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Investigating Supply Parts Delivery Delay from Supply Depot to King Khaled Air Base in Royal Saudi Air Force

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INVESTIGATING SUPPLY PARTS DELIVERY DELAY FROM SUPPLY DEPOT TO KING KHALED AIR BASE IN ROYAL SAUDI AIR FORCE

THESIS

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Abstract

Aircraft supply parts is an important factor in preparing the aircraft to do its mission. Due to delayed delivery of parts or inefficient delivery process, time may be lost waiting for aircraft supply parts, causing mission delay or failure. By tackling the delivery delay causes we can insure improvement on delivery process. In order to gather data for this thesis two different tools were used, aircraft parts data and an interview. Data was gathered from the F15 maintenance and supply squadrons in the Royal Saudi Air Force. Results of this research showed diverting in the main duty of supply depot and forecasting mismanagement which resulted in insufficient parts stock. The study finally concluded with recommendations to improve current process by performing better and dynamic forecasting in order to achieve timely replenishment of parts by supply depot.

To God, with whom all things are possible

To my Country

To my Parents

To my Lovely Wife

To my Kids

To my brothers and Sisters

For their unwavering support

Acknowledgement

I would like to convey my sincere appreciation to my academic advisor, Dr. William Cunningham, for his remarkable support and helpful guidance throughout this research and during all classes I have attended with him. His knowledge, sincerity, and vision have encouraged me. It was a wonderful opportunity and honor for me to study and work under your supervision.

Rashed Alkhathami

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INVESTIGATING SUPPLY PARTS DELIVERY DELAY FROM SUPPLY DEPOT TO KING KHALED AIR BASE IN ROYAL SAUDI AIR FORCE

I. Introduction

1.1 Background

Aircraft readiness has long been a priority for all air forces around the world. The air force's dominance plays a key role in helping nations uphold their political positions. The Royal Saudi Air Force (RSAF) is considered among the best air forces in the region with its advanced fleets of aircraft, skilled pilots, and well-trained technicians. Therefore, keeping aircraft ready around the clock is an important matter for every country across the world. "Without a sufficient number of mission-capable aircraft ready to fly at any given time, the Air Force cannot perform its stated mission" (Fry, 2010). For instance, a lot of combined and challenging work has been done by the RSAF to maintain the kingdom and the region's security. Pratim Adhikari et al., (2014) says that it is important for aviation authorities to manage aircraft readiness in order to improve mission availability, reliability, and to keep maintenance costs as low as possible. Thus, many aspects contribute to achieving the aircraft readiness objective. Time is a very valuable and important part of military operations, which makes it hard to keep track of. "In military operations, time is everything" (Givhan, 1996). Moreover, maintenance time starts when the aircraft lands and maintenance technicians are directed to start post-flight inspections. Time may be lost during the aircraft maintenance process while waiting for

aircraft spare parts. As a result, accurate management of spare parts demand and availability helps improve aircraft readiness (Choi & Suh, 2020).

1.2 Problem Statement

In the RSAF, it is necessary to have the supply parts delivered in an accurate and rapid way. Aircraft parts are vital to a fleet's operational readiness. However, problems have been raised at King Khaled Air Base (KKAB), which operates certain platforms and has an issue with long delivery times for high-priority aircraft parts from supply depot to the base. Moreover, the delivery times varied in an unexplained manner every time a part was requested, which negatively affected the aircraft maintenance workflow and lowered the aircraft's readiness

1.3 Research Objectives and Questions

The object of this research is to investigate the causes of supply parts delivery delay between supply depot and KKAB base supply.

The research questions are:

1. What are the main reasons for supply parts delivery delay?
2. What modifications could be done to improve the status of parts delivery delay?

1.4 Methodology

A specific list of parts is obtained from KKAB for this study. to address the issue and be compared with other bases operating similar platforms, which are king Faisal air base (KFAB) and king Abdelaziz air base (KAAB), at the same time for problem validation. The researcher also used interviews to collect additional data on part delivery delays. With regards to the interviews, they included questions that were designed to determine whether the long delivery time is due to the current delivery approach or some other factors. Furthermore, the researcher intends to interview various levels of management in maintenance and supply to identify the current method of part delivery and gather more data on the reasons behind part delivery delays. Moreover, the researcher will have the opportunity to compare the given data with interviews to provide recommendations that may improve the current delivery process.

1.5 Limitations and Assumptions

With regards to the limitations, there were certain limitations that the researcher was aware of. For instance, the researcher intended to assess the parts delivery process by visiting maintenance squadrons' base supply and depot supply, but this option is not feasible due to travel constraints. Therefore, the delivery process will be determined based on interviews with participants. Furthermore, the RSAF's lack of data and information classification limited researchers' ability to conduct more in-depth analyses of the problem.

This research assumed that whatever applies for KKAB will also be true for KFAB since they show similar trends in delivery times and are located at approximately similar distances from the depot supply.

1.6 Implications

This research will help find out the supply-parts delivery delay reasons in the current process that is applied by the RSAF, aiming to bring up valuable findings that will help the RSAF reduce the time waste for parts delivery and enhance aircraft readiness.

II. Literature Review

2.1 Chapter overview

This section will cover some of the most critical evaluations and analyses to do with investigations of delays in the supply of aircraft parts. This section will consider previous and contemporary literature in the areas of aircraft maintenance, time in military operations, aircraft readiness, aircraft supply chain, manpower qualifications, centralized and decentralized storage management, factors affecting supply chain, Gold-esp, and RSAF parts request processes. The most key factors affecting supply-chain part delivery in aviation will also be analyzed in detail.

2.2 Aircraft's Maintenance

The management of aircraft maintenance is one of the key strategies for optimizing costs (Ward, et al., 2010). Junqueira, Nagano, & Miyata, (2018) claim that the fundamental goal of aircraft maintenance management is to perform maintenance at low costs, with the highest level of service and offer delivery times that are competitive, all without compromising safety and quality. According to Basten and Arts (2017), they consider two goals to be accomplished via the conduct of a review in the aviation sector and aircraft maintenance research. One is for determining whether a given problem has been investigated or examined in the past, and, if so, what approach has been utilized to

solve the problem and its outcomes. On the other hand, it is also for determining whether or not a proposed problem will be solved.

Radnoti (2012) emphasizes the fact that scheduled maintenance checks can be organized into services or categories, and that these can be programmed in an order that ranges from the simplest and most routine to the most intensive, which includes a comprehensive examination of the aircraft's structural integrity. The Federal Aviation Administration requires that scheduled maintenance checks be based on predetermined flight hours and establishes that there are typically four levels of inspection, which are referred to as checks A, B, C, and D (Federal Aviation Administration, 2022). Similarly, maintenance in the Air Force categorizes inspections into certain levels that deal with specific types of tasks and achievement priorities. For example, organizational maintenance, intermediate Maintenance, and depot maintenance levels. According to Pabedinskaitė & Akstinaitė, (2013), extensive maintenance must be carried out within a hangar using specialized tools, also requiring the participation of a large number of individuals with advanced levels of education. These inspections must also be planned to make the most of the maintenance facilities and resources.

2.3 Time in Military

It is essential for any military defense department and the successful completion of its objectives to have spare parts readily available for use when they are needed to accomplish maintenance (Sharma, Singh, & Kulkarni, 2016). According to Kusek & Rist

(2004), this represents a major measure of whether the funds spent on parts for such operations annually are being used in a cost effective, efficient, and effective manner is whether or not there are shortages of spare parts.

Other outcomes by (Basten & Arts, 2017) suggested that the military agencies should execute several overall logistics efforts that are intended to strengthen the logistic systems and reduce shortages of spare parts. Considering the above-mentioned body of research, the supply chain management model put into practice in the delivery of components for military operations must successfully fulfill the deadlines from the very beginning to the very end. Another study carried out by (Milambo & Phiri, 2019), looked at Air Force purchases of spare parts that are at low demand and determined the total amount of money the Air Force military spends on low-demand components. The research identified and aggregated the best commercial buying and supply chain management methods that are utilized for designing supply strategies for such commodities. It then advised ways in which the Air Force might enhance its supply strategies for such items based on these findings.

