ADDIS ABABA UNIVERSITY
SCHOOL OF COMMERCE
LOGISTICS AND SUPPLY CHAIN MANAGEMENT UNIT

THE ROLE OF MAINTENANCE, REPAIR AND OVERHAUL SUPPLY CHAIN INTEGRATIONAND INVENTORY MANAGEMNET IN FLIGHT DISPATCH RELIABLITY; THE CASE OF ETHIOPIAN AIRLINES

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A thesis submitted to Addis Ababa University, School of Commerce for the partial fulfillment of the degree of Masters of Art in Logistics and Supply Chain Management

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Declaration

I, Andinet Girma, declare that this paper is a result of my independent research work on the topic entitled "**The role of Maintenance, Repair and Overhaul Supply Chain Integration and Inventory Management in flight dispatch reliability"** in partial fulfillment of the requirements for the Degree of Master of Arts in Logistics and Supply Chain Management at Addis Ababa University. This work has not been submitted for a degree to any other university. All the references are also duly acknowledged.

Andinet Girma

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Date **_____**

Confirmation

This is to certify that Andinet Girma has carried out this research work on the topic entitled *"***The role of Maintenance, Repair and Overhaul Supply Chain Integration and Inventory Management in flight dispatch reliability**" under my supervision. This work is original in nature and has not been presented for a degree at any University and it can be submitted for the partial fulfillment of the requirements for the award of the degree of Master of Arts in Logistics and Supply Chain Management.

Tariku Jebena,PHD

Signature_____

Date _____

Abstract

One of the major challenges for airline operators is ensuring on time performance of flights. Flight dispatch reliability is affected by chains of activities. One of the factors affecting flight dispatch reliability is aircraft technical problem related with maintenance. For many operators, the division responsible for aircraft maintenance is authorized and certified repair and maintenance center called Maintenance, Repair and Overhaul Organization. Maintenance, Repair and Overhaul Supply Chain Integration and Inventory Management plays vital role to ensure on time performance of flights. Thus, the purpose of this study is to look at the role of Maintenance, Repair and Overhaul supply chain integration and inventory management in flight dispatch reliability. To examine the role of Maintenance, Repair and Overhaul supply chain integration and inventory management in flight dispatch reliability; a survey method was employed. 106 staffs were selected as the participants of the study. Closed ended and open ended questionnaire and interview were used as data gathering instruments. Descriptive statistics such as mean, standard deviation and frequency, correlation, and multiple linear regression analysis were employed in the study. The result showed that Maintenance, Repair and OverhaulSupply Chain integration and Inventory management played vital role to improve flight dispatch reliability and flight dispatch reliability is dependent on Ethiopian Maintenance, Repair and Overhaul supply chain functions integration; Inventory Management& and Supplier Relationship Management. The research result revealed that poor inventory management, poor material planning, system and physical inventory discrepancy are the major drivers of flight delay. The study also revealed that internal integration among Maintenance Repair and Overhaul Supply Chain functions and supplier relationship management plays vital role to improve dispatch reliability.

Keywords: *supply chain management, maintenance, repair and overhaul supply chain, internal integration, external integration, inventory management*

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Contents

Chapter One 1

Introduction 1

1.1. Background of the study 1

1.2. Statement of the problem 3

1.3. Research Questions 5

1.4. Research Objective 5

1.5. Significance of the Study 6

1.6. Scope of the Study 6

1.7. Limitation of the Study 6

1.8. Operational Definition of Key Terms and Concepts 7

1.9. Organization of the Study 8

Chapter Two 9

2. Related Literature Review 9

2.1. Service Supply Chain 9

2.2. The concepts and nature of MRO Supply Chain Management 9

2.3. Airlines MRO Supply Chain Integration 11

2.4. Airline /MRO Inventory Management 13

2.5. Measuring flight Dispatch Reliability 16

2.6. Concepts of flight dispatch reliability 16

2.7. Empirical Review of the role of MRO Supply Chain Integration on flight Dispatch Reliability 18

2.8. Conceptual Framework of the Study 19

Chapter Three 20

Methodology of the Study 20

3.1. Research Approach 20

3.2. Research Design 20

3.3. Population and Sampling Techniques 20

3.4. Sources of data 21

3.5. Data Collection Procedures 21

3.6. Method of Data Analysis 22

3.7. Testing Reliability of the Data 22

3.8 Ethical Consideration 23

CHAPTER FOUR 24
RESULT, DISCUSSIONS AND INTERPRETATION 24
4.1. Demographic Information of the respondent 24
4.2. Level of Integration among Ethiopian MRO supply chain Functions 26
4.3. Supplier Relationship Management 28
4.4. Causes for Inventory being out of Stock 30
4.5. Correlation Analysis on the relationship of dispatch reliability and supply chain integration 32
4.6. Multiple Linear Regression Analysis 33
Chapter Five 35
Summary, Conclusion and Recommendation 35
5.1. Summary of the Research Results 35
5.2. Conclusion 37
5.3. Recommendation 38
5.4. Suggestions for further Studies 38
References 39
Appendix A – Questionnaire 42
Appendix B - Interview Questions for key informants 47

Acronyms and Abbreviation

ATA- Air Transport Association

AOG- Aircraft on Ground

DR – Dispatch Reliability

EASA-European Aviation Safety Agency

ECAA- Ethiopian Civil Aviation Authority

FAA- Federal Aviation Administration

IATA-International Air Transport Association

MRO- Maintenance, Repair and Overhaul

MRR – Monthly Reliability Report

OEM-Original Equipment List

OTP-On Time Performance

RCB- Reliability Control Board

RSPL-Recommended Spare Parts Lists

Chapter One

Introduction

The main focus under the introduction session is background of the study, statement of the problem, research questions, research objectives, significance of the study, scope of the study, limitation of the study, definition of key terms, and organization of the study.

1.1. Background of the study

A supply chain is a complex network of entities that perform several interrelated and depending tasks to produce and deliver products or services to the market. This involves, but not limited to, activities of; sourcing, purchasing, storage, production, transportation, delivery, maintenance and repair (Tsadikovich*et al*., 2016).

Supply Chain management has been defined by different researchers and scholars. Councils of Supply Chain Professionals defined supply chain management as the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics activities.

According to Zailani&Rajagopal(2005), the simultaneous integration of customer requirements, internal process and upstream supplier performance is commonly referred to as supply chain management. The institute for supply chain management describes supply chain management as the design and management of seamless, value added processes across organizational boundaries to meet the real needs of the end customer.

According to IATA report (2016), the world's airlines currently serve 3.5 billion passengers a year. This figure is expected to nearly triple by the year 2030. The airlines are therefore expanding their fleets. The industry has to ensure excellent interplay within both the system itself and its processes. This is the foundation for a reliable supply of premium products and services to customers. In airline business there is an urge to measure the effectiveness of the maintenance process in order to find the best

trade-off between safety and costs. According to Niehues(2001), delay costs can be from 0.6% to up as much as 2.9% of airlines revenues and one way to increase the operating profit is to pay more attention to On-Time Performance (OTP).

From a very humble beginning to a Leading African Aviation Group, Ethiopian Airlines has come along 70 plus years of successful journey. Of course, Ethiopian is aging beautifully. Throughout the past seven decades, the airline has established itself as adept in all facets of the aviation industry: technology leadership, network expansion and aviation mentoring. (Ethiopian Fact Data Sheet, January,2018).

Ethiopian started operation with the first 5 C-47 aircraft, scraps of 2nd World War, back in 1946 during its debut flight to Cairo via Asmara. Ever since, Ethiopian has been growing in leaps and bounds and has kept on introducing new aviation technology and systems, with so many firsts in the history of African aviation as an aircraft technology leader; providing the first jet service in the continent, availing the first African B767, the first African B777- 200LR in 2010 and the first African and second only to Japan B787 Dream liner in 2012. In a continuation of that tradition, Ethiopian was the first in Africa to acquire Airbus A350 XWB, introducing the extra effect to the African continent. Leading the way once again, Ethiopian was the first African Airline to operate the latest Boeing 787-9 in 2017. Below the industry average, Ethiopian currently operates 97 of the young and most modern fleet, with less than five years of age, and has 59fleet on order. (Ethiopian Fact sheet, January, 2018).

