ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCELOGISTICS AND SUPPLY CHAIN MANAGEMENT DEPARTMENT

IMPACT OF SUPPLY CHAIN MANAGEMENT IN ETHIOPIAN AIRLINES MAINTENANCE, REPAIR AND OVERHAUL (MRO) SERVICES PERFORMANCE

A Thesis Submitted to Addis Ababa University School of Commerce in Partial Fulfillment of the Requirements for the Degree of Masters of Art in Logistics and Supply Chain Management.

By: Melaku Mekonen

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ADDIS ABABA UNIVERSITY

SCHOOL OF COMMERCE

"***IMPACT OF SUPPLY CHAIN MANAGEMENT IN ETHIOPIAN AIRLINES MAINTENANCE, REPAIR AND OVERHAUL (MRO) SERVICES PERFORMANCE.***"

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Declaration

I, Melaku Mekonen declare that this paper is a result of my independent research work on the topic entitled **"Impact of Supply Chain Management in Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) Services Performance"** in partial fulfillment of the requirements for **the Degree of Masters of Art in Logistics and Supply Chain Managementat Addis Ababa University.** This work has not been submitted for a degree to any other university. All the references are also duly acknowledged.

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Date _____

Confirmation

This is to certify that **Melaku Mekonen**has carried out this research work on the topic entitled **"Impact of Supply Chain Management in Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) Services Performance"** under my supervision. This work is original in nature and has not been presented for a degree in any University and it can be submitted for the partial fulfillment of the requirements for the award of the degree of Masters of Art in Logistics and Supply Chain Management.

Teklegiorgis Assefa(**Asst. Professor**)

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Date _____

ABSTRACT

The intense investments and other unexpected events to the airline tested the knowledge and proficiency of the SCM's on time delivery of the requested parts/services whenever the aircraft grounds. Theobjective of this study was to assess the impact of SCM in Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) service performance. The study employed both qualitative and quantitative approach (descriptive and inferential) to investigate the problem under study. The researcher used probability (simple random) and non-probability (judgmental) sampling techniques to select sampling population. The data collection considered all the team leaders and some selected senior technicians from component, engine & landing gear shops and base & line maintenance. It also took the team leaders and managers from SCM (Procurement, Logistics, Warehouse, AOG Desk, Material Planning, and Strategic sourcing) into consideration. The data collected were analyzed by using IBM SPSS for statistics. The findings clearly indicated the importance of SCM in Ethiopian MRO's survival, existence and its future expansion plan to serve customers from the whole world. Despite the limitations, the study created awareness about the concept, principle and practices of SCM in Ethiopian Airlines MRO performance. Thus, the close working relationship of the SCM as a whole with different departments including maintenance, repair shops & other supporting departments including finance & engineering is supposed to positively impact the competing power of the MRO and is currently resulting in better cost saving, efficient & timely use of resources and developing skills of employees towards aviation market level. Finally, the respondents agreed that the MRO should organize continuous trainings, experience sharing and workshop visits to its employees. And the respondents also believe that the MRO should improve communication, relationship and partnership with suppliers and operators.

Key words: Supply Chain Management (SCM), MRO, Component Repair Shops, TAT (turnaround times of components), Piece Parts, Ethiopian airline, Aviation.

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Acronyms and Abbreviations

SCM	Supply Chain Management
SPSS	Statistical Package for Social Science
TAT	Turn Around Time
MRO	Maintenance, Repair and Overhaul
AOG	Aircraft on Ground
IATA	International Air Transport Association
SC	Supply Chain
ATA	Air Transport Association
RFQ	Request for Quotation
OEM	Original Equipment Manufacturer
MXI	Maintenix System deployed by the airline
RSPL	Recommended Spare Parts List
CSP	Component Support Program
FAA	Federal Aviation Administration
PO	Purchase Order
RID	Request ID in Maintenix system
POREQ	Purchase Order Required Request ID on Maintenix system
TCS	Total Component Support
EASA	European Aviation Safety Authority
IATP	International Airlines Technical Pool

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Today, with increasing competition & globalization and challenging working environment, every airline is developing ways to reduce costs and increase efficiency in providing quality passenger and cargo services. The airline industry can be characterized as a very unique kind of industry.According to (Bourgeois and Eisenhardt, 1988) aviation industry is a highly volatile environment, where there is sharp and discontinuous change in demand, competitors, technology, and regulation, overlapped with continuous dynamisms or volatility.

Every on-time take-off of an aircraft is the result of various airline functions such as Operation, Ground Handling, Maintenance, Logistics and Supply chain etc. working seamlessly together. Service quality and safety of the airlines is governed and audited by national authority- Ethiopian Civil Aviation Authority and different international regulatory bodies like Federal Aviation Administration (FAA) and European Aviation Safety Authority (EASA). The Airline complies with regulatory bodies' requirement to provide maintenance service to third party and to fly to different continents.

Despite all the challenges, Ethiopian Airlines remained one of the most successful Airlines in the world. In 2013, International Air Transport Association (IATA) ranked the airline as the 17th profitable airlines in the world and the most profitable airline in Africa.

Ethiopian MRO is one of the seven business units in Ethiopian Airlines group and its main purpose is to provide maintenance, repair and overhaul service to aircrafts & component parts of the airline and other airlines. The Airlines major area to compete in this challenging and competitive aviation market is to reduce maintenance repair and spare parts cost without compromising quality services. And to this end,Supply Chain plays a major role asit is backbone of the Airlines MRO service performance. Procurement and Supply chain as a

main department in Ethiopian MRO comprises Stores & Warehousing, Purchasing, and Logistics Management.

Every decision process begins with identifying the correct part(s) required for specific maintenance repair (either component or aircraft) by technicians and stores is notified about the requirement. Stores & warehousing is responsible to locate or allocate the requested part(s) and advises the user regarding availability of the part(s). And for all requested available parts, stores is designated to deliver within 30 minutes as per the SLA (service level agreement) signed between the parties (stores & maintenance) but sometimes it depends on nature of the requested part. If the requested part is very bulk item, then stores will be forced to check for availability of forklifts & other loading and unloading machines which takes some times due to shortage of these machines in the area and it needs involvement of other departments like Engine shop, base service, motor pool, etc to deliver the requested part(s) to the user.

In a time of unavailability of the requested part(s), stores keeps the user informed as the part(s) is/are unavailable (nil in stock) or insufficient (when the requested quantity is greater that the stock balance of the part) and makes it purchase order required (POREQ) in a system which stands to state that the respective ATA (Air Transport Association that classifies aircraft parts in chapters) buyer shall take the required action to avail the part(s) based on the request priority. The request priority AOG is for only grounded aircrafts that are looking for the requested part & NO-GO items for which the aircraft cannot fly without them installed, Critical is for the aircraft scheduled to be back in service within five days & components required for the aircrafts under similar schedule and Normal is for stock & components required to keep in stock after maintenance. All these processes go through the system called Maintenix (MXi).

Once the part(s) is confirmed unavailable in stock, the respective ATA buyer sendsrequest for quotation (RFQ) to the Original Equipment Manufacturer (OEM) and different approved list of suppliers. The quotes are then evaluated based on cost & lead time of the part and buyer places the order to the selected approved supplier. The supplier acknowledges the

order, dispatches the shipment & notifies the buyer as the parts are ready for collection in their facility as Ethiopian uses Free on Board origin (F.O.B.) where the seller states price at point of origin, and agrees to load a carrier, but assumes no further responsibility of the freight. Inbound logistics team then arranges collection in coordination with selected FF (Freight Forwarder) and deals in cost of delivery based on the request priority informed by buyer. As stated above, if the request priority is for the aircraft on ground (AOG)& the aircraft is only looking for this part to be back in revenue service, it's obvious that logistics team is forced to check any available flights without considering the cost of carrying the freight. In short, that's why logistics & supply chain play a very great role in MRO service performance of the airline industry.

The main research study has concentrated on the importance of effective and efficient Supply chain systems for the overall service performance of Ethiopian MRO and to study the extent by which the Ethiopian MRO is affected by this system.

1.2 Statement of the Problem

Airline Industry is highly dependable on aircraft parts and components to keep the aircrafts on air. And as a business unit, Ethiopian MRO is one of the main business units highly affected by Supply ChainManagement systems. The main problem of the research question is to see how Supply ChainManagement is playing a key role in ensuring that aircrafts are departed on time and to see how parts unavailability in stock affects MROs operation and leads to flight cancelations and/or delays. It is not easy to hold optimal inventory level of spares as per the OEMs recommended spare parts list (RSPL) to keep the aircraft in the air. And in the airline industry, it is not uncommon to hear flight delays and/or cancellations mainly due to part related issue and the airline is in turn forced to incur additional aircraft on ground (AOG) related cost as a result of this. The MRO's main challenge is regarding continuity of smooth operation with minimum possible cost.

Due to corporate cost saving strategy, the Airline doesn't want to hold maximum inventory level of high value items and on the other hand, the management is unpleased to hear flight

delays and cancellations happened as a result of Supply Chain Management related issues. Ethiopian Airline is frequently facing aircraft on ground (AOG) situation mainly due to out of stock of critical parts, mainly "NO GO" category parts. AOG procurement is processed when the aircraft is on ground due to part related issues while scheduled to fly & it's is very costly to support maintenance in AOG procurement. This is due to many reasons. Among them safety is the first issue.

There is also limitation on literature in this specific area and all available data's are only accessed by regulatory bodies like FAA, EASA, civil aviation of the countries, etc.

1.3 Research Questions

In order to achieve research objectives, this study answered the following research questions:

- How quickly does supply chain respond to scheduled and non-scheduled aircraft maintenance activities?
- What is the role ofSCM in a turnaround time of foreign repair(FR) components?
- How isflight delays/cancellations maintenance related to SCM performance?
- How is on-time return of aircraft back to service after planned maintenance related to SCM performance?
- What is the role of SCM in cost saving strategies of the Airline's MRO?

1.4 Objective of the Study

In line with the preceding problems and research questions, the general and specific objectives were the following:-

General Objectives

- To assess the impact of Supply Chain Management in Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) services performance.

Specific Objective

In particular, the specific objectives of this study were:

- To assess how flight cancelations and flight delays are directly related to performance of Supply Chain Management
- To assess the effect of procurement as part of supply chain on scheduled (C-checks and A-checks) and non-scheduled aircraft maintenances.
- To analyze the role of Supply Chain Management in turnaround times (TAT) of components sent to Foreign Repair (FR)
- To investigate success & failure area of Supply Chain Management in returning the aircrafts back in to service on time.

1.5 Significance of the Study

The study will have strong contribution to:

Ethiopian MRO

The MRO will use finding of this study to improve its performance, mainly by proposing ideas by which AOG situations, flight cancellation and delays will be reduced. It will also reduce TAT of in-house and foreign repaired components by addressing finding of this study. Ethiopian MRO will clearly understand the importance of holding optimal inventory level as per the aircraft manufacturers resource documents-Recommended Spare Parts Lists (RSPL). And finally, the MRO will strongly support the importance of developing good interdepartmental and interdivisional relationships for smooth operation of the MRO based on findings of this study.

