



**RSAF F-15 REPARABLE ITEMS CAPACITY PLANNING &  
EXECUTION**

THESIS

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EXECUTION**

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RSAF F-15 REPARABLE ITEMS CAPACITY PLANNING &  
EXECUTION

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## **Abstract**

This research focuses on improving the F-15 repair cycle processes in the Royal Saudi Air Force (RSAF). The current RSAF repair cycle capacity planning process has not been mapped and optimized. As a result, inventory management and asset turnaround times continue to impact the RSAF's ability to sustain mission readiness. Because the F-15 is the first line of Saudi Arabia's defense, it is essential that they be fully mission ready in the shortest time possible. That can be done by understanding the current relation between the depot supply directorate and the sources of repair (SOR) available to RSAF in the United States (U.S.). How the parts routing decision is made, what capacity is available at each SOR and what contracts between the Saudi government and U.S. government control that relation. The selected techniques are supply chain mapping, LEAN management approach and capacity planning methods. The research suggests that those techniques can help to improve the F-15 supply chain process in the Royal Saudi Air Force for several reasons. One of the most important reasons is a better work loading to different SORs which will improve the turnaround time.

*To my parents*

*To my wife*

*To my little princess*

*To my country*

## **Acknowledgments**

I would like to express my sincere appreciation to my faculty advisor, Dr. William Cunningham for his guidance and support throughout the course of this thesis effort. The insight and experience were certainly appreciated. I would also like to thank Mr. Kent Mueller and Mr. Donald Bagley, from United States Air Force F-15SA Program Office (AFLCMC/WWQI), for both the support and latitude provided to me in this endeavor.

Naif H. Alatawi

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# RSAF F-15 REPARABLE ITEMS CAPACITY PLANNING & EXECUTION

## I. Introduction

### Overview

Royal Saudi Air Force (RSAF) F-15 fleet readiness is of vital importance to the security of The Kingdom of Saudi Arabia. One of the most important countries in the world and a key player in the maintenance of regional stability, The Kingdom must maintain military capability to fulfill its security both at home and in the region. Other members of the Islamic world also depend upon The Kingdom. Therefore, The Kingdom must be able to meet security challenges and respond to issues that concern both The Kingdom and Muslim communities around the world. For these reasons The Kingdom built its defense systems to defend its sovereignty from any violation. Of course, the centerpiece of the defense systems is the airpower of the RSAF which is one of the Ministry of Defense (MOD) branches, and the centerpiece of capability of RSAF is the fleet of F15C/D/S and the new Saudi Advanced (SA) F-15 aircraft. The RSAF maintains and operates a large fleet of F-15 fighter aircraft to support long term defense, the RSAF developed a requirement for a Fleet Modernization Program (FMP) which was formalized as a Foreign Military Sale (FMS) program through a Letter of Agreement (LOA) from The Kingdom to the United States Department of State (AFLCMC/WWQI, 2015). The United States Air Force (USAF) is the implementing agency for the LOA which is managed by the Security Assistance Program Manager (SAPM) who directs the program office.

Naturally, this large fleet of F-15 fighters will need larger and better supply chain management to support the operational requirements of the RSAF, and the need to achieve higher aircraft availability. The current material management system is not up to the expectations of the RSAF supply managers or operational commanders (Royal Saudi Air Force Interviews, 2015). The ability of RSAF to maintain its mission readiness has been negatively impacted by the current supply chain process. Therefore, the depot to source of repair (SOR) supply chain process needs to be mapped and analyzed to identify what parts of the supply chain can be improved in order to optimize the capacity planning performance.

### **How Does The System Work?**

When a part breaks on an aircraft, it is the responsibility of the maintenance technicians to remove the part from aircraft and open a work order in the GOLDesp (software used by RSAF in logistics management) and fill related documents. The part then begins the long trip through a series of processes within the maintenance squadron. Then the parts are submitted to base supply and prepared to be shipped to the depot supply in Dahran (eastern region of Saudi Arabia). In the depot supply the part also passes through a series of processes and documentation requirements. Staffs at the depot identify the SOR for each part according to the contract in place for that item, which will be explained in detailed later on, and submit it to the contracted freight forwarder (FF) which ships each part to the identified SOR. Each SOR schedules parts repair and after repairing the part submits it back to the freight forwarder who returns it to the depot supply. Depot supply then distributes the parts to the four bases according to the requirements. The F-15 program office at Robins AFB did a detailed value stream mapping of base and depot

supply processes. But in general, this study is taking a top view over the enterprise level supply chain system to identify the big gaps in SORs which limit the system ability to return the repaired parts in a shorter and known time frame. The supply chain managers in RSAF Headquarters think it is the SOR that is taking a long time to repair parts, called turnaround time (TAT) and that is why the Lean event was initiated.

### **Supply Chain Mapping**

The nature of any firm is that it exists in a chain of suppliers and customers and it is the responsibility of managers to manage the relationships of their firm with other firms which exist in the same supply chain. Mapping of the supply chain is the first step to solve any problem and improve the environment of the supply chain (Lambert, 2014).

### **LEAN**

LEAN is a management method that was developed to improve the productivity of the process and quality of products. LEAN is mainly about eliminating waste in the process and continuous improvements. The Toyota Company was the innovator of this way of management technique and used it to compete against other auto companies for a long time. Many commercial companies and government organizations eventually adopted LEAN to improve their processes and were successful (Womack, 2007).

LEAN is basically a method of waste elimination to improve the output of the system. In the RSAF supply system the waste can be defined as unreasonable long time when parts sit idle. This research proposes to apply LEAN concepts to the overall RSAF system to identify where waste accrues. By applying this method of management thinking, the waste time would be identified and the system could work faster which is expected to result in a high aircraft availability to meet the operational requirements of RSAF.

## **Capacity planning**

Capacity planning is a process for determining the infrastructure that will be required to meet future workload demands. It is an essential discipline, but for most companies, it is getting increasingly hard to find people who are capable of doing it. Planning ensures that operating cost are maintained at a minimum possible level without affecting the quality. It ensures the organization remains competitive and can achieve the long-term growth plan (MSG Experts, 2015).

## **Motivation**

The motivation for the proposed research is the RSAF HQ ongoing initiatives intended to optimize operational availability of aircraft, cost of inventory, accountability, in transit visibility (ITV), accurate forecasting of replenishment spares needs and diminishing source mitigation.

## **Problem Statement**

RSAF F-15 material management needs are not being met by the existing repair cycle processes. The current RSAF repair cycle capacity planning process has not been mapped and optimized. As a result, inventory management and asset turnaround times continue to impact RSAF's ability to sustain mission readiness. The F-15 Depot Supply has a direct bearing on SOR selection and in turn, how long it takes to satisfy a demand for reparable parts. These processes must be improved to provide RSAF material managers insight needed to effectively route repairs to meet growing RSAF expectations for improved turnaround and cost performance.

## **Importance**

Accurate repair cycle capacity planning and allocation requires a better understanding of gaps in the RSAF capacity planning process at the enterprise level, including the GOLDesp, Security Assistance Management Information System (SAMIS), SOR sub-processes and direct commercial sale repairs. Improvement initiatives developed specifically for the RSAF repair processes, can be implemented in changes to RSAF Manual 67-1 to reflect new processes and a commitment to continuous process improvement.

