistics procedures. Similarly, [KVZ16] outlined that in maintenance service management, reduction in the requirement for safety stocks can decrease the holding costs and obsolesce risks and it can result in effective compensation of higher manufacturing costs.

Operational coast related to the maintenance logistics also one major parameter. [PHJ17] discussed a business case for offshore wind operations and maintenance logistics yielding 1% savings in levelized cost of energy is included on how to expand working hours from daytime to also work at night. In this research, the researchers discussed [PHJ17] the Operations and maintenance (O&M) costs make up approx. 50% of offshore wind OpEx and the research findings presented in this paper show that logistics makes up at least 34% of O&M costs and consequently at least 17% of OpEx costs. Logistics is therefore a key cost factor which deserves more focus at a policy level, in academia, and from practitioners. According to a study performed on the offshore wind farm [Sha15].The design of an offshore wind farm (i.e., geographical placement or layout, location of installations with respect to wind and wave direction) is an important element that can heavily influence the maintenance logistics decisions. Here we can understand the significance of the asset location in the performance of maintenance service logistics. The authors stated that [Sha15]a well-organised maintenance logistics is required not only to reduce the O&M costs but also to ensure that power generation matches the demand and greenhouse gas emissions are cut in a cost-effective way.

Service operation vessels are becoming the dominant mode for the maintenance of most offshore wind farms [NVT21]. A study performed by [NVT21] stress the important role of service logistics in reducing the cost of renewable energy generation. The researchers proposed an operational model which takes into account a detailed environment where vessel routing is integrated with the scheduling of maintenance operations using different components [NVT21]. The maintenance logistics networks are confronted with a variety of decision-making problems [KKN20]. Such decisions can be classified into strategic, tactical, and operational categories [KKN20]. The crucial issues in maintenance logistics are service provision and customer satisfaction by prompt equipment delivery [KKN20]. The design of the good maintenance service logistics networks a key challenge to support the after-sales service activities. The globalization of the worldwide economy and the rapid growth of cutting-edge technologies drive toward a shorter product lifecycle, more volatile customer demand and a need for a time-critical after-sales logistics service.

Consequently, a well-constructed distribution network has become more critical [MNS09]. Spare parts logistics significantly impact the performance of the maintenance service logistics and the maintenance management system. The logistical process chain of maintenance order processing, thus integrates personnel and team planning, equipment and material logistics as well as spare parts logistics [LO14]. Any relay in the resource planning can affect the maintenance service logistics' availability and impact the movement of the spare parts for the rectification.

Based on the above analysis, it can be concluded that significant relationships exist between maintenance service logistics activities and organizational performance.

4 Importance Of Maintenance Service Logistics In Maintenance Management Systems

Maintenance service logistics is closely related to all the processes and business organisations and therefore acts as a key business service factor according to the majority of previous studies in the literature.The importance of the techniques used by the logistics in a company engaged in engineering activities is huge, in order to be able to connect the user of his service the technical implementation, with the equipment produced for the given demand[Pee20].Design and management of an efficient maintenance service network are vital to obtain a high asset availability and to reduce the downtimes [TKA20]. Thus, many companies have invested in capabilities to enhance their existing maintenance networks to improve the service levels and to get resilient to uncertainties (e.g. availability of resources) [TKA20].

Maintenance service involves different types of supporting services as well as coordinating functions that are involved in the operation, maintenance and management of physical assets in the workplace[MD14].Maintenance service logistics can be successfully applied to the operation of diverse types of already constructed facilities and maintenance of logistics and warehousing activities. Another significant role that services logistics maintenance

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place includes is providing assures of the warehousing system's full service, including material handling, utilities, and equipment maintenance[ETV17]. Interventions of maintenance service logistics have been identified to be useful in various contexts such as performance measurement of logistic operations and maintenance practices, maintenance of warehouses end control over outsourced maintenance service logistic contracts [MD14]. [RFH+16] have further mentioned that Recently there have been developments in proactive smart logistics applicable in maintenance service logistics as well. In case of successful implementation of such processes, it is necessary that appropriate management practices are introduced in particular areas of maintenance. A study performed by [TFL18] stated that the integrated logistics and maintenance decisions would allow more efficient maintenance programming and execution. In Maintenance management, the maintenance service logistics provide great support for the transportation of the maintenance teams from one point to another location. [DLD+15] stated that the transportation systems' main tasks in a maintenance operation are to provide accommodation for crew and technical personnel, loading, transporting and assembling failed turbine components in the offshore environment. Marine logistics plays a critical role in this context, and thus is crucial for wind park operators to operate their assets successfully with high availability and positive returns [ELK14]. All the literature considered in the study pointed out the importance of maintaining service logistics in the organisation's overall performance. More and more companies have started to consider supply chain and logistics performance important elements for the achievement of competitive advantages [HC02]. Here we can observe the performance of maintenance management system has a relation with organizational performance.Hence it could be hypothesized that,

H2: Maintenance Service logistics positively influences the maintenance management system.