Ethiopian is currently implementing a 15-year strategic plan called Vision 2025 that will see it become the leading airline group in Africa with seven strategic business units. Ethiopian joined Star Alliance, the world's largest Airline network, in December 2011. Ethiopian is a multi-award winning airline including: SKYTRAX Best Airline Staff Service in 2013 & 2016, 'Best African Airline' in 2017, and Four Star Airline Certification in 2017. Ethiopian has been registering an average growth of 25% per annum for the past seven years (Ethiopian Fact Sheet, January, 2018).

Ethiopian Airlines Maintenance, Repair Overhaul Services (ET MRO services) is one of the seven business units of Ethiopian airlines and the MRO is the largest MRO

service in Africa and serves Africa and the Middle East. The facility is fully equipped with Hangars, Engine and Component Maintenance workshops with all equipment needed to repair/ overhaul aircraft, engines and components. The MRO service was established in 1957 and it currently employs over 2,800 employees. Ethiopian MRO provides Line Maintenance services at stations where Ethiopian flies and extends the services to other operators at some of the stations. The facility is fully certified by the ETCAA, FAA and EASA. Ethiopian MRO offers world-class services to its customers and helps make Ethiopian one of the most dependable and safest airlines in the world (Ethiopian Fact Sheet, January,2018).

According to IATA reports in 2013, Airlines operator are facing difficulty in keeping the aircraft in the air due to different reasons across the supply chain. To ensure dispatch reliability of flights, airline operators need to assess the main factors affecting flight dispatch reliability. On time performance of flight is highly dependent on chain of activities. To be competitive in the airline industry and attract passengers, Ethiopian airlines needs to ensure on time performance of flights. Ethiopian Airlines Maintenance, Repair and Overhaul Services is one of Ethiopian Airlines business units highly related with flight dispatch reliability and the research is aimed at studying the role of Ethiopian Maintenance, Repair and Overhaul supply chain integration and inventory management on flight dispatch reliability.

1.2. Statement of the problem

In the airline industry, it is very common to hear flight delay and flight cancellation and as a result the airline operators are exposed to additional cost ranging from availing parts on AOG basis to compensating passengers for the consequences. According to Niehues (2001), punctuality has become the daily concern inside the airline industry. It can be seen as a key performance indicator and a valuable differentiator in customer services. In fact, researches show that an improvement on On-Time Performance (OTP) is positively correlated with operating profit as it helps to accomplish considerable cost savings. Every airline operator wants to improve dispatch reliability of flights so as to attract customer and increase customer satisfaction.

In airline industries, an operator has to deal with two types of issues: the aircraft operating cost and customer satisfaction. Aircraft maintenance planning plays a major role in both of them. On the one hand, based on an analysis in 2012 conducted by the International Air Transport Association (IATA)'s Maintenance Cost Task Force, the maintenance cost takes up about 13% of the total operating cost, and it can be reduced by a good planning. On the other hand, an excellent maintenance program can effectively avoid flight delays and cancellations, thus improve customer satisfaction and competitiveness in the industry. Spare parts inventories exist to serve the maintenance planning. An excess of spare parts inventory leads to a high holding cost and impedes cash flows, whereas inadequate spare parts can result in costly flight cancellations or delays with a negative impact on airline performance.

Aircraft on ground (AOG) situations or delays in MRO operations disrupt flight schedules and have a tremendous financial impact. Supply chain disruptions are prevalent root causes of operational delays. They can result from natural disasters (e.g. earthquakes, volcano eruptions, floods) and subsequent logistical challenges as well as from manmade risks. Executives should be aware that the successful integration and management of key business processes across members of the supply chain will determine the success of an enterprise. Usually managing the supply chain is left to chance. For this reason, executives usually are striving to interpret and to determine how to manage the company's supply chain network, and thereby achieve the potential of SCM (Lambert et al., 2000).

As per Ethiopian Airlines monthly delay report, Ethiopian airlines isfacing flight delay and flight cancellation. As per Ethiopian Airlines monthly flight delay review and as per Maintenance Reliability Board reports of December, 2016, out of 95 flight delay faced in December,2016, 60 of the delays were occurred due to lack of supply chain integration among MRO function, supplier relationship management and aircraft inventory being out of stocks; however, there was no study made to clearly assess the level of internal integration among MRO functions, supplier relationship management within MRO functions and the causes for aircraft parts being out of stock.

Therefore, the researcher aimed to study the level of internal integrations among MRO functions; supplier relationship management and MRO Inventory Management system to improve flight dispatch reliability.

1.3.Research Questions

The followings are the research questions:

1. What is the level of internal integration among MRO functions?
2. What roles supplier relationship management plays to improve dispatch reliability
3. What are the major causes for which aircraft parts are being out of stock?

1.4. Research Objective

1.4.1. General Objectives:

The general objective of the study is to assess the role of Ethiopian MRO Supply Chain integration and Inventory Management in flight dispatch reliability.

1.4.2. *Specific Objectives:*

The followings are the specific objectives of the research:

1. To assess the level of internal integration among EthiopianMRO functions to improve dispatch reliability
2. To assess the role of supplier relationship management (Ethiopian MRO division integration with suppliers) to improve dispatch reliability
3. To assess the major causes for aircraft parts being out of stock

1.5. Significance of the Study

The study has significant effect for the airline operators by proposing ideas by which flight delay and flight cancellation shall be reduced. The study will help policy makers in the airline industry and aviation sectors to design policy which will help airline operators to improve on time performance. The study will also help policy makers to understand the importance of developing effective and efficient MRO supply chain management systems for the overall performance of the airlines. The study helps airline operators to design integrated MRO system which help airline operators to improve dispatch reliability.

This study is 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

The scope of the study wasEthiopian Airlines MRO division and the study didn't consider on time performance affected by external issues such as dispatch reliability affected by bird strike, lightning, weather condition and other external environment. The study considered only chargeable flight delays as the researcher thinks most of the flight delays of Ethiopian Airlines are chargeable and non-chargeable and non-avoidable flight delay is not affected by MRO services. The study targets only aircraft inventory management system of MRO.

1.7.Limitation of the Study

There was few researches done in the area and it was difficult to find related literature in the area. The other limitation was lack of data to get industry average dispatch reliability due to confidentiality of the data. Due to time limitation, the researcher didn't cover customer integration as part of this study.

1.8. Operational Definition of Key Terms and Concepts

1. **Supply Chain Management**: Supply chain management is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective &efficient ways possible
2. **Supply Chain Integration:** Level of cooperation and information sharing among trading partners in the supply chain management. Supply Chain Integration is how everyone and every section in the company and its trading partners work in synchronization to achieve the same business objectives via integrated business process and information sharing.
3. **Internal Integration:** Internal integration is the extent to which business functions work cooperatively and interact through cross-functional process integration to resolve conflicts and achieve mutual goals.
4. **External Integration:** External integration relates to the extent to which a company establishes collaborative relationships, shares information and coordinates external integration activities with both suppliers and customers.
5. **Inventory Management:** Inventory management is the process of efficiently overseeing the constant flow of units into and out of an existing inventory. It is activities employed in maintaining the optimum number or amount of each inventory item.
6. **Recommended Spare Parts Lists(RSPL):** is a document issued by the aircraft manufacturer to evaluate aircraft spare parts holding based on the estimated removal and the number of aircrafts the operator operates

7. **Flight Dispatch Reliability**: Dispatch reliability is expressed as the percentage of flights that depart within a specified time of the scheduled departure time. The first step is to define the margin. The airlines use a 15-minute margin between actual and scheduled departure time for a flight to be considered as having departed "on time."

8. **Maintenance Repair andOverhaul (MRO):**is anorganization in the aviation industry that performs the servicing, repair, modification,overhaul, inspection of aircraft components and determination of condition of the aircraft.

1.9. Organization of the Study

The main research study has been organized as follows:

Chapter One: Introduction- In the introduction part of the paper, the background of the study, research problem, research questions, research objectives and scope of the study were discussed

Chapter Two: Literature Review- In this chapter related literature review about supply chain management, service supply chain, supply chain integration, flight dispatch reliability and conceptual framework were reviewed.