Airline Operators and other MRO Service Providers

If the findings of this study are correctly applied, the Airline operators and other MRO Service Providers might have a better ways of improving their logistics and SC process. This helps them to have a better ways of handling SC processes for smooth operation of the airline's MRO.

Academics and Researchers

Findings from this study will assist academicians or other researchers to use as a base for further research or study hence it will provide little understanding of the nature and influence of MRO Supply Chain Management. The study will also be significant in terms of providing the necessary resource in light of the possibility of future research projects that might be proposed or even carried out in the same area.

1.6 Scope of the Study

Since Ethiopian Airlines is very broad and has about seven vast business units, the study considered only impact of SCM in MRO service performance. Aircraft parts procurement, logistics and other related supply chain activities are mainly interpreted by a researcher. Non-aircraft parts procurement system as part of supply chain management has a different approach and procedures and the researcher thinks that non-aircraft procurement doesn't have much effect on the MRO operation except supporting the operation by tools & ground handling equipments. The researcher only considered Ethiopian MRO due to budget limitation, time and distance to assess other airline's MRO.

1.7 Organization of the study

The paper is organized into five chapters. Chapter one deals with introduction part, chapter two deals with the review of related literature, chapter three presents the methodology part. Chapter four is about data presentation, analysis and interpretation. Finally, chapter five strongly deals with summary of findings, conclusion and recommendations with proposed strategy.

1.8 Limitation of the Study

The major limitation of the study was that the data was collected from a small number of populations since it participatedonly most of the employees who are working at the managerial position in Ethiopian MRO service. Another limitation of this study was that it

took a sufficient time to collect data due to workloads in the Airline. Third, there was limitation on references for the researcher as most of the aviation data is being handled by the regulatory bodies which makes it impossible to access. Finally, since the study area focus only in a SCM sector in Ethiopian MRO, it is important to note that the findings of this study can only be used for comparative purposes.

The followings are what the researcher done to reduce the negative impact of the limitations:

- Before collecting data, the researcher briefed the participants about the objective of the study so as to persuade them to give clear and correct information.
- Since the target populations were located in Ethiopian MRO business unit, the researcher had a follow up period with the participant for timely return of the filled questionnaire.

CHAPTER TWO: LITERATURE REVIEW

2.1 Maintenance, Repair and Overhaul (MRO) Fundamentals

An MRO is a Maintenance and Repair Organizationwhich specializes in performing maintenance actions on aircraft and their components, such as jet engines, landing gear and different components.Like almost anything in aviation, an MRO must have proper certificates which allow it to perform certain tasks on aircraft in accordance with their approval schedule.

D. R. Vieira & P. L. Loures (2016) define MRO as "all actions that have the objective of retaining or restoring an item in or to a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial and supervision actions". According to Boeing 2014 report the importance of MRO can be judged by the fact that it typically constitutes 12-15 per cent of an airlines operating cost, with annual expenditures estimated to be US $50 billion in 2013 and employment of 480,000 people in the world. Phillips et al. (2011) explain that the record aircraft production following strong sales in 2006 and 2007, given the typical 18,000-cycle or 8–10 years between overhauls, has created an unprecedented demand for landing gear overhauls on both long and short-haul aircraft. McFadden and Worrells (2012) state that the worldwide MROs have grown in response to continuous and increasing demand into a viable segment of the aviation industry.

Maintenance, repair and overhaul (MRO) in the aviation industry is a complex process that has strict and precise requirements defined by airworthiness authorities to guarantee the safety of passengers and aircrew. Billions of dollars are spent by airlines every year to comply with such requirements, which represent a relevant portion of their total operational costs. Despite the extensive market and process knowledge, MRO service is a world relatively unexplored by Aircraft Original Equipment Manufacturers (OEMs), such as Airbus, Boeing, Bombardier, Embraer, Gulfstream and others (Vieira&Loures, 2016).

Phillips et al. (2011) corroborate that maintenance forms an essential part of aircraft airworthiness criteria; its main objective is to ensure a fully serviced, operational and safe aircraft. Proper maintenance is an essential contributor to the high levels of safety experienced today; in contrast, improper maintenance can have tragic effects (Marias, K &Robichaud M., 2012). Pipame (2010) explains that to maintain and repair their equipment, airlines take into account the manufacturers' instructions and standards of international organizations to improve the quality and safety of flight. “A number of entrepreneurial operators and support providers have adopted a new group of postproduction support strategies. Although there has been a considerable amount of improvement in the quality and reliability of components and systems, as well as in materials and procedures, over the 100-year life of aviation, they still have not reached total perfection. Aviation equipment, no matter how good or how reliable, still needs attention from time to time”.

Marais et al. (2012) emphasize that increasing the level of investigation surrounding aviation incidents is recommended for improved safety. Marais et al. (2012) also agree with many of the FAA (Federal Aviation Administration) incident reports which simply state that a particular component failed and more detailed investigations would reveal the root causes of component failures and would, as suspected, identify inadequate maintenance to be an important factor.

Regarding in-house airline maintenance capabilities, Carpenter and Henderson (2014) explain that commercial airlines can establish MRO services in their own fleets and operate as profit centers; however, it is not uncommon for airline operators to spin-off these MROs and act as a separate, corporate activity. "Third Party Independents perform similar functions as In-house MROs but are not affiliated to an airline operator. Independents often provide these services at a lower price. Therefore, independents market themselves as the value proposition over the OEMs and In-house MROs”.

Analyzing the operation side, Kinnisson (2012) explains that aircraft maintenance can be divided into scheduled and unscheduled maintenance. Scheduled maintenance is a preventive action to ensure that a product functions properly at pre-set intervals.

Unscheduled maintenance is not planned or programmed, but it is required when an item has failed or broken down. Kinnisson (2012) clarifies that scheduled maintenance includes routine and detailed inspections called transit, 48 h, A, B, C and D checks, subdivided in line and base categories.

According to Yoon (1994) maintenance can be carried out either on or off the aircraft. When off-aircraft maintenance is performed, the equipment and components are removed from the aircraft and replaced with serviceable units. The removed units are then modified into materials for replacement and routed to the repair facility. The pace may be slower than on-aircraft maintenance, but its short turnaround for maintenance (meaning time to repair), is important and sometimes necessary.

The Aviation Safety Bureau (2013) describes different types of aircraft repair:

- ***Aircraft Structural Repairs***: structural repairs are made to aircraft that have sustained damage to the structure (i.e., external skin, stringers, formers, bulkheads, etc.). There are several ways an aircraft structure can be damaged. It is usually caused by ground service equipment, maintenance stands, bird strikes, or lightning strikes.
- ***Component Repairs***: component repairs range from simple part replacements to an entire overhaul. If a component fails to operate properly, it is removed from the aircraft and replaced by one that operates properly. The removed component is then repaired.

2.2 Supply Chain Management Definition and Concepts

Supply chain management (SCM) is a challenging concept, with elusive goals, and is a critical success factor for today's businesses (Qi, Boyer & Zhao, 2009; Duarte &Machado, 2011). A supply chain is a network of facilities and distribution options that begin with the procurement of materials up to rendering service packages to the end consumer (Jain et al., 2010). An efficient supply chain enhances the opportunity of reducing operational costs, improving productivity along with some complex challenges regarding end-to-end

integrated planning, increased availability of assets, inventory optimization and effective spend management (L. Khandelwal, 2011).

As a result of the importance of SCM, companies are searching for ways to improve their performance (El-Tawy&Gallear, 2011), make strategic decisions, and develop competitive strategies that add value in the eyes of customers (Lee, 2002; Ambe&Badenhorst-Weiss, 2011). A supply chain strategy specifies how a firm will achieve its competitive advantages through its supply chain capabilities, such as cost efficiency, response speed and flexibility (Ismail &Sharifi, 2006). A supply chain strategy also specifies how the manufacturing, purchasing, marketing, and logistics functions work together to support the desired competitive strategy (Qi, Zhao &Sheu, 2011). It is therefore imperative for supply chain managers to understand customers' needs, and to choose and implement an optimal supply chain strategy to satisfy customer demands.

The supply chain in the airline industry is very complex according to Bales et al. (2004). Each component of an aircraft must be certified by the airworthiness authorities, which define strict requirements to guarantee safety. Due to the high level of requirements to qualify a supplier, there are a very limited number of companies authorized to provide parts and services in the aeronautical industry. This predicament leads to limited options when selecting a supplier for a new aircraft program and results in a lack of leverage to negotiate commercial conditions. Additionally, the same system suppliers operate in different sub tiers, so they become suppliers of their competitors, which may negatively impact the relationship between them and, ultimately, the final customer.

Based on report from Aviation Week & Space Technology (AW&ST, 2013), most major aircraft maintenance and repair work is provided by repair shops, which carry out MRO operations for the aircraft operators. According to Pipame (2010), 80% of MRO repair shops are small and medium enterprises. "Heavy airframe maintenance, which is especially labor intensive, offers an opportunity to reduce costs by off-shoring into lower wage countries such as Eastern Europe and Asia" (Cohen, M. A. and Wille, J. H. 2006). According to Aviation Week and Space Technology (AW&ST, 2013), the market is actually dominated

by Asian companies and the majority of the top 10 MRO global leading players are indeed in this geographic area.

Aviation Week Netwrok (2015) states that each type of MRO has a different supply chain need. For example, with line MROs, the supply chain is handled by operators; some low cost airlines have outsourced this to large MROs. Operators maintain large inventory of spare parts – more than 50% of industry inventory.

According to UPS report (2013), the MRO supply chain, which comprises millions of items, presents huge challenges for manufacturers and suppliers. They need to maintain the highest possible service levels, to minimize downtime of hugely expensive aircraft. At the same time, they must comply with a host of regulations.

Supply chains became vulnerable to the disruptions that occurred during the productionprocess (F. Treuner et. al 2014). The aerospace industry has refocused in the recent years towards a new supply chain structure which is based on an extensive process outsourcing. This can be seen in the latest aircraft development programs B787 Dreamliner and A350XWB. In both cases the companies Boeing and Airbus have established a new form of partnership which involves more complex work packages compared to the previous programs but are designed to reduce costs and delivery time component (Responsibility made by Airbus Group, 2014).

The procurement of the critical raw materials take quite a long time (such as carbon fiber), these materials being also quite expensive (these materials are highly subject to shortages and price increases). The suppliers hold usually only limited quantities of these materials to effectively manage their financial resources. Regarding the workforce, the novelty used in materials and processes for the development programs of the new generation aircraft could lead to production problems related to the quality and reliability of some of the materials provided. A major obstacle is the size of the industry, but, the policy coherence with other aspects of procurement, such as the overall strengthening of the supply chain is also important. Although it is enjoying an aura of advanced technological and strategic value, the total turnover of the aerospace industry is a fraction of the automobile industry (Advani,

2013). According to Daniela MOCENCO (2016) the difficulties or delays in MRO (Maintenance, Repair and Overhaul) operations disrupt flight schedules and have a huge financial impact.

