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CREW SCHEDULING: The case of the New Schedule of Ethiopian Airlines

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CERTIFICATE OF ORIGINALITY

This is to certify that the project titled **“Crew Scheduling: The Case of the New Schedule of Ethiopian Airlines”** is an original work of the Student and is being submitted in partial fulfillment for the award of the Master’s Degree in Business Administration of Indira Gandhi National Open University. This report has not been submitted earlier either to this University or to any other University/Institution for the fulfillment of the requirement of a course of study.

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ABSTRACT

Crew scheduling is one of the vital but sensitive area in airlines operations for its dire consequences on all other activities. On one hand, flights are disrupted when schedules fail to be efficient. On the other hand, schedules highly affect the economic status of the airline as crew costs constitute the second largest expenses of an airline only next to fuels. Scheduling is a very challenging task for other reasons such as difficulty to meet the objective of meeting the business interest of the airline without infringing upon the diverse personal needs of each crew member. There are also so many constraints to be considered like collective agreement as well as national and international aviation policies and regulations. Various researches have been undertaken to tackle the airline crew scheduling problem for the last forty years. Despite the efforts, review of literature in the area suggests that crew scheduling is still a major problem in the airline industry. This paper aims to assess the practices of the Ethiopian Airlines (EAL), specifically, the new scheduling system. The research is designed in such a way that data is gathered from crew members, personnel and documents. The findings show that pairing doesn't allow flight crew members a minimum number of hours of rest between duties. Besides, a great percentage of crew believe the load is not acceptable. Overall, the result of the research has provided evidence on the need to revisit the scheduling process in general and the pairing aspect in particular.

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LIST OF ABBREVIATIONS AND ACRONYMS

BASA	Bilateral Air Service Agreement
BATA	Bilateral Air Transport Agreements
DOO	Day of Operations
EAE	Ethiopian Airports Enterprise
EAL	Ethiopian Airlines
ECAA	Ethiopian Civil Aviation Authority
ECARAS	Ethiopian Civil Aviation Rules and Standards
FAA	Federal Aviation Administration
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILO	International Labour Organization
KLM	Koninklijke Luchtvaart Maatschappij (Royal Dutch Airlines)
KQ	Kenya Airways
MRO	Maintenance, Repair and Overhaul
NPComplete	Nondeterministic Polynonial
SAS	Scandinavian Airlines
SPSS	Statistical Package for the Social Sciences
TAFB	Time Away From Base
US	United States
USD	United States Dollar

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

1.1.1 Conceptual Background

Airlines operations and research communities have tried to come up with efficient and effective methods for solving crew scheduling problems (Bodin et al, 1983). Scheduling aircraft is the first stage in solving the airline scheduling problem (Etschmaier and Mathaisel, 1985). This involves constructing timetables and allocating aircraft to these timetables to have a flight schedule (David, 1992).

Finding a good quality solution to this problem is beneficial and important to airlines. Unfortunately, the problem is difficult to solve optimally because of the stochastic nature of many of the inputs such as demand, fleet assignment, and aircraft routing problems.

Most airlines use simplified manual or heuristic techniques based on only a few of the possible inputs or variables to create a flight schedule to match demand and minimize some aircraft costs. A number of mathematical programming techniques have been developed recently to solve this problem more effectively (Balakrishnan et al., 1990; Subramanian et al., 1994 and Day and Ryan, 1997).

There are different variables to be considered in the preparation of schedules which emanates mostly from the various rules and regulations applied in the industry. The variables that limit the construction of schedules include rest periods, flight time limitations, and spread between breaks. Some of the types of restrictions that are typical in the industry are the following:

- Within a duty period, there are prescribed maximum and minimum sit times between flight segments called max-sit and min-sit, respectively. The elapsed time of a duty period including the brief and debrief periods called elapse must be less than a maximum allowable value called max-elapse. The total number of hours of actual flying time called fly in a duty period cannot be greater than a maximum value called max-fly. Legal paring may be composed of up to a maximum number of duty periods called max-duties. Pairing must allow a minimum number of hours of rest between duties, called min-rest. In some cases, for instance, when a duty violates max-fly or a previous rest was shorter than min-res; a longer compensatory rest may be required.

- Contractual obligations also require that the total flying be divided among the flight crews at different crew bases. These crew base constraints require that the total amount of flying in hours assigned to crews from a given crew base must be within a specified interval. These restrictions ensure that crews at the various bases will all have the opportunity to receive credit for approximately the same number of hours of work of each month in the form of monthly or weekly rest periods. Each employee is entitled to a certain monthly or weekly rest period and the schedule should allow employees to exercise it (Vance et al., 1997).

Crew scheduling is one of the challenging aspects in planning. Traditionally, airlines usually used to begin by solving a schedule design problem first, in which they determine the flights to be flown during a given airline crew scheduling time period. Second, they solve the fleet assignment problem in which they decide what type of aircraft to assign to each flight. Third, the maintenance routing problem follows whereby individual aircrafts are assigned to flights so as to ensure that each aircraft spends adequate time at specific airports in order to undergo routine maintenance checks. Fourth, the airlines addresses the problem of scheduling crews (Vance et al, 1997).

The airline industry used to traditionally take a sequential approach to scheduling aircraft and crews. Accordingly, after the schedule design and fleet assignment are completed, the aircraft routing problem generates generic aircraft routes. These routes are generally constructed feasibly with respect to only the most frequent maintenance requirements.

In the crew pairing problem, generic pairings are generated so as to minimize crew costs respecting crew rules. In the crew rostering problem, the pairings are put together to form monthly rosters. The tail assignment problem is solved only a few days before the day of operation. Individual aircraft are assigned to the generic routes generated in the aircraft routing problem afterwards. Maintenance requirements are considered and the planner makes sure that routes are feasible (Vance et al., 2003).