Chap**ter Three: Research Methodology-**In this chapter the research approach, research design and sampling techniques employed were discussed

Chapter Four: Data Analysis, Results and Discussion-In this chapter the research result were presented and analyzed using IBM SPSS 20.

Chapter Five-Summary, Conclusion and Recommendation-In this Chapter the research summary was discussed and conclusion and recommendation was made

Chapter Two

2. Related Literature Review

In this chapter related literature was reviewed. The chapter covered theoretical literature review, empirical review, conceptual framework and literature gap.

2.1. Service Supply Chain

The services sector is growing at a fast rate during the last years promoting remarkable improvements to the enhancement of economies and is observed as a major part of the workforce in some countries (Prajogo, 2006). Characterized by intensive interactions with customers and direct linked with operational performance level, service is identified as a crucial activity within an organization due the impacts that are generated in the client retention. However, due to historical facts, the attention and studies of SCM within service operations still trail behind the manufacturing operations (Giannakis, 2011).

Simchilev*iet .al* (2000) notes that the convectional objective of an airline supply chain is to get the right material to the right place at the right time. The secondary objective has been to manage the parts procurement and supply chain function as efficiently as possible. Beamon (1999) adds that in today's highly competitive airline market and increasingly in the future- efficiency in supply chain operations has reached a new and more critical dimension.

2.2. The concepts and nature of MROSupply Chain Management

Many scholars have defined supply chain management. Ellram and Cooper (1993) defined SCM as "an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer."

Christopher (2005) describes supply chain management as a wide concept that builds

upon the ‘single-plan’ framework of logistics and which explains the flow of products and information through a business. In this sense, supply chain management aims to achieve coordination and linkage between operations and the business processes that take place between an organization, its suppliers and its customers. The concept may be regarded simply as the integration of key business processes among industry partners with the view to adding value for customers. It closely links numerous successive elements of the industry value chain, from upstream suppliers, through sub-assembly manufacturers, distributors and retailers to the end customers. For instance, in travel operations, one linkage may be from catering suppliers to individual cruise ships moored in dock to individual customers. Any changes that take place within this relationship may be based upon cost savings, quality enhancement or, ideally, both. The main aim is to have a commercial and competitive advantage over rival organizations by making the process more cost-effective and more efficient, and the products more differentiated (Richard and Wisner, 2005).

Increasingly SCM is being recognized as the management of key business processes across the network of organizations that compromise the supply chain. According to the Global Supply Chain Forum SCM is the integration of key business processes from end user through original suppliers, which provide products, services, and information that add value for customers and other stakeholders (Global Supply Chain Forum, 1998). Mentzer*et al.* (2001) define supply chain management as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.

The processes involved in aviation MRO is inherently complex for several reasons including a premise that aviation MRO activities cannot be precisely defined solely within manufacturing or service term alone as they are a product of both (Al-kaabi*et al.*, 2007; Ayeni, *et al.* 2016). Added to the complexity is the fact that each component needs to be certified by competent airworthiness institution and this does demand a high level of requirements to guarantee safety operations (Vieira &Loures, 2016). Moreover, due to the high-quality requirements, the constrained pool of authorized

companies available to serve parts and services in the sector can limit the options available to MRO organizations in selecting and managing the associated supply chain network.

2.3. Airlines MRO Supply Chain Integration

According to Lambert *et al* (1998), the success of an organization depends on the integration and effective management of the critical business processes, within the company boundaries, and along strategic partners from the SC. The business processes integration within an SC can be characterized into four different stages of development fragmented operations inside an organization, limited integration among the functional areas of a company, complete internal integration of entire planning process, and the fully integration of planning process with the upstream and downstream strategic members of the SC. Therefore, the essence of SCM depends on the existence, and combination, of three main elements; the structure of the SC network, the business processes, and the managements components of the SC. (Lambert *et al.*,1998).

Supply chain integration is defined as "the extent to which all activities within an organization, and the activities of its suppliers, customers, and other supply chain members, are integrated together" (Narasimhan, *et al.*1998). SCM has three independent variables in its original scale they are: internal, suppliers and customer integrations. Some also considers integration in two levels: internal integration and external integration (Tutuncu and Kucukusta, 2008). Finally, Stevens (1989) classifies supply chain integration into three levels, from functional integration to internal integration and to external integration. The dominant belief is that supply chain integration (SCI) is a useful approach to improve various measures of firm performance (Van der Vaart and Van Donk, 2008). The basis of integration can therefore be characterized by cooperation, collaboration, information sharing, trust, partnerships, shared technology, and a fundamental shift away from managing individual functional processes, to managing integrated chains of processes (Pagell, 2004).Simchilevi*et al* (2000)argues that the airline supply chain can only be possible with integrating both the internal and external suppliers the factors to put into consideration include

but are not limited to: partnership emphasis, total aircraft support, pool access and component maintenance in one fully integrated program, daily support, consignment stocking and integrated consumable management.

2.3.1. Internal Integration

Internal integration involves cross functional teams that may bring together a carefully selected array of specialists who share information and make product, process, and manufacturing decisions, jointly and simultaneously (Koufteros, Vonderembse and Jayaram, 2005). Internal integration is defined as a process of inter-functional interaction, collaboration, coordination, communication and cooperation that bring functional areas together into a cohesive organization (Flynn *et al,* 2010).

2.3.2. External Integration

As the competitive environment is becoming increasingly challenging, firms are undertaking efforts to compete along multiple fronts. However, many firms find it difficult to compete in the market by relying on their internal resources and competencies alone. They have turned to collaborate with their customers and suppliers to obtain information and complementary resources, which they can deploy to build competitive advantage. External supply chain integration reveals two major areas of emphasis. They are: Customer integration (CI) and Supply integration (SI). Supplier integration also called "backward" integration (Frohlich and Westbrook, 2001) refers to the process of interaction and collaboration between an organization and its suppliers to ensure an effective flow of supplies (Zhao *et al,* 2011). Customer integration, also called "forward" integration (Frohlich& Westbrook, 2001) refers to the process of interaction and collaboration between an organization and its customers to ensure an effective flow of products and/or services to customers (Zhao *et al*. 2002). Customer integration involves sharing demand information, help the manufacturer to understanding better the customer needs and to forecast better customer demand, as well as collaborative involvement of customers with respect to product design, provision of better quality products at lower cost and more flexibility in responding to customer demand (Flynn *et al.* 2010).

2.4. Airline /MRO Inventory Management

The principle of effective inventory management is based upon the production of only the quantity of stock required for immediate demand. On the one hand, the aim is not to hold excess stock as this brings with its storage costs, so a minimal level of inventory must be maintained based on demand management tools. On the other hand the costs of not holding stock can be manifest as lost revenue through the unavailability of items, and potentially, and the resulting negative image that may accompany such an incident if a number of customers are affected and are consequently dissatisfied with the level of service. From both perspectives, inventory is more focused on cost reductions, even though it has not been seen in that light in the past. However, times are changing, and the high cost of inventory has encouraged organizations to concentrate on efficient supply chain and quality management (Russell and Taylor, 2009).

In airline industries, an operator has to deal with two types of issues: the aircraft operating cost and customer satisfaction. Aircraft maintenance planning plays a major role in both of them. On the one hand, based on an analysis in 2012 conducted by the International Air Transport Association (IATA)'s Maintenance Cost Task Force, the maintenance cost takes up about 13 percent of the total operating cost, and it can be reduced by a good planning. On the other hand, an excellent maintenance program can effectively avoid flight delays and cancellations, thus improve customer satisfaction and competitiveness in the industry. Spare parts inventories exist to serve the maintenance planning. An excess of spare parts inventory leads to a high holding cost and impedes cash flows, whereas inadequate spare parts can result in costly flight cancellations or delays with a negative impact on airline performance. Since the airline industry involves with a large number of parts and some of them are quite expensive, it is important to find an appropriate inventory model to achieve a right balance

In the Aviation industry, Spare Parts Management plays a vital role in achieving the desired availability of aircrafts. Some of the unique challenges faced during aviation spare parts management include moving assets, long and variable lead times, OEM dependencies, maintenance policies governed by regulators and demand

unpredictability. Operators/MRO uses RSPL to calculate the optimal inventory level in line with the expected service level. While the OEM provides original float recommendation in RSPL, the requirements can change over a period of time depending upon the number of aircrafts in the operation, age of the aircrafts and the actual scrap rates, utilization of aircrafts, repair TAT depends on the purchase TAT and so on (Saravanan Rajarajan,2013)

According to IATA report (2015), in the airline industry spare parts inventory is categorized as Rotable Inventory, Repairable Inventory &Expendable Inventory.