2.4 Aircrafts Readiness

Several authors have pointed out that the level of readiness of an aircraft is, in many cases, a more relevant performance indicator of how effective the aircraft is. In addition, the task must satisfy the requirement that the aircraft must be ready. Within the framework of performance-based contracting, Basten & Arts, (2017) apply the fleet readiness metric. They obtained an approximation of this metric by first computing the

aircraft readiness using the binomial distribution and then using the availability as the likelihood that an aircraft is accessible at some arbitrary point in time. This estimate is more manageable than the real readiness of the fleet, but it assumes that the readiness and availability of various aircraft are independent of one another at any given point in time. In the context of a multi-echelon, multi-indenture spare parts inventory, (Costantino, Gravio, Shaban, & Tronci, 2013) utilized a technique that was analogous to the one described above. These researchers also used the phrase "fleet readiness" to refer to the average number of aircraft in an available fleet. The conclusion that must be drawn from this is that the writers in question take into consideration the availability multiplied by the size of the aircraft rather than the fleet preparedness in the sense that it is most often understood.

2.5 Aircrafts Supply Chain

Supply chain management refers to a collection of tactics that are undertaken to efficiently integrate a company's suppliers, manufacturers, warehouses, and retail locations. This is done to maximize efficiency throughout the whole supply chain (Lu & Swaminathan, 2015). This ensures that items are made and distributed in the right amounts, to the suitable places, and at the appropriate times to lower the total costs of the system while still achieving the criteria for service level. When it comes to the management of the supply chain, it is thus very necessary to have a strategic attitude to take advantage of the benefits offered by interconnectivity. Research was conducted on the methods of supply chain management utilized by Boeing Commercial Airplane

Company within the context of the larger aerospace sector (Horng, 2006). The results of this research indicated that there have been significant adjustments made to the supply chain management systems that are utilized in the aviation industry. These changes include the close integration and restructuring of supplier networks to achieve gains of efficiency, the delegation of greater production and design responsibility to major suppliers through strategic supplier partnerships, as well as the evolution of greater system and subsystem integration capabilities for key suppliers. In addition, a lifecycle approach of supply chain design and management was given a lot of attention to cut down on the overall cost of goods and systems throughout the course of their whole lifecycles.

In addition, a different study by (Costantino, Gravio, Shaban, & Tronci, 2013) found that supply chain management had been fully implemented throughout all levels of governments globally and that customized policies had been developed to meet the requirements of the supply chain management policy. Regardless of the application of the concept, there remain obstacles that prevent the complete execution from reaching its potential (Costantino, Gravio, Shaban, & Tronci, 2013). There are still obstacles in the way of the execution of the public supply chain management plan.

2.6 Manpower Qualification

Licensed airframe and powerplant (A&P) aviation mechanics are essential in the aviation industry to fulfill the role of ensuring that a fleet of commercial and general

aviation aircrafts continues to be in a state of airworthiness. Before any of these individuals may fly an aircraft that has been deemed certified and flyable, they are required to go through a training program that is regulated by the federal government. Every national government has a department that lays out these requirements for training in the form of minute-by-minute regulations. Every government agency supervises the certification of aircraft manpower. To guarantee that these people, who may have varying degrees of educational background, receive the necessary formal training, the government agencies and organizations operate. To earn their experience, those who want to become aircraft mechanics often go through eighteen to twenty-four months of formal education and "extremely extensive technical training instruction" (Brooks, 2019). After completing the necessary training, which entails knowledge training, a knowledge assessment, practical training, a practical evaluation, and passing the licensing exam, these individuals join the workforce at the bottom of the line. This results in their working in shifts for the business, executing the necessary maintenance chores for the aircraft type they are given (European Union Aviation Safety Agency (EASA), 2016).

2.7 Centralized and Decentralized Storage Management

A search of the published literature has been carried out looking for phrases that are relevant to the centralization and decentralization of the management of spare parts storage (Dadashpoor & Yousefi, 2018). Previous frameworks have concentrated their attention primarily on inventory control using the classification of individual stock

holding units and the examination of demand trends to establish optimal stock levels, with a primary emphasis on operational choices. To facilitate the making of strategic, tactical, and operational choices regarding the management of spare parts storage, various researchers have derived different frameworks, as summarized in table 1 below. This table is in no way intended to be exhaustive; rather, the frameworks it presents are indicative in terms of the emphasis area, strengths, and limitations of the existing frameworks.

Table 1: Inventory Centralization Decision Framework for Spare Parts. Adopted From (Gregersen, Nicklas, Herbert-Hansen, & Zaza, 2018)

References	**Framework Types**	**Strengths(S) and Weaknesses(W)**
(Cavalieri, Garetti, Macchi, & Pinto, 2008)	Coding, classification, prediction, stock policy, and validation are the five phases of the decision-making framework.	S) Utilizes forecasts of demand for categorization of each spare part. W) Concentrates on inventory management for spare components
(Hu, et al., 2018)	The framework considers the lifespan of spare components, goals for spare parts management and relevant disciplines to managing spare parts.	S) Comprehensive framework for spare parts management which provides lifecycle management for spare parts. W) No methodology geared toward practitioners; simulations and theory-only
(Arts, et al., 2015)	Decision frameworks for spare parts maintenance	S) Spare part classification and demand history forecasting W) Assumes that central planning for inventory is done across all sites
(Xie, et al., 2008)	Framework inventory control optimization	S) Focus on a complex supply chain inventory system. W) A simple inventory system is not a good fit for a genetic algorithm.

2.8 Factors affecting supply parts delivery in aviation

Despite the widely held belief that a company's output is only as good as its inputs, businesses and researchers have paid far less attention to managing supplier quality than they must to managing finished goods quality (Cavalieri, Garetti, Macchi, & Pinto, 2008). Costantino, Gravio, Shaban, & Tronci, (2013) affirm that a company's internal operational procedures and its interactions with consumers have an impact on a supplier's ability to deliver high-quality goods and services. The relationship between the customer and the supplier is what sets external quality performance apart from internal quality performance. Numerous studies have looked at how the supplier's quality performance is impacted by the customer-supplier relationship. Both Lu & Swaminathan, (2015) investigated the impact of two various customer-supplier communication formats produced by an aerospace industry supply company. They discovered that, compared to a serial communication structure, the parallel communication system had fewer component flaws. Amine et al, (2021) conducted a study of 300 United Kingdom based automotive suppliers to ascertain the impact of various client organizations' supplier management strategies on the caliber of the suppliers. It was found that the organization's activities relating to supply chain management had a minor impact on the supplier’s quality management. Instead, suppliers used a system known as "stratified quality control," which graded the quality of their products by the purchasing power of the customer, in order to respond to client organizations that had large purchasing power (Amine, et al., 2021). It was thought that requiring suppliers to use specialized quality management

techniques as a condition of purchase would be enough to make suppliers improve their products.

2.9 GOLD-esp

For several years, the RSAF used different logistics software to manage its supply and maintenance logistics services. GOLD-esp is fully deployable software that was established for aftermarket logistics support (the World Security Index 2021). However, GOLD-esp software is currently in use by RSAF and was mentioned due to its significant functions and for successfully serving the RSAF data base for various purposes such as flying hours, maintenance work orders, supply parts tracking, and other discrepancies management for its different platforms.

2.10 RSAF Parts Requesting Process

The RSAF parts request process entails several sections and squadrons within the logistics wings at the RSAF bases. It usually begins when a technician places an order in the GOLD-esp logistic system, moving on to the next authorizing stage, which is the material control section at the maintenance squadron. Soon after the supply squadron receives the order from maintenance material control, However, if the part is not available at base supply, the request will be redirected to depot supply for further action. If the requested part is available at depot supply, a temporary hold in the system will be placed on the part prior to processing the part request. This verification process is practiced by depot supply to ensure the part is physically available and serviceable.