Different writers approach the problem of crew scheduling in different ways by using one or more of mathematical models and with different assumptions. (Michel Gamache etal, 1999) listed out the various articles which discussed the general solution approaches in constructing monthly schedules for airline crews under the following six groups:

a) Rosters are constructed by assigning high-priority activities to high-priority employees as cited in Glanert (1984) and Marchettini (1980).

b) A series of assignment problems is solved. Employee rosters are thus constructed day-by-day as cited in Nicoletti (1975), Buhr (1978), Tingley (1979), and Sarra (1988).

c) Monthly rosters are constructed sequentially for individual crew members, one after another. Once constructed, each employee's roster does not change as cited in Moore et al. (1978) and Byrne (1988).

d) The two preceding methods are combined: an initial step sequentially constructs employee rosters (c) that are then re-optimized day-by-day in a second step (b) as cited in Giafferri et al (1982).

e) The rostering problem is modeled as a generalized set partitioning problem. To solve it, a heuristic is first used to generate a priori a set of feasible rosters for each employeeas cited in Ryan (1992), and additional details are given in Ryan and Falkner and Michel Gamache et al (1999).

f) The linear relaxation of the generalized set partitioning problem is solved by column generation; an integer solution is then obtained by branch-and-bound. The solution method and the sub problem modeling are presented in Gamache and Soumis and Michel Gamache et al (1999).

Michel Gamache et al (1999) and others also evaluated the above mentioned approaches. Accordingly, the first four methods have the advantage of being easy to implement as they are based on well-documented, standard algorithms and heuristics. They also simplify part of the planners' task by computerizing it.

Despite the aforesaid traditions, recent changes in paradigms have witnessed the dominance of integrated approaches in scheduling using more than one aspect of the issues dealt with in phases or steps. A more recent approach in scheduling integrates aircraft routing, crew pairing, and crew rostering in one (Ruther et al, 2010).

Ruther et al, (2013) propose a new integrated approach to aircraft routing, crew pairing and crew rostering. They consider the long lapse in time as a constraint for the traditional and sequential methods used in scheduling. The refute the traditional approach that the actual circumstances do not often unfold according to the assumptions made in planningresulting in costly adjustments on the day of operations (DOO). They propose a new paradigm suggesting an alternative way of managing crew and aircraft planning, to take advantage of the more accurate information available close to the DOO. They claim this paradigm allows aircraft routes and pairings to be designed based on more up-to-date information. They favor the option of increasing robustness of the resulting schedule by solving an integrated problem.

This study assesses the new scheduling system if aircraft routes and pairings are designed based on up-to-date information to increase robustness in an integrated way.

1.1.2 Background of Ethiopian Airlines

Ethiopian Airlines (EAL) was established on December 30, 1945. It started operation on April 8, 1946. Currently, EAL has 61 international and 17 domestic destinations. Its headquarters is in Bole International Airport, which is located in Addis Ababa, Ethiopia.

EAL serves as the national carrier. It is wholly owned by the Government of Ethiopia. Bole International Airport is the hub of EAL. The company flies to more destinations in Africa than any other airline. Likewise, it is one of the Sub-Saharan African profitable airlines, as well as one the fastest growing airlines in the industry. The airline's cargo division has been awarded The African Cargo Airline of the Year in early 2011 and 2012.

Under Skytrax's five-star ranking system, Ethiopian's service merits three stars. Ethiopian is a member of the **Star Alliance since** 2011 and the African Airlines Association since 1968(http://www.staralliance.com/en/about/airlines/ethiopian_airlines/Downloaded on March 20, 2014).

During the past sixty plus years, Ethiopian has become one of the continent's leading carriers, unrivalled in Africa for efficiency and operational success, turning profits for almost all the years of its existence.

Spearheading operation with technology, it has also become one of Ethiopia's major industries and a veritable institution in Africa. It commands a lion's share of the Pan African network including the only daily east-west flight across the continent. In addition to this, it is working diligently to make the Ethiopian Aviation Academy the leading aviation academy in Africa. Ethiopian is one of the airlines, in the world, operating the newest and youngest fleets including the recently introduced Boing Dreamliner 787 (http://www.tadias.com/12/12/2011/ethiopia-boeing-787-dreamliner-touches-down-in-africa-for-first-time/).

The **vision** of EAL is to be the most competitive and leading aviation group in Africa by providing safe, market driven and customer focused passenger and cargo transport, aviation training, flight catering, MRO and ground services by 2025.

EAL's **mission** is to become the leading Aviation group in Africa by providing safe and reliable passenger and cargo transport, aviation training, flight catering, MRO and ground services whose quality and price “value proposition” is always better than its competitors and to ensure being an airline of choice to its customers, employer of choice to its employees and an investment of choice to its owner, moreover, to contribute positively to socio economic development of Ethiopia in particular and the countries it operates in general by undertaking its corporate social responsibilities and providing vital global air connectivity.

With regard to human resources, 29% of the employees are engaged in Marketing and Sales and 28% of the employees are engaged in Maintenance and Engineering. The Cabin Crew and Cockpit Crew consist 12% and 6% respectively. 25% of the employees constitute other departments (http://www.ethiopianairlines.com).

The new scheduling system of the Ethiopian Airlines was put in place in October 2008.

1.2 Rationale of the Study

Any organization using valuable resources and employing a large number of staff faces the problem of ensuring the efficient and productive utilization of both resources and staff. As such, optimum allocation of limited resources is required to achieve objectives of maximizing profit or minimizing the cost of organizations. However, allocation of resources is not an easy task and is a general problem of interest in many situations in reality. One of such problem areas is scheduling.

Different methods and techniques, both scientific and non-scientific, have been employed to make scheduling decisions. Scheduling generally involves deciding how tasks are to be performed and how these tasks are to be allocated to each member of the organization over some period of time (Paul R. Day et al., 1997).

Scheduling is a prevalent function throughout many industries and applications. Scheduling involves accomplishing a number of tasks that tie up various resources for a period of time.

A scheduling problem can be defined as a set of constraints to satisfy. A solution to the scheduling problem is a set of compatible schedule decisions that guarantee the satisfaction of the constraints (Noronha and Sarma, 1991). The order in which decisions must be made needs to be determined (Jay Liebowitz et al., 1997).

The name **"crew scheduling problem"** is often used to indicate a variety of scheduling problems in freight transport and mass transit industries (e.g., airline, bus, and railway industry) that may differ in the objective function and in the duty constraints, such as union contract, company regulation, etc (A. Mingozzi et al., 1999).

The airline scheduling problem involves timetabling flights and scheduling both aircraft and crew (i.e., pilots, copilots, and flight attendants) to these flights and other miscellaneous duties (Paul R. Day et al., 1997).