## **Why Should this be Studied Now?**

In June 2013, a RSAF Directorate of Supply letter requested AFLCMC/WWQI assemble a LEAN supply team to assist RSAF analyze supply processes and streamline their supply system, including a list of Top 10 RSAF supply issues. Since that time AUTOLOG was shut down in November 2013 and GOLDesp was initiated in December 2013, increasing the importance of identifying and integrating material management process improvements. In 2014 and 2015 some improvements in contract TATs were achieved, but SOR capacity gaps continued to delay repairs due to misrouting of items to SORs that lacked capacity, leaving other sources underutilized. This study will investigate SOR capacity planning, and suggest a more efficient methods of work loading of the sources of repair supporting the RSAF.

## **Research Focus**

The research will focus on RSAF F-15 repair cycle requirements, SORs, capacity planning and allocation, and will seek to identifying opportunities for more effective work loading and cycle time reduction in RSAF repair cycle. This research will include, but is not limited to, the consideration of the following.

- 1) Existing repair cycle capacity, SOR, and how SOR are work loaded
- 2) Current RSAF material management policies and practices for reparable assets
- 3) Asset tracking, resource visibility, performance data and reporting enabling enterprise-wide performance management of all assets
- 4) Potential trend analysis and forecasting analytics designed to improve pipeline performance

## **Research Objectives and Research Questions**

The objective of this research is to investigate current repair cycle capacity planning practices used in assigning SOR, and the recommendation of a framework for better assigning repairs. In considering this narrowly defined segment of the RSAF SCM value stream, the results will reflect selected theories, identified gaps, and recommendations for appropriate analytical tools, process improvement, and opportunities for additional research.

The following are the research questions that need to be answered by the end of this research

**Q1:** What reparable capacity planning processes does the RSAF currently use?

**Q2:** When do the SOR decisions occur, and what are they currently based upon?

**Q3:** Who are the capacity planning process owners for regulations, policies, procedures?

**Q4:** What factors govern the current throughput of the system?

**Q6:** What capacity planning initiatives might be undertaken to optimize throughput?

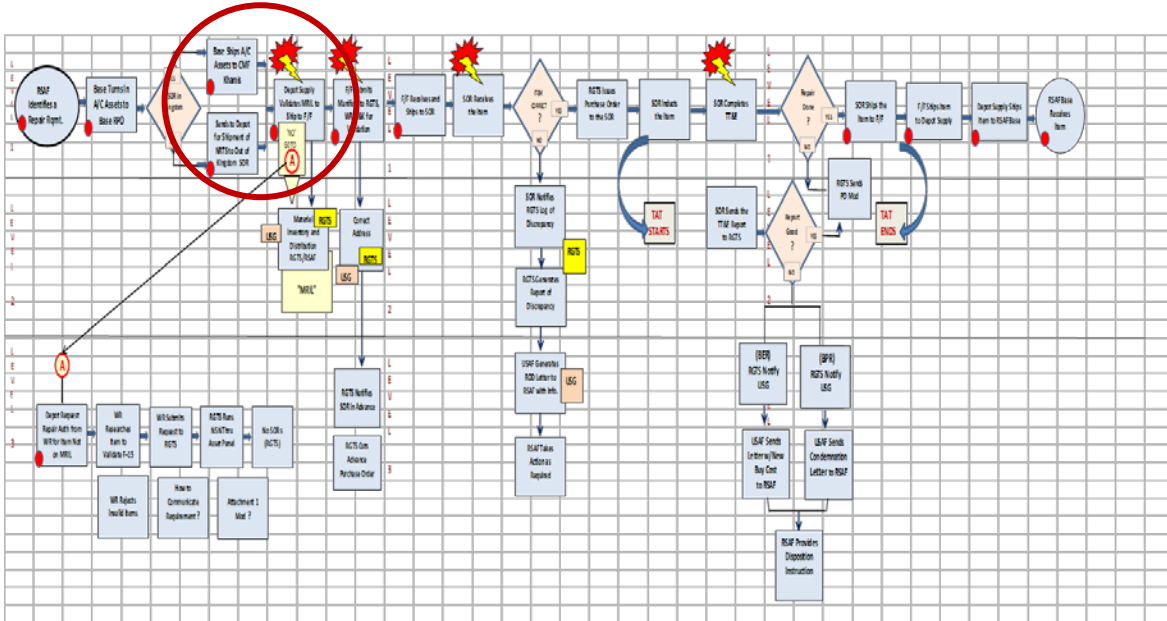


Figure 1. Repair Cycle Capacity Planning decision point in Value Stream Map of RSAF Supply Chain from Apr 2014 Lean Event

## Methodology

The proposed research will be conducted using case study design. The data needed will be available from the RSAF and USAF, in accessible regulations, policies, and material management reports, briefings, and papers. In addition, the materials supporting the theoretical framework of the proposed study are available in open source literature. Analysis techniques for the proposed research will include a literature review and the application of LEAN, Supply Chain Mapping, and capacity planning methods. will be

collected from open sources, USAF, AFIT, AFLCMC/WWQI, and RSAF DOS/DOM. No limitations relating to access to data are anticipated.

### **Assumptions/Limitations**

This research will deal with available resources and will not try to go deep into any financial matter or administration processes. It will focus on the enterprise level of the RSAF repairable parts supply chain.

### **Implications**

This research harmonizes with HQ RSAF material management initiatives directly contributing to RSAF policy guidance development, and current RSAF repairable sustainment initiatives. The results will contribute to the development of more effective FMS sustainment agreements with the U.S. government, as well as contracts rising from Kingdom of Saudi Arabia F-15 FMP LOA guidance, as well as direct commercial sale support contracts.

## **II. Literature Review**

### **Chapter Overview**

This chapter presents an overview of the salient material investigated while researching the problem statement of this thesis. Although only the literature considered helpful in analyzing this problem is mentioned here, it will be helpful to understanding the conclusions reached in this work.

### **What is Supply Chain Management?**

The definition of supply chain management is a key starting point to do the analysis of any supply chain. But before defining supply chain management it is important to understand what basically supply chain is? Douglas Lambert in his book “*Supply Chain Management Processes, Partnerships, Performance*” published in 2014 defined supply chains as “A chain of firms or organizations work with each other as suppliers and customer for each other to deliver products or services for the end consumers”. The management of these chains therefore is supply chain management. It is important to know that managing a supply chain requires a variety of business functions within any firm or organization associated within the supply chain.

### **Relationships in the Supply Chain**

To create a strong supply chain, relationships between the supply chain members must be developed and maintained since supply chain management is basically managing the relationships among the supply chain members. For that, managers of the supply chain need to understand the importance of developing and maintaining strong business relationships with other members of the supply chain. To build a high-performance

relationship, the firm's managers need to set strategies that determine what goals they need to achieve with such a relationship and form a cross-function team from every organization within the supply chain. The cross-functional team then will develop operational plans to implement the strategies of the supply chain (Lambert, 2014).

### **Supply Chain Mapping**

The nature of any firm is that it exists in a chain of suppliers and customers and it is the responsibility of managers to manage the relationships of their firm with other firms that exist in the same supply chain. Management of the relationships starts from the source of the raw materials to the end consumer of the final products or services to create a better visibility of any activity inside that supply chain. It is hard to create such visibility in a complex network of relationships. Supply chain mapping is a powerful tool to encompass all the organizations which exist within the supply chain.