Moreover, when depot supply verifies the availability of the part, the issuance process begins by notifying the requester through an altered request status in GOLD-esp and then starts the delivery phase in the part request process. Although at times the system indicates the part is available at depot supply, sometimes for infeasible reasons, part delivery times vary in an undefined manner.

III. Methodology

3.1 Chapter Overview

Research methodology offers a systematic approach to finding a solution to a particular problem. This chapter covers the methods used to gather information during the study. The chapter provides information on the study and participants. The researcher states and explains the study's research design. This research also offers a specific reason that motivated the choice made. In particular, the choice of research method is based on the appropriate research objective and the resources available. The instrument utilized in the data collection process is also described in this chapter. Finally, this chapter also explains how the data collected is analyzed.

3.2 Quantitative methodology

Generally, two types of research methods are used, qualitative and quantitative. Furthermore, mixed method of quantitative and qualitative could be used as well. In the quantitative research method, data is collected in the form of numbers, contrary to the qualitative research method, where data is collected in the form of interviews or surveys. quantitative data are commonly used alongside empirical social scientific measuring

approach (Boodhoo and Purmessur, 2009). Quantitative data is usually expressed in numbers.

3.3 Qualitative methodology

The researcher also followed a qualitative methodology concept in this study. As discussed later, fully structured interviews were used to collect data. Over the past few decades, there has been a significant increase in the use of qualitative methodology. Many studies argue that qualitative research provides better findings because it is subjective (Connell, Klein, and Meyer, 2004). However, the qualitative research method can be used to explore areas that cannot be quantified, such as human behavior.

3.4 Interview

In the qualitative methodology, interviews are also a popular data collection technique. However, the researcher can select the most appropriate type of interview from three options: structured, unstructured, and semi-structured. Furthermore, these types are accomplished through the use of specific communication methods, such as face-to-face interviews or e-interviews (Bampton & Cowton, 2002). Through interviews, the researcher could gain more detailed knowledge on the research topic.

3.5 Participants

Officers and technicians from the Royal Saudi Air Force are taking part in this study. Participants have experience in the supply and maintenance field in the RSAF; their experience ranges from 10-26 years of working in the RSAF. The participant qualifications are various, between master's degrees and Bachelor of Engineering degrees for the officers. The technicians have usually earned associate degrees along with a few bachelor's degrees. Both officers and technicians' English is good. Finally, twenty people are expected to complete the interview. However, the researchers were able to gather sixteen interviews by phone, email, and face-to-face.

3.6 Development of research instruments

The development of research instruments stems from the primary goal of this study. As mentioned earlier, to accomplish the objectives of this research, the given list of data along with participant interviews would be the appropriate tools for this research. The given part-ordered details in the three bases (KKAB, KFAB, KAAB) were used to provide quantitative data. The collected data from interview questions provided qualitative data. The researcher was able to construct the research instrument by developing interview questions with advisor assistance to ensure their validity. A copy of the interviews conducted with participants is attached in Appendix A.

3.7 Data Collection method

To achieve the goal of this research, more research data would be more beneficial for additional data analysis and findings. However, due to travel constraints and difficult access to parts of the data, the researcher relied on the given data and face-to-face and online interviews to execute the best possible results. Both qualitative and quantitative methodologies are utilized in this research. The researcher, by using a combination of both quantitative and qualitative data, is expecting to add additional strength to the research as it combines both textual and statistical information.

IV. Results analysis and findings

4.1 Introduction

This chapter records a detailed analysis and findings of the data and results of the study. The findings are presented based on the data given and the interviewee's feedback regarding the several factors that contributed to the delayed delivery of parts. The subheadings will be used to categorize the results section into subsections to create a more readable and organized discussion. This section's main headings are introduction, parts data analysis, and interview analysis.

4.2 Parts data analysis

As shown in Table 2, the delivery time for parts orders at King Khalid Air Base (KKAB) from January 2021 to January 2022 demonstrated a random figure; there was no constant flow of events that could create a better analysis. Also, figure 1 below displays a high variation pattern in part delivery times during this period. Conceptually, while it took two days to order transmitter countermeasures during the first order, it took up to ten days for the next order. Similarly, while the fourth order of oxygen regulators arrived in three days, the fifth order arrived in ten days, resulting in an un-uniform pattern as shown in figure 2.

Table 2: Parts Delivery Times from Jan 2021 to Jan 2022 (King Khalid Air Base, 2022)

		waiting time in days							
part description	orders #	1	2	3	4	5	6	7	8
transmitter, countermeasures	5	2	10	8	6	4			
cabin air pressure valve-assy	3	4	8	4					
oxygen regulator	5	4	6	7	3	10			
drive, constant speed,HY	7	1	8	7	9	7	9	11	
alternating generator	7	7	4	8	4	7	3	5	
hydrulic utility manifold	7	7	4	7	8	7	5	3	
shimmy damper	8	7	3	1	5	6	8	4	5
fuel transmitter assy	7	2	3	7	8	7	6	8	
electric control panel	6	8	7	9	4	12	4		
AMSS - Video memory unit	8	2	8	4	3	3	6	7	3
hydrulic pump	4	4	7	3	7				

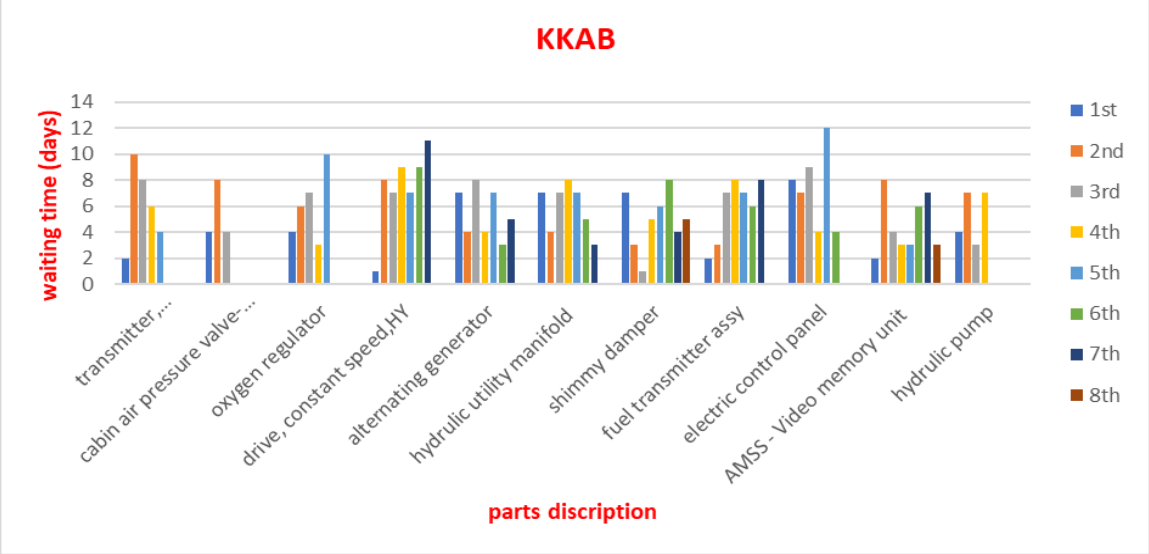

Figure 1 KKAB Parts Delivery Time

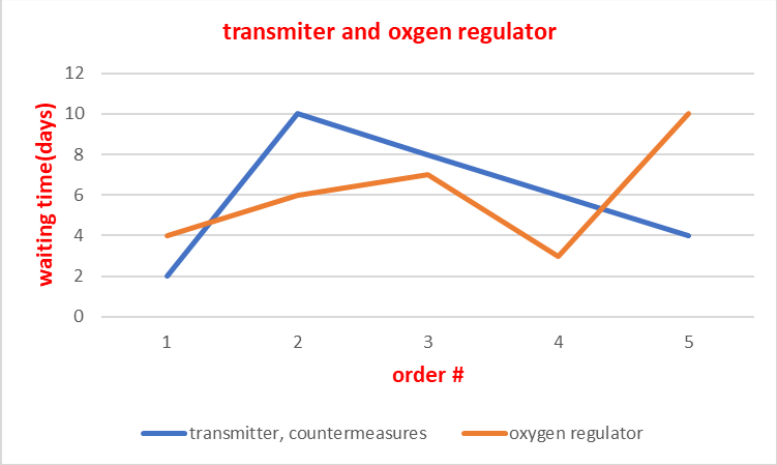

Figure 2 KKAB Sample Parts Delivery Time Pattern

As displayed above, the ununiform pattern and high variations were not unique to one or multiple parts, yet they appeared throughout all parts, which means the root cause for such observations is not due to the nature of the part per se but rather the overall process. Also, the same list of data that was analyzed at KKAB was asked for at the same time from King Abdelaziz Air Base (KAAB), which uses the same platform for recognition and comparison purposes as KKAB, as shown in Table 3.