Apparently, one of the areas of concern in the airline industry is the problem of airline crew scheduling. The scheduling of air crews is a problem that has attracted considerable attention from both airlines and the scientific community. This is because of the fact that air crews are amongst the most valuable of airline resources and efficient utilization of crews is obviously an important consideration in airline operations. Besides, next to fuel costs, crew expense represents the largest expense component to an airline (Glenn W. Graves et al., 1993).To increase profits, airlines continually look for ways to better use their resources and to improve scheduling decisions.

Airlines spent a lot of money on crews. For example, American Airlines spent $1.3 billion in 1991 as mentioned in Anbil and also United Airlines spent $0.6 billion in 1993 as cited in Graves. Graves also cited, combined crew costs involve billions of dollars of investment, second only to fuel costs among all airline costs, giving airlines incentives to efficiently use their crew resources (Glenn W. Graves et al.' 1993; Joyce W.Yen et al.). When schedules become disrupted, the potential for even more scheduling inefficiencies increases (Glenn W. Graves et al., 1993; Ulrich Dorndor et al., 2007).

As crew members (pilots and flight attendants) are critical backbone for the success of the airline, EAL needs to ensure optimum utilization of its crew members to meet challenges, comply with binding legal requirements emanating from collective agreements, civil aviation authority and International Labour Organization (ILO), and minimize costs. This could only be achieved if the organization bases its decision on practical research. In view of this, this proposal is developed to conduct a study on the effectiveness of the new crew scheduling system put in place by Ethiopian Airlines.

1.3 Statement of the Problem

All organizations use resources to meet their objectives. These resources could be categorized into two: **human and non-human**. Human resources are employees, skills and knowledge. Business cannot function without these human resources (Kinard 1988:5).

The effectiveness and efficiency of human resources is dependent on the way they are deployed to meet organizational objectives on a daily basis. Often, large organizations perform these using schedules. As such, scheduling plays a pivotal role in the optimum utilizations of resources: both human and non-human.

Organizations need a properly designed and maintained system of schedules to ensure long-term survival and cope up with competitive pressures. After all, human resource is a strategic input to create competitive advantages.

In airline industry, the assignment of crew problems deals with constructing personalized schedules that assign pairings, day off, vacation and other activities in airline crew members in which the tasks are to be performed so that the available resources are most efficiently used (in some defined sense) to perform the specified tasks with minimum costs.

The crew scheduling problem tends to be complex since each member in a crew may be qualified to serve on more than one type of aircraft. The problem involves a careful allocation of the available crews among the various routes (flights) so that minimum cost is achieved while satisfying the restrictions dictated by the collective bargaining agreements and the Civil Aviation Authority. As per my preliminary discussions with some staff members, many crew members have left the organization immediately after the implementation of the new scheduling system as their level of dissatisfaction has increased.

In addition to the aforementioned challenges, Ethiopian airlines is also expected to comply with **national and international rules and regulations from government, labor unions and organizations** such as the ILO to meet the minimum criteria of conditions of work and pay systems. To this end, research has to be conducted to make assessment of the prevailing situations on the ground and see alternative solutions to solve problems, if any. In view of the above issues of concern and problems, EAL needs to assess its status. This paper considers the proper investigation and analysis of the new airline crew allocation and scheduling system put in place by the Ethiopian Airlines on October 2008.

1.4 Research Questions

The research seeks to assess the status of the new crew scheduling system of EAL. It seeks to answer main and specific questions.

1.4.1 Main Questions

The main question that the research seeks to answer is how the new scheduling system is undertaken by making assessment of the current practice.

1.4.2 Specific Questions

The specific questions of the research are the following question:

- What is the new crew scheduling system followed by Ethiopian Airlines?
- Is the new crew scheduling system followed by Ethiopian Airlines reliable and efficient?
- What are the variables and factors considered by Ethiopian Airlines in scheduling crews to flights?
- What is the scheduling method used by the company?
- What suggestions will help Ethiopian Airlines to implement a more stable and predictable scheduling system?
- What are the various factors to be considered in crew scheduling for optimum allocation of crew members to flights?
- What are the opportunities and challenges faced by Ethiopian Airlines and its crew members from the introduction of the new scheduling system?

1.5 Research Objectives

The research has main and specific objectives:

1.5.1 Main Objective:

The main objective of the research is to assess the practices of EAL scheduling system.

1.5.2 Specific Objectives

The specific objectives of the research are to:

- Assess the new crew scheduling system of Ethiopian Airlines with regards to its reliability and efficiency.
- Identify the variables and factors considered in scheduling crews to flights and assess their application.
- Identify the scheduling method used by the company, and based on the result, give suggestions which help the Company to come up with a more stable and predictable scheduling system.
- Explore the various factors to be considered in crew scheduling for optimum allocation of crew members to flights.
- Find out the opportunities and challenges faced by both Ethiopian Airlines and its crew members because of the introduction of the new scheduling system.

1.6 Scope and Limitation of the Study

This study basically focuses on investigation of Ethiopian Airlines new crew scheduling system and is specifically concerned with the investigation of cabin crew scheduling system. The scope of the study will be limited to checking the cabin crew scheduling system with actual schedules of employees who have been assigned using the new scheduling system.

The research planned to analyze schedules and rosters. However; the researcher was unable to receive any schedule or roster. Besides, the rules and policies of the Ethiopian Civil Aviation Authority were not accessible.

As the new scheduling is a relatively recent phenomenon, research has not been widely undertaken on the subject. As a result, shortage of information sources on the topic is expected.

1.7 Significance of the Study

The wide usage of scheduling to respond to changes in general and the launching of new scheduling system at the EAL in particular make the study desirable. Studying the new scheduling system and related issues gives vital input for future decisions on Scheduling for the betterment of service. The study will also have implication for human resource practitioners to improve the scheduling system.

Recent developments in scheduling indicate that scheduling services will continue to go through dynamic changes as it has impact on retention of staff and attraction of competent and capable personnel. As such, scheduling is a major area of change that attempts to keep the momentum and growth of the airline industry day-by-day.

It is believed that the research will provide insightful information for planning the development of an effective and efficient scheduling system, if the current system is failing, and helps devise a strategy to address the growing and dynamic needs and demands of fliers and personnel and control turnover.