Supply chain mapping is a significant effort and requires data about each organization in the supply chain to help understand the nature of the relationships that need to be established with each firm. Mapping of the supply chain provides managers a complete view over the enterprise level activities and identify any limitations and areas of waste in the supply chain. Mapping is more than gathering data about suppliers or customers, it involves detailed analysis to create a strong complete mapping for the supply chain (Alshehri, 2015).

Mapping the supply chain is an important first step in managing relationships in the supply chain. It helps in classifying customers and how to serve them accordingly, create

competitive environment for the firms, improve both supplier's performance and customers' ability to manage their inventory, making decisions about outsourcing for potential suppliers and avoid any potential risks possible.

### **Relationship-based Map:**

The management of supply chain is actually managing the relationships with suppliers from origin of raw materials to the end consumers in that supply chain. To allocate resources within the firms in the supply chain, the use of relationship-based maps is very helpful in allocating resources and managing relationships between the focal company and other firms in the supply chain. Supply chain mapping is the first step to make clear understanding about the business process of the firms' supply chain. This understanding of supply chains' business processes help managers to see potential opportunities for improvements or risk to mitigate which is hard to identify without supply chain mapping. Management of the relationships is not only with direct customers or suppliers. That is wrong and poor management, since it is the responsibility of managers to create better relationships with suppliers or customers beyond the first tier. Mapping the supply chain based on relationships will help in identifying the opportunities of outsourcing and of making better decisions in marketing too. The first advantage of relationship-based mapping is reducing the complexity of the supply chain network and making it more manageable.

It is necessary to use mapping in identifying the nature of the members in their supply chain, whether they are primary or supporting members. Primary members are those firms who add value to the real process of the supply chain. And the supporting

members are those who support the process with training, resources, and facilities to the primary members of the supply chain.

Some companies can be both primary and supporting members at the same time. Identifying who is primary and who is supporting members is not always easy job to do, and supply chain mapping helps managers to distinguish that between firms. This identification provides the guidelines for managers to manage the relationships within their chain.

Relationships or business process links in supply chain mapping is hard to integrate and manage for most business because of their complexity. Therefore, it is important to represent the strength of relationships in the maps to help managers monitor important relationships closely.

Managing relationships in the supply chain will be different from link to link, and from time to time. Some business process links are more critical for the organization to manage than others. For that there are different types of business process links that can be used to represent the strength of relationships in the supply chain mapping (Lambert, 2014).

Douglas Lambert in his book *“Supply Chain Management Processes, Partnerships, Performance”* published in 2014 in pages 210-213 indicates that:

*“Four fundamentally different types of business process links can be identified between members of a supply chain: managed process links, monitored process links, not-managed process links and non-member process links.*

**Managed Process Links:** *Managed process links are those that management of the focal company finds important to integrate and manage. In the supply chain shown in Figure 2, the managed process links are indicated by the thickest solid lines. The focal company will integrate and manage process links with Tier 1 customers and suppliers as well as with key firms beyond Tier 1.*

**Monitored Process Links:** *Monitored process links are not as critical to the focal company; however it is important to the focal company that these process links are integrated and managed appropriately between the other member companies. Thus, the focal company, as frequently as necessary, simply monitors or audits how the process link is integrated and managed. The thick dashed lines in Figure 1 indicate the monitored process links.*

**Not-managed Process Links:** *Not-managed process links are links that the focal company is not actively managing, nor are they critical enough to use resources for monitoring. In other words, the focal company fully trusts the other members to manage the process links appropriately, or because of limited resources leaves it up to them. The thin solid lines in Figure 1 indicate the not-managed process links.*

**Non-member Process Links:** *Managers should be aware that their supply chains are influenced by decisions made in other connected supply chains. For example, a supplier to the focal company is a supplier to the chief competitor which may have implications for the supplier's allocation of manpower to the focal company's development and product commercialization process, availability of products in times of shortage, and/or protection of confidentiality of information. Non-member process links are links between members of the focal company's supply chain and non-members of the supply chain. Non-member links are not considered as links supply chain structure, but they often affect the focal company's performance and its supply chain. The thin dashed lines in figure 1 illustrate examples of non-member process links.”*

The supply chain mapping must be easy to build and should provide better visibility of the network of the firms in the supply chain. Additionally, it must have complete details about the business process supported with accurate data. Supply chain maps must be current to enable managers to make better decisions to avoid risks and exploit opportunities. Managers must be aware of mapping risks which can negatively

impact the organization's position such as exposing confidential information. And like any project, supply chain maps must be validated by the process owners to be more applicable and represent the reality of the supply chain (Gardner & Cooper, 2003).

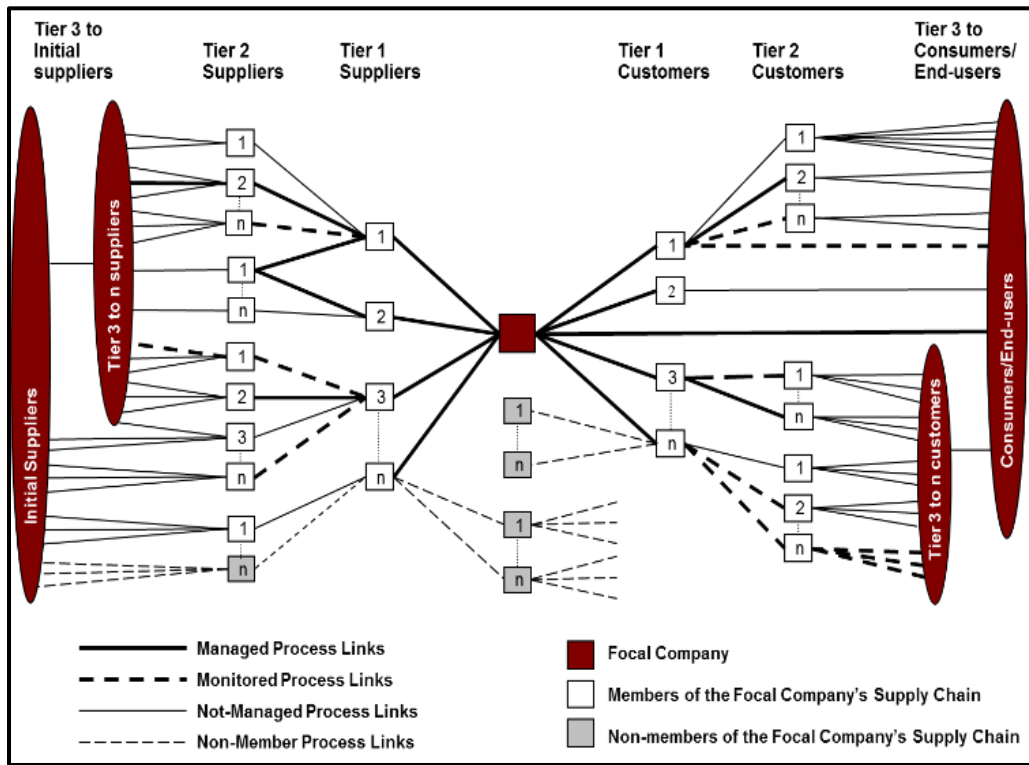


Figure 2. types of inter-company business process links (Lambert, 2014)

## LEAN History

Whenever LEAN is mentioned, the name of Toyota production executive Taiichi Ohno is there as he was the first one to use the principles of lean management in the early 1960s. He was the enemy of any kind of “muda” or waste in the production process and made Toyota a leader in the auto market in terms of production numbers. With his way of thinking, Toyota could shorten the time it took to change dies from a day to three minutes. His thinking was basically eliminating any activity that added no value to the final products (Womack, 2007).