2.4.1. Rotable Inventory

According to IATA report (2015),rotable inventory is defined as an inventory that can be economically restored to a serviceable condition and, in the normal course of operations, can be repeatedly rehabilitated to a fully serviceable condition over a period approximating the life of the flight equipment to which it is related. Of course there are scrap rates as with all inventory, however, with Rotable inventory the scrap rate is assumed to be very low, perhaps only a few percentage points or even a fraction of a point.Rotables are unusual in that the repair cycle causes them to depart from mainstream notions regarding inventory. Rotables are typically held on a firm's books, and depreciated on a schedule that may range from 5-7 years to 20-25 years, depending on the firm's goals and mode of business. Some businesses, such as trading firms or surplus firms, may depreciate on a much more aggressive schedule of even just several years, but typical depreciation schedules tend to follow the life cycle of the parent aircraft to which the inventory belongs. As such, a company that leases its aircraft on a 5-year term, but purchases Rotable inventory for operations support may depreciate on a 5-year schedule. Conversely, an airline that either purchases or leases aircraft, but has a long term fleet plan which incorporates the parent fleet into operations for 20 years will generally adopt a 20-year depreciation schedule for their purchased Rotable inventory.

2.4.2. Repairable Inventory

According to IATA (2015), Repairable Inventory generally follows the same conventions of Rotable inventory with one important distinction: Repairable inventory

has a higher scrap rate than Rotable inventory. Each airline typically defines their break-point between Rotable inventory and Repairable inventory at different levels depending on their own economic analysis. Furthermore, some airlines may not even classify inventory as Repairable, but only maintain the Rotable and Expendable categories. However, the Repairable inventory classification is important to airlines and vendors of aircraft inventory because some of the assumptions about Rotable inventory will not apply to Repairable inventory in certain situations such as leasing, exchange agreements, loaning of parts to other airlines, or entering into pooling arrangements. The main danger in intermixing inventory that is clearly Rotable with inventory that is clearly Repairable in nature is that in agreements with parts vendors, maintenance providers, exchange houses, lessors, and a firm that loans parts or any other parts interchange is that both parties should account for the scrap rate that will certainly have an impact in long-term agreements.

2.4.3. Expendable Inventory

According to IATA (2015), Expendable inventory is by definition, inventory with 100% scrap rate and therefore 100% replacement for every use. Expendable inventory often meets the criteria most laymen and financial professionals think of when they consider inventory. Expendables range from common fasteners to filters to items which are scrapped upon use and removal. Cost-wise, Expendables can be as expensive as or more expensive than inventory assets in the Rotable or Repairable class. Their main distinction is the 100% scrap rate.

According to IATA (2015) financially, expendables are usually expensed at the time of use or issue, depending on the financial dictums of the operator. Bulk items are often expensed at the time of issue to a station or maintenance base, and this practice can induce problems that mask the true inventory levels in the operation, particularly if there are not robust systems for inventory tracking and audit. If station visibility is lost, often planners are induced to over order their Expendable levels, driving up Expendable balances due to the lost visibility at stations. Obsolescence is another issue faced very acutely in Expendable management. Because airlines usually stock Expendables at usage plus safety stock levels, oftentimes a large quantity is on hand across the inventory system at any given time. If a fleet is retired or engineering/ regulatory action

replaces the current Expendable part with a new one, a mass of parts is suddenly outdated and useless. One side effect is the market value will plummet for the parts in question, and Expendables often surplus at pennies on the dollar. As with Repairable inventory, Replenishment Lead Time (RLT) is paramount in Expendables management. Despite their sometimes apparent simplicity, the supply chain for Expendables can be long and tedious. Disruptions in raw material supply, manufacturing priorities, new aircraft deliveries, and a host of other factors can cause the RLT for Expendables to fluctuate wildly. Any Expendable management theory should take into account the variability of RLT on the expected delivery of Expendable quantities.

2.5. Measuring flight Dispatch Reliability

Airline operators work across the supply chain to ensure scheduled flight release to service; however, many different events may occur before aircrafts are positioned for flight and some of the events may cause flight delay and flight cancellation. The departure delays have increased significantly in the past decade due to several factors such as the increasing demand of air transport (Yuan, D, 2007). Dispatch reliability is percentage of flights that depart within a specific window after the scheduled departure time.

Measuring dispatch reliability may vary by world region. Dispatch Reliability is expressed as the percentage of flights that depart within a specified time of the scheduled departure time. The first step is to define the margin. The airlines use a 15-minute margin between actual and scheduled departure time for a flight to be considered as having departed “on time. The second step in measuring dispatch reliability is to define and categorize the causes of delays. When measuring Dispatch reliability, airlines exclude non-aircraft issues such as severe weather, air traffic control congestion, and delays driven by airport security (Tulinda Larson, 2015)

2.6. Concepts of flight dispatch reliability

According to National Business Aviation Association (NBAAA) report, Dispatch reliability is the percentage of scheduled departures that do not incur a delay,

cancellation, turn back or diversion.

According to National Business Aviation Association (NBAAA) report, flight delays can be categorized as chargeable and non-chargeable:

1. Chargeable Delays are defined as delays, or cancellations caused by known or suspected mechanical malfunctions of the aircraft, its systems, or components not defined as non-chargeable. Only chargeable delays and cancellations shall be counted in the Dispatch Reliability rate calculations. Cancellations shall include flights for which another aircraft was substituted
2. Non-chargeable delays are defined as malfunctions, delays, cancellations or failure of the aircraft, its systems or components, caused by accidental damage, foreign object damage (FOD), random events: (e.g. bird strikes, lightning strikes, weather), misuse, neglect or unauthorized repairs. Deferrable snags: which may be deferred within the terms of the MEL or CDL? Note that if the amount of time required to clear such a snag in accordance with the MEL makes it impossible to avoid a delay, then the delay would be counted as chargeable - but it is expected that the MEL/CDL would normally preclude a cancellation. Replacement of Time Limited parts at their time limit or wear out parts at their wear limit will not be used as a reason for a delay or cancellation

According to Larson (2015) globally, one out of every three flights arrives five minutes late; one out of ten flights arrives more than thirteen minutes late; one out of every hundred departures cancels altogether.

According to Larson (2015); Average dispatch reliability across the fleet operated by major US airlines was 79% on average from 2003 today; an average of 80% of flights had an on time gate arrival; the average gate departure delay was 11.7 minutes, and the average gate arrival delay was 12.6 minutes; when flights were delayed more than 15 minutes, the average delay was 55 minutes.

2.7. Empirical Review of the role of MRO Supply Chain Integration on flight Dispatch Reliability

According to IATA (2013), the flight disruptions occurred in the aerospace supply chain is the predominant cause of the operational delays. These can result from natural disasters (such as earthquakes, volcanic eruptions, floods) and subsequent logistical challenges, from other manmade risks. These delays are not the only challenges in the air operations. The difficulties or delays in MRO (Maintenance, Repair and Overhaul) operations disrupt flight schedules and have a huge financial impact.

According to Larson(2015);About 2/3 of late or cancelled operations are due to weather and airspace conditions ;1/3 of delays and cancellations are due to factors within an airline's control such as aircraft are not available due to maintenance problems, i.e. exceeds allowable flight time ,flight crews that time-out due to limits on duty days, or that are out of position due to late inbound flights or missed connections ,lack of airport equipment or gate space to handle flights ,Passenger service issues, such as baggage transfer, IT problems or catering issues.

According to a study made by Federal Aviation Administration, and University of Californian2007, the cost of domestic flight delays puts a $ 32.9 billion debts into the U.S economy, and about half of the cost is borne by airline passengers. The research was commissioned by the Federal Aviation Administration (FAA), and University of California, and the final report was delivered to the agency. The comprehensive study analyzed flight delay data of 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.