Maintenance service logistics incorporate a wide range of processes especially involving transportation and delivery of capital goods such as manufacturing equipment industrial equipment and other primary maintenance and supervision processes for the users [DPZ+13]. Availability of inventory stock is of key importance in maintenance service logistics, and achievement of high availability in maintenance is required throughout the life cycle of processes. Multiple types of different resources are involved, such as spare parts, equipment parts, service engineers as human resources, tools and so on. Maintenance service logistics ensures that these resources are available at the right place and at the right time [ABH18]. Moreover, maintenance service logistics functions also include maintenance planning and designed for maintenance activities that directly impact other processes' efficiency in industrial program production processes. Many underlying processes in maintenance service logistics such as performance-based service contracting have been identified to be helping in the reduction of asset ownership costs while at the same time ensuring effective system performance. Maintenance service logistics also plays an important role in incorporating service level agreements and decision-making related to operations management exceptions and the development of a combined and holistic tactic for making decisions about interferences chosen in large-scale systems.

It is important that the technical requirements in services and maintenance service needs in a plant are identified and defined specifically prior to recommending services for outsourcing. Generic approaches in plant maintenance services are based on fundamental frameworks which are offered by the plant throughout the life cycle. Maintenance management systems are an important component of production systems in manufacturing and other industry sectors. These systems help companies maintain effective control over resources and utilities throughout the manufacturing process cycle [Opt20]. Recent technological developments have improved maintenance management activities through the implementation of technologies such as CMMS software. Logistics and maintenance management plays the role of controlling the different movement of equipment parts and equipment repairing crew. Minimizing breakdown is the main objective of maintenance service logistics management which include preventative maintenance inspections, inventory management and requirements analysis along with minimization of costs for repairing facilities (Maintenance services logistics also provides effective support in maintaining consistent product quality and production within a minimum of downtime. The results and efficiency of maintenance services logistics systems in organisations can be measured by reviewing the “Overall Equipment Effectiveness solution (OEE)”, and this can ensure that maximum output is gained from the available resources in any production process. [Chr18] has mentioned in a recent article that every part of the supply chain management process can be related to maintenance services logistic management operations such as transportation. For example, in the supply chain management of perishable products, maintenance services are required for ensuring delivery of the products in designated places on time and maintenance of effective storage conditions for the products throughout the supply chain movements. Therefore, according to most previous studies, maintenance management systems are significantly dependent on service logistics management within the supply chains.

Asset availability is a key factor in the performance of every organization. Downtime of a capital good may lead to delayed or even lost production, or it leads to inferior service levels and reduced satisfaction at customers [ABH18]. To achieve it, the necessary maintenance needs to be performed. Many different resources required to complete the maintenance of assets. Maintenance service logistics encompasses all processes that ensure that the resources required for maintenance are at the right place at

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the right time [ABH18]. Effective maintenance strategies supported by a resilient maintenance service network ensure high availability of assets [TKA20]. In this direction, the researchers [TKA20] model and solve a multi-skilled workforce planning problem to establish a resilient maintenance logistic network containing a single repair facility.

Consider the offshore wind energy industry, the maintenance service logistics play a key role in the performance of this industry. Maintenance logistics' is known as an important competitive factor in the offshore wind energy industry, having a significant impact on the profitability of wind projects [Sha15]. Maintenance service logistics support the effective maintenance management of the asset owned. Any failure to deliver proper maintenance logistics due to lack of spare parts, unavailability of means of transportation, or insufficient staffing may adversely affect the wind farm availability and thereby reducing power output as well as profitability [Sha15].