The ideal way in any process is the highest quality possible with no waste and a satisfied customer. It is important for the process managers to understand what exactly needs to be produced, when, where, how much and what is the perfect quality required at what cost? It is understanding customers' needs and the ability of how the process can meet those needs to get their highest satisfaction with the participation of all employees.

The three M's in LEAN include "Muda, Muri and Mura" which are the main elements of LEAN and they are interrelated with each other. The meaning of these words is waste- "Muda", unevenness- "Muri", and overburden "Mura". If in any production there is "Muri" or "Mura" this means there is waste. It could be waste of time or materials or any other kind of waste. Ohno has identified seven types of waste in Toyota production process which could be applicable in any other process as there are many forms of waste which can exist in any process. Those seven types of waste are:

1. Mistakes.
2. Producing items no one need.
3. Any non-adding value processing steps.
4. Employees Movement without purpose.
5. Transportation of goods from location to another without purpose.
6. Workers in a downstream waiting for upstream activity to end.
7. Products don't meet the customer satisfaction (Womack & Jones, 2003).

### **Lean Principles**

Lean Thinking is a management technique aimed to produce the best value with minimum waste. Best value for the customer first of all and for the stakeholder at the same time while still providing best value for the process owners and employees. Satisfaction of

all members of the supply chain is the objective of lean thinking management. This satisfaction can be achieved by knowing the five key points of lean which will help managers to draw their road map in managing their process by lean thinking techniques and they are stated below:

1. Setting the value the customer expects in terms of quality and cost and focusing all activities in the organization toward achieving that value.

2. Set every step in the process to achieve that value by creating a value stream from the raw material to final goods. It is important to know that the process is as good as the weakest step in the process.

3. Keep the products moving in smooth flow avoiding any batching or queuing in the process which can disturb the flow. This can be accomplished after eliminating any waste in the process and then creating better output of the weakest link or what is called “bottleneck”.

4. Make customers pull products and operate the system as needed in a quick response to customer demand thus avoiding overproduction.

5. Implementing the previous points on a process makes perfection more achievable. Perfection means the process can be successful in delivering the right quality with perfect value to the customer at the right time with zero waste in time or materials at the right cost (Womack & Jones, 2003).

### **How Does Lean Relate to Government?**

Lean started in the manufacturing sector to improve productivity, but after demonstrated success it has been widely used in the service sector to help with many managerial issues. Many United States government agencies initiated Lean events in the

past decade to help managers make better decisions in order to improve customer service, financial issues, and demand management. Also, military branches recognized the effectiveness of lean techniques and initiated many events to improve the processes and eliminate any possible waste in many systems.

### **Gap Analysis**

When managers of the business process implement and maintain the improvements, gap analysis is used to examine and evaluate the improvement status. The method of conducting gap analysis is to determine which supply chain components must be improved and set goals or expectations for that improvements. After implementing the improvements on the process, the results of the improvements should be compared with the expected goals. If the difference between the goals and score is high, that indicates managers need to close that gap.

Managing gaps in the process may need re-allocation of resources to improve the score of process performance. The procedure to manage gaps is to first list all of the gaps and identify how each gap is critical to the whole process and with its degree of variation from the expected goal. The last step is establishing an action plan to implement the changes over time by a cross functional team to insure perfect implementation and resolve the gaps in the process (Lambert, 2014).

### **Past Lean Events Done on RSAF F-15 Supply Chain**

RSAF initiated a lean event on F-15 parts repair and return supply chain in 2009 in co-operation with the F-15 program office at Robins AFB to improve the efficiency and readiness of the F-15 air fighter fleet. The aim of the lean event was to accomplish continuous process improvement. Many results and changes have taken place in the past

few years and some improvements have been achieved in the supply chain, but the full expectations for improved supply chain performance have not yet been achieved.

For that reason, RSAF and USAF managers of the F-15 parts supply chain need to further study the entire supply chain, and focus on what can be done to link all processes needed as whole to improve performance.

### **Capacity Planning**

Capacity is defined as the ability to achieve, store, or produce. For an organization, capacity would be the ability of a given system to produce output within the specific time period. In operations management, capacity is referred as an amount of the input resources available to produce relative output over a period of time. In general terms, capacity is referred to as the maximum production capacity, which can be attained within a normal working schedule.

A technique used to identify and measure overall capacity of production is referred to as strategic capacity planning. Strategic capacity planning is essential as it helps the organization in meeting the future requirements of the organization. Effective planning ensures that operating cost are maintained at a minimum possible level without affecting the quality. It ensures the organization remains competitive and can achieve the long-term growth plan.

## **Capacity Planning Classification**

Capacity planning based on the timeline is classified into three main categories long range, medium range, and short range.

1. **Long Term Capacity:** Long term capacity of an organization is dependent on various other capacities like design capacity, production capacity, sustainable capacity and effective capacity. Design capacity is the maximum output possible as indicated by equipment manufacturer under ideal working condition. Production capacity is the maximum output possible from equipment under normal working condition or day. Sustainable capacity is the maximum production level achievable in realistic work condition and considering normal machine breakdown, maintenance, etc.
2. **Medium Term Capacity:** Planning undertaken by an organization for 2 to 3 years of a time frame is referred to as medium term capacity planning.
3. **Short Term Capacity:** Planning undertaken by an organization for a daily, weekly, or quarterly time frame is referred to as short term capacity planning.

## **Goal of Capacity Planning**

The ultimate goal of capacity planning is to meet the current and future level of the requirement at a minimal wastage. The three types of capacity planning based on goal are lead capacity planning, lag strategy planning, and match strategy planning.

## **Steps in the Capacity Planning Process**

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities and identify gaps
3. Identify alternatives for meeting requirements
4. Conduct financial analyses of each alternative
5. Assess key qualitative issues for each alternative
6. Select the alternative to pursue that will be best in the long term
7. Implement the selected alternative
8. Monitor results

### **III. Methodology**

#### **Chapter Overview**

This chapter explains the research methodology, the problem statement, hypothesis, research questions and the importance of this thesis. In order to improve the performance of the RSAF supply enterprise it is first important to define the problem. Through a qualitative study, this research will suggest the general problem, frame it with hypothesis and questions, and utilize previous RSAF USAF studies, data, and interviews to identify enterprise level problems, recommend actions, and suggest additional research. The expected outcome will support the RSAF continuous process improvement objectives for asset visibility, capacity planning, inventory, and operational readiness.

#### **Research Questions**

The research is focused at the enterprise level of supply chain performance and is intended to set the stage for follow-on deeper studies. There are two principle questions that provide framework for this study.

1. How can the repairable capacity planning processes be optimized and mapped in order to increase the availability of repairable parts?
2. Is the source of repair decisions that occurs in the RSAF based on full understanding of capacity?