Based on an analysis made by IATA in 2012, maintenance cost takes up to 13% of the total operating cost and it can be reduced by a good planning. According to the IATA 2015 report, effective and efficient supply chain integration, maintenance planning and good inventory management system avoid flight delay and cancellations, thus improve customer satisfaction and competitiveness in the industry.

2.8. Conceptual Framework of the Study

Many chains of events occur before flight takes off and on time performance of flights can be affected by some of the factors. Dispatch reliability of flights can be affected by a single reason or many reasons. One of the factors affecting on time performance of flight is technical issue related with aircraft maintenance. In the aviation industry, MRO division or organizations are responsible to maintain and ensure airworthiness of flights before flight take off. Internal supply chain integration among MRO members, supplier relationship management and aircraft parts inventory management plays vital role to ensure on time performance of flights. The conceptual framework showing factors affecting flight dispatch reliability can be depicted as follows.

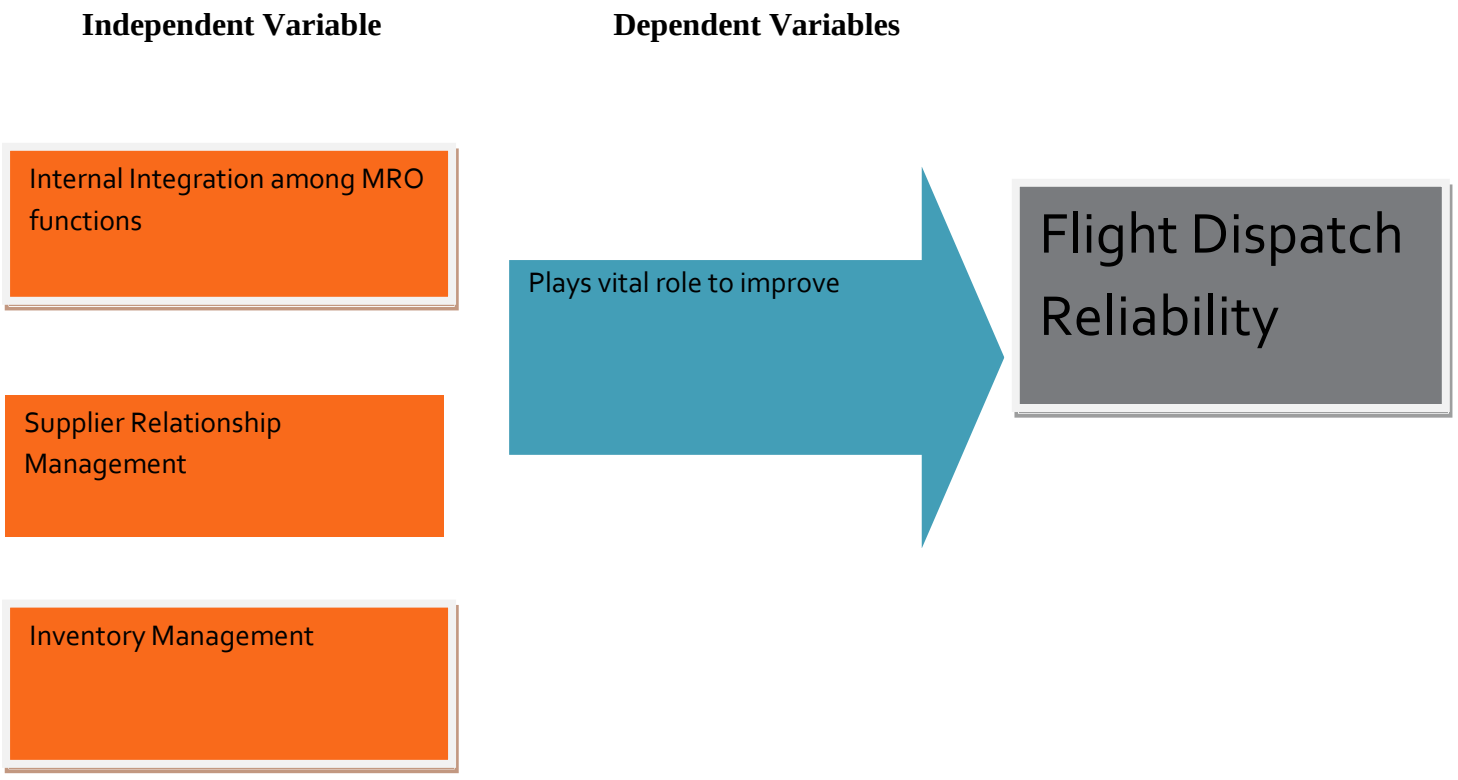

Figure 2.1: Conceptual Framework; source (own research, 2017)

Chapter Three

Methodology of the Study

Under this chapter, concepts such as research approach, research design, population and sampling techniques, data sources and types, ethical consideration, and research reliability were discussed.

3.1. Research Approach

The study employed a non-experimental approach particularly a survey study to assess the level of internal integration among MRO functions in improving flight dispatch reliability; the role of supplier relationship management in improving dispatch reliability andthe causes of aircraft parts being out of stock.

Mixed research approach was used to assess the overall role of supply chain Integration on Ethiopian Airlines flight dispatch reliability to triangulate the data obtained from the respondents and the interviewee.

3.2. Research Design

As the research was to study the role of supply chain integration in flight dispatch reliability, descriptive research design was used so as to assess the role of Ethiopian MRO internal integration and external integration in improving flight dispatch reliability. Descriptive research design was used as the research tried to describe the role of MRO supply chain integration in flight dispatch reliability.

3.3. Population and Sampling Techniques

Population: The populations under the study were2850staffs working under the MRO division in the Ethiopian Airlines Enterprises. (Source: Ethiopian Airlines MRO portal, 2017).

Sampling Technique and Sample Size: The researcher usedboth probability and no**n-**probability sampling. Purposive sampling used to select the MRO divisions' Line maintenance and Procurement and Supply Chain Management because these two departments are highly related with dispatch reliability of flights. The respondents were selected based on employee experience in the area and knowledge of the subject under study, and willingness of the employee to participate in the study and to give his/her consent after being advised about the purpose of the study

The researcherused the probability sampling technique particularly simple random sampling. By using this sampling technique, 106 respondents were selected as sample size of the study. The sample size was determined by using online sample size formula using 95% confidence level and 9.35% margin of error (Source: https://www.surveymonkey.com/mp/sample-size-calculator)

3.4. Sources of data

Both primary and secondary sources of data were employed in the study. The primary sources of data were questionnaire and semi-structured interview. The secondary data was obtained from company reports and documents.

3.5. Data Collection Procedures

Secondary Data: Secondary data was collected from different company sources like daily aircraft delay report, daily critical parts report, deferred reports from aircraft planning section, component maintenance weekly component status report and post mortem report after schedule maintenance.

The Primary data was gathered through two major ways:

Questionnaire Surveys: The researcher distributed questionnaires to the selected respondents at their working offices and collected the questionnaires. This was conducted on the sample population of about 106.

Semi-Structured Interview: Semi-structured interview was conducted with Line Maintenance and Procurement and Supply Chain Management directors' office for about an hour.

3.6. Method of Data Analysis

The researcher used IBM statistical package for social studies (SPSS) version 20 to get the required analysis results for study and the researcher presented the results using descriptive statistics such as mean, standard deviation, percentile and frequency. Correlation and multiple linear regression analysis were also employed for data analysis. The assumptions of multiple regressions are one continues dependent variables; two or more dependent variables; linearity; multicollinarity.

Dispatch reliability of flights can be affected by many variables; however, for the purpose of the study the researcher considered three major variables affecting flight dispatch reliability. And hence both the independent and dependent variables are continuing variables and they are consistently related with the assumptions of correlation and multiple linear regression.

3.7. Testing Reliability of the Data

In order to ensure the reliability of the research, theresearcher distributed 10 questionnaires to sample respondents and gathered the questionnaire to test reliability of the research.

Coefficient alpha (also known as "Cronbach's alpha") is the most widely used reliability coefficient. It estimates test-score reliability from a single test administration using information from the relationship among test items. According to Mohsen Tavakol and RegDennick (2011) Cronbach's alpha of less than 0.5 is unacceptable, α less than or equal to 0.6 is poor, α less than 0.7 is questionable, α less than 0.8 and greater than or equal to 0.7 is acceptable, α less than 0.9 and greater than or equal to 0.8 is good and finally α greater than or equal to 0.9 is excellent. Accordingly, the pretest made for ten sample questioner was found that α of 0.85 which is acceptable range.