The contribution of the study to theory and practice also includes helping management to plan change based on input from assessment of the existing scheduling system. This enables improvement and intervention based on concrete data on how efficient and effective the current system is. It also helps to motivate other researchers to undertake study on the area of management science topics such as scheduling and follow their application in the EAL. Besides, the EAL can use the study or the recommendation as a base to improve operation after carefully evaluating its impact.

1.8 Organization of the Study

Structurally, the study is divided into five chapters. The first chapter gives introduction. Under this chapter, definitions and terminologies of scheduling and related issues will be explained. The second chapter covers the theoretical and conceptual literature review such as problems of scheduling, national and international labor laws and standards. This chapter also dwells on the trend with regard methods of Scheduling. The third chapter deals with research methodology. The fourth chapter makes data analysis and presents results and discussions. Finally, the fifth chapter gives conclusion and recommendations.

1.9 Definition of Terms

The airline industry frequently uses some terms. Researchers (Noronha and Sarma (1991) and Vance et al. (1997)) define and explain scheduling and other related terms and they are compiled as follows:

Bidline:isa monthly schedule is called a bidline (or roster) for the crew. It is called bidlinebecause pilots can bid on the generated lines based on seniority and other considerations.

Compensatory rest:isa rest that is required when a duty violates max-fly or a previous rest was shorter than min-res.

Crew base:is a city where crews are stationed.

Crew scheduling:is the problem of assigning a group of workers (a crew) to a set of tasks.

Deadhead: isa pairing in a flight in which the crew flies as passengers. It is typically used toreposition a crew to a city where they are needed to cover a flight, or to enable the crew to return to their base at the end of a pairing.

Deadhead:is to reposition a crew from one base to another base, a pairing in a flight in which a crew flies as passengers and this kind of flight is called deadhead. Generally deadheads are used to transport a crew where they are needed to cover a flight or to return to their home base.

Deadheading:istransporting crew members as passengers.

Duty period:isa single workday for a crew. It consists of a sequence of flight legs with short rest periods or sits separating them including brief and debrief periods at the beginning and end of the duty period respectively. Note that the same crew members typically stay together throughout the duration of a duty period.A duty period consists of a sequence of flight legs with short rest periods or sits separating them. Also included in the duty period are brief and debrief periods at the beginning and end of the duty period respectively. A duty period can be viewed as a single workday for the crew that is sandwiched between two overnight rest periods. Within a duty period there are prescribed maximum and minimum sit times between flight legs called maxsit and minsit respectively.

Elapse:is defined as the elapsed time of a duty period including the brief and debrief periods.

Flight leg or Segment: is a single nonstop flight.

Fly in a duty period: is the total number of hours of actual flying time called fly in a duty period. It cannot be greater than a maximum value called max-fly

Flying time:is defined as the total number of hours of actual flying time.

Time away from base (TAFB) is defined as the total elapsed time including the overnight rests between duty periods in a pairing.

Layovers: is staying at a city other than the home base.

A Leg: is an individual flight segment.

Max-duties: is a maximum number of duty periods in a (that constitute) legal pairing.

Max-elapse: is a maximum allowable value of elapsed time of a duty period including the brief and debrief periods called elapse.

Max-fly: is the maximum value in a total number of hours of actual flying time called fly in a duty period. The total number of hours of actual flying cannot be greater than max-fly.

Max-sit: is a prescribed maximum sit times between flight segments.

Min-sit: is a prescribed minimum sit times between flight segments.

Min-rest: is a minimum allowable number of hours of rest between duties that often results from paining.

Pairing: is a sequence of duty periods or combination of legs with overnight rests or layovers inbetween beginning and ending at the same crew base, which are the cities where crews are stationed.Often a duty period starts and ends at different airports. Therefore, the crew cannot always return home at the end of a duty period but instead must often layover until the next day's duty period begins. Typically, crews spend anywhere from one to five days in a row away from home. In general, a crew will stay together for all of the duties within a pairing.A pairing can also be viewed as a sequence of duty periods with overnight rests between them. Each pairing begin and end at the same crew base, which is where the crew is stationed. In some cases the crew can fly as passengers in a pairing. This type of flight is called a deadhead. Deadheads are typically used to reposition a crew to a city where they are needed to cover a flight, or to enable the crew to return to their base at the end of a pairing.

Rest periods: is a prescribed maximum and minimum sit times between flight segments called max-sit and min-sit.

Schedule: is a set of pairings that covers all of the legs exactly once (or at least once if deadheading (flying without working) is allowed.It is simply a sequence of pairings with periods of time off in between.

Scheduling:involves accomplishing a number of things that tie up various resources for a period of time.

Time-away-from-base (TAFB) is the maximum elapsed time of a pairing.

CHAPTER TWO: LITERATUR REVIEW

This chapter is organized in sixsections. The first section deals with literature on schedules and scheduling.Itreviews literature on airline crew scheduling. It also discusses about the role and impact of scheduling on efficiency and effectiveness in services. Various researchers have stated that crew scheduling is an important aspect of the airline industry that attracts focus for research. The section discusses the economic importance of doing scheduling and its impact and challenges on other activities or operations of the airline industry. The second section discusses methods in scheduling/rostering.The third section covers an overview rules such as governmental work rules, collective agreements, and international legal requirements and standards with reference to the scheduling system in the Ethiopian Airlines. The fourth section dwells on models. Specifically, it discusses mathematical programming models and heuristics approach and procedures in crew scheduling. The fifth section focuses on variables considered in solving crew scheduling problems. It discusses the scheduling problem. Scheduling has been one of the most important and key function of different airlines. Each has tried to solve the problem of crew scheduling in different ways considering various variables.The sixth part gives an overview of theapproaches in solving scheduling problems.

2.1Schedules and Scheduling

A schedule is a set of pairings that covers all of the legs exactly once (or at least once if deadheading (flying without working) is allowed. It is simply a sequence of pairings with periods of time off in between (Noronha and Sarma (1991) and Vance et al. (1997).