2.2.1 Supply Chain Outsourcing by MRO

With the advent of deregulation, airlines began outsourcing some parts of their operation not considered a core competency, and that trend is now escalating. Many airlines began by entrusting maintenance, repair, and overhaul (MRO) to OEMs or MRO specialists. Some are even spinning off their own MRO units into independent companies according to Lisa Terry (2014). She also adds that when outsourcing MRO, as well as the logistics around MRO parts and other components, airlines are seeking global reach, speed, visibility, 24/7 service, a single point of contact, and management of spare parts inventory including reverse logistics. Airlines only make money when they're flying, so service providers must be highly responsive and offer exceptional service levels. "When outsourcing, the main concern of air carriers is not how much it costs, but how the service provider will do what needs to be done," says Glusman (2015). "Price comes second to customer service."

"We're seeing an increase in the number of urgent shipments for aircraft on ground (AOG)," says Morten Jensen, corporate market director, aerospace and defense, for Geodis, a global logistics provider based at France. "Because manufacturers are trying to reduce inventories and enable just-in-time delivery, the number of urgent shipments is up."

Organizations need to manage the integration of business, technology and processes across extended enterprises to be successful (Awad&Nassar, 2010). An integrated supply chain improves customer satisfaction and loyalty, as customers experience better on-time delivery. Technology enables help supply chain members to establish partnerships for better supply chain performance (Fawcett et al., 2007; Jain, Dangayach&Agarwal, 2011). Accurate and timely information allows a firm to minimize inventories, improve routing and scheduling of transportation vehicles, and generally improve customer service levels (Barve, 2011). Modern information technology makes possible the fast and safe transmission and

processing of extensive amounts of data, both internally for users within the company, and externally for suppliers and customers (Shukla et al. 2011). High levels of responsiveness can be achieved when companies collect and share accurate and timely data generated by operations (Nel&Badenhorst-Weiss, 2010). According to Duarte and Machado (2011), end-to-end visibility of information is a key enabler for an agile supply chain.

Sourcing decisions are crucial because they affect the level of efficiency and responsiveness the supply chain can achieve. Outsourcing certain processes to other parties may increase a supply chain's efficiency, but may reduce its responsiveness because of possibly longer lead times to achieve economies of scale (Nel&Badenhorst-Weiss, 2010).

Increasing competition, cost pressures (rising energy costs, high commodity prices, etc.) and the impact of the global financial and economic crisis are some of the issues that aerospace industry is facing (Bublitz, 2013). To combat these challenges, the manufacturers and suppliers are using the advantages deriving from the globalization of the aerospace supply chain. On the other hand, globalization affected the aerospace industry with a variety of pressures, such as time compressing aircraft programs, reducing costs, increasing productivity and global competitiveness (Advani, 2013). Major aircraft manufacturers have become extremely selective in choosing suppliers. Suppliers are in the position to assume greater responsibilities in the supply chain to meet the relevant requirements and specificities, to be selected as a partner. In their turn, suppliers are facing problems within the value chain, the experience to manage these complex programs being rather limited.

2.2.2 Value Chains and Challenges in MRO Supply Chain Management

According to D. Mocenco (2016), the airline industry value chain comprises all phases directly or indirectly involved in meeting customer requirements. This network of production usually involves many actors with different functions (manufacturers, suppliers, transporters, warehouses, retailers, etc.) There are also several categories of suppliers participating in the development of aircraft, classified in many levels:

- ✓ *The Original Equipment Manufacturers (OEMs)*- these are the companies that assemble large aircraft components and provide final products to customers. Their work involves: design, development and manufacturing or complete assembling of the aircraft as well as their testing (transport planes, fighter jets, helicopters, etc.). The main OEMs on the aviation industry global market are: Airbus - Europe and Boeing - USA, followed by Bombardier - Canada, Embraer - Brazil and United Aircraft Corporation of Russia.

- ✓ *First-tier suppliers*- they are the direct OEM suppliers. First-tier suppliers manufacture/ assemble major sections, aircraft systems (including engines, avionics, aircraft interior, landing gear, etc.). First-tier suppliers are companies like Alenia in Italy, Dasa in Germany and Casa in Spain. Prime contractors are also the engine manufacturers such as Rolls Royce, Pratt & Whitney and General Electric.

- ✓ *Second level suppliers*- usually are the key suppliers of the tier I (first-tier suppliers). These are commonly small and medium-sized companies. Second-tier supplier delivers complex manufacturing products obtained from his own production or a variety of other external providers. E.g. Sonaca Montreal, Areola

- ✓ *Third level suppliers*- perform special components and specific processes, e.g. raw materials, electronic components, etc.

D. Cizmeci (2005) states that this century's emerging trends and practices in supply chain management in the commercial aircraft industry are guided by basic lean supply chain management practices that have been spreading more widely within the defense aerospace industry over the past decade. During this period, as part of the wider diffusuon of lean practices, the most striking improvements across supplier networks in terms of cost reduction has been through process improvements, including the adoption of process technologies.

According to KiranBala (2014), the below issues and challenges in SCM play a major role in MRO's service performance:

- *Supply Chain Integration*: Supply chain management (SCM) executives face unique challenges, with respect to integrating supply chain-specific strategies with the overall corporate business strategy.

- *Information Sharing*: Information sharing in a supply chain faces several hurdles. The first and foremost challenge is that of aligning incentives of different partners. It would be naïve of a partner to think that information sharing and cooperation will automatically increase his or her profit. In fact, each partner is wary of the possibility of other partners abusing information and reaping all the benefits from information sharing. For example, supply chain partners seldom share information that relates to sensitive cost data.

- *Supply Chain Network Design*: Another aspect that requires more attention is the full integration of forward and reverse activities in SCM. As we can conclude from the surveyed literature, only a few papers attempt this integration and, again, significant simplifications are made (e.g., a single product or deterministic parameters are considered). One aspect that has been scarcely considered in (integrated) supply chain planning concerns postponement decisions, which refer to the possibility of not filling customer demands on time. As a result, backorders are generated that incur penalty costs.

2.3 Classification of Aviation MRO

2.3.1 Aircraft MRO

Base maintenance is quite large owning a hangar (which is required for aircraft base maintenance) and employs a vast group of skilled man powers to perform base maintenance tasks. Thus, the hangar required to maintain different aircrafts is classified based on the size of fleets as Wide Body Hangar, Narrow Body Hangar, Propeller & Q-400 hangar and Diamond & Cesena aircrafts hangar. The hangars have the ability to carry out heavy checks, commonly known as C-checks and structural checks (sometimes referred to as D-checks). Such maintenance checks can take from a few weeks to even a few months, are complex and their costs are calculated in millions of dollars.

Whereas,Line Maintenance is mainly required to provide necessary, minor maintenance tasks in between flights. These tasks include regular daily and weekly checks as well as some defect rectification. Line maintenance is able to replace wheels, brakes and most LRUs (line replaceable units) on the aircraft. They also release the aircraft to service before its further flight.Line maintenance, unlike their base maintenance counterparts, is fairly small and mobile. In order to satisfy the airlines, they need to be available at many airports, often 24 hours a day and with an ability to react instantly to unforeseen circumstances, such as a sudden aircraft defect. They are often based out of a small office and all their tools and supplies can fit on a single van. The parts request from both Base & Line maintenance are being addressed to main warehouse even if some expendables & rotables are warehoused around the maintenance centers. Supply chain plays a very major role to deliver the requested parts on time for the scheduled a/c maintenance & to avail the NIS items in a right time using different procurement options (Pool agreement, borrowing, exchange, outright purchase, surplus market, free of charge (FOC), etc).

2.3.2 Engine and Landing Gear MRO

These two types of aviation MROs deserve a specific mentioning, as they are very important in the life of an airline. In most cases, such MROs specialize only in engines (or only in

landing gear) and at a specific family type at that. This is due to the fact, that the overhaul and repair process of such major aircraft components is really complex and sophisticated. Therefore – it is also very expensive.

Engine and landing gear MROhave their own big facilities and a production line much similar to those found in factories. They have a standstill. On the contrary, they're overwhelmed with customer requests to complete the overhaul of their equipment in a very short period of time. Aircraft engine is a multimillion dollar asset and no reasonable airline will want it to sit around in an MRO rather than earning its lease rates.Engine and landing gear MRO have very skilled and highly trained workers to perform the required work, and also have their own NDT personnel.

For these maintenance centers, the warehouse is located near to them & even they have the dedicated buyers due to criticality of their requirement. The warehouse and logistics personnel assigned to these stores spend their time around these shops by identifying their requirement & availing the requested parts on immediate basis. Most of the parts belong to the Landing Gear & Engine OEM's, the SCM directly deals with the manufacturers &sometimes, there are occasions SCM searches the parts in surplus market due to diversified geographical location of OEM.

2.3.3 Component MRO

Component MROs have to be certified like all the other types, but in many cases the type of maintenance they provide does not require as sophisticated an approach as that from engine or landing gear MROs. There are exceptions to that, of course, particularly in the field of hydraulics, avionics and emergency equipment (like emergency door slides, stretchers, slide rafts & life vests for instance). There are different repair shops under Ethiopian MRO which are stood to perform maintenance of different components based on area of specialization & skilled manpower availability.

Currently the MRO owns the following approved shops: Structure, Interior, Paint, Tailor, Hydraulic, APU, Melting, Pneumatic, Electric, Instrument, Radio, Fuel, Harness, etc. The shops maintain, repair & certify the parts for which Ethiopian is approved for & evaluate the parts defect level for those that are addressed to foreign repair (FR). Unlike Engine & Landing gear maintenance shops, component shops do not own their own warehouse and they also use centralized purchasing. For components that the shops got in-house capability, the turnaround time depends on piece parts availability in stock. Sometimes, 'NO GO' component piece parts are very costly to avail but for the fact that they aircraft couldn't fly without these components, it is a responsibility of purchasing & supply chain to avail these piece parts by any cost.

Regarding foreign repair (FR) components, Logistics & Supply chain have major contribution to the airline by sending the component to the right repair center, following up the timely status of the unit, approving repair costs and using the best & efficient forwarder options for incoming shipments. The airline saves millions of dollars if these processes are undergone as required & hence, it needs a dedicated motivation from Logistics & supply chain side. The purchasing & logistics team are also aware that the best turnaround time (TAT) of the FR unit is, the best their employer can be satisfied with their performance.

2.4Supply Chain, Cost Saving and Outsourcing

The commercial aviation supply chain is under pressure from vigorous airline cost-cutting and low traffic demand. The various links in the chain are trying to cut costs yet expand their reach, although not always in ways that are best for the overall system. Aggressive outsourcing bids have reduced maintenance, repair and overhaul (MRO) margins, especially on the airframe side.

Visibility into lower-tier suppliers is less than clear. And the top suppliers on new aircraft programs are flexing their muscles to the detriment, some say, of airlines and their MRO suppliers. On the brighter side, MROs still have room to grow and opportunities to cut costs and improve performance according to B. Rose & J. Smith (2015)."Besides cost savings, the

big benefit is that once an aircraft is produced, changes to parts can be implemented more rapidly because of the small amount of stock in the supply chain (A. Behrens, 2010). “This strategy is intense to manage, but far more flexible."

Thomas A. Crimi& Ralph G. Kauffman(2012)state that a total cost of ownership (TCO) savings model mustinclude training of business units, the SC group, and top managementpersonnel. They also identified the ways of cost savings: Cost Reduction in whichcost saving results from a situation where something is currently purchased and thecost of obtaining it is reduced and Cost Avoidance in which cost saving resulting from a situation where, without some action on the part of thebuying organization, some form of increased cost would be incurred.