## **Methodology**

The aim of this study is to help managers at all levels of the F-15 parts repair and return supply chain in RSAF identify and mitigate gaps and bottlenecks in their supply chain. Detailed information and studies were available through AFLCMC/WWQI which is the USAF program office for FMS support for The Kingdom of Saudi Arabia. Following are the steps done by the researcher to complete this research.

The conference call meeting was with Mr. Kent Mueller (from the F-15 program office in WRAFB), Dr. William Cunningham and the researcher at AFIT in Dr. Cunningham office. Mr. Mueller introduced the importance of this study and how it impacts the supply process of the F15 parts in RSAF. He mentioned that the managers of the supply chain in RSAF are concerned about the turn-around time in the SORs and this what they think is creating most of the delay.

Mr. Mueller explained in detail how the supply chain works and how parts move in each stage and what previous studies has recommended for improvements. Also, in this meeting, the main members of the supply chain were identified to start the first draft of the supply chain mapping. The F-15 program office provided extensive data for the supply process from depot supply in The Kingdom to the SOR in the United States and the way back to the depot. This data provided useful details which were used in the research.









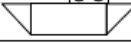
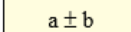
Based on that, analysis of the data and interviews were made to achieve a deeper understanding of the strength of the relationships among all members and how they communicate with each other during supply chain activities.

The first step in the analysis was an evaluation of the supply chain maps done by a former researcher at AFIT, CAP Ali Alshehri, flow of parts and methods of transportation

represented the average flow time for the parts in each stage on the supply chain map. To build the load distribution, the key supply node was identified as the depot supply located in the eastern region of The Kingdom of Saudi Arabia. Then assessments were made of relationships between the depot supply and other key nodes of the supply chain, and those relationships were reflected in the supply chain value stream maps featuring detailed business process links.

The researcher needed to analyze the received data and compare the average flow time of parts at SORs with the actual ones. Differences between actual flow time and expected time identify what process create delay in the supply chain and then direct managers to manage those processes closely. Table 1 shows what shapes mean in supply chain maps used in building the F-15 repair and return process.

Table 1: Shapes Meanings in Supply Chain Maps

Shape	Description
	Members of the supply chain.
	Non-managed relationships.
	Managed relationships.
	Monitored relationships.
	Non-member of the supply chain.
	Direction of parts flow.
	Ground transportation method.
	Air transportation method.
	Ocean transportation method.
	Latter a represent the mean flow time. b standard error.

Second, the researcher conducted interviews and surveys various employees of different segments in the supply chain. Interviews and surveys are in appendices and were

helpful to the researcher in understanding how parts flow in the supply chain. The main points of interviews and surveys supported assessments of relationships between members of the supply chain as well as how they communicate with each other in the supply chain, and any impact of flow rates.

Third, the data was organized in Microsoft Excel sheet and statically analyzed.

Following are the types of analysis done on the data:

1. The data included flow data from 2010 to 2016 for more than 14,022 part numbers at different SORs. Those data include technical information which are more than what was needed for the purpose of this research. The researcher used Microsoft Excel sheet to eliminate any parts with incomplete tracking data or incomplete status (only repaired parts were used).
2. Statistical analysis was done by Microsoft Excel sheet software using data received from the F-15 program office in WRAFB to better understand the SORs repair time.
3. Statistical analysis on each source of repair done using Microsoft Excel sheet to assess the ability of each repair source and their load size and compare it with the average lead time in the contracts and agreements. And represent the result of the statistical analysis in charts to better see how all sources of repair perform in comparison with what is there in the contracts.
4. The repair/return list, and repair/replace list were analyzed using Microsoft Excel sheet (IF functions) to find the number of NSN that were common, and evaluated which path would serve the RSAF TAT demands.

## **IV. Analysis and Results**

### **Chapter Overview**

This chapter will contribute to a better understanding of how the RSAF supply chain works and the level of efficiency in the supply chain. The chapter will show the result of different analyses of available data, surveys, and interviews. Those surveys were given to two employees in each stage of the supply chain. The remaining stages of the supply chain were analyzed based on the data from the F-15 program office. The researcher also interviewed one of the specialists at Al Raha Group for Technical Services (RGTS), which is the repair and return services prime contract, and received useful data that contributed to this study.

### **Contracts Differentiation**

The first step in the analysis was classifying the contracts used by RSAF for repairs. based on the surveys and interviews with different process owners to document their observations on the process flow time. The process starts at the base, when the maintenance technician removes a broken part from the aircraft, and then enters required information into the RSAF supply chain tool, GOLDesp system, and completes needed documents for the base supply. At Base Supply, they complete the needed documents, update the status in the GOLD system, identify the priority, packing parts, and then ship the parts to the depot supply by air weekly or by contracted truck shipping company. The depot then inspects documents to ensure they are properly completed, updates the status in the system, identifies the source of repair, and checks fund status prior to preparing the parts for shipment.

The RSAF has different contracts and routes in place for repairing the F15 parts with the DoD. The depot supply can choose from them based on their needs. These routes are explained as follow:

1. Parts and Repair Ordering System (PROS): these are non-standard items that is not in DoD inventories or bought on a continuing basis for regular use by DoD activities. A non-standard item may range from a major end article to an individual part of a component or assembly and may or may not have an assigned NSN or other stock number.

In this case the RSAF main contractor is responsible for the maintenance of this item. The contract is managed by a dedicated program office at AFSAC that oversees the contractor's performance and controls the flow of FMS requirements to the contractor.

2. Direct commercial sale repair: this type of repair is managed entirely by RSAF contractor based on the RSAF needs outside of their contract with USAF, it could be done in The Kingdom or in the U.S.
3. Central Facility repairs: repairs on this list are done directly by RSAF at depot maintenance in King Abdul-Aziz Air Base (KAAB) or at maintenance squadrons in the other bases.
4. Cooperative Logistics Supply Support Arrangement (CLSSA): also called the repair and replace. In this contract the DoD offers the CLSSA as an effective means of replenishing the in-country stocks of spares and repair parts which were initially furnished with end items of equipment. The CLSSA is an FMS agreement for the furnishing of secondary items from the U.S. logistics system to a country in support

of specific major end items/systems. The arrangement requires the country to make a financial investment in the DoD logistics system to fund its anticipated support requirements. The country, with the recommendation of the system program managers, identifies (by stock number and quantity) those secondary and support items which the country anticipates it will require annually. This list is known as the Materiel Repair Requirements List (MRRL), because of the RSAF investment in the U.S. supply system. The investment permits the USAF to augment its stocks in anticipation of the RSAF actual demands. The CLSSA is used for replenishment of consumables or for replacement of repairable components. The CLSSA is not intended for initial support, but rather as a mechanism to resupply the initial support package.

5. Repair and Return: items on the Master Repairable Item List (MRIL) are parts that can be recondition or economically repaired for reuse when it becomes unserviceable. This contract is the prime support for the RSAF and it handle the majority of RSAF repairs.

Under the repair and return concept, The RSAF must request approval for repair through the inventory manager (IM) before shipping materiel to the U.S. for repair. After receiving approval and shipping instructions from the IM, the RSAF ships the materiel to the designated repair facility where it is entered into the repair queue. After repairs are completed, the item is shipped back to the RSAF.