Table 3: Parts delivery times from Jan 2021 to Jan 2022 (King Abdelaziz Air Base, 2022)

		Waiting time in days										
Part description	**orders #**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Transmitter, countermeasures	**5**	0.47	0.19	0.32	0.38	0.14						
Cabin air pressure valve-assy	**9**	0.62	0.85	0.45	0.58	0.22	0.99	0.85	0.19	0.28		
Oxygen regulator	**5**	1.07	0.89	0.65	0.34	0.73						
Drive, constant speed,HY	**11**	0.51	0.22	0.14	0.13	0.29	0.53	0.10	0.46	0.20	0.40	0.72
Alternating generator	**4**	0.65	0.76	0.43	0.55	1.34	0.20	0.53				
Hydrulic utility manifold	**9**	0.13	0.41	0.34	0.18	0.57	0.26	0.35	0.82	0.43		
Shimmy damper	**7**	0.37	0.16	0.66	0.90	0.89	0.40	0.57				
Fuel transmitter assy	**6**	0.61	0.28	0.42	0.22	0.17	0.93					
Electric control panel	**6**	0.96	1.18	0.93	0.21	0.68	0.22					
AMSS - Video memory unit	**7**	0.12	0.18	0.46	0.71	0.38	0.26	0.75				
Hydrulic pump	**7**	0.53	0.36	0.88	0.29	0.55	0.57	0.35				

However, the aforementioned information on KAAB parts likewise displayed a high variation in delivery time, as it appeared in Figure 3 below.

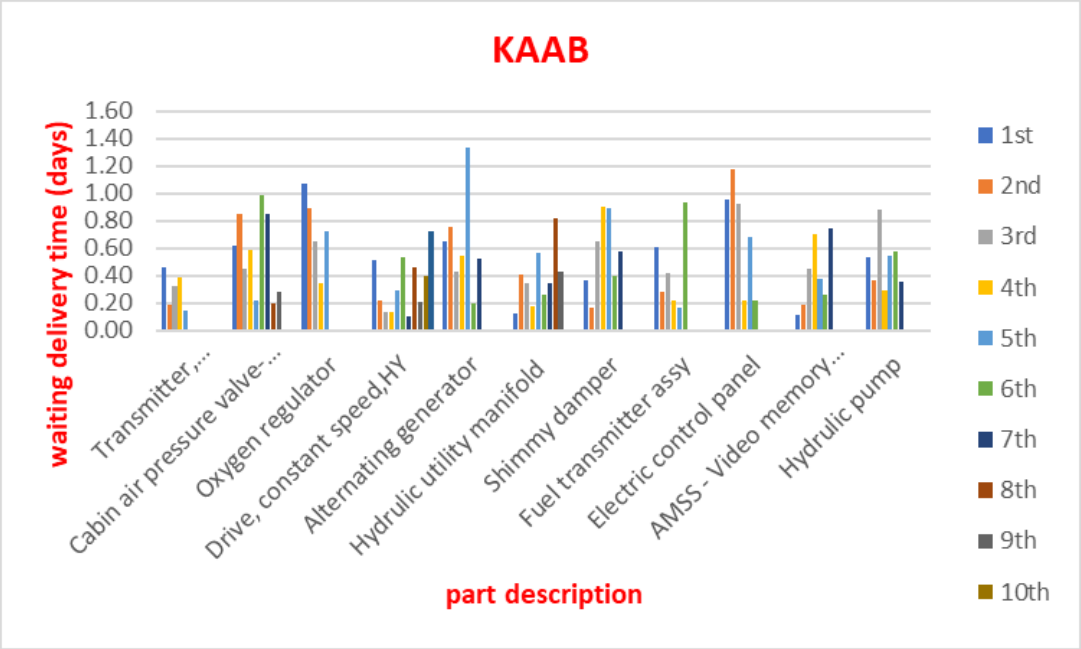

Figure 3 KAAB Parts Delivery Time

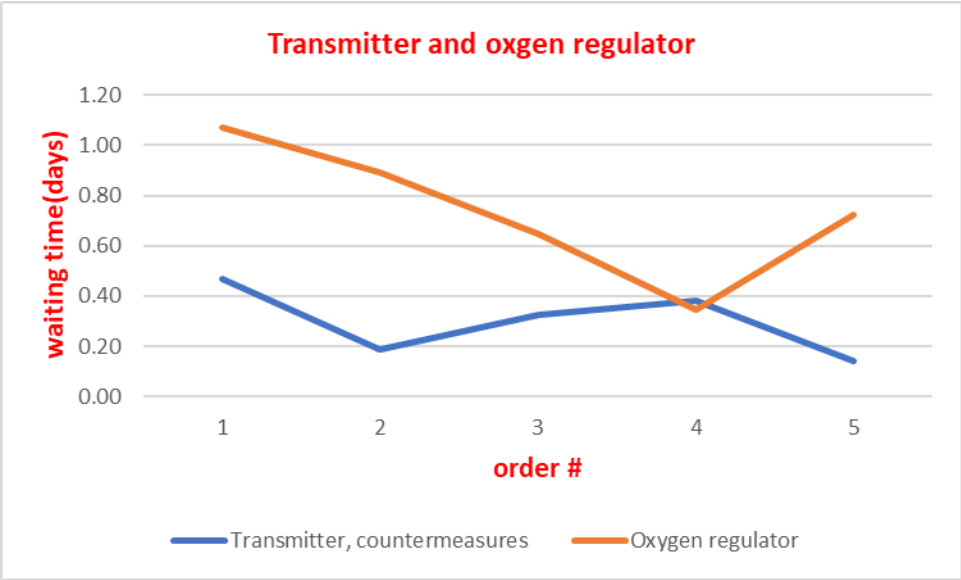

Figure 4 KAAB Sample Parts Delivery Time Pattern

Even though both KKAB and KAAB have parts delivery times that vary a lot and do not follow a regular pattern, there is a big difference between the two bases that is easy to see. As shown in Figure 5, the delivery time for all parts in KAAB was within a day, and more than a day in very few orders, which demonstrates a high level of availability, serviceability, and sustainability of the flight planning process in the base.

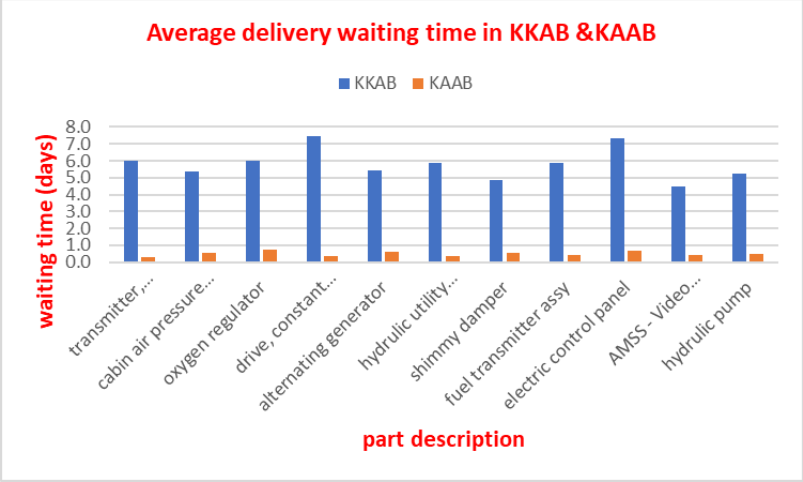

Figure 5 Average Delivery Time Comparison of KKAB and KAAB

Consequently, such results drove the researcher to further investigate whether supply depot location was truly a factor that influenced the delivery time difference between those two bases by requesting data with the same parameters from King Faisal Air Base (KFAB), as shown in Table 4 below, which also operates the same kind of platform and is located at approximately the same distance from depot supply as KKAB.