With the advent of deregulation, airlines began outsourcing some parts of their operation not considered a core competency, and that trend is now escalating. Many airlines began by entrusting maintenance, repair, and overhaul (MRO) to OEMs or MRO specialists, followed by catering, aircraft loading/unloading, and fueling. Some are even spinning off their own MRO units into independent companies. When outsourcing MRO, as well as the logistics around MRO parts and other components, airlines are seeking global reach, speed, visibility, 24/7 service, a single point of contact, and management of spare parts inventory including reverse logistics. Airlines only make money when they're flying, so service providers must be highly responsive and offer exceptional service levels.

In the other side, airlines are partnering with different operators and pools support providers to save costs that result in holding minimum inventory of high value components. For instance, Ethiopian currently has a component support program (CSP) agreement for B777 fleets with Boeing & Air France Industries, TCS (Total Component Support) agreement with Lufthansa and Rockwell Collins for Q-400 & B787 fleets & ICS program with KLM & SR Technics for B737 fleets.These agreements are mainly advantageous for on time parts availability (for grounded aircrafts), diversified geographical locations, and reduced inventory holding for high value items that results in low inventory carrying cost.

Another pool term for which the airline is among the members is IATP (International Airlines Technical Pool) which is a convention of Airlines sharing Technical Resources to generate economic savings and support on time dispatch reliability and operational safety.IATP represents a unique tool for Cost Saving, AOG Resolution, Operations Simplification, Technical Updates and Networking.

The benefits of IATP pooling agreements or being member of IATP are:

- ✓ To resolve AOG situations based on local airline support (by simplified Material Access and Release in case of AOG, to avoid to contact different Spare Parts providers, free loan period up to 14 days (plus 7 days for logistic), Quick problem solution),
- ✓ Worldwide presence: 110 pooling participants in 890 stations,
- ✓ Spare parts availability: more than 4,000 pool items,
- ✓ Cost avoidance on Assets Investment,
- ✓ IATP annual Membership fee (paid in two seasonal invoices),
- ✓ Pooling Annual fees very convenient,
- ✓ Pooling Annual remuneration for provided pools (If pool participated by other airlines),
- ✓ Simplified pooling administration and fees verification,
- ✓ Platform Benefits (AOG contact details of more than 130 Airlines & service providers, on time broadcasts for parts pooling change information, simplified Pooling Contract: one click!, seasonal Invoice elaborated by IATP and processed through ICH, on Line Administration, Documentation, and IATP Forms, general information about IATP, web-based e-learning modules),
- ✓ Kit's fees and costs (Fair Fees Structure based on annual landings and participated kits, Free Use of the kit up to 10 days, Convenient rates compared to non-IATP member), etc.

Inventory sharing and pooling arrangements have been embraced by European and Asian airlines for decades. The ATLAS and KSSU parts consortiums were formed in Europe in the mid-1970s to support the introduction of widebody jets. While those pools ceased operating about 20 years ago, Air France Industries KLM Engineering & Maintenance have major pools supporting three geographic regions, with locations in Miami, Kuala Lumpur, Singapore, Paris and Amsterdam. Those are supplemented by smaller local pools at various strategic locations around the world.

When the aircraft is grounded and in need of a part, time is of the essence. Getting the part there is the bailiwick of providers & forwarders. When a customer needs a part, then it's supply chain searches and locates the part with providers/suppliers & then FF formulates a solution within one hour by using whatever means necessary to deliver the part—via ground, the customer's own airline, another airline's scheduled service, charter, even hand-carried to deliver to the grounded aircraft. This is done only in presence of strong supply chain & logistics management.

Generally, every airplane, engine & landing gear and components MRO require the strong and healthy relation with the Logistics and SC management to ensure on time delivery of the piece parts required for component repair. They also need a close work relation to ensure the TAT (turnaround time) of FR items is based upon agreements with different repair agents. But above all, the maintenance personnel doesn't want to hear the word "NIS (Nil in Stock)" which merely affects the schedule of maintenance and leads to work stoppage for engine, landing gear & components and flight cancellation & delay for airplanes. Hence, parts availability in stock plays a positively important role in scheduled maintenance and it's a responsibility of material planning & purchasing to have a timely follow up on safety stock level of each parts.

2.5 Challenges in MRO Supply Chain

Lack of Integration in Supply Chain Functions and other Departments

As per(L. Khandelwal, 2011), the MRO supply chain consists of three key functions, i.e. Asset management, inventory and Warehousing Management, and Sourcing and Procurement functions. Although MRO supply chain organizations are focused on integrating transactional processes such as work order execution, purchase requisition management, inventory issue/receipt/return and purchase order processing, they are yet to move forward to integrate end to end processes, right from the level of planning to the level of execution across all MRO supply chain functions.

The stronger the relation and communication link between departments in MRO (IT, finance, maintenance, SCM and component maintenance shops), the more successful the MRO could be by delivering on time dispatch of aircrafts, reducing the TAT of in-house and foreign repaired components, by planning and preparing ahead of scheduled maintenance, by settling payments to partners and part suppliers in a reasonable time in order to get the next available order released in a good time, etc. Contrarily, a lack of integration of processes and systems in MRO SC functions and different supporting departments results in suboptimal inventory management, high procurement and logistics costs, higher unavailability of assets, and overall higher operating cost to the airlines MRO.

Flight Delays and Cancelation due to parts unavailability

The cost of domestic flight delays puts a $ 32.9 billion dent into the U.S economy, and about half of the cost is borne by airline passengers, according to a new study commissioned by the Federal Aviation Administration (FAA), and University of California. The comprehensive new study analyzed data from 2007 to calculate the economic impact of flight delays on airlines and passengers, the cost of lost demand, and collective impact these costs on the U.s economy. In a ruling,November 2009,the European Court of Justice changed the interpretation of Regulations(EC) 261/2004 regarding flight delays, to include cash compensation similar to flight cancellations if the delay is three hours or longer at the destination.

However, this unless the airline can prove that the delay was caused by 'extraordinary' circumstances before the ruling cash compensation was only rewarded for cancelled flight but not for delays. The study recommends that the strong link between SCM and Maintenance can overcome the effect of flight delay or cancellation which results in high operating cost of the airlines.

Lack of Demand visibility from Maintenance Planning

MRO demands are categorized in to two: Planned and Unplanned demands. Planned demand arises out of expected and pre-planned maintenance activities for scheduled maintenance whereas unplanned demand arises mainly from breakdown and unplanned maintenance activities such as bird strike incidents in aircrafts and aircraft components, unexpected damages in structure of aircrafts, and other unexpected accidents that grounds the aircrafts. Actually, this demand invisibility will affect inventory management and sourcing processes significantly and will result in higher costs throughout the MRO supply chain (L. Khandelwal, 2011).

Warehouse inefficiency and Inventory Inaccuracy

Since MRO materials are large in number and differ in size, shape and attributes ranging from gas to solid, light and simple consumable parts to large and complex subassemblies, some parts being prone to pilferage, others perishable in nature with short shelf life, some parts requiring sophisticated prevention techniques and still others require controlled environmental storage conditions. All these factors make the warehouse extremely complex and challenging and require highly skilled resources who understand commodities and warehousing requirements of such commodities. (L. Khandelwal, 2011)states some implications of challenges to warehouses and inventory management:

- Insufficient stock availability that leads to equipment under break down for longer duration and increased TAT of in-house repaired components
- Unavailability of spare parts in a right time which may result in flight delay, cancellation of flight, scheduled & non-scheduled maintenance delays, increased TAT of components
- Inventory shrinkage due to pilferage and damages

- Maintenance personnel lose faith in current operating system

Complex and Non-uniform procurement Processes

Value of MRO materials varies significantly, and so the associated procurement, logistics, payment, delivery time and approval processes. The procurement and logistics process of parts for grounded aircraft costs the MRO a huge amount of money whereas the planned purchase for stock replenishment and planned maintenance follow the normal SC process and saves a lot to the airline.R. Pavkovic, A. Dramsi and J. Armstrong (2009) in their study on MRO optimization state that complexity in procurement processes results in increased order processing cost, increased logistics cost, more flight delays and cancelation, etc.

2.6Approaches for Improving MRO SC Efficiencies

In order to address the above challenges the MRO supply chain faces, it's recommended that organizations/airlines should develop commonly accepted approaches:

Form Strong Interdepartmental and Inter-functional Integration

Different researches suggest that airlines should work on strong relation between sub functions and inter departments to gain increased and improved MRO performance. Supply chain and logistics merely depend on supporting departments to ultimately support the unpredictable and planned demands from maintenance. It would help SCM by fixing immediate system problems, Finance on the other hand assists SCM by processing and effecting cash in advance payments, Maintenance might assist SCM by requesting the correct parts for the specific maintenance tasks, Engineering might also support SCM by checking and advising alternate parts and options for the task. Hence, MRO performance is strongly correlated with the strong interdepartmental relation.

IT Enablement

According toL. Khandelwal (2011), most of the ERPs do not come with features such as dynamic inventory planning, parts cataloguing, e-procurement which are highly useful and specific to MRO supply chains. The benefits of using up-to-date IT applications are:

- Enriched parts catalogue with reduced chances of duplication of codes
- Automated and dynamic inventory planning leading to optimized inventory
- Automated procurement process processes leading to reduced procurement lead times PO processing costs
- Reduced system inefficiency and minimized system & physical balance problem

Improve Integrated Planning

According to aviation week report (2015), organizations should access their current state of planning processes, implement a well-defined process for annual and periodic planning of maintenance and ensure that the processes are strictly followed by maintenance planning teams. Benefits envisaged trough these planning processes are:

- Improved demand visibility
- Improved inventory planning
- Improved service levels
- Improved category planning and reduced cost of procurement and logistics process
- Reduced MRO operating cost

Improve tactical procurement process

One of the characteristics of MRO supply chain is significantly high counts of parts requests leading to increased purchase order generations. PO processing and post order expediting processes consume most of the time of procurement and logistics personnel, leaving them with limited time to focus on the strategic aspects of sourcing. Its recommended that the organization should review their existing annual spend based on part's criticality, cost, supply source, geographical locations, etc, simplify and automate procurement processes and select suitable procurement methods. Simplification and automation in procurement processes will help the airlines in reducing the procurement lead times and PO processing and expediting costs.

Initiate Parts Pooling/Enter agreements with pool providers

Airlines are entering to parts pool agreements with pool providers like Lufthansa Technik, SRT, KLM Engineering, Boeing CSP & ICS programs to reduce inventory of expensive parts and increase service level by leveraging parts pooling and exchange programs. A centralized inventory planning and strategic sourcing of the MRO SC play a crucial role in pooling processes.