Schedules and other building blocks such as pairings are different. Their key difference is that schedules are associated with individual crew members, rather than complete crews. The reason is that each crew member has different needs for time-off throughout the schedule period, which is typically a month. These include vacation time, training time, etc. Thus, in assigning crew schedules, we must take into account the needs and preferences of individual crew members in addition to those of the airline (Noronha and Sarma (1991) and Vance et al. (1997).

Considering the key differences, the cost of a schedule is quite different from the other components. The focus within duties and pairings is on actual labor costs. The cost of a schedule is considered to be more of a function of crew satisfaction and of workload balance.

Vance et al. (1997) define crew scheduling as follows:

> Crew scheduling can be defined as the problem of assigning a group of workers (a crew) to a set of tasks. The crews are typically interchangeable, although in some cases different crews possess different characteristics that affect which subsets of tasks they can complete.

Crew scheduling problems may be categorized as bus and rail transit, truck and rail freight transport and freight and passenger air transportation. Various researches have been undertaken with focus on each depending on the choice of the researcher. However; Vance et al (1997) stress that crew scheduling of the airline industry has received the greatest level of attention from the industry and the academic community for the following reasons:

> There are a number of reasons for focusing on airlines. First, they provide a context for examining many of the elements common to all crew scheduling problems. Second, the airline problem is truly a planning problem in the sense that airlines typically have a fixed schedule that changes at most monthly. Therefore, substantial time and resources can be (and are) allocated to solving it. Third, airline crews receive substantially higher salaries than equivalent personnel in other modes of transportation; the savings associated with an improved airline crew schedule can be quite significant. Finally, a large number of restrictive rules, mandated both by the FAA (or equivalent governing agencies for non-U.S. carriers) and strong labor unions, greatly restrict the set of feasible solutions, making airline crew scheduling one of the hardest crew scheduling problems.

The airline crew scheduling is chosen by many for research. Both the academic and business entities are interested to study the discipline.

2.2Methods in Scheduling and Rostering

There are two major approaches to scheduling: bidding systems and equitability systems. Bidding systems allow crew members to bid for certain structures in their own work schedule. Bids are then normalized in order of decreasing seniority in the crew rank (Paul R. Day and David M. Ryan, 1997).

Bidding systems are further divided into two: Preferential Bidding or Bid Line approach.Preferential Bidding allows crew members to bid for particular duties, whereas the Bid Line approach requires crew members to bid for particular complete lines-of-work called bid lines. These bid lines are complete work schedules created to satisfy regulations and provide adequate staffing for all scheduled flights needs.

In both preferential bidding and bid line approaches, the roster construction procedure is usually based on simple greedy sequential heuristic methods. It is expected that bidding systems lead to in-equitability within the crew ranks and often require the use of reserve crews to carry out those duties (open flying) that cannot be assigned during the construction of the roster (Paul R. Day and David M. Ryan, 1997).

Equitability systemsbuild schedules that attempt to distribute the work content more evenly or fairly to crew members according to their ranks. However; achieving an equitable roster is still difficult due to attain due to combinatorial complexity. Most airlines requiring equitable rosters use heuristic methods.Despite this; however, this approach still leads to some in-equitability (or even infeasibility) within the roster, and this choice doesn’t use crew members productively (Paul R. Day and David M. Ryan, 1997).

In December 2009, The Navtech, Inc., a company specializing in flight operations software and services, and Delta Air Lines, the then world's largest airline, completed the airline's transition to Navtech's Preferential Bidding System (PBS), enabling this crew rostering tool to be used by all Delta pilots for their January 2010 scheduling. This was the largest installed base of users for the Navtech PBS - close to 11,000 pilots, including 4,500 from the former Northwest Airlines (NWA). PBS consisted of scheduling and bidding components and is best known for its ability to balance needs of airlines with quality of life requirements of crew. Delta has used Navtech PBS since 2005. It expanded its use to crew members of the former NWA after an evaluation of multiple products by Delta/NWA pilot groups and airline management. Live bidding with Navtech PBS began in August for NW's September pilot's schedule, going enterprise-wide just four months later (http://www.navtech.aero/index/delta_completes_transition_to_new_crew_rostering_software.html)posted in December 09, 2009 and accessed in May 1, 2014).

The Carmen Crew Rostering system was used at several major European airlines including British Airways, KLM, Iberia, Alitalia, and Scandinavian Airlines (SAS) as well as at one of the world's largest passenger transportation company Deutsche Bahn (German State Railways).

2.3 Constraints and Rules –Schedule Requirements and Governmental Work Rules, Collective Agreements and International Legal Requirements and Standards

Crew schedules have to obey a set of rules and regulations in order to be taken as legal. These regulations may emanate from national labor law, international labor law or aviation requirements. Collective Agreements and national and international standards may put restrictions on airlines. Federal, national and international aviation restrictions are often imposed in order to protect the security in air traffic. Additionally, there might also be further agreements among employee unions and the airline. Over all, there are a number of rules to be rigidly fulfilled as constraints.

According Gopalakrishnan and Johnson (2005), for a solution to the crew pairing problem to be considered feasible, the pairings mustobey the Federal Aviation Regulations (FAA) of the US, collective agreement or union contract requirements and other airline specific rules.

Suchrestrictive rules help to reduce the size of the problem but make crew scheduling even more complex. The following are some of the important rules on legal pairings in the US:

Within a duty period there are prescribed maximum and minimum sit times betweenflight legs called *maxsit* and *minsit* respectively. Typical values for maxsit and minsit are4 hours and 45 minutes respectively. The elapsed time in a duty period must be less than anallowable time limit called *maxelapse*, which is usually 12 hours. The total actual flyingtime in a duty must not exceed *maxfly*, which is typically 8 hours. A duty conforming tothese rules is said to be legal or valid. Similarly a valid or legal pairing must satisfy somerules. Legal pairings may be composed of up to a maximum number of duty periodscalled *maxduties*. A pairing must allow a minimum number of hours of rest betweenduties, called *minrest*. This *minrest* may need to be extended when the flying time in atwenty-four hour period exceeds eight hours.

As cited in Kohl and Karisch (2004) such constraints can be classified into horizontal, vertical, and artificial rules as follows.