Maintenance service logistics plays an important role in the facilities management (FM) sector. According to [DM12], improved logistics performance via FM and maintenance services is a significant factor in achieving continued competitive advantage. The performance of the maintenance service logistics closely related to achieving the business objectives in the facilities management sector. Spare parts logistics is a part of maintenance service logistics. Effective spare parts management required to completed the various maintenance activities. According to [LO14] the challenge is to find an effective approach to handle the complex situation for the operational maintenance processes as well as the spare part logistics. In a complex situation if the spare parts logistics failed to provide the required spares on time, which can affect the maintenance activities, asset availability, and the performance of the maintenance service logistics and ultimately impact the organization's performance. According to [Pee20]the engineering logistics professionals in the services sector need to be seen as highly qualified staff whose knowledge surpasses their counterparts in standard economic logistics in technical terms. In the maritime sector, maintenance and service logistics support are known to be a significant part of the overall operating costs. Maintenance and service logistics support (i.e. after-sales logistics activities needed to enable capital goods to be maintained and function properly) are essential to ensure high availability and reliability during the asset life time [ETV17]. Therefore, the issued connected with the maintenance services logistics must be given great and careful consideration to ensure the asset availability, reduce the operating costs and avoid the risks related to the maritime sector.

Based on the collected evidence and its analysis from previous studies, it can be concluded that maintenance service logistics also play a significant role in driving the maintenance management system efficiently

5 Conclusion & Implications

5.1 Conclusion

Previous studies have also explored the different challenges faced by maintenance management staff in logistics management within the production and manufacturing industry or in other industries [Jur16]. Variable number of opinions have been presented by previous authors showing that maintenance operations in different industries vary according to organizational requirements which also is a very critical task. It has been identified in this study that maintenance service logistics plays an important role in the overall maintenance management systems since it ensures the availability of resources and timely delivery of finished products throughout the product life cycle.

Maintenance service logistics are involved in different activities throughout the production lifecycle such as in transport, stakeholder's satisfaction, warehousing and storage, inventory management and other areas. Most of the previous studies have found that maintenance staff and maintenance services are involved in all of the steps of production and major philosophies used in maintenance management include reactive approach and proactive approaches. Both direct and indirect relationships have been implicated in previous studies between maintenance services and logistics management in organizations. Maintenance services logistics management has also been identified to be closely related to asset management and cost management in organizations, and hence at every point of the supply chain, it remains as an important factor. Management of maintenance technicians and staff are also hello apart under the maintenance service logistics activities. Therefore, the hypothesis, in this case, can be accepted (Fig 1), which is to be further tested and analyzed by implementing a systematic literature review of peer-reviewed articles.

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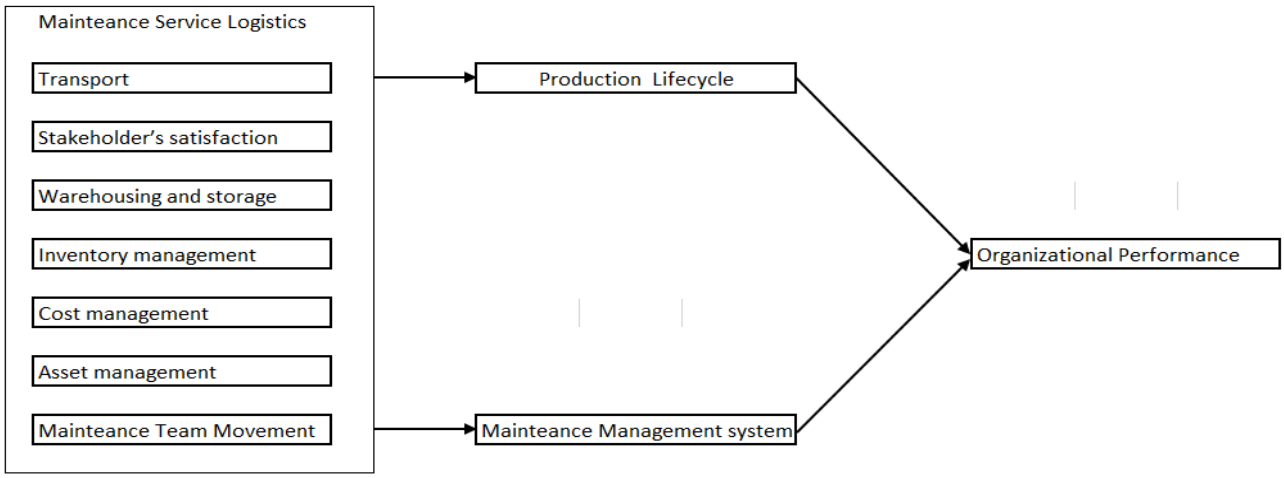

Figure 1

5.2 IMPLICATIONS

Sufficient evidence could not be gathered and analyzed in this study because of limited time availability and access to quality resources. Certain gaps in literature could also be identified, such as lack of enough studies focusing on the logistics part of maintenance services, and most previous literature is mostly focused on maintenance services tasks and opportunities. In future, further investigation about the maintenance service logistics activities and issues will be performed in the study which can provide effective implications about the existing and emerging problems and relationships.

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