The researcher has tested the reliability of questionnaires with Crobanch alpha on 10 respondents. The reliability test of the variables measuring the extent of internal integration among MRO functions, the role of supplier relationship management and causes for aircraft parts being out of stock

The reliability test of variables measuring the level of internal integration among MRO functions, the role of supplier relationship management and causes for aircraft parts being out of stock are shown on table 3.1

Cronbach's Alpha	N of Items	Variables
.85	12	Level of internal integration among MRO functions
.82	6	Supplier relationship management
.85	10	Causes for aircraft inventory being out of stock

Table 3.1 Reliability test, source: own research, 2017

3.8 Ethical Consideration

To ensure ethicality of the research, prior to distribution of the questionnaire, the respondents were briefed about the purpose of the study and the respondents were informed that the data obtained from them will be kept confidentially and it is only used for research synonyms. And then consent of the respondents was asked and based on their willingness data were collected. The purpose of the research was clearly communicated to the respondents, interviewees and the company's data owners so that they can provide accurate information.

CHAPTER FOUR

RESULT, DISCUSSIONS AND INTERPRETATION

This chapter focused on presenting the research finding, analyzing the result, and discussions on the research finding on the data that was gathered through questionnaire, semi-structured interview, observation and documents.

4.1. Demographic Information of the respondent

In this section demographic data of the respondents is presented and analyzed. The demographic data of the respondents considered in the study are sex of respondents, age of respondents, educational status of respondents, and experience of the respondents. The demographic data of the respondents is presented and analyzed on table 4.1

Table 4.1 Data showing demographic data of the respondents: research data (2017)

	Sex of Respondents			Age of Respondents					Educational status of Respondents				Experience of Respondents					
	M	F	Total	18-25	26-35	36-45	>45	Total	D	DE	M	T	<5	5-10	11-15	16-20	>20	T
Frequency	82	24	106	22	53	30	1	106	3	87	16	106	31	46	18	10	1	106
Percent	77.4	22.6	100	20.8	50.0	28.3	.9	100.0	2.8	82.1	15.1	100.	29.2	43.4	17.0	9.4	.9	100.0
Valid Percent	77.4	22.6		20.8	50.0	28.3	.9	100.0	2.8	82.1	15.1	100	29.2	43.4	17.0	9.4	.9	100
Cumulative Percent	77.4	22.4		20.8	70.8	99.1	100		2.8	84.9	100.0		29.2	72.6	89.6	99.1	100	

Source: Own research,2017

Input: M represents Male respondents, F represents Female respondents, D represents Diploma, DE represents Degree, M represents Master, T represents total.

As it is indicated on table 4.1, out of the 106 respondents 82(77.4%) of them are male and the rest 24 (22.6%) are female. This implies there are more male employees at line maintenance and procurement and supply chain management.

As it is seen on the table 4.1, out of 106 respondents 53(50%), 30(28.3) of the respondents were in the age range of 26-35 and 36-45respectively. This shows most of the respondents were young in productive age.

Regarding educational status of the respondents, as it can be observed from the table 4.1, out of the 106 total respondents 87(82.1%), 16(15.1%) of the respondents have University degree and Master degree respectively. This shows most of the respondents were educated up to university degree.

As per the data analyzed on table 4.1, 46(43.4%), 31(29.2%), 18(17.0%), 10(9.4), 1(.9%) of the respondents have <5, 5-10, 11-15, 16-20,>20 years of experience at Ethiopian MRO respectively.

The demographic data analysis shows that most of the MRO employees are male at productive age with first degree educational level with service year from 1 to 15 years of experience.

4.2. Level of Integration among Ethiopian MRO supply chain Functions

The first research question was to assess the level of internal integration among Ethiopian MRO supply chain functions. The respondents reply to the level of internal integration among MRO functions is depicted on table 4.2

		Frequency	Percent
Valid	not integrated	4	3.8
	partially integrated	29	27.4
	Integrated	42	39.6
	full integrated	31	28.5
	Total	106	98.1
Missing	System	0	
Total		106	100.0

Table: 4.2 Descriptive Statistics, source: own research, 2017

As part of the assessment, the respondents were requested to answer 12 questions to indicate level of integration. As it is analyzed on table 4.2, out of the 106 total respondents 42 (39.6%) and 31(28.5%) of the respondents reply to the integration level among Ethiopian MRO functions as integrated and fully integrated respectively, and 29(27.4%) and 4(3.8%) of the respondents reply to the integration level requests as partially integrated and not integrated.

The researcher designed questions on table 4.3 to assess the level of integration among Ethiopian MRO Supply Chain functions.

Item	Supply Chain Integration	N	Mean	SD
1	The level of integration between Line Maintenance and Procurement and supply chain management has affected dispatch reliability	106	3.7642	1.1095
2	The level of integration between Component Maintenance and Procurement has affected dispatch reliability	106	3.6792	.99088
3	The level of integration between Schedule Base maintenance and Procurement has affected dispatch reliability	106	3.5472	1.13919
4	The level of integration between Line Maintenance and Engineering has affected dispatch reliability	106	3.4623	1.19662
5	The level of integration between Material Requirement Planning and Procurement has affected dispatch reliability	106	3.8396	.99653
6	The level of integration between Engineering and Procurement has affected dispatch reliability	106	3.3491	1.11306
7	The level of integration between Procurement and Finance has affected dispatch reliability	106	3.5943	1.11080
8	The level of integration between Procurement and Logistics has affected dispatch reliability	106	3.7925	1.21669
9	The level of integration between Warehouse and Inventory management, and Procurement has affected dispatch reliability	106	3.4245	1.3866
10	The level of integration between Component Maintenance and Line maintenance has affected dispatch reliability	106	2.9623	1.53017
11	The level of integration betweenSchedule Base Maintenance and Line Maintenance has affected dispatch reliability	106	3.2453	1.5749
12	The level of integration betweenEngine Maintenance and Line Maintenance has affected dispatch reliability	106	3.3208	1.50900

Table 4.3 Descriptive Statistics:own research, 2017

As it is analyzed on the table 4.3, the three highly integrated MRO functions are Material Requirement Planning and Procurement (M=3.8396, SD=.99653), Procurement and Logistics (M=3.7925, SD=1.2166), Line Maintenance and

Procurement (M=3.7624, SD=1.1095). From the different functions in Ethiopian MRO, Component Maintenance and Line maintenance (M=2.9623, SD=1.53017) and Schedule Base Maintenance and Line Maintenance (M=3.2453, SD=1.5749) are the least integrated functions in Ethiopian MRO.

The interview result made with director Purchasing and Supply Chain management and director Line maintenance also shows that internal integration among MRO functions is very important ant for dispatch reliability and for MRO performance and the level of integration between some function needs to be improved to minimize flight delay and flight cancellation. The interview result shows that the level of integration between line maintenance & procurement; the level of integration between component maintenance and line maintenance; the level of integration between line maintenance and base maintenance needs attention to improve flight dispatch reliability.

4.3. Supplier Relationship Management

Considering supplier relationship management, the importance of developing good relationship with suppliers and the importance of supplier management in improving on time performance of flight wereassessed. As part of the assessment, the respondents were requested to answer 6 questions to assess the importance of supplier relationship management. Respondents reply to the six questions is indicated on table 4.4.

		Frequency	Percent
Valid	Strongly Disagree	0	0
	Disagree	0	0
	agree	24	22.6
	strongly agree	82	77.4
	Total	106	100.0

Table: 4.4 Descriptive Analyses; source: own research

As it is analyzed on table 4.4, out of the 106 total respondents 82 (77.4%) and 24 (22.6%) of the respondents reply strongly agree and agree respectively. None of the respondents answered disagree and strongly disagree to the questions. This shows the importance of considered factors and relatedness of the questions to dispatch reliability.

The researcher designed questions on table 4.5 to assess the importance of supplier relationship management.