2.3.1 Horizontal Rules

The majority of these rules are applied only to a single roster instead of considering several rosters or a combination of rosters. Such rules restrict the general compatibility of a crew member based on the task and the time setting for the scheduling. In addition to this, it includes regulations, such as rest time between flight legs, flight duties, and pre-scheduled activities. Off-day patterns for weekly rest periods are also imposed, e.g., after a maximum of up to five working days that can be filled with flight legs, flight duties or pairings, a weekly rest period of two complete off-days (midnight to second next midnight) or 36 consecutive hours is required.

Accumulated values are commonly used to restrict, e.g., the maximum number of flying hours, working hours or takeoffs.

2.3.2 Vertical rules

The second group of rules addresses at least more than one roster in the solution. A typical application for this kind of restriction is that of the crew complement for a certain flight leg. Even though the crew scheduling problem is usually divided by fleet and crew function, some activities may require crew complements with dedicated characteristics. Examples for this kind of constraints are the handling of inexperienced flight personnel, must-fly-together requests, interpersonal incompatibilities, language qualifications, but also flying-below-rank (or downgrading).

2.3.3 Artificial rules

In addition to the above set of rules, artificial rules may be applied in order to enhance the quality solution. They ensure aspects such as robustness against disruptions during the operational phase, e.g., by penalizing valid, but very short rest periods. Also solution methods can be supported by certain penalization strategies that prevent the consideration of valid, but unfavorable solutions (Markus P.Thiel, 2005).

2.4 Mathematical Programming Models and Heuristics in Crew Scheduling

Airlines operations & research communities have tried to come up with efficient and effective methods for solving crew scheduling problems (Bodin et al, 1983). Scheduling aircraft is the first stage in solving the airline scheduling problem (Etschmaier and Mathaisel, 1985). This involves constructing timetables and allocating aircraft to these timetables to have a flight schedule. (David, 1992).

Finding a good quality solution to this problem is beneficial and important to airlines. Unfortunately, the problem is difficult to solve optimally because of the stochastic nature of many of the inputs such as demand, fleet assignment, and aircraft routing problems.

Most airlines use simplified manual or heuristic techniques based on only a few of the possible inputs to create a flight schedule. A number of mathematical programming techniques have been developed over the years to solve this problem more effectively (Balakrishnan et al., 1990; Subramanian et al., 1994, Day and Ryan, 1997, and Ruther et al (2010)). The following is a summary of the major ones:

2.4.1 Dynamic Programming, Integer Programming and Linear Programming

Dynamic programming, integer programming and linear programming are some of the models used to solve crew scheduling problems (Tom M. Cavalier et al., 1986). Most researchers are; however, used to be inclined to use integer programming model for solving problems related with crew scheduling in Airlines and other transportation industries (Kelly Easton et al., and Roy E. Marsten et al., 1979).

Integer programming was effective mechanism for solving a wide variety of difficult combinatorial optimization problems of practical interest. While no technique can solve every instance of such problems quickly, integer programming had been robust and effective enough to play a key role in solving problems in applications such as airline crew scheduling, telecommunications network design, sports scheduling and many other applications.

The size of the problem and the type of the decision variables make it difficult to solve most problems using the standard algorithms available such as linear programming, integer programming and dynamic programming. Some problems are NPcomplete (Nondeterministic Polynomial). Besides, the computational effort to find the optimum solution grows exponentially with the problem size. So in such cases, heuristics are preferred (Kelly Easton et al., and Roy E. Marsten et al., 1979).

2.4.2 **The Heuristic Approach and Procedures**

Early in 300 A.D. Pappas, writing on Euclid, suggested the approach of approximate methods. They are easy to use but do not guarantee optimality. The works of Descartes and Leibniz popularized heuristics. It is allied with logic, philosophy and psychology and has the aim of investigating the methods of invention and discovery. The name was derived from the Greek word heuriskein-to discover. In today's application, heuristic means a method which, on the basis of experience or judgment, seems likely to yield a good solution to a problem but which cannot be guarantee to produce an optimum solution (L. R. Foulds, 1983).

There are four basic strategies in heuristic procedures. Many methods comprise a combination of more than one of these strategies.

2.4.2.1 The Construction Strategy - The input for methods is the data which defines a specific instance of the problem. A solution is built up one component at a time. A construction strategy begins by examining this data. It then attempts to identify an element which is likely to be a valuable part of a very good final solution. Successive additional elements of a solution are added afterwards. The better construction heuristics employ a kind of 'look-ahead' mechanism. That is, additions are made, not just because they appear a good idea at the time, but for they are likely to be of genuine value in the complete solution. Once the final solution has been found, it may be obvious that improvements can be easily effected. The strategy is often applied to the output of the construction method.

2.4.2.2 The Improvement Strategy - theinputs for this method is a solution to the problem. This solution is progressively improved by the application of a series of modifications in the process. Sometimes, it may be impossible to make much progress in this way, and yet the final product may still be far from optimality. As a result, some improvement strategies are far-sighted. Some iterations of the 'improvement' process may actually be allowed to result in a worsening in solution value if it can be seen that this will create a situation where worthwhile gains can be made. This strategy is worthwhile when it is relatively easy to generate starting solutions. A variety of solutions can be used as input and the final result chosen. Sometimes the strategy is used to convert an infeasible solution into a feasible one.

2.4.2.3 The component analysis strategy - Some problems are so large or very complicated that the only practical approach is to break them up into manageable parts. Sometimes these parts or portions are then dealt with independently by heuristics or even algorithms. The solutions for the portions are then combined to form master plan. It may be extremely difficult to piece together the solutions to the different components into an acceptable plan.

If the components can be ordered in some logical sequence, it usually makes sense to examine them in the same order. This ordering is often based on time-scale which is an integral part of the problem. The output of the analysis of one component may be a valuable input for the analysis of later components.

2.4.2.4 The learning strategy - Methods in this strategy often use a tree-search diagram to chart their progress. Specifically, the different options which appear at various stages are represented by different branches of a tree. The sequences of choices made can be traced by a path through the tree. The choice of which branch to take is guided by learning from the outcome of earlier decisions (L. R. Foulds, 1983).