Table 4: Parts delivery times from Jan 2021 to Jan 2022 (King Faisal Air Base, 2022)

		waiting time in days									
part description	orders #	1	2	3	4	5	6	7	8	9	10
transmitter, countermeasures	9	3	9	4	3	8	3	2	6	3	
cabin air pressure valve-assy	9	1	6	4	7	9	9	3	5	6	
oxygen regulator	6	8	6	11	6	3	5				
drive, constant speed,HY	7	4	9	2	6	4	6	4			
alternating generator	8	7	7	5	9	3	9	7	2		
hydrulic utility manifold	7	7	8	5	4	8	9	4			
shimmy damper	5	8	4	3	9	4					
fuel transmitter assy	5	5	9	8	7	6					
electric control panel	10	7	6	7	9	6	8	6	7	9	8
AMSS - Video memory unit	6	2	6	7	6	9	2				
hydrulic pump	10	6	9	3	7	5	8	8	2	1	6

Even though this list of parts obtained from KFAB has also shown unexplained high variations and an ununiform pattern in the delivery time as analyzed for KKAB, Furthermore, the common factor between KKAB and KFAB is the distance from the depot, and the distinguishing difference between these two bases and KAAB is that KAAB is within a few miles of the supply depot. Figure 6 compares the average delivery times of the three bases.

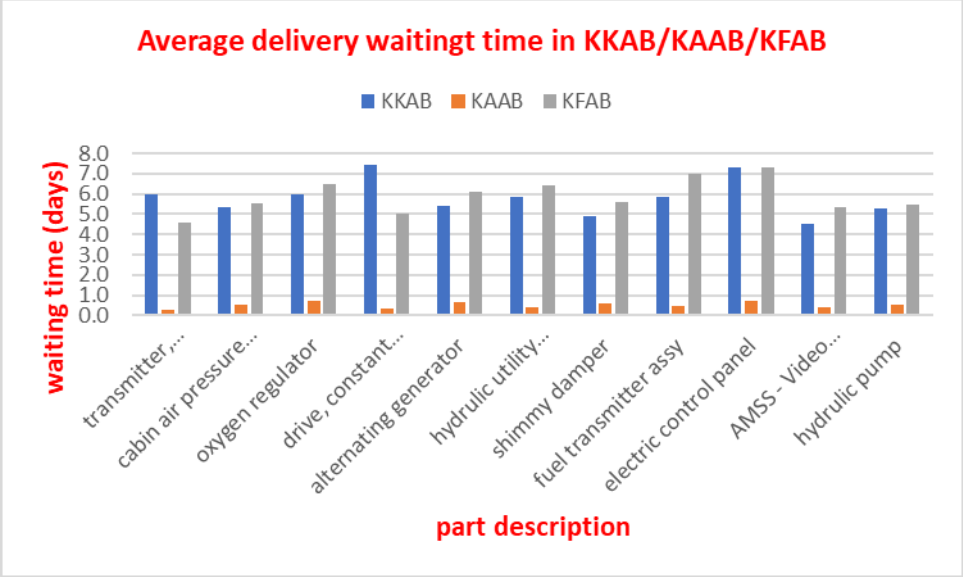

Figure 6 Average Delivery Time Comparison of KKAB, KAAB and KFAB

In addition, if the researcher assumed the delivery delay time in KKAB and KFAB is high based on the factor of the parts' availability in the kingdom, this assumption contradicts itself because KAAB did not experience the same issue. In other words, parts are available in the kingdom because they are always delivered quickly to

KAAB. Therefore, it is appropriate to exclude the parts unavailability factor and assume that there is an inconvenient stock level distribution between KAAB on the one hand and KKAB and KFAB on the other.

In conclusion, for the quantitative analysis, a number of observations are made about the overall process, like the high variations in delivery times for the same parts as well as the unintended pattern. Although these observations are worthy of deeper investigation, they do not answer the main question raised by KKAB except for the last observation, which is the significant difference in average delivery time between KKAB and KFAB on the one hand and KAAB on the other. Hence, it is reasonable for the researcher to state that:

1. The delivery delay is not due to parts per se.
2. The delay is not due to unavailability of parts in kingdom.
3. The location is main factor for fast delivery for KAAB and vice versa for the other two bases KKAB and KFAB.

4.3 interview analysis

Participant experience

Question regarding facts such as question 1 which extensively involved years of experience revealed that 63% of participants had 11 to 20 years of experience, 31% had

21 years of experience or more, and the remaining 6% had 10 years or less, as shown in figure 7.

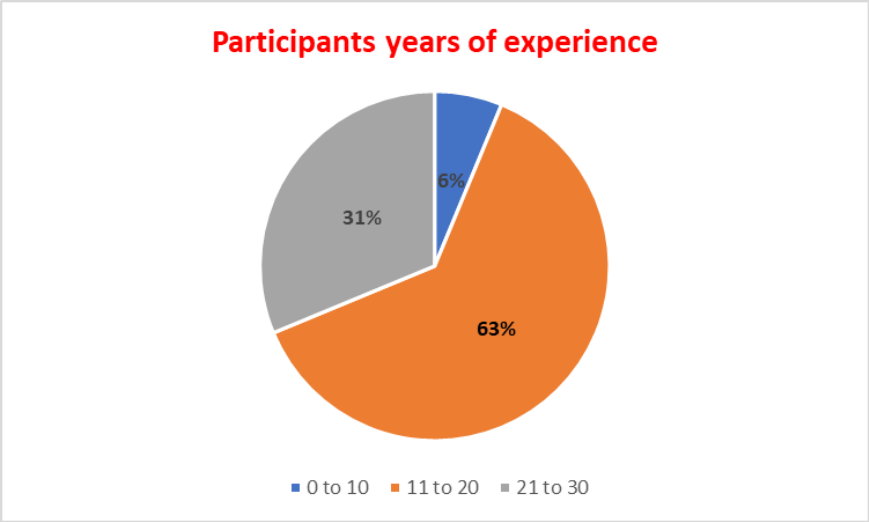

Figure 7 Participants Years of Experience

Reasons For Aircraft Parts Delivery Delay

There are several reasons that account for delays in the delivery of aircraft parts. Based on the interviews, a significant number of interviewees are convinced that the shipping method is the problem. On the other hand, others are convinced that varied reasons could be the main cause of delay, as shown in Figure 8. As reported by several interviewees, depot supply offers priorities based on the type of orders. According to some interviewees, depot supply has the tendency of holding high-priority orders with other orders and accumulating them to facilitate cheap shipping. This happens when few orders are to be shipped, which would lead to an excessive cost of shipping. Combining

the orders and shipping them as a group could effectively reduce shipping costs but negatively impact base readiness. Unavailability of direct flights and shortages of air force flights, especially the C-130 flights, lead to delays as parts have to weigh a certain amount to be shipped. In the RSAF supply manual, shipments of parts are promised a timeline based on a time range: 1-3 days for high-priority orders, as mentioned by interviewees 5 and 15. These reasons are related to other responses that claimed the shipping method could have an impact on the process. One interviewee also argued that the unavailability of parts in depot supply may also result in a delay in delivery. Due to the shortage of parts in the depot, there may be fewer flights between the depot and base, which always affects the delivery of parts. A significant number of respondents also claimed that the distance between bases and depot supplies could create inconveniences in parts delivery to the bases.