Some of the parts on the MRIL are also common with the MRRL, reasons for that and situations when to send the parts on each of them will be explained later on.

This research will only consider the SOR that handle the items on the MRRL or MRIL, since these two contracts have the majority of repairs and the highest cost impact on RSAF. This research is also a broad view of the supply chain. The study will include only main members of the supply chain and will not analyze the deep details or processes inside the supply chain. The main members are Tabouk Base Maintenance Squadron (TB M), Taif Base Maintenance Squadron (T M), Kamis Base Maintenance Squadron (K M) and Dahrhan Base Maintenance Squadron (D M), Tabouk Supply Squadron (TB S), Taif Supply Squadron (T S), Kamis Supply Squadron (K S), Dahrhan Supply Squadron (D S), depot at Dahrhan Airbase, Freight Forwarder (FF), and sources of repair (SOR). Given all the information, the supply chain is shown in Figure 4, where the focal firm is the depot supply. Also Figure 3 shows non-member of the supply chain whom their repair requirement can affect the RSAF F-15 repair and return supply chain as they use some of the repair sources those RSAF use. The non-member of the supply chain are the USAF, Israel Air Force, and Japan Air Force who operate the F-15 fighter aircraft.

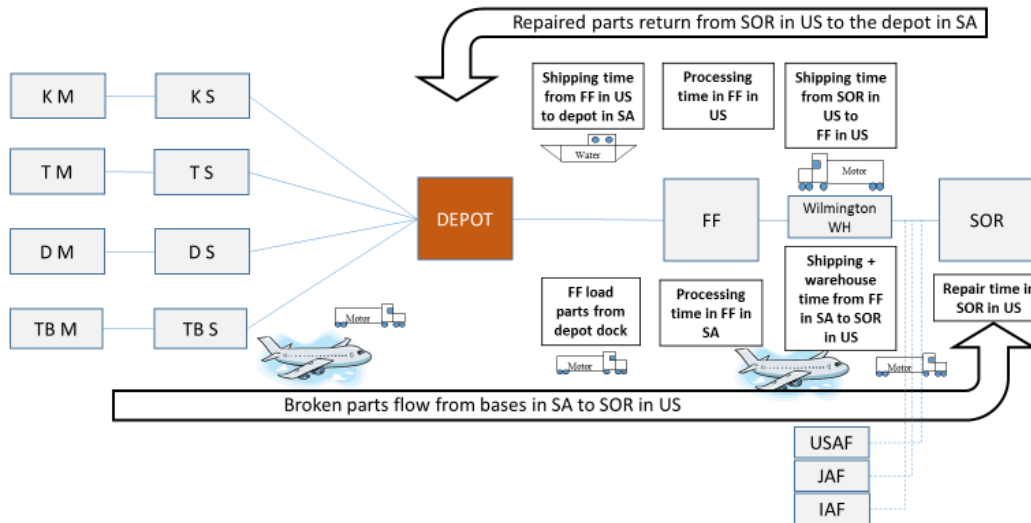


Figure 3. Repair and return supply chain map

The best supply chain scenario in repair and return contract is when there are no errors or missing components, incomplete documentation, and parts and information flow smoothly throughout the supply chain. Parts need one day on average to be ready for shipment from base to the depot. Parts are shipped weekly from bases to the depot by C-130 except for Dahrhan Airbase, where they send parts from bases to the depot daily by freight forwarder trucks. The depot needs an average of one week to make parts ready for shipment to sources of repair and the freight forwarder load containers from the depot docks. Shipment from Saudi Arabia to the U.S. is by air cargo or ocean, and after clearing customs, parts will be consolidated in the Wilmington warehouse then distributed to different SOR. The freight forwarder requires one month to ship parts from depot to sources of repair, based on the judgment of experts in the program office. After the repairs are completed, the freight forwarder will ship them back to the depot in The Kingdom. Usually, shipments are completed by ocean, along with consumables and other parts.

however, urgent parts will be shipped by air. Ocean shipments usually need three to four weeks to clear customs and reach to the depot.

### Data Preparation

The program office provided SAMIS code data, which include more than 14,000 data points for the repair and return process from OCT 2010 to OCT 2016 with different repair status at SORs.

The researcher eliminated data with incomplete status (i.e. WIP and on hold). 12,333 data points were with complete or awaiting parts (AWP) status information. Figure 4 shows the percent of the repairs done by SORs that complied with the common historical average repair time for every NSN on the MRIL.

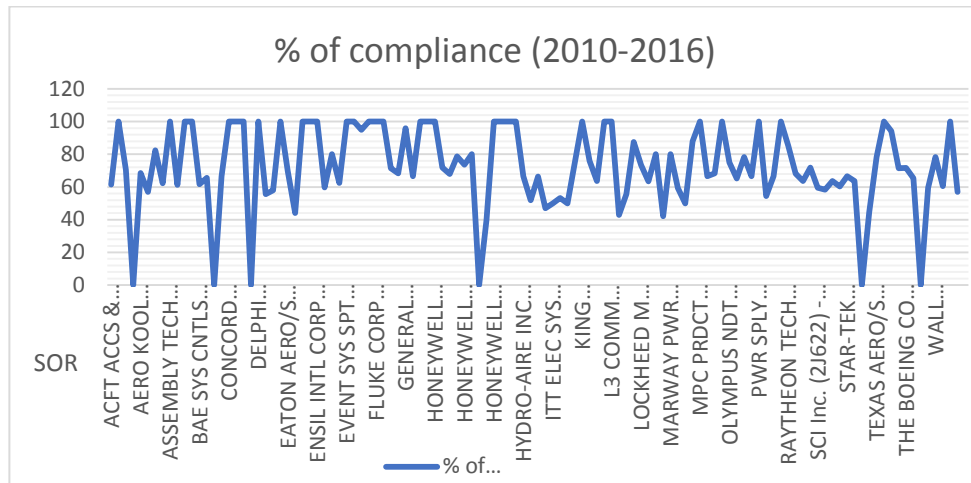


Figure 4. SORs performance vs average repair time

Figure 5 represent the number of total repairs done by each SOR in the giving time period.

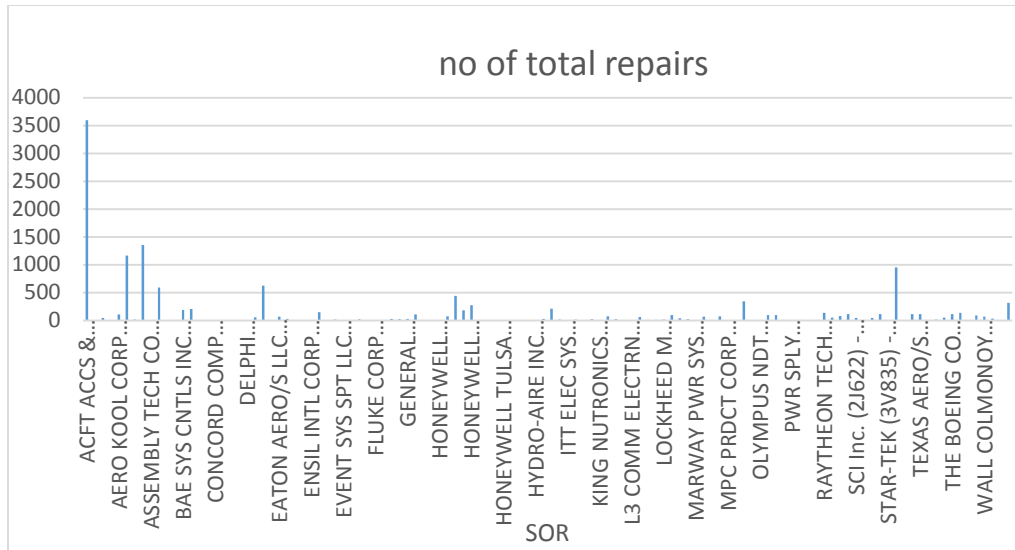


Figure 5. Total repairs by each SOR

Further analysis of the data revealed that there are 199 NSN that get shipped to different SORs for the same repair, these parts have 70% compliance rate with average repair time if they go through MRIL (figure 6), which indicates that these parts need to be further analyzed to configure the cost value of shipping them either way.