2.5**Variables Considered in Crew Scheduling**

Various variables are taken in to account during preparation of schedules. These are ramifications of the rules and regulations applied in the airline industry. These are constraints that include rest periods, flight time limitations, and spread between breaks. Some of the types of restrictions that are typical in the industry are the following:

In a duty period, there are prescribed maximum and minimum sit timesbetween flight segments called max-sit and min-sit, respectively. The elapsed time of a duty period including the brief and debrief periods called elapse must be less than a maximum allowable value called max-elapse. The total number of hours of actual flying time called fly in a duty period cannot be greater than a maximum value called max-fly. Legal pairing may be composed of up to a maximum number of duty periods called max-duties. Pairing must allow a minimum number of hours of rest between duties, called min-rest. In some cases, for instance, when a duty violates max-fly or a previous rest was shorter than min-res; a longer compensatory rest may be required.

There are also contractual obligations that require that the total flying be divided among the flight crews at different crew bases. These crew base constraints require that the total amount of flying in hours assigned to crews from a given crew base must be within a specified interval.

These constraints and restrictions ensure that crews at the various bases will all have the opportunity to receive credit for approximately the same number of hours of work of each month - Monthly (weekly) rest periods. Each employee is entitled to a certain monthly (weekly) rest period and the schedule should allow employees to exercise it (Vance et al., 1997).

2.6**Approaches Used in Solving Crew Scheduling Problems**

Crew scheduling is one of the challenging aspects in planning by airlines. In the traditional approach, airlines usually begin by solving a schedule design problem, in which they determine the flights to be flown during a given airline crew scheduling time period. Next comes the fleet assignment problem in which they decide what type of aircraft (such as Boeing 767, 727 etc.) to assign to each flight, as a function of the forecasted demand for that flight. The maintenance routing problem follows whereby individual aircraft are assigned to flights so as to ensure that each aircraft spends adequate time at specific airports in order to undergo routine maintenance checks. After the three tasks, the airlines then address the problem of scheduling crews (Vance et al, 1997). The following figure shows the steps in the traditional scheduling process:

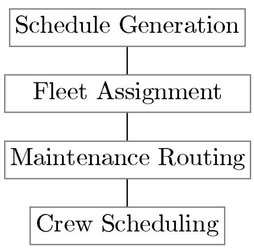


Fig. Z Schedule Planning

As explained above, the airline industry used to traditionally take a sequential approach to scheduling aircraft and crews. Accordingly, after the schedule design and fleet assignment stages are completed, the aircraft routing problem generates generic aircraft routes, i.e. sequences of flights, each to be known by a single (as yet unspecified) aircraft. These routes are generally constructed feasibly with respect to only the most frequent maintenance requirements, since the scheduling of less frequent maintenance is tail-dependent (it depends on the specific, individual, aircraft, and its maintenance history) (Vance et al, 1997).

Gopalakrishnan and Johnson (2005) divide the planning into five stages, unlike Vance etal (1997) who make it four as explained above. According to these authors, the five stages of airline planning are Schedule Development, Fleet Assignment, Aircraft Routing, Crew Scheduling and Crew Assignment. They state that , ideally all five problems should be solved as a single problem, even though they admit that this may not be feasible computationally. They reckon that it may be possible to combine some of the more closely related stages in airline planning. The five stages of planning are explained as follows:

1. Flight Schedule – all flights are constructed based on market demands for the flight segments. For example, flights may be scheduled to Washington DC, Dulles Airport, Monday, Wednesday, Saturday departing 9:00 am.
2. Fleet Assignment – available aircrafts are assigned to flight legs. Here, the objective is to maximize revenue with the constraint that requires all the flight legs to be flown using the fleet that is available. Several other constraints also have to be satisfied too.
3. Aircraft Routing - involves the routing of aircraft such that maintenance constraints are satisfied, all flights flown by the fleet are covered and revenues are maximized.
4. Crew Pairings – a sequence of flight legs or segments are constructed that begin and end at a crew base such that in a sequence the arrival city of a flight leg coincides with the departure city of the next flight leg with the objective of finding a subset of these pairings

with minimal cost that covers all the flight legs in the schedule exactly once (sometimes more than once depending on the model used for this stage). This is referred to by some as a trip or rotation.

5. Bidlines/Rosters – developing a monthly schedule that can be flown by the crewis drawn using the optimal set of pairings generated from the previous stage. A monthly schedule is called a bidline (or roster) for the crew. It is called bidline for the reason that pilots can bid on the generated lines based on seniority and other considerations. It is to be noted that thisstage determines the exact number of cockpit crewmembers that the airline will requirefor the month. Each bidline/roster must satisfy several constraints similar tothe previous two stages.

The last two stages in airline planning are usually referred to by a common name - airline crew scheduling.The crew scheduling process begins with the daily crew-pairing optimization problem.

In the daily problem, all flight legs are assumed to be flown every day. After solvingthe daily problem, adjustments are made for weekly exceptions and crew base balancing.

Once pairings are found that exactly cover every flight leg for the month, bid lines orrosters are made up for the month and are assigned by a bidding process to crewmembers.

Klabjan et al. (2002), have addressed this problem by considering a partial integration of schedule planning, aircraft routing and crew scheduling. Freling, Huisman, and Wagelmans (2000) discuss models and algorithms for integrating vehicle and crew scheduling.

Integration of the fleet assignment and crew scheduling problems in airline planning have also been attempted. It is estimated that by integrating crew and aircraft planning the airline industrycould save an additional half a billion dollars per year on crew costs alone. Some of the recent work on integrated airline planning have moved a step closer to achieving the dream of integrated planning.

Ruther et al (2013) describe the crew scheduling problem as follows:

> In the crew pairing problem, generic pairings are generated so as to minimizecrew costs while respecting all crew rules. In the crew rostering problem, the pairings are puttogether to form monthly rosters for specific crews. A few days before the day of operations, thetail assignment problem is solved. Individual aircraft are assigned to the generic routes generatedin the aircraft routing problem. The planner needs to ensure that routes are feasible withrespect to all maintenance requirements, taking into account the actual location, maintenanceand flying history of an aircraft at the beginning of the planning horizon, and as a consequencemay need to make adjustments to the generic routes.

However; recent changes in paradigms have witnessed the dominance of integrated approaches using more than one aspect of the issues dealt with in phases or steps (Ruther, 2010). The following gives an overview of the historical development in this regards.