Item	Statement	N	Mean	SD
1	Developing strategic alliances with aircraft manufacturers such as Boeing, Airbus and Bombardier plays vital role to improve Ethiopian Maintenance ,Repair & Overhaul performance	106	4.3774	.73618
2	Getting field service support from aircraft manufacturers such as Boeing and Airbus helps to improve flight dispatch reliability	106	4.4057	.74038
3	Settling service and product invoices as per the agreed credit terms helps Ethiopian Airlines to develop good relationship with suppliers	106	4.4151	.82656
4	Developing good relationship with aircraft parts suppliers helps Ethiopian Procurement & Supply Chain department to ensure optimal inventory stock availability and avoid AOG situations	106	4.4434	.63666
5	Aircraft manufacturers such as Boeing & Airbus support is very important whenever Ethiopian Airlines face AOG situation due to spare shortage and special maintenance requirements	106	4.8956	.49797
6	Designing integrated supply chain system between procurement and suppliers is vital to improve dispatch reliability	106	4.5472	.58768

Table: 4.5 Descriptive Statistics; Source: own research

As it is analyzed on table 4.5 , the three very important parameters as part of supplier relationship management are developing strategic alliances aircraft manufacturers such as Boeing & Airbus support is very important whenever Ethiopian Airlines face AOG situation due to spare shortage and special maintenance requirements (M=4.8956,SD=.49797), designing integrated supply chain system between procurement and suppliers is vital to improve dispatch reliability (M=3.7624,SD=1.1095) and developing good relationship with aircraft parts suppliers helps Ethiopian Procurement & Supply Chain department to ensure optimal inventory stock availability and avoid AOG situation(M=4.4434,SD=.63666).This implies that supplier relationship management is important ant to avoid operational disruption.

The interview result made with director Purchasing and Supply Chain Management and director Line Maintenance also shows that developing good supplier relationship plays vital role to improve flight dispatch reliability and flight dispatch reliability is dependent on the level of suppliers support mainly provided by aircraft manufactures such Boeing and Airbus.

4.4. Causes for Inventory being out of Stock

This section is to assess the second research question which is causes for aircraft inventory being out of stock. Respondents were requested to answer nine questions which are considered as causes for inventory being out of stock.

		Frequency	Percent
Valid	Neutral	2	1.9
	Agree	53	50.0
	strongly agree	51	48.2
	Total	100	100
Total		106	100.0

Table 4.6: Descriptive Statistics, source: own research,2017

As it is analyzed on table 4.6, out of the 106 total respondents 53 (50%) and 51(48.2%) of the respondents' reply agree and strongly agree respectively. This implies that the selected questions can be considered as causes for aircraft inventory being out of stock and the questions are the majors causes for aircraft parts being out of stock.

The researcher designed questions on table 4.7 to assess the causes for inventory being out of stock.

Item	**Causes for Inventory being out of stock**	**N**	**Mean**	**SD**
1	Inventory misallocation	106	4.2925	.83913
2	Poor Material Requirement Planning (not holding optimum inventory level)	106	4.6321	.50380
3	Physical and System balance inventory discrepancy	106	4.5377	.66439
4	Long Lead of aircraft parts and components	106	3.7358	.89764
5	Complexity and delay in approval and procurement processes	106	3.7453	.91611
6	Procuring parts from unreliable and undependable sources in terms of lead time & product quality	106	3.3679	1.08956
7	Logistics delay in shipments handling	106	4.0566	.89262
8	Lack of automated inventory management and material requirement planning system	106	3.8962	1.20261
9	Shipment hold up from vendor side due to unpaid overdue invoices	106	4.0056	.89260
10	Long turnaround time of foreign repaired components	106	4.0943	.68392

Table 4.7 Descriptive Analysis: Causes for Inventory being out of stock, source: own research

As it is analyzed on table 4.7 , the three major attributing causes for inventory being out of stock are Poor Material Requirement Planning (not holding optimum inventory level) (M=4.6321,SD=.50380), Physical and System balance inventory discrepancy (M=4.5377,SD=.66439), Inventory misallocation (M=4.2925,SD=.83913).From the factors considered as causes for inventory being out of stock, Procuring parts from unreliable and undependable sources in terms of lead time & product quality (M=3.3679,SD=1.08956) and long lead of aircraft parts and components (M=3.7358,SD=1.0807) are the list causes for inventory being out of stock.

Interview conducted with Director Line maintenance and Director Procurement and Supply Chain also showed that physical and system balance discrepancy, poor inventory management, long lead time of spare parts and long turnaround time of components are the main causes for parts out of stock situation.

4.5. Correlation Analysis on the relationship of dispatch reliability and supply chain integration

Table4.8: Correlation Analysis on the relationship of dispatch reliability with Internal Integration, Supplier Relationship Management and Inventory management;

Relationship with dispatch reliability		Internal Integration	Supplier Relationship Management	Inventory out of stock
	Correlation Coefficient	.391**	.285**	601**
	Sig. (2-tailed)	.000	.003	.000
	N	106	106	106
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

Source: Own Research,2017

As table 4.8 revealed flight dispatch reliability is positively related with Inventory management, supply chain integration, supplier relationship management (r=.60),(r=.39) and (r=.28) respectively. This indicates their correlation is significant at 0.01 levels. This shows that inventory management, supply chain integration and supplier relationship are correlated with dispatch reliability.

4.6. Multiple Linear Regression Analysis

Table 4.9Multiple linear regression analysis on the relationship of dispatch reliability and supply chain Integration and Inventory Management:

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B		Correlations			Co linearity Statistics
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance
Inventory out of stock	.490	.096	.434	5.088	.000	.299	.681	.563	.465	.401	.854
MRO supply Chain Internal Integration	.216	.060	.299	3.598	.001	.097	.336	.444	.348	.284	.898
Supplier Relationship Management	.207	.113	.148	1.829	.071	-.018	.432	.258	.185	.144	.949

a. Dependent Variable: Dispatch Reliability

Source: Own research,2017

As table 4.9 shows that inventory being out of stock, t(5.088)=.000.Beta =..434, internal supply chain integration (3.598)=.001.Beta=.299,supplier relationship management ,t(1.829)=.08.Beta=.148 significantly influence flight dispatch reliability. This shows that inventory being out of stock, level of internal integration among MRO functions and supplier relationship management influences dispatch reliability. The result also shows inventory being out of stock has more impact on flight dispatch reliability.

Chapter Five

Summary, Conclusion and Recommendation

This chapter focused on summarizing the research finding, conclusion drawn from the research finding and recommendation.

5.1. Summary of major findings

5.1.1. Level of Supply Chain Integration among MRO Supply Chain Functions

The research finding shows that from the different functions/departments in Ethiopian MRO division, Material Requirement Planning and Procurement are integrated; and Line Maintenance and Procurement are integrated when compared to the level of integration among other MRO functions. The research result also shows that Component Maintenance and Line maintenance are the list integrated functions in the MRO division. As per the research result, Ethiopian MRO needs to work on internal integration. Component maintenance and line maintenance are the major maintenance sections to providemaintenance services to components and aircrafts and the integration between the two sections is important to ensure on time performance of flight and the company needs to work to improve the integration between the two sections. Schedule base maintenance and Line Maintenance is also less integrated and the company needs to work to improve the integration level between the two sections as the collaboration and timely information flows between the two sections is important for on time performance improvement.

5.1.2. Supplier Relationship Management

The research result shows that developing strategic alliances with aircraft manufacturers; developing good relationship with suppliers played vital role to improve flight dispatch reliability and timely settlement of service and product invoices is important to develop and maintain good relationship with the vendors. The research also shows that getting field service support from aircraft manufacturers such as Boeing and Airbus is important to minimize flight delay and flight cancellation. The research finding also shows that developing integrated supply chain management with manufacturers and suppliers will helps Ethiopian MRO to improve dispatch reliability. The finding of the research also shows that the support of aircraft manufacturers such as Boeing and Airbus is important whenever the airlines faces AOG situation due to spare shortage and special maintenance requirements.

5.1.3. Causes for aircraft inventory being out of stock

The research result found out that the three main reasons for inventory being out of stock are Poor Material Requirement Planning (not holding optimum inventory level as per original equipment manufacturer RSPL document); physical and system balance inventory discrepancy and inventory misallocation. The research also revealed that long lead time and long turnaround time of foreign repaired components are also the causes for inventory being out of stock.