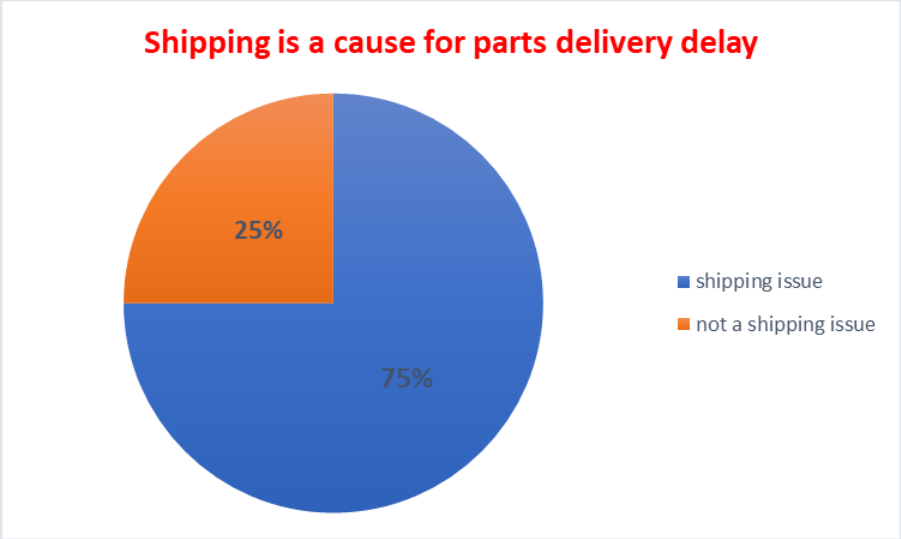

Figure 8 Shipping is the Cause of Delivery Delay

shipping method

Interviewees were asked how shipping methods are chosen, and most of them claimed that it is based on the priority of the order. Orders that are given higher priority are shipped by air and are expected to be delivered within 1–3 days, according to seventy-six supply manuals. Other factors include base location, size of parts, and availability of shipping methods, as seen below in Figure 9. Notably, while some interviewees are convinced that shipping methods differ by base, others are convinced otherwise. The interviewees who responded with a "yes" to the question of whether the shipping method differed by the base had different explanations for their answers. For instance, a respondent who had 22 years' experience working in the field claimed that all bases follow the same procedure, resulting in uniformity in shipping methods. This was backed up by the first respondent, who had 25 years' experience, and the tenth respondent, who explained that all shipping methods follow the same procedure. Below is Figure 10, which demonstrates the percentage of people who are convinced that the shipping method differs by base against those convinced otherwise.

Figure 9 Choice of shipping method

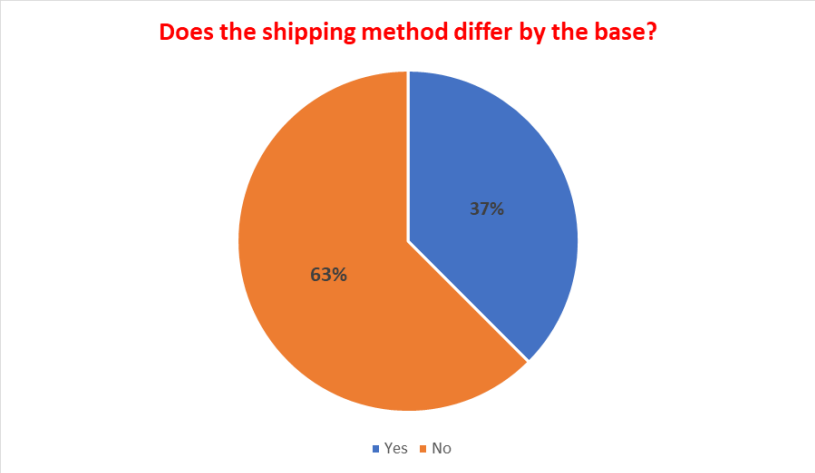

Figure 10 Difference in shipping method by base.

Parts stock level

Inventory visibility is a key factor for stock management. The majority of interviewees agreed that the stock level at the base level accounts for part delivery delays, but some others disagreed, as shown in figure 11 below. Moreover, the respondent, who

had 26 years of experience, stated that the inventory management concepts are followed at the base level and depot to ensure part availability in stock.

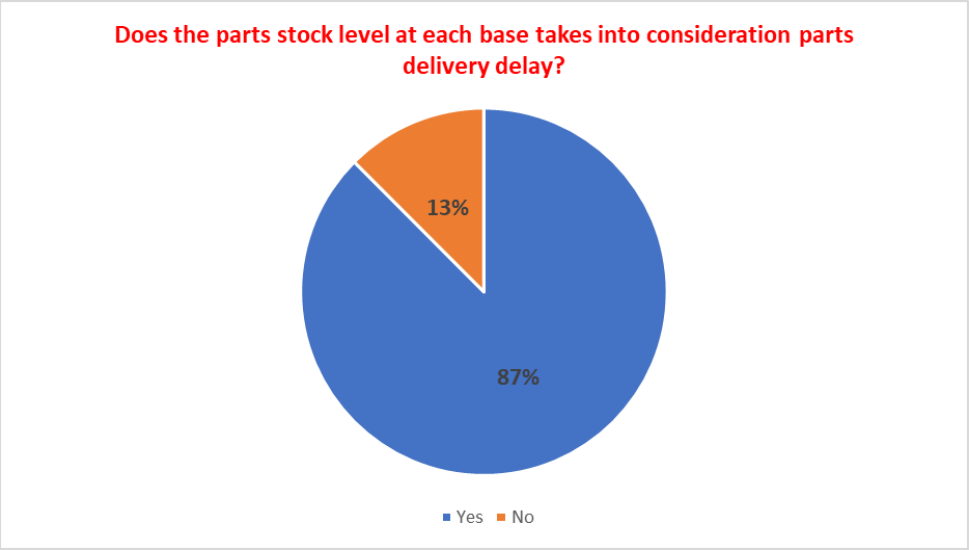

Figure 11 Bases stock level consideration of parts delivery delay

Supply Depot location

The following question addressed one of the factors asked of the interviewees, which is about depot supply location and its impact on part delivery delay. Hence, figure 12 shows that 56 % of the respondents are convinced that depot location negatively impact parts delivery. Nonetheless, 44 % are unconvinced that depot location impacts the delivery of parts.

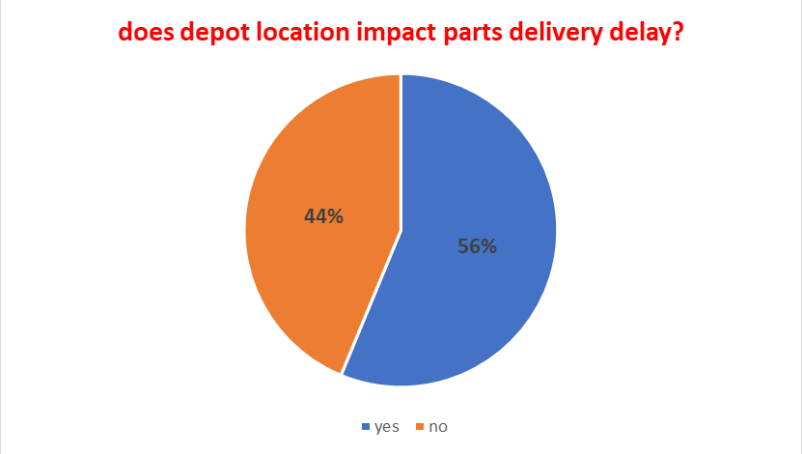

Figure 12 Depot supply location effect on delivery time.

Parts delivery improvements

Different interviewees had different answers to the same open question. However, we saw a significant similarity in the answers offered to the closed questions. Question 7 was more of a personal question because it required answers based on opinions on what one thinks can be done to improve parts delivery delays. It is evident that there is a need for an advanced approach to improve the parts delivery delay. Using various suggestions from the participants, the delivery can be made more convenient. Contracting an air cargo carrier to provide faster services would play an incredible role in achieving the goal. Contracting allows the depot to choose the best shipping agent, which would increase the convenience of the delivery process. In order to find a solution to a problem, it is preferable to address the source of the problem. Given that one of the causes of delay is a lack of constant shipments, scheduling regular flights from the depot

to the base would increase convenience and reliability. As one of the respondents suggested, management teams from different shipping agents should organize meetings and find a way to eliminate delivery delays that would serve the RSAF. Given that the global supply of aircraft parts is slow, this automatically affects the supply chain of the parts. Thus, increasing storage levels in bases would help avoid shortages and delays.