As cited by Michel Gamache et al (1999):

a) Rosters are constructed by assigning high-priority activities to high-priority employees as cited in Glanert (1984) and Marchettini (1980).

b) A series of assignment problems is solved. Employee rosters are thus constructed day-by-day as cited in Nicoletti (1975), Buhr (1978), Tingley (1979), and Sarra (1988).

c) Monthly rosters are constructed sequentially for individual crew members, one after another. Once constructed, each employee's roster does not change as cited in Moore et al. (1978) and Byrne (1988).

d) The two preceding methods are combined: an initial step sequentially constructs employee rosters (c) that are then re-optimized day-by-day in a second step (b) as cited in Giafferri et al (1982).

e) The rostering problem is modeled as a generalized set partitioning problem. To solve it, a heuristic is first used to generate a priori a set of feasible rosters for each employee as cited in Ryan (1992), and additional details are given in Ryan and Falkner and Michel Gamache et al (1999).

f) The linear relaxation of the generalized set partitioning problem is solved by column generation; an integer solution is then obtained by branch-and-bound. The solution method and the sub problem modeling are presented in Gamache and Soumis and Michel Gamache et al (1999).

Michel Gamache et al (1999) and others also evaluated the above mentioned approaches. Accordingly, the first four methods have the advantage of being easy to implement as they are based on well-documented, standard algorithms and heuristics. They also simplify part of the planners' task by computerizing it.

Most of the traditional methods used in airline scheduling approaches were sequential. To alleviate some of the issues of the sequential airline scheduling approach, several integratedmodels have been developed over the last 15 years (Klabjan et al. 2002) as cited by Ruther (2010) and Ruther et al (2013).The following is an overview of the developments:

- Plane-count constraints were introduced to the crew pairing problem. This ensured feasibilityof the aircraft routing problem under the assumption that maintenance is performed at nightwhen all aircraft are inactive on the ground.
- A number of studies (Cordeau et al., 2001; Mercier et al., 2005; Sandhu and Klabjan, 2007;Mercier and Soumis, 2007; Papadakos, 2009) have applied Benders decomposition toseveral integrated airline scheduling problems. This approach decomposes the integrated problem into smaller individualproblems. The Benders' cuts then act as the linking constraints.
- Cordeau et al. (2001) integratedaircraft routing and crew pairing and introduce constraints that model short connections. Aircraft routingis handled in the master problem and crew pairing in the Benders sub-problem.The sub-problem generates crew pairings using only the currently allowed set of short connections. Both theBenders master and sub-problem are solved by column generation.
- The above model was developed further by Mercier et al. (2005) by introducing the concept of restricted connections.
- Cohn and Barnhart (2003) included aircraft routing decisions in their so-called extended crew pairing model. The authors realized that if aircraft routing is a feasibility problem, the only impact of aircraft routing on the integrated problem is the choice of short

connections. Under this assumption, only a fraction of all aircraft solutions need to be considered, namely those representing unique and maximal short connection sets.

- Mercier and Soumis(2007) further enhanced the model by using flight re-timing, where flights are allowed to depart five minutes earlier or later.
- Sandhu and Klabjan (2007) integrated fleet assignment and crewpairing while also considering some aircraft routing aspects. Plane-count constraints ensured thatat most the number of available aircraft is used, while maintenance requirements are ignored.The model respected that crews are trained for specific aircraft types by requiring that if a pairingis assigned to a crew, all flights in the pairing must be assigned to the correct aircraft type.
- Papadakos (2009) developed a model that fully integratedfleet assignment, aircraft routing, andcrew pairing. According to this model, crews are fleet dependent, requiring a Benders' sub-problem for each crew type.The master problem related information to the sub-problems regarding the current assignmentof flights to fleets and which short and restricted connections were to be used.

A recent trend in airline scheduling attempts to increase solution robustness that is to generateschedules that are less sensitive to disruptions (Ruther et al, 2013). Weide et al.(2010) solved the aircraft routing and the crew pairing problem iteratively. In this model, the algorithm startswith an unconstrained crew pairing problem, followed by an aircraft routing problem whichmaximizes the number of restricted connections that are also used in the current crewing solution. Then, the crew pairing problem simultaneously minimizes crewing cost and penalties assignedto changing aircraft on restricted connections.

As cited by Ruther et al, 2013, Duck et al. (2012) proposed an integrated stochastic aircraft routing andcrew pairing problem that simultaneously minimizes crewing cost and the sum of secondarydelays. Just like Weide et al. (2010), the aircraft routing and the crew pairing problems aresolved iteratively. Similarly, Dunbar et al. (2012) proposed to solve the aircraft routing andcrew pairing problems iteratively.

A more recent approach in scheduling integrates aircraft routing, crew pairing, and crew rostering in one Ruther (2010) and (Ruther et al, 2013). The authors proposed a new integrated approach to aircraft routing, crew pairing and crew rostering. They argue that, traditionally, most stages of planning were carried out weeks or even months in advance of the day of operations, while crew rostering, as the penultimate stage of the planning process, is carried out at least one week before the day of operations. As a result, these long lead times to plan execution give rise to decisions in aircraft routing, crew pairing, and crew rostering that are done using information from estimates and forecasts based on flight operations of previous months and years. Consequently, the actual circumstances do not often unfold according to the assumptions made in planning, resulting in costly adjustments on the day of operations (DOO). Efforts to increase schedule robustness in the planning stage by aligning crew connections to aircraft routes may also not eventuate, as adjustments to aircraft routes in the tail assignment process may change aircraft connections.

Ruther et al (2013) further state that, naturally, information becomes significantly more accurate as the DOO approaches. They propose a new paradigm suggesting an alternative way of managing crew and aircraft planning, to take advantage of the more accurate information available close to the DOO. According to their proposal, whilst crew rosters would still be constructed based on crew pairings as in current approaches, the rosters presented to crew would not necessarily indicate the species of their work periods; the roster would specify periods (corresponding to pairings) in which the crew can anticipate undertaking flying duties, but would not specify the sequence of flights to constitute those duties. Instead, a few days before the DOO, an integrated aircraft routing, crew pairing, and tail assignment problem would be solved, to decide the upcoming flying duties of each crew. Therefore, the crew would be advised only several days in advance of the pairings they are to fly in their upcoming work periods.

Ruther et al (2013) postulate that the integrated planning problem would be solved in a rolling time horizon setting, updating information about the