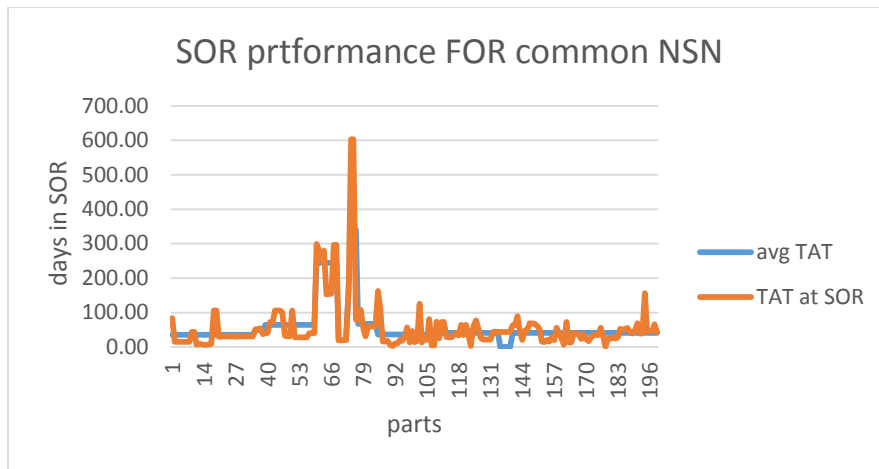


Figure 6. Common NSN on MRIL vs average repair time

## **Evaluation of Data Findings**

The results of the analysis for the supply chain data clearly show there are gaps between the actual repair time and the average repair time. Repair sources are managed by the repair and return services prime contract. These sources repair more than 926 unclassified national stock numbers (NSN). Approximately 60% of parts repaired in these SORs complies with the average repair time.

The prime contractor of repair and return services should evaluate sources of repair and apply the incentive and remedy recommendation of the program office, which applies to their contract. Flowing down incentives will help encourage sources of repair to perform. The contractor should also evaluate SORs capacity to determine who can best meet the RSAF needs.

The following are findings and recommendations resulting from this study. Additional research is required for deeper studies to evaluate each segment individually. Each one of these findings is a limitation which constrains the speed of the flow in the supply chain.

### **1. Relationships**

The working relationships of the supply chain managers (RSAF and USAF) are vital to success. If relationships are poor between depot and different segments, delays and inaccuracy will result. Most of the supply chain members have weak relationships with its next member in the chain and no relationships with their tier-two members.

Recommendations are to form cross-functional teams from the RSAF, USAF program office, and repair and return services prime contract to improve their relationship. Also, LEAN and continuous process improvement initiatives should be continued, which would evaluate the supply chain performance during quarterly meetings.

## **2. SOR capacity**

SOR capacity reflects the negotiated task ordering level that the repair source agrees to and prices. That number of repairs, or an agreed upon range of repairs, and stipulations on cost become the contracted capacity (Bagley, 2016). For MRRL repairs, SOR capacity will be forecasted based on examining the "eight quarter look back" of repair history for both USAF and RSAF since this repair process is used by both, that then is used to establish repair capacity targets.

As a recommendation, RSAF need to coordinate with program Office to continuously updates the MRRL and add items that have a high occurrence rate. Also, the RSAF depot supply who is the decision maker for the type of repair (MRRL or MRIL) should evaluate the high Mission Impaired Capability Awaiting Part list (MICAP) items and forecast their future need based on that, then they could ask the prime contractor to renegotiate the agreed upon capacity with contracted SOR or they could add more approved ones to the list. The depot should also partly include the SOR on their GOLDesp system, so that the SOR know and prepare for the coming parts ahead of time, since some of these parts need special

items for repair. In doing so this will help improve the TAT and increase the RSAF mission ready rate.

In some cases, RSAF have the option to choose from MRIL or MRRL for common NSN on both list. This decision is currently based on the urgency of parts, as the MRRL feeds the RSAF directly from USAF inventory so there is no waiting time for repairs to be done. Although some depot managers may not prefer this method as you get a different item back. That you send a low service hours part back and in return you get a serviceable but yet a high service hour part. On the upside when choosing the MRRL for common NSN, it provides a better communication with SOR through the program office. the researcher recommends that MRRL to be used in the common NSN if they are not highly sensitive to service hours as it comes with no additional cost to RSAF, they are charged the same amount as USAF, and in case of highly urgent needs.

### **3. Communication**

The supply chain coordination flow of information is slow and is slowing parts flow as well. Currently, communication between RSAF and SOR is through official letter sent by regular mail to resolve any issue. Delivery of these letters, in a best case scenario, may take a week. As a result, delays occur if for any reason the flow of a part has been stopped, (i.e. incomplete documents, missing components, etc).

As a recommendation, supply chain coordination should use secured email, fax, and phone to accelerate communication and the flow of information. In

addition, points of contact (POC) in the RSAF directorate of supply and in USAF Program Office should be assigned for daily performance tracking and to solve any issue in the shortest possible time.

#### **4. Fund Authorization**

A constraint in the supply chain is non-availability of repair funding. In the letter of offer and acceptance (LOA), RSAF have funded repair activities according to contracts, typically for five-year periods of performance. Based on the way the obligation authority for depot supply authorizing repairs is regulated, (divided into equal dollar value for each period of time (i.e. quarterly or monthly), when the allowed funding for the specified period is completely used up, the depot is not allowed to ship more parts to the SOR.

As a recommendation, RSAF need to coordinate with program office to allocate budget of repair according to the LOA, so that depot supply has the authority to ship parts based on the line funding. In using this method, close coordination between the RSAF and USAF managers will ensure expenditures are closely managed. And will also prevent the SOR from been overwhelmed with parts that have been waiting once the funds are available.

## **V. Conclusion**

### **Chapter Overview**

This chapter summarizes results and recommendations discovered while completing the analysis of the RSAF SOR capacity planning. And concludes evaluation of existing supply chain data and interviews with participants in the supply chain from depot, through the U.S. government program office and repair and return services prime contractor.

### **Research Conclusions**

This thesis has analyzed and defined the gaps of the RSAF F-15 repair and return supply chain, including main members of the supply chain. The findings of this study suggest ways for RSAF and USAF managers of the F-15 repair and return supply chain to evaluate SORs, which will improve the end-to-end TAT of the repair and return process.