2.7Measurement Variable

2.7.1 Dependent variables:

1. **The importance of SCM to the MRO**

   - ✓ Availability of SC strategies within the MRO
   - ✓ Availability of performance measurement metrics
   - ✓ Functional performance of SCM
   - ✓ Minimization of amount of touches & the touch times in SC transaction

2.7.2 Independent variables:

2. **SCM internal & external customer relationship**

   - ✓ Degree of cooperation between SCM & other departments
   - ✓ Handling relationship & partnership with suppliers & operators
   - ✓ Lead time, Fast Order Cycle Time, Management Support & on time Payment
   - ✓ Department's performance on handling relationships
   - ✓ Closely working relationship

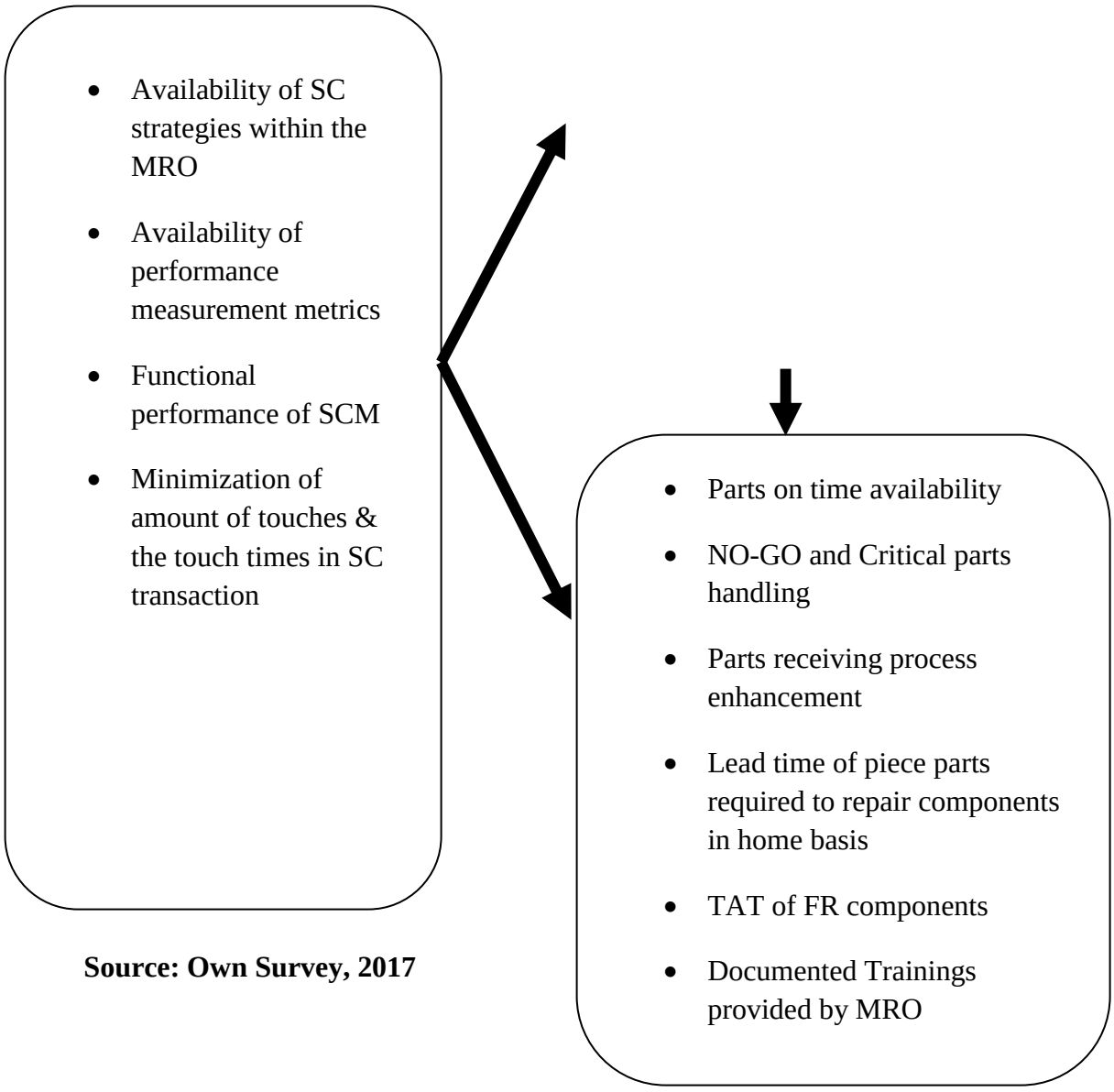
- ✓ Effective communication with FFs, Suppliers & Operators
- ✓ Timely & proprietary information communication within the departments

3. Response Rates to Users & Trainings Provided by the MRO

- ✓ Parts on time availability vs. flight delay & cancellation
- ✓ Readiness level of the departments for critical requirements
- ✓ Level of NO-GO & critical parts holding
- ✓ Response level to critical requirements
- ✓ Parts receiving process enhancement
- ✓ TAT of components repaired at home basis
- ✓ Response rate of different shops & other departments in MRO
- ✓ Strengthening performance of pooling agreements
- ✓ Documented trainings provided by MRO

2.8Conceptual Framework

- Degree of interdepartmental cooperation within MRO
- Lead time and fast order cycle time



Source: Own Survey, 2017

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The study mainly focuses on impact of Supply Chain Management on Ethiopian Airlines Maintenance Repair and Overhaul (MRO) by taking different MRO shops in to consideration. The study used both quantitative and descriptive approach used to investigate the problem under study.

3.2 Study Population and Sampling Technique

Here, the researcher selected65 team leaders and 40 selected senior technicians from component, engine & landing gear shops and base & line maintenance. This consideration also took25 team leaders and managers from SCM (Procurement, Logistics, Warehouse, AOG Desk, Material Planning, and Strategic Sourcing)in to account. Therefore, the total population of this study summed up to 130 figures. The researcher used non-probability (judgmental) sampling technique to select respondents at managerial position in the Airline's MRO and probability (simple random sampling) technique was employed to select the senior technicians.

3.3 Data Collection Instrument and Procedure

Here, the researcher used primary data and those were collected from all component, engine & landing gear shops and base & line maintenance. Primary data were collected by using predesigned questionnaires developed by the researcher thatwere tested using reliability test and filled by the population under study. The secondary data wascollected from the Airlines, Ethiopian Civil Aviation and Federal Aviation Administration(FAA) reports, scientific papers and data'sthat were relevant to study.

3.4 Data Management and Analyzing Procedures

After the researcher completed data collection, data entry and data cleaning for the study, the researcherused IBM statistical package for social science (SPSS) version 22 to get the required analysis results for study. The results were presented using tables, graphs and different kinds of statistical data presentation technique. And based on the analysis results,

the researcher tried to infer statistically accepted inferences by giving special attention for those research questions refused in the study. Forany incompleteness and /or inconsistency that would've appeared, correction was made by returning back to those respondentsfor which incompleteness appeared. The researcher conducted a visual checks, data lists and data cleaning was given due attention as it was the means for identifying the errors.

3.5 Assessing Reliability Test Result

The reliabilities of importance of SCM to the MRO, SCM internal and external customer relationship and response rate to user requirements and documented trainings were assessed with Cronbach's Alpha. Table 3.1demonstrates mean, standard deviation, correlation and reliability values for each of constructs. According to AnolBhattacheerjee, (2012), if Cronbach's Alpha coefficient greater than 0.9 implies excellent, greater than 0.8 is good, greater than 0.7 is acceptable, greater than 0.6 is questionable, greater than 0.5 is poor, and less than 0.5 is unacceptable".

Table 3.1: Item-Total Statistics for reliability

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
The Importance of SCM					
SCM Strategy for the company	50.48	64.386	.558	.411	.854
SCM Response rate to scheduled and non-scheduled maintenance requirements	50.13	65.657	.496	.403	.857
Warehouse performance for immediate reply and delivery the requested parts as per the SLA	50.98	69.479	.284	.342	.865
Warehouse and distribution points close to different repair shops	50.93	67.919	.394	.364	.861
SCM function effectiveness and efficiency	50.34	63.034	.574	.475	.853
SCM Internal and External Customer Relationship					
Degree of interdepartmental cooperation within MRO	50.65	66.599	.516	.417	.856
Lead time and fast order cycle time	50.36	64.249	.491	.459	.857
Handling the relationship and partnership with suppliers and operators	50.73	65.243	.590	.472	.853
Closely working relationship	50.79	65.158	.591	.480	.853
Information Management and On time communication	51.04	62.528	.632	.505	.850
Response rate to user Requirements and Documented Trainings					

Parts on time availability	49.89	66.719	.429	.333	.860
NO-GO and Critical parts handling	50.97	66.335	.487	.403	.857
Parts receiving process enhancement	50.83	65.709	.533	.380	.855
Lead time of piece parts required to repair components in home basis	50.94	66.274	.466	.430	.858
Turnaround time (TAT) of Foreign repair (FR) components	51.05	66.619	.448	.375	.859
Documented Trainings provided by MRO	51.28	63.394	.465	.343	.860

Source: Own Survey, 2017

Based on the researcher's test, the reliability of each construct with Cronbach's alpha on 120 respondents' scores above 0.850 for all designed questionnaires which resulted in a good Cronbach's Alpha coefficient.

3.6 Ethical Consideration

Considering the relevance of ethics in research work, the researcher considered all ethical issues as much as possible. To this effect, the researcher formally requested the official letter from Addis Ababa University School of Commerce to let Ethiopian MRO and selected respondents know that the researcher is a graduating student. After the approved letter was transferred to Ethiopian Airlines MRO, the purpose of the study was properly explained to all participants. The issue of confidentiality was explained in advance to each participant and the questionnaires were supposed to be answered anonymously. The analysis was done collectively based on participants under study population.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

This chapter presents research findings, analysis of the data and interpretation of the data collected from the respondents. It also presents findings and the discussion about Supply

Chain Managementpractices on the performance of Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) service. The data was collected and reports were produced in form of tables and figures and qualitative analysis done in prose.

4.1. Response Rate

A total of 130 questionnaires were administered to Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) service, 120 were filled by the respondents. This gave us a response rate of 92.3%. According to Mugenda, O.M and Mugenda, A.G (2003) the statistically significant response rate for analysis should be at least 50%.

4.2. General Information on Demographic Background

From the total 120 respondents from the two selected departments, 72.5% of them are male and 27.5% of them are females. This implies the gender distribution of selected companies is not balanced. The participation of females within selected departments is not satisfactory or can be conclude as low.

Most of the respondents fall in 26-45 age bracket as 25% of them were found at the age bracket 18-25 years, 48.33% respondents were found at the age of 26-35, 24.17% respondents were are found at the age of 36-45 years, and remaining respondents were found above 45 years. This indicates most of companies' heads were mature with appropriate work experience and therefore they were well versed with relevant information on Impact of SCM on Ethiopian MRO service which was needed forthe study.

Most of the respondents have an education background of BA Degree and above as only 32or 26.70% of them have college Diploma This indicates most of the companies officials are middle level officials, this suggests our respondents give and accurate information needed for the study of Impact of SCM on Ethiopian MRO service performance.

From a total of 120 respondents of the two respondent firms,103 of them are under 15 years business related experience. Hence, this implies most of the respondents are young

professionals and they are more cooperative and easily understand the questionnaire which is required to be filled by them. It's supposed that the respondents gave information that is well up-to-date with the Impact of SCM on Ethiopian MRO serviceand therefore, they gave the correct and accurate information the researcher needed for the study.