To summarize, the high percentage of highly expert interviews for qualitative information is a positive factor in the validity of the driven information. 75 % of the respondents believe the shipping process is the main factor for delayed deliveries. Also, the majority thinks that shipping is chosen based on the order priority. Regarding, the process of monitoring stock levels at the bases, most of the interviewees believes these processes are ongoing. As for supply depot location and whether it affects delivery time, half of the interviewees believes it does. For the last question of what recommendation would improve the processes, there were three main suggestions that have been repeated among interviewees, which are: First, improving the shipment method, either through a private contract or regular and adequate flight scheduling. Second, expanding the base stock capability. Third, better forecasting of future demand and adjusting parts stock accordingly.

V. Conclusion and recommendations

5.1 Chapter introduction

Going back to the main driving force behind doing this research, which is simply "why KKAB suffers from parts delivery delay," To answer this question, it was essential to validate the question per se. Here are the steps taken to validate and investigate the issue: quantitative and qualitative, which both provided reliable insights and helped to build a better understanding of the issue, diagnose probable symptoms, and suggest recommendations.

5.1 Discussion

The quantitative analysis in the previous chapter revealed two process inconveniences in all bases: high variance and ununiform pattern, which are not within the scope of our primary interest despite being highly concerning and necessitating extensive investigation. Nevertheless, it was noticed during the analysis that there is a positive relationship between supply depot location and the bases. Knowing that, an important question arises: "Is it supposed to matter?" For example, should the Starbucks branch that is located five hundred miles away from the Starbucks supply distribution center suffer a supply shortage? Should Starbucks' logistics team manage its supplies to

this specific branch in such a way that adequate supply is ensured in all branches, regardless of location?

After comparing the data given between the three bases in the one-year time period, it was proven that location matters. RSAF's supply structure encounters this issue by assigning duties. The base supply duty is to manage day-to-day orders to end users. The supply depot's main duty is to make sure base supply has enough stock to facilitate day-to-day orders. This mission cannot be done without a reliable forecast. Adopting the base supply duty diverted the depot from its main objective of predicting future demand and replenishing the right amount of stocks in the bases around the kingdom. Unclarity between these two duties disadvantages the RSAF structure that was installed. Based on the findings, it is highly appropriate to suggest that the supply depot overtook the duty assigned to the base supply, which resulted in two phenomena:

1. The first phenomenon is the short delivery time to KAAB.

2-long delivery time to both bases, KKAB and KFAB.

In the qualitative analysis, a number of agreements between the interviewees in general were noticed. The first agreement is that the shipping method has played a key role in the delivery delay and improving it would reduce the delay. Some interviewees were more precise in specifying other factors, like better management of stocks based on demand and expanding base storage capability. The qualitative analysis in bulk satisfies

the quantitative analysis since the interviewees spent most of their answers tackling how supply depots process their shipments and did not lean to the main duty of the supply depot, which is replenishing stock levels at the bases. Moreover, it is hard to distinguish whether the interviewees are answering questions knowing that the supply depot role is conceptually different from base supply or not.

Finally, here is the answers for research questions:

1. **What do you perceive are the main reasons for supply parts delivery delay?**

   Insufficient parts stock in base supply as a result of inefficient replenishment by supply depot resulted from forecasting mismanagement as a result of diverting from the main duty of supply depot, which is replenishing stocks in bases based on the correct demand forecast.

2. **What modifications could be done to improve the status of parts delivery delay?**

   - better and more dynamic forecasting (for example, every three months).
   - Timely replenishment according to forecasted demand.

5.3 Recommendation for future study

It is suggested that the next researcher may have the opportunity to access a large data set and conduct a wider analysis of internal supply depot regulations and further investigate the high variations in delivery times and unexplainable patterns in the current data to more standardize the process.

Appendix A

Interviewee 1

1. **How many years of experience?**

   25

2. **What are the main reasons for parts delivery delay?**

   The shipping method is the main reason for parts delivery delay

3. **How is the shipping method chosen?**

   Its chosen based in part priority

4. **Does the shipping method differ by the base and if so, how?**

   No, it is the same for each base air shipping is the main and then ground shipping is the secondary shipping method and that is all based in part priority and part classification.

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, parts delay is considered in the process of observing stock level

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, depot supply location have negative impact on parts shipping

7. **Do you have any suggestions to improve the parts delivery delay?**

Contracting with an experience air shipping would improve the parts delivery, reorganizing storage plan and distribution of parts stock over different bases helps minimize load of shipping on the air force and avoid high priority orders delay

8. **Do you have any additional comments?**

   No

Interviewee 2

1. **How many years of experience?**

   22 years of experience

2. **What are the main reasons for parts delivery delay?**

   Transportation is the main reason for the parts delivery delay

3. **How is the shipping method chosen?**

   The shipping method is chosen based on part priority and item classification

4. **Does the shipping method differ by the base and if so, how?**

   No, all bases are following the same procedure written in the supply manual

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, it does

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, location is important and if it is located somewhere in the middle, it would provide more flexibility in logistics of spare parts

7. **Do you have any suggestions to improve the parts delivery delay?**

I would suggest air force may contracting with air cargo carrier to provide faster services to the bases

8. **Do you have any additional comments?**

   Finding a convenient location to provide to support parts logistics services and contracting with air carrier

Interviewee 3

1. **How many years of experience?**

   16

2. **What are the main reasons for parts delivery delay?**

   Far distance from depot supply and order priority, also following up on the order and processing the order

3. **How is the shipping method chosen?**

   It is done based on order priority by the depot supply

4. **Does the shipping method differ by the base and if so, how?**

   Yes, and that is based on availability of shipping method

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, and they follow up with depot and shipping section wither its air shipping or through SIMSA or through ground shipping contractor

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes.

7. **Do you have any suggestions to improve the parts delivery delay?**

   Contracting with best shipping companies like SIMSA and DHL

8. **Do you have any additional comments?**

   Contracting with shipping companies and providing them with location within the bases would improve delivery process, also building new storages at bases to increase the stock at each base

Interviewee 4

1. **How many years of experience?**

   19

2. **What are the main reasons for parts delivery delay?**

   Holding parts together for different orders and sending them once whether it is by air or by ground shipping

3. **How is the shipping method chosen?**

   Shipping method depends on order priority, if its high priority they send it by airlines, C-130 and the classified parts are sent by C-130. Routine orders are sent through ground shipping contractor.

4. **Does the shipping method differ by the base and if so, how?**

   No

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

Yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, and that is due to low availability of flights to bases

7. **Do you have any suggestions to improve the parts delivery delay?**

   Schedule regular flights from depot to the bases due to the need for sending parts from bases weekly

8. **Do you have any additional comments?**

   Increasing ground shipping capacity within the air force to fulfill the air force needs and avoid contracting with other shipping source

Interviewee 5

1. **How many years of experience?**

   12

2. **What are the main reasons for parts delivery delay?**

   Unavailability of direct flights also, it is stated in supply manual that priority orders can take any time between 1 to 3 days to be delivered

3. **How is the shipping method chosen?**

   The method is chosen depending on order priority and aircraft status (AA, AB)

4. **Does the shipping method differ by the base and if so, how?**

   No, it is the same

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, and each base has its own way on following up for their requirement

6. **Does the depot supply location have an impact on parts delivery delay?**

   no

7. **Do you have any suggestions to improve the parts delivery delay?**

   Regarding parts delay I suggest high management meeting by air force and airlines to find out a way of commitment for delivering parts and air shipping availability with direct flights to the bases

8. **Do you have any additional comments?**

   No

Interviewee 6

1. **How many years of experience?**

   20

2. **What are the main reasons for parts delivery delay?**

   Delay in shipping methods by air and by road also unavailability of parts in depot