This study used supply chain mapping , LEAN and statistical data analysis to explore if time can be saved during the F-15 repair and return supply chain. Supply chain mapping and LEAN made it possible to discover areas to improve a process of the supply chain repair and return processes. which made the process easier to understand and provided process improvement recommendations.

While gathering information for the thesis, it became clear that relationships, communication (including asset visibility) between the RSAF Headquarters, depot supply, the U.S. government program office, RGTS (the RRSs prime contract), and the SOR can be improved. Communication, asset visibility, or “flow of information,” are the biggest gap in the F-15 repair and return supply chain.

LEAN considers waiting time and unnecessary or extra movement as waste that should be eliminated. The F-15 repair and return supply chain uses a lot of time in communication, lack of forecasts, mistakes, and over-processing. This thesis concludes all of the wastes can be eliminated or reduced by applying LEAN.

### **Significance of the Research**

The RSAF and U.S. government program office started end to end supply chain mapping as a result of the initiative of the RSAF Headquarters' Chief of Supply. This thesis is the first attempt to perform detailed analyses of SORs, which is the next essential step in improving supply chain performance. RSAF suffered for decades from non availability of needed parts on supply shelves due to long lead time of repair and return process.

This research presents the main causes of the long customer-waiting time for the F-15 repair and return in SOR. The process of repairing and returning parts to the supply shelves can be improved, and lead times shortened, by eliminating the negative effects of the findings presented in Chapter 4 in this thesis. Enhancing relationships between members of the supply chain, as well as using new communication, and tracking system presents the greatest opportunities to improve the capacity planning and reach higher aircraft readiness.

### **Research Limitations**

This study is only a theoretical study. It has not yet been applied to the Royal Saudi Air Force F-15 repair and return process.

## **Recommendations for Action**

1. Forming cross-functional RSAF/USAF teams to continue LEAN/continuous process improvements initiatives to complete efforts and improve performance.
2. Increase communication/focus with quarterly RSAF/USAF Performance Reviews that include key inventory issues such as replenishment spares and sources of repair capacity planning.
3. Assigned point of contact for daily performance tracking, RSAF

director of supply Analysis Section and the Program Office Operations & Analysis Section.

4. Evaluate contract with repair sources and review performance continuously.
5. Grant SOR limited access to the GOLDesp system to better help them prepare for incoming parts before they are shipped.
6. Forecast the demand for 6-12 months based on MICAP rates.
7. Demand the prime contractor to look for approved SORs in case the current one do not satisfy demand.
8. RSAF could add more items to MRRL that are of urgency and possibly save money.
9. Review both MRRL and MRIL to see if there is any common items who cost more when they get fixed on each of the lists.

## **Recommendation for Future Research**

RSAF Headquarter Chief of Supply and the U.S. program office should sponsor further research into the development of additional sources of repair in The Kingdom. At least for the national stock number which have regular demand occurrence rates in order to

reduce or eliminate overseas shipping time and increase the visibility of SORs. The examination of expanding in Kingdom repair must include the identification of items for which the RSAF and U.S. government have data rights needed to complete repairs. In addition, the research should address the supply chain and component parts vendors that would support in Kingdom repair with emphasis on the impact of export licensing and individual component pipeline time.

This future study could shorten support times for some of the frequently used items, and optimize others that still must be repaired internationally.

### **Summary**

This research analyzed SORs to identify factors that impact TAT at SOR causing delays in the RSAF F-15 reparable parts supply chain. Main causes of delay identified in this thesis are relationships, communication, demand forecasts, and SOR capacity planning requirements. RSAF and USAF managers of the supply chain are recommended to improve their relationship with SORs, improve communication methods and inventory management systems, demand forecasts , and continue ongoing initiatives of process improvement.

## Appendix A

### Survey number 1

Depot Supply: Repair & return only

1. What are major problems that when they occur make flow time longer or create some delay with SOR?
  - Problem1: fund constrains , When SOR not authorized due to non fund, the parts will be hold in Wilmington till SOR is authorized,
  - What actions need to solve the problem and how long it takes?  
3-6 Months, speed up the signing of the repair contract and make more finds available to prime contractor.
2. To what extent can you track the part in the supply chain?  
Complete tracking (the repairable spares are tracked by serial number)
3. How do you communicate with? Maintenance & base supply (mail), FF (officially through depot commander) & SOR (officially through the program office)
4. How do you assess the relationship b/w • Depot supply and FF (poor). • SOR (weak through program office)

## Appendix B

### Survey number 2

Source of Repair:

1. 1What are the priorities and policies to repair broken parts for aircrafts?
  - MICAPs
  - Quick fix (clean, align, calibrate, test)
  - AWP in order of the arrival of the needed parts
  - Parts requiring Engineering Disposition
2. What is the average processing time to repair parts?

80 days by contracts.
3. What are major problems in received parts that make flow time longer or create some delay?
  - Problem1: poor description of actual problems with parts

What actions need to solve the problem and how long it takes?

Inspection, run test then induct to repair.

  - Problem2: missing components inside parts (5 times last quarter)

Actions: Send letter to RSAF to inform and suggest action.
4. How do you communicate with depot?
  - the program office, formal action is through letters (all letters must issue from the United States government Program Office)
5. How do you assess the relationship b/w SOR with depot supply?
  - SOR do not communicate with Depot Supply since they are contractually obligated only to the RRS prime contractor.

## Appendix C

### List of recommendations

1. Forming cross-functional RSAF / USAF teams to continue LEAN/continuous process improvements initiatives to complete efforts and improve performance.
2. Increase communication/focus with quarterly Royal Saudi Air Force /United States Air

Force Performance Reviews that include key inventory issues such as replenishment spares and sources of repair capacity planning.

3. Assigned Point of Contact for daily performance tracking, Royal Saudi Air Force directorate of supply Analysis Section and the Program Office Operations & Analysis Section.

4. Evaluate contract with repair sources and review performance continuously.
5. Grants SOR limited access to the GOLDesp system to better help them prepare for incoming parts before they are shipped.
6. Forecast the demand for 6-12 months based on MICAP rates.
7. Demand the prime contractor to look for approved SORs in case the current one do not satisfy demand.
8. RSAF could add more items to MRRL that is of urgency and saves money.
9. Review both MRRL and MRIL to see if there is any common items who cost more when they get fixed on each of the lists.

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<b>14. ABSTRACT</b> This research focuses on improving the F-15 repair cycle processes in the Royal Saudi Air Force (RSAF). The current RSAF repair cycle capacity planning process has not been mapped and optimized. As a result, inventory management and asset turnaround times continue to impact the RSAF's ability to sustain mission readiness. Because the F-15 is the first line of Saudi Arabia's defense, it is essential that they be fully mission ready in the shortest time possible. That can be done by understanding the current relation between the depot supply directorate and the sources of repair (SOR) available to RSAF in the United States (U.S.). How the parts routing decision is made, what capacity is available at each SOR and what contracts between the Saudi government and U.S. government control that relation. The selected techniques are supply chain mapping, LEAN management approach and capacity planning methods. The research suggests that those techniques can help to improve the F-15 supply chain process in the Royal Saudi Air Force for several reasons. One of the most important reasons is a better work loading to different SORs which will improve the turnaround time.					
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