Among a total of 120 respondents at the two respondent firms,81.67% of them fall at a work below 5 years. And this implies most of the respondents are working on their current job between 1-5 years and it concludes that most of the respondents are less acquainted with the current practice of their company.

4.3. Supply Chain Management Performance in Maintenance, Repair and Overhaul (MRO) Service

Table 4.1: The importance of Supply Chain Management

Descriptive Statistics			
	N	Mean	Std. Dev.
SCM Strategy for the Company	120	3.61	.964
Response Rate to scheduled and non-scheduled maintenance requirements	120	3.97	.925
Warehouse performance for immediate reply and delivery of parts per the SLA	120	3.11	.807
Warehouse and distribution points close to different repair shops	120	3.17	.823
SCM function effectiveness and efficiency	120	3.75	1.071
Valid N (list wise)	120		

Source: Own Survey, 2017

From table 4.1, the researcher sought to establish the importance of supply chain management to the MRO service, the respondents were instructed to respond to the statements on a 5 point Likert scale and indicate the extent they agree with the statements that is 5-To extremely great extent, 4-To a Great extent, 3-To a Moderate Extent, 2-To a Small Extent, 1-Not at all. A mean (M) score of 0-1.50 means that the respondents confirm not at all, between 1.50-2.50 means to a small extent, 2.5-3.5means to a moderate extent, 3.5-4.5 means to a great extent and above 4.5 means to extremely great extent.

Based on the findings from the above table, the respondents agreed to a great extent for some factors are:SCM Strategy for the Company (M=3.61; SD=0.964), Response Rate to scheduled and non-scheduled maintenance requirements(M=3.97, SD=0.925), and SCM function effectiveness and efficiency (M=3.75, SD=1.071).

However, the respondents also scored to a moderate extent for some factors: Warehouse performance for immediate reply and delivery of parts per the SLA (M=3.11, SD=0.807), Warehouse and distribution points close to different repair shops (M=3.17, SD=0.823).

Table4.2: SCM Internal & External Customer Relationship

Descriptive Statistics			
	N	Mean	Std. Dev.
Degree of interdepartmental cooperation within MRO	120	3.44	.797
Lead time and fast order cycle time	120	3.73	1.083
Handling the relationship and partnership with suppliers and operators	120	3.37	.840
Closely working relationship	120	3.30	.846
Information Management and On time communication	120	3.05	1.036
Valid N (listwise)	120		

Source: Own Survey, 2017

Based on the findings of table of 4.2, the researcher also sought to measure SCM internal & external customer relationship and found the respondents agreed to a great extent on SCM internal & external customer relationship foronly Lead time and fast order cycle time (M=3.73, SD=1.083).

Whereas, the respondents agreed to a moderate extent for the remaining metrics:Degree of interdepartmental cooperation within MRO (M=3.44, SD=0.797), Handling the relationship and partnership with suppliers and operators (M=3.37, SD=0.840), closely working relationship (M=3.30, SD=0.846), and information management and on time communication (M=3.05, SD=1.036).

Table 4.3: Response Rate to User Requirements & Training

Descriptive Statistics			
	N	Mean	Std. Dev.
Parts on time availability	120	4.20	.913

NO-GO and Critical parts handling	120	3.13	.865
Parts receiving process enhancement	120	3.27	.867
Lead time of piece parts required to repair components in home basis	120	3.15	.904
Turnaround time (TAT) of Foreign repair (FR) components	120	3.04	.893
Documented Trainings provided by MRO	120	2.82	1.223
Valid N (listwise)	120		

Source: Own Survey, 2017

Based on the findings of table of 4.9, the researcher also sought to measure the degree of SC response rate to user requirements and training provided by MRO and found the respondents agreed to a great extent only for Parts on time availability(M=4.20, SD=0.913

The remaining metrics were marked to a moderate extent by respondents: that are:NO-GO and critical parts handling (M=3.13, SD=0.865), parts receiving process enhancement (M=3.27 SD=0.867), lead time of piece parts required to repair components in home basis (M=3.15,SD=0.904), turnaround time (TAT) of foreign repair (FR) components (M=3.04, SD=0.893),documented trainings provided by MRO (M=2.82, SD=1.223).

4.4. Correlation Analysis

Relationship between the dependent variable (Importance of Supply Chain Management to the MRO) and independent variables (SCM Internal & External Customer Relationship and The Response rate to user requirements & Training) examined by using correlation analysis. In this study, the researcherused Pearson's correlation coefficient to check the relationship between variables. The Pearson correlation coefficient ranges between -1 and, and the furthermore 1, the stronger the linear association between the numbers. A positive correlation implies that a high value in one variable is associated with a high value in the other variable. The correlation result between the constructs listed below in a correlation matrix.

Table 4.4: Correlation Table 1 Correlations Matrix

		Var2_1	Var2_2	Var2_3	Var2_4	Var2_5
Var1_1	Pearson Correlation	.325**	.350**	.376**	.444**	.441**
	Sig. (2-tailed)	.000	.000	.000	.000	.000

	N	120	120	120	120	120
Var1_2	Pearson Correlation	.282**	.352**	.221*	.303**	.317**
	Sig. (2-tailed)	.002	.000	.003	.001	.000
	N	120	120	120	120	120
Var1_3	Pearson Correlation	.173	-.034	.139	.137	.114
	Sig. (2-tailed)	.059	.713	.129	.137	.215
	N	120	120	120	120	120
Var1_4	Pearson Correlation	.297**	.182*	.385**	.217*	.315**
	Sig. (2-tailed)	.001	.004	.000	.001	.000
	N	120	120	120	120	120
Var1_5	Pearson Correlation	.278**	.457**	430**	.436**	.504**
	Sig. (2-tailed)	.002	.000	.000	.000	.000
	N	120	120	120	120	120

***. Correlation is significant at the 0.05 level (2-tailed).**

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: The researcher's own survey result, 2017

The correlation table displays the relation between various constructs of the study. The first construct stated below briefly looks at how the importance of SCM to the MRO correlates with the SCM internal and external customer relationship. As figured out on the above table, all the factors are strongly and positively correlated for the metrics: SCM Strategy (Var1_1), SCM Response rate to scheduled and non-scheduled maintenance requirements(Var1_2), warehouse or distribution points close to different shops (Var1_4) and SCM function effectiveness and efficiency (Var1_5)i.e. Degree of interdepartmental cooperation within MRO, lead time and fast order cycle time, handling the relationship and partnership with suppliers and operators, closely working relationship and information management& on time communication with correlation significant at $p<0.01$ and $p<0.05$.

On other hand, warehouse performance for immediate reply and delivery the requested parts as per the SLA (Var1_3) is also positively correlated with degree of interdepartmental cooperation within MRO (Var2_1), handling the relationship and partnership with suppliers and operators (Var2_3), closely working relationship (Var2_4) and information management& on time communication (Var2_5) with correlation of $r=0.173$, $r=0.139$, $r=0.137$ and $r=0.114$ respectively.

Whereas, lead time and fast order cycle time (Var2_2) is negatively correlatedto warehouse performance for immediate reply and deliver the requested parts as per the SLA(Var1_3) with correlation of r=-0.034.

Hence, the results of the findings of questionnaires indicated that the importance of SCM to the MRO is highly and positively correlated with SCM internal and external customer relationship for most of the constructs. Contrarily, warehouse performance for immediate reply and deliver the requested parts as per the SLA is negatively correlated lead time and fast order cycle time. This implies that the warehouse is operating below the industry level and the airline should give due attention in this regard. This has been costing the airline to delay and cancel flights over twice a day for a long time.

Table 4.5: Correlation Table 2 Correlations Matrix

		V3_1	V3_2	V3_3	V3_4	V3_5	V3_6
Var1_1	Pearson Correlation	.271**	.160	.347**	.299**	.205*	.331**
	Sig. (2-tailed)	.003	.001	.000	.001	.002	.000
	N	120	120	120	120	120	120
Var1_2	Pearson Correlation	.386**	.215*	.294**	.327**	.236**	.284**
	Sig. (2-tailed)	.000	.001	.001	.000	.001	.002

	N	120	120	120	120	120	120
Var1_3	Pearson Correlation	.198*	.269**	.054	.369**	.402**	.088
	Sig. (2-tailed)	.003	.003	.555	.000	.000	.337
	N	120	120	120	120	120	120
Var1_4	Pearson Correlation	.123	.254**	.161	.305**	.345**	.189*
	Sig. (2-tailed)	.001	.005	.079	.001	.000	.003
	N	120	120	120	120	120	120
Var1_5	Pearson Correlation	.327**	.306**	.443**	.291**	.116	.305**
	Sig. (2-tailed)	.000	.001	.000	.001	.002	.001
	N	120	120	120	120	120	120

***. Correlation is significant at the 0.05 level (2-tailed).**

****. Correlation is significant at the 0.01 level (2-tailed).**

Source: Researcher's own Survey result, 2017

Like the previous correlation table, the above correlation table displays the relation between various constructs of the study. The first construct to look at is how the importance of Supply Chain Management to the MRO correlates with the Response rate to user Requirements and Trainings. As figured out on the above table, all the factors are strongly and positively correlated for the metrics: SCM Strategy (Var1_1), SCM Response rate to scheduled and non-scheduled maintenance requirements (Var1_2) and SCM function effectiveness and efficiency (Var1_5) i.e. Degree of interdepartmental cooperation within MRO, lead time and fast order cycle time, handling the relationship and partnership with suppliers and operators, closely working relationship and information management& on time communication with correlation significant at $p<0.01$ and $p<0.05$.

Whereas, four factors are highly and positively correlated with warehouse performance for immediate reply and delivery the requested parts as per the SLA (Var1_3), i.e. degree of interdepartmental cooperation within MRO (Var2_1), lead time and fast order cycle time (Var2_2), closely working relationship (Var2_4) and information management& on time communication (Var2_5) with correlation of r=0.198, r=0.269, r=0.369 and r=0.402 respectively, significant $p<0.01$and 0.05.

On the other hand, five factors are positivelycorrelated with warehouse or distribution points close to different shops (Var1_4) i.e. degree of interdepartmental cooperation within MRO (Var2_1), lead time and fast order cycle time (Var2_2), working relationship (Var2_4), information management& on time communication (Var2_5) and documented trainings provided by the MRO (Var2_6)with correlation of r=0.123, r=0.254, r=0.305, r=0.345 and r=0.189 respectively, significant at p<0.01 and 0.05.

The results of the findings of questionnaires indicated that SC play a major role in sending the components to foreign repair, communicating the repair agents for immediate maintenance and following-up the components are received in good condition. The findings also indicate that SCM plays a major role in partnering with different operators and pools support providers to save costs that result in holding minimum inventory of high value components. Those agreements are mainly advantageous for on time parts availability (for grounded aircrafts), diversified geographical locations, and reduced inventory holding for high value items that results in low inventory carrying cost.

4.5. Regression Analysis

The researcher carried out a regression analysis to establish the association between the independent variables with the dependent variable on data collected from the two respondent departments in Ethiopian Airlines MRO services (Maintenance & MRO SCM).