3. **How is the shipping method chosen?**

   The shipping method by C-130 or ground ship

4. **Does the shipping method differ by the base and if so, how?**

No

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   no

7. **Do you have any suggestions to improve the parts delivery delay?**

   no

8. **Do you have any additional comments?**

   No

Interviewee 7

1. **How many years of experience?**

   13

2. **What are the main reasons for parts delivery delay?**

   Because they gather high priority orders with other priorities orders and send them by ground shipping due to less availability of C-130 flights

3. **How is the shipping method chosen?**

   They choose the shipping way based on item classification and order priority

4. **Does the shipping method differ by the base and if so, how?**

No

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   No, if they shipping process goes right the location would not make any difference

7. **Do you have any suggestions to improve the parts delivery delay?**

   Contracting with more than one airline and holding them responsible for any delay would improve the delivery process

8. **Do you have any additional comments?**

   Good luck in your research

Interviewee 8

1. **How many years of experience?**

   13

2. **What are the main reasons for parts delivery delay?**

   Unavailability of parts on depot supply also managing shipping method results on delivery delay for the bases

3. **How is the shipping method chosen?**

   Based on two categories: parts priority and base location

4. **Does the shipping method differ by the base and if so, how?**

No

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes

7. **Do you have any suggestions to improve the parts delivery delay?**

   No

8. **Do you have any additional comments?**

   No

Interviewee 9

1. **How many years of experience?**

   19

2. **What are the main reasons for parts delivery delay?**

   Shipping method and far location of depot supply from the bases

3. **How is the shipping method chosen?**

   Depends on the availability of shipping method

4. **Does the shipping method differ by the base and if so, how?**

   No, all follow same procedure

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   No

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, negative impact

7. **Do you have any suggestions to improve the parts delivery delay?**

   Increase storage level in those far bases to avoid shortage and delay

8. **Do you have any additional comments?**

   No, thank you

Interviewee 10

1. **How many years of experience?**

   15

2. **What are the main reasons for parts delivery delay?**

   Shortage of parts in depot, and less flights between depot and bases affect delivery of parts

3. **How is the shipping method chosen?**

   By order priority

4. **Does the shipping method differ by the base and if so, how?**

   No, all follow the same procedure

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes

7. **Do you have any suggestions to improve the parts delivery delay?**

   No

8. **Do you have any additional comments?**

   No

Interviewee 11

1. **How many years of experience?**

   10

2. **What are the main reasons for parts delivery delay?**

   Low availability of air and road transportation

3. **How is the shipping method chosen?**

   This depends on size of shipment also the priority

4. **Does the shipping method differ by the base and if so, how?**

   Yes, the near bases from depot supply gets their orders faster

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   No

7. **Do you have any suggestions to improve the parts delivery delay?**

   Increase the number of flights between depot and the bases

8. **Do you have any additional comments?**

   No

Interviewee 12

1. **How many years of experience?**

   17

2. **What are the main reasons for parts delivery delay?**

   Unavailability of parts on depot stock and not enough flights between depot and bases

3. **How is the shipping method chosen?**

   According to supply manual by the priority and confidentiality of shipment

4. **Does the shipping method differ by the base and if so, how?**

   Yes, based on the location from depot supply

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   No

6. **Does the depot supply location have an impact on parts delivery delay?**

   No

7. **Do you have any suggestions to improve the parts delivery delay?**

   Increase shipping flights also, increase the storage of parts for the bases having issue due its far location from depot and based on its operational necessity

8. **Do you have any additional comments?**

   No

Interviewee 13

1. **How many years of experience?**

   21

2. **What are the main reasons for parts delivery delay?**

   Distance between bases and depot supply

3. **How is the shipping method chosen?**

   Based on size of parts ordered and priority of order

4. **Does the shipping method differ by the base and if so, how?**

   Yes, for example the base near by depot have their parts processed earlier because they do not require air shipping

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, if depot is in center of the kingdom would have less delivery time

7. **Do you have any suggestions to improve the parts delivery delay?**

   Scheduling more C-130 flights to solve delivery issues

8. **Do you have any additional comments?**

   Updating inventory management plans of depot supply by raising stock level on bases and managing them through (GOLD-esp.) system lower the load of shipping regularly and helps improving delay issues

Interviewee 14

1. **How many years of experience?**

   24

2. **What are the main reasons for parts delivery delay?**

   The parts cannot be found (warehouse refusal), transportation section has no available vehicles they are all out on delivery tasks

3. **How is the shipping method chosen?**

   The most efficient shipment method is subject to priority. for high priority by air (RSAF, or civilian). for routine low priority by surface transportation

4. **Does the shipping method differ by the base and if so, how?**

   For all bases in kingdom the method is the same, for deployment outside kingdom by air

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   each base has its parts stock level determined by consumption. This does not account for parts delivery delay. Delivery delays if known must be manually input by depot item management personnel

6. **Does the depot supply location have an impact on parts delivery delay?**

   The location of depot in KSA can have an impact due to distance to requesting bases. Routine requests will be transported by road, reportable priorities by air. The exception is a co-located depot/base where there is minimal impact of delivery time.

7. **Do you have any suggestions to improve the parts delivery delay?**

   For reportable priority requests a dedicated priority picking team at both depots and bases will speed up delivery. Also using civilian air transport when RSAF aircrafts are not available for reportable priority shipping

8. **Do you have any additional comments?**

   Base item manager to inform depot item manager of any stock level problems, ensure the priority requests delivery times are adhered to.

Interviewee 15

1. **How many years of experience?**

   26

2. **What are the main reasons for parts delivery delay?**

   unavailability of parts on depot supply stock, order tracking and processing of shipment also could be a reason of delay, classified parts required special shipping process and may affect the delivery sometimes

3. **How is the shipping method chosen?**

   This depends on (location, priority of order (high or low) and parts classification), high priority shipped by air (air force flights and civil airlines) also by truck and if its classified parts it would only be shipped through air force flights or by truck with security, high priority orders should be delivered on (1-3) days according to 76 supply manuals

4. **Does the shipping method differ by the base and if so, how?**

   No

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, on bases reorder point and safety stock level on depot supply, these inventory management concepts are followed to insure parts availability on stock

6. **Does the depot supply location have an impact on parts delivery delay?**

   No, it is not necessarily to have the source like depot near to the bases, but the base supply should have good stock control plan to avoid parts shortages

7. **Do you have any suggestions to improve the parts delivery delay?**

   Personal qualification, have good forecasting of demand and adjust stock level based on requirements, bases are ready some may need extra warehouses to accommodate, this adjustment based on operational requirements would save efforts and money for air force, decrease time waste, and increase aircrafts readiness. All these factors would help improve the current delay.

8. **Do you have any additional comments?**

   Supply must be aware of all decisions of maintenance, engineering, and operation requirements sections always to avoid future issues and adjust plans accordingly.

Interviewee 16

1. **How many years of experience?**

   12

2. **What are the main reasons for parts delivery delay?**

   Shortage of air force flights between bases, classified parts affect the shipping because they cannot be shipped with civil airlines, technical issues

3. **How is the shipping method chosen?**

Based on priority of order (routine/ expedite / MICAP), air is the main shipping method.

4. **Does the shipping method differ by the base and if so, how?**

   Yes, the operational requirement and level of the base is taking into consideration the shipping method

5. **Does the parts stock level at each base takes into consideration parts delivery delay?**

   Yes, but issues have occurred during transferring form old supply system to the new system (GOLDesp) may affected forecasting and created gap

6. **Does the depot supply location have an impact on parts delivery delay?**

   Yes, as example bases within the area of depot supply does not experience delay as other bases

7. **Do you have any suggestions to improve the parts delivery delay?**

   More cooperation with cargo, civil airlines and private shipping companies would lower delay percentage. Also raising storage stock level at each base and building new warehouses, would lower frequent shipping and save lots of money on the long run for the air force.

8. **Do you have any additional comments?**

   No

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