5.2. Conclusion

From the research finding, it can be concluded that Material Requirement Planning, and Procurement are highly integrated; and procurement and line maintenance are also highly integrated. However; the company needs to work on the level of integration between line maintenance and component maintenance as these two sections plays vital role in the overall performance of MRO and thereby dispatch reliability.

The research finding also shows the importance of developing good and strategic relationship is important to ensure parts availability and get field service support from the aircraft manufacturers to get the required service whenever the airline faces AOG situation and special maintenance requirements.

The research finding also shows that internal integration among MRO functions are important to improve flight dispatch reliability and provide timely information among MRO functions.

From the research result, it can also be concluded that the company needs to design a system by which system and physical balance discrepancy shall be reduced. The company also needs to design a system by which inventory misallocation shall be reduced. The research finding also shows the importance of developing good and strategic relationship is important to ensure parts availability and get field service support from the aircraft manufacturers to get the required service whenever the airline faces AOG situation and special maintenance requirements

Generally, it can be concluded that internal integration among MRO functions and external integration with suppliers are vital for the overall performance of Ethiopian MRO division and thereby improving flight dispatch reliability. And currently the level of integration between component maintenance and line maintenance; and schedule base maintenance and line maintenance needs high attention.

5.3. Recommendation

The followings are some of the recommendations made from the research findings:

- ✓ The research shows thathigh level of integration among MRO functions is vital to improve dispatch reliability
- ✓ The level of integration between Line Maintenance and Component Maintenance needs attention and improvement and so does the level of integration between schedule base maintenance and line maintenance
- ✓ The research finding also shows that supplier relationship management is very important to improve flight dispatch reliability. Timely settling of product and services invoice is important to develop good and strategic relationship. The research also shows that field service support of aircraft manufactures plays vital role for on time performance of flights.
- ✓ The research finding shows that physical and system balance discrepancy; poor material requirement planning and inventory misallocation are the three major factors for poor inventory management and thereby affecting flight dispatch reliability. And hence the company needs to design a system to minimize system and physical inventory discrepancy. To this end, the company has to work on employees' skill development and discipline to properly use the system whenever parts are issued from the system and to property bin parts at their proper location.

5.4. Suggestions for further Studies

The study was concentrated on Ethiopian Airlines MRO supply chain Integration and Inventory management asmainfactor which affect dispatch reliability of flights. The study didn't consider other factors and variables which may affect flight dispatch reliability. And hence future studies can be made to assess other variables which affect dispatch reliability. The study didn't consider customer integration as part of the supply chain integration and future study may consider customer satisfaction as part of the study. Different research can be made on other operators/MRO and the result can be compared.

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Addis Ababa University

School of Commerce

Department of Logistics & Supply Chain Management

Survey Questionnaires to be filled by selected respondents

Dear Respondent,

The purpose of this questionnaire is to collect data for the study designed to assess the role of Ethiopian Airlines MRO supply chain integration and Inventory Management in flight dispatch reliability. The study is conducted for partial fulfillment for the degree of Master of Arts in Logistics and Supply Chain Management at Addis Ababa University School of Commerce Department of Logistics and Supply Chain Management.

You are kindly requested to fill each question objectively as your response is vital for the outcome of the study.

The survey may take between 15 and 20 minutes. I would like to thank you for your valuable time to complete the survey. Your response will be confidential and will be used only for the purpose of the study.

Answering Instructions:

Please answer all questions. Most of the questions can be answered simply by circling the best answer or by ticking the best answers from the given alternatives. On some of the questions, space is provided to add further comment. Please tick (√) the appropriate column to indicate the extent to which you agree or disagree with each statement.

Appendix A – Questionnaire

Part A: Demographic related Information (please use X on the choice you make)

1. Gender: Male ☐ Female ☐

2. Age: 18-25 ☐ 26-35 ☐ 36-45 ☐ above 45 years ☐

3. Highest formal education attended

a) Certificate ☐ c) Degree ☐

b) Diplomad) Ma ☐ ☐

e) Other (please specify) _____

4. How long have you been worked at Ethiopian Airlines

a) Less than 5 years ☐

b) 5-10 years ☐

c) 11-15 years ☐

d) 16-20 years ☐

f) Above 21 years ☐

Part B: Level of Supply Chain Integration among MRO Supply Chain Functions

The item scales are five-point Likert type scales with the below showing the extent of integration between different sections in Ethiopian MRO. Please select the level of integration from the alternatives

1=I don't know

2=Not Integrated

3=Partially Integrated

4=Integrated

5=Fully Integrated

Item	Statements	Alternatives				
		1	2	3	4	5
1	The extent of integration between Line Maintenance and Procurement has affected dispatch reliability					
2	The extent of integration betweenComponent Maintenance and Procurement has affected dispatch reliability					
3	The extent of integration betweenSchedule Base maintenance and Procurement has affected dispatch reliability					
4	The extent of integration betweenLine Maintenance and Engineering has affected dispatch reliability					
5	The extent of integration betweenMaterial Requirement Planning and Procurement has affected dispatch reliability					
6	The extent of integration betweenEngineering and Procurement has affected dispatch reliability					
7	The extent of integration betweenProcurement and Finance has affected dispatch reliability					

8	The extent of integration betweenProcurement and Logistics has affected dispatch reliability					
9	The extent of integration betweenWarehouse and Inventory management, and Procurement has affected dispatch reliability					
10	The extent of integration betweenComponent Maintenance and Line maintenance has affected dispatch reliability					
11	The extent of integration betweenSchedule Base Maintenance and Line Maintenance has affected dispatch reliability					
12	The extent of integration betweenEngine Maintenance and Line Maintenance has affected dispatch reliability					

PART C: Supplier Relationship Management

The item scales are five-point Likert type scales with 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A), 5 = strongly agree (SA).

Item	Statement	1(SD)	2(D)	3(N)	4(A)	5(SA)
1	Developing strategic alliances with aircraft manufacturers such as Boeing, Airbus and Bombardier plays vital role to improve Ethiopian Maintenance ,Repair & Overhaul performance					
2	Getting field service support from aircraft manufacturers such as Boeing and Airbus helps to improve flight dispatch reliability					
3	Settling service and product invoices as per					

	the agreed credit terms helps Ethiopian Airlines to develop good relationship with suppliers					
4	Developing good relationship with aircraft parts suppliers helps Ethiopian Procurement & Supply Chain department to ensure optimal inventory stock availability and avoid AOG situations					
5	Aircraft manufacturers such as Boeing & Airbus support is very important whenever Ethiopian Airlines face AOG situation due to spare shortage and special maintenance requirements					
6	Designing integrated supply chain system between procurement and suppliers is vital to improve dispatch reliability					

Part D: The Causes for Inventory Out of Stock Situations

The item scales are five-point Likert type scales with 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A), 5 = strongly agree (SA).

Item	**Statement**	**1(SD)**	**2(D)**	**N(3)**	**4(A)**	**5(SA)**
1	Inventory misallocation					
2	Poor Material Requirement Planning (not holding optimum inventory level)					
3	Physical and System balance inventory discrepancy					
4	Long Lead of aircraft parts and components					
5	Complexity and delay in approval and procurement					

	processes					
6	Procuring parts from unreliable and undependable sources in terms of lead time & product quality					
7	Logistics delay in shipments handling					
8	Lack of automated inventory management and material requirement planning system					
9	Shipment hold up from vendor side due to unpaid overdue invoices					
10	Long turnaround time of foreign repaired components					

Final Thoughts

1. How do you describe the role of MRO supply chain integration & Inventory Management in improving flight dispatch reliability?

2. In your view, how do you describe the current level of integration between MRO services and aircraft suppliers such as Boeing &Airbus?

Thank you

Appendix B - Interview Questions for key informants

1. In your view, how do you describe the importance of internal integration among MRO supply chain functions so as to improve flight dispatch reliability? In your view, how do you rate the level of integration between different function within Ethiopian MRO? Integration between which MRO functions is poor?
2. Do you think inventory being out of stock is the major causes for flight delay and flight cancellation? If your answer is Yes-in your view, what are the major causes for part being of stock?
3. How could you describe the importance of supplier relationship management to improve flight dispatch reliability of Ethiopian Airlines?

Thank You