Table 4.6: Regression coefficients for the Importance of SCM to MROforboth Predictor Variables

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.897	.204		4.400	.000

Degree of cooperation	.092	.050	.126	1.855	.066
Lead time and fast order cycle time	-.005	.037	-.010	-.142	.004
Handling the relationship and partnership with suppliers and operators	.043	.048	.062	.895	.001
Closely working relationship	.030	.049	.044	.619	.002
Information Management and On time communication	.273	.041	.483	6.663	.000
Parts on time availability	.081	.040	.126	2.031	.003
NO-GO and Critical parts handling	-.045	.045	-.067	-.999	.001
Parts receiving process enhancement	.012	.045	.018	.274	.003
Lead time of piece parts required to repair components in home basis	.154	.043	.238	3.610	.000
Turnaround time (TAT) of Foreign repair (FR) components	.082	.041	.125	1.995	.004
Documented Trainings provided by MRO	.048	.031	.100	1.563	.121

a. Dependent Variable: The Importance of SCM to MRO

Source: Own Survey, 2017

According to the above table,there is a significant association between themost of the metrics of the independent variables with the dependent variable Importance of SCM to MRO since the p-value is less than 0.05. Whereas, degree of cooperation and Documented Trainings provided by MRO show as insignificant relationship with Importance of SCM to MRO. And the resulting regression equation is as follows;

$$\mathbf{Y=0.897+0.092X_1-0.005X_2+0.043X_3+0.030X_4\ldots\ldots\ldots\ldots\ldots+e}$$

Where, Y= *Importance of SCM to the MRO,*

Xn=*Factors in Independent Variables and*

e=*The residual amount.*

The regression equation above shows as by taking all factors into account constant at zero, the importance of SCM to the MRO will have a value of 0.897. And the findings presented also show that taking all other independent variables at zero, a unit increase in degree of interdepartmental cooperation within MRO would lead to a 0.092increase in the importance

of SCM to the MRO;a unit increase in handling the relationship and partnership with suppliers and operators would lead to a 0.043increase in the importance of SCM to the MRO; a unit increase in Closely working relationship would lead to a 0.030increase in the importance of SCM to the MRO.

Whereas, taking all other independent variables at zero, a unit increase in information management and on time communication would lead to a 0.273increase in the importance of SCM to the MRO; a unit increase in parts on time availability would lead to a 0.081increase in the importance of SCM to the MRO;a unit increase in Parts receiving process enhancementwould lead to a 0.012increase in the importance of SCM to the MRO;a unit increase in Lead time of piece parts required to repair components in home basis would lead to a 0.154increase in the importance of SCM to the MRO.

In another case, taking all other independent variables at zero, a unit increase in Lead time and fast order cycle time would lead to a 0.005decrease in the importance of SCM to the MRO; and a unit increase in NO-GO and Critical parts handling would lead to a 0.045decrease in the importance of SCM to the MRO

Table 4.7: Model Summary for Dependent Variable: The Importance of SCM to MROfor both Predictor Variables

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.834[a]	.695	.664	.33918

a.

b. Predictors: (Constant), Documented Trainings provided by MRO, Lead time of piece parts required to repair components in home basis, Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability,

Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication

c. Dependent Variable: The Importance of SCM to MRO

Source: Own Survey, 2017

R-Square which is the coefficient of determination is a commonly used statistic to evaluate model fitness. The adjusted R^2, is also called the coefficient of multiple determination, is the percentage of the variation in the dependent variable explained uniquely or jointly by the independent variables. From results captured from the above table, 69.5% of the variations inthe Importance of SCM to the MRO can be attributed to the combined effect of the predictor variables. This means that 30.5% of the changes can beattributed to other factors.

Table 4.8: ANOVA Result for the Importance of SCM to MROfor both Predictor Variables

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.327	11	2.575	22.385	.000[b]
	Residual	12.425	108	.115		
	Total	40.752	119			

a. Dependent Variable: The Importance of SCM to MRO

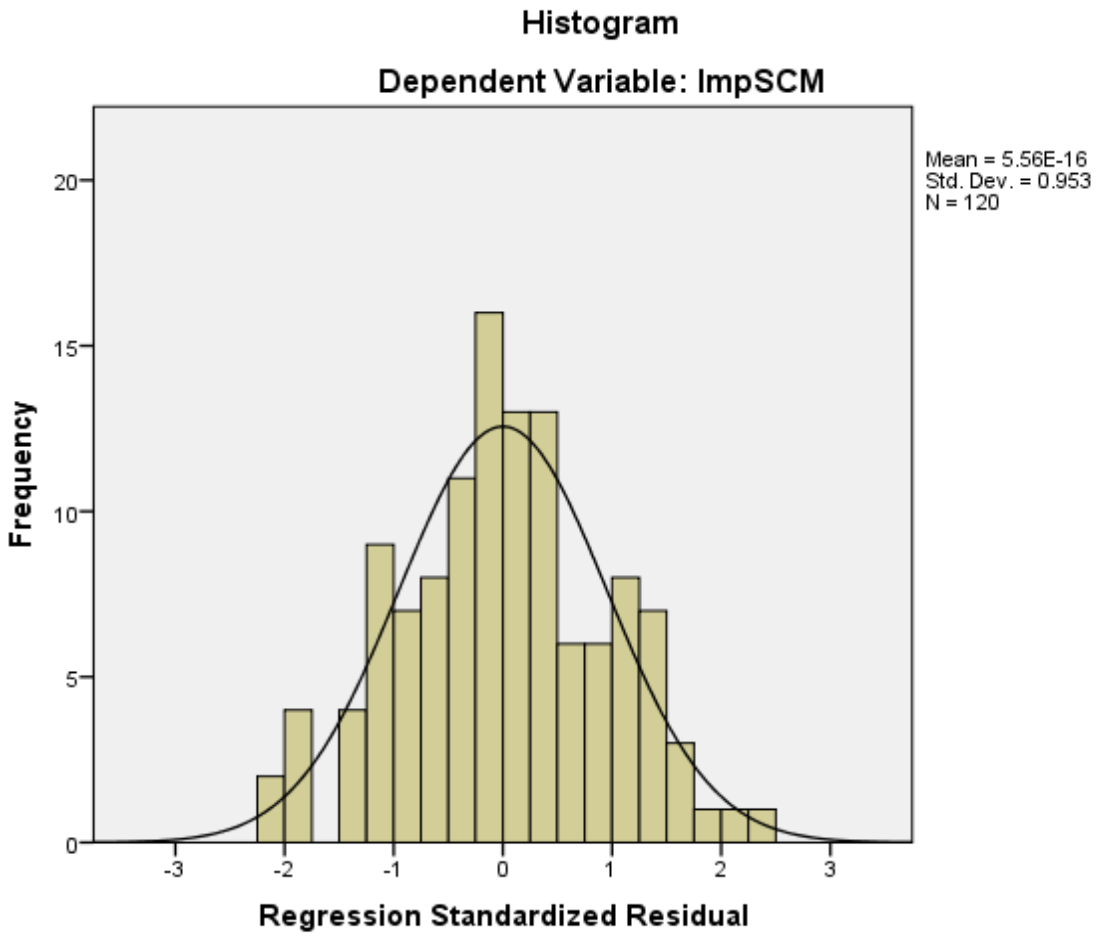
b. Predictors: (Constant), Documented Trainings provided by MRO, Lead time of piece parts required to repair components in home basis, Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability, Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication

Source: Own Survey, 2017

The above table shows the P-value of 0.000which indicates that the regression relationship is significant in predicting how the factors independent variables (Documented Trainings

provided by MRO, Lead time of piece parts required to repair components in home basis, Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability, Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication) influence the importance of SCM to the MRO. The F value calculated is 22.385which is greater than the F critical at 5% level of significance and thus, showing that the model is significant.

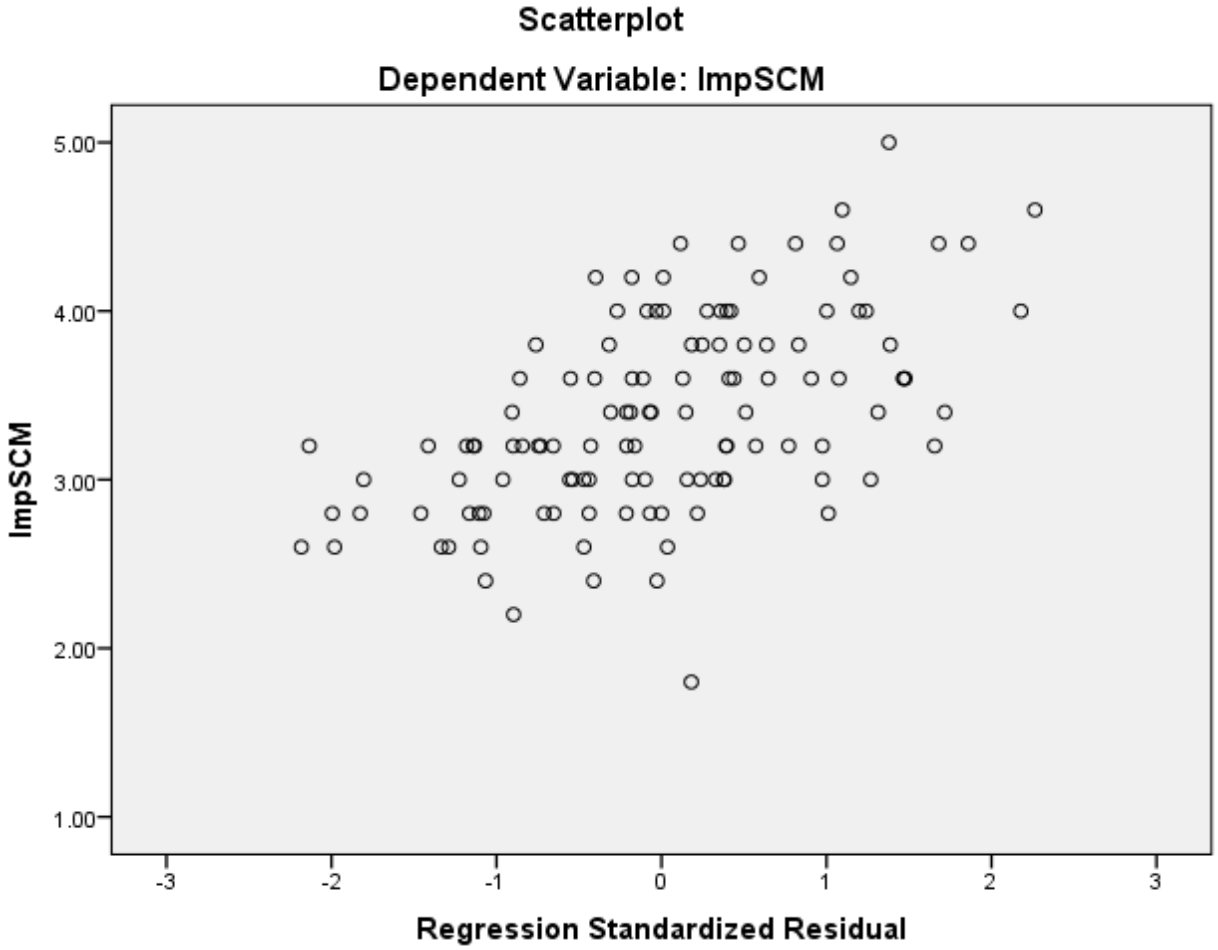
Chart1: Histogram result for the Importance of SCM to MRO for Predictor Variable SC Internal and External Customer Relationship



Source: Own Survey, 2017

As shown on the result of the above graph, the correlation between the dependent variable (the importance of SCM to the MRO) and the factors in independent variables (Documented Trainings provided by MRO, Lead time of piece parts required to repair components in home basis, Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability, Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication) is positive and in a good fit.

Figure1: Scatterplotresult for the Importance of SCM to MRO for Predictor Variable SC Internal and External Customer Relationship



Source: Own Survey, 2017

According to the above scatterplot result, the data shows an uphill pattern as we move from left to right that reflects positive relationship between the dependent variable (the importance of SCM to the MRO) and the factors in independent variables (Documented Trainings provided by MRO, Lead time of piece parts required to repair components in home basis, Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability, Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication).

CHAPTER FIVE: CONCLUSIONS AND

RECOMMENDATIONS

This study wanted to explore the impact of SCM performance in Ethiopian Airlines MRO service. The researcher gave answer for the research questions, howquickly supply chain responds to scheduled and non-scheduled aircraft maintenance activities, what important role SC in a turnaround time of foreign repair (FR) components and lead time of piece parts that directly affect the operation, etc. Therefore, this last chapter of the research discusses the key findings and their relation to the research questions. Conclusions and recommendations drawn on how to make Ethiopian Airlines Maintenance, Repair and Overhaul (MRO) service more competitive in the aviation industry are also presented in this chapter. Finally, directions for future research are indicated.

5.1. Conclusion

According to different researchers and the research findings, Ethiopian MRO is one of the strongest MRO's in Africa and world. This is as a result of strong management of MRO to act on any customer maintenance requirements. The results of the findings indicated that SCM as part of MRO plays a major role in partnering with different operators and pools support providers to save costs that result in holding minimum inventory of high value components. Despite the MRO's strong trend of customer handling, there is a weak interdepartmental communication between sections in the MRO and supplier handing is supposed to be below the industry level as currently there are different occasions Ethiopian MRO has entered in to conflict with suppliers, pooling partners and operators due to payment holdings. According to the regression analysis, we have significant association between the independent variables and the dependent variable-the importance of SCM to MRO and also from the findings in the correlation coefficient table; the ANOVA and the R-square summary tables, we can conclude that SCM performance influence the whole MRO performance.

Hence, based on the data from this study, most of the factors (Documented Trainings provided by MRO, Lead time of piece parts required to repair components in home basis,

Degree of interdepartmental cooperation within MRO, Lead time and fast order cycle time, Parts on time availability, Turnaround time (TAT) of Foreign repair (FR) components, Parts receiving process enhancement, NO-GO and Critical parts handling, Closely working relationship, handling the relationship and partnership with suppliers and operators, Information Management and On time communication) have a strong correlation with increased SCM performance to the MRO success.

Finally, the new knowledge added to previous studies were that the maintenance shops are given due attention in a very detailed concepts. The relationship of each classification of MRO with SCM is briefed in well-organized manner. The strength of the study is that it participated only the experienced population of MRO population that resulted in very good reliability test for which it can be a main guide and reference of future studies in the area. All the supporting previous researches were referenced in the study.

5.2. Recommendations

Despite the limitations, the researcher believes that the study contributes to the knowledge of SCM impact in Ethiopian Airlines MRO & others MRO's services as well. So, the main recommendations derived from this empirical study could be:

- To organize continuous trainings, experience sharing and workshop visitsto the employees of MRO to cope up with the ever-changing aviation trend.
- Improved communication, relationship and partnership with suppliers and operators.
- On time performance of maintenance to process paperwork for unserviceable (replaced) units and FR components.
- Patience from top management to develop policies and SOP (standard operating procedures) and reduce stick approach view (punishing, suspending, firing employees for silly mistakes).
- Proper troubleshooting of problems to minimize costs and maximize customer satisfaction.
- Entering in to partnering agreements with different operators and pools support providers to save costs that result in holding minimum inventory of high value

components. Cost cutting is becoming everybody's business now a day to stay in competition.

- The MRO should consider developing capability for most of the components to save costs related to foreign repair, inbound and outbound logistics, and man-hour.
- Above all, every employee should consider safety in mind before deciding and processing any activity related to the MRO.

5.3. Suggestion for Further Study

This study and other present studies used only the MRO service of airlines as general; future studies should consider expanding their scope to study each shop, line and hangar maintenance supply chain performance in detail. Further studies related to Supply Chain Management, Logistics Management in Airline MRO can be conducted.

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Addis Ababa University

School of Commerce

Department of Logistics and Supply Chain Management

Survey Questions to be filled by selected respondents

Dear respondent,

This questionnaire is designed to explore the impact of Supply Chain Management in Ethiopian airlines MRO service performance. This study is conducted in partial fulfillment of the requirements for the Master's degree in Logistics and Supply Chain Management at Addis Ababa University.

Your response is vital to the outcome of the study and you are requested to completely and objectively answer all questions. The research is going to be carried out based on your responses and other relevant data that could support it. It forms a major part of the research and the information you will enable the researcher to critically analyze the impact of supply chain management in Ethiopian airlines MRO service performance.

Your cooperation to respond genuinely is very important to this study because it represents a number of other MRO's in the aviation industry. Please answer all questions. Space is provided at the end of the questionnaire for you to add further explanations or comments. I would promise that all information you provide would be strictly confidential.

Most of the questions can be answered by simply making **a circle** on only one best answer for each question.Thank you in advance for your indispensable cooperation to spare invaluable time and energy to complete these questionnaires.

- Demographic related information (please use **X**mark on the choice you make)
  1. Gender : Male ☐ Female ☐
  2. Age :18-25 ☐ 26-35 ☐ 36-45 ☐ Above 45 years ☐
  3. Department _____
  4. Work Related Experience in the Airline's MRO

     1-5 years ☐ 6-10 years ☐ 11-15years ☐ 16-20 years ☐

Above 20 years ☐

5. Highest formal education attended
   - High school ☐
   - Technical school: 1 year ☐ rs ☐ s ☐
   - College: 1 year ☐ 2 years ☐ 3 years ☐
     Diploma ☐ Bachelor's Degree ☐
   - Advance Degree Study ☐
   - Please specify your specialization……
6. Years of service on the current position
   - Less than one year ☐ 1-5years ☐ 6-10 years ☐
     More than 10 years ☐

❖ Impact of Supply Chain Management.

❖ Most of the questions can be answered by simply making a circle on **only onebest answer** for each question.

✓ Please answer **all** questions. There is no right or wrong answer.

✓ The number represents the following: 1 = Not at all, 2 = To a small extent, 3 = To a moderate extent, 4 = To a great extent, 5 = To extremely great extent

No.	**Section 1: The Importance of Supply Chain Management**					
1	Does the MRO have a supply chain strategy for the Company and does it create value for the MRO & its customers?	1	2	3	4	5
2	To what extent do you see supply chain strategy contributing to the overall achievement of corporate and marketing goal of the MRO?	1	2	3	4	5
3	Does the company have any metric that is used to measure/assess supply chain performance?	1	2	3	4	5
4	Does SCM play important role in responding to scheduled (A-checks, C-checks, EO compliance, etc) and non-scheduled maintenance requirements?	1	2	3	4	5
5	How important is supply chain management concepts with clients and suppliers to the achievement of MRO goals and objectives?	1	2	3	4	5
6	How do you measure overall aircraft parts procurement system of Ethiopian MRO relative to its competitors in the industry?	1	2	3	4	5
7	How do you measure the warehouse performance to reply to parts availability/unavailability and to deliver the requested parts as per the SLA signed between the user and stores?	1	2	3	4	5
8	Does the supply chain minimize the amount of touches and the	1	2	3	4	5

	touch time in supply chain transactions, so as to reduce the number of potential failure points to deliver the requested parts?					
9	How does the warehouse respond to stock critical parts at appropriate distribution points close to different shops?	1	2	3	4	5
10	To what extent do you consider that the warehouse, purchasing, logistics & inventory functions affect the efficiency of supply chain organization?	1	2	3	4	5
	Comments: --- --- ---					

No.	**Section2: SCM Customer relationship (internal & external)**					
1	What is the Degree of cooperation between SCM with other departments in MRO like IT, planning, systems engineering, repair shops, etc?	1	2	3	4	5
2	How do you value effort of strategic sourcing in creating partnership with different suppliers & operators to save huge costs of the MRO?	1	2	3	4	5
3	How important are lead time, fast order cycle time, top management support & on time payments when developing a successful supply chain relationship with a supplier or operator?	1	2	3	4	5
4	How does purchasing handle the relationship and partnership with different MRO approved suppliers and nearby operators?	1	2	3	4	5
5	How does receiving work closely with quality assurance (receiving inspection), documentation, binning and warehousing sections?	1	2	3	4	5
6	How effective is logistics management by identifying and communicating the best freight forwarders for incoming routing, urgent, critical and AOG shipments?	1	2	3	4	5
7	To what extent the critical, timely and proprietary information is communicated between supply chain and other departments within the MRO?	1	2	3	4	5
	Comments: --- --- ---					

No.	**Section3: Response rate to user requirements & training**					
1	How do parts on time availability play major role in reducing flight cancellation/delay & returning the aircrafts back in to service?	1	2	3	4	5
2	How ready is the line purchase team to take immediate actions on time of top critical requirement to dispatch the aircrafts?	1	2	3	4	5
3	To what extent the warehouse holds stock items & NO-GO parts in a sufficient quantity?	1	2	3	4	5
4	How quickly does dispatch stores team respond to critical line requirements especially when passenger is on board?	1	2	3	4	5
5	Does receiving inspection team ensure that adequate checks, tests, and inspection are performed based on MRO requirements?	1	2	3	4	5
6	To what extent receiving & inspecting respond to the critical part requirement (for parts at receiving process)?	1	2	3	4	5
7	How fast is the lead time of piece parts required to repair components in home basis?	1	2	3	4	5
8	How fast does the AOG Desk respond to the aircrafts grounded in outstations and home bases by providing the requested support?	1	2	3	4	5
9	To what extent does outbound logistics team respond to requests from different shops and purchasing in preparing appropriate shipping containers and sending the shipments to the requested repair/overhaul/test stations?	1	2	3	4	5
10	How quick do repair shops process foreign repair (FR) parts to reduce the turnaround time (TAT)?	1	2	3	4	5
11	How important role does strategic sourcing play in MRO strength by providing pooling agreements in different stations that the airline operates?	1	2	3	4	5
12	How dedicated is the MRO to provide the documented Training Program to address the required "competencies" of personnel involved in planning, performing, supervising, inspecting, SCM or certifying?	1	2	3	4	5
	Comments: ---------- ---------- ---------- ----------					

- ✓ What are the main outcomes on MRO service performance that results from enhanced Supply Chain Management Practices?
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- ✓ In your opinion, what should be done by the following parties to enhance performance of SCM to enhance improved MRO service?

  RepairShops:_____
  ___
  _____
  _____
  _____
  _____

  Line and Hangar maintenance:
  _____
  _____
  _____
  _____

Customers_____

_____
_____

_____

Top Management of the airline:
_____

_____

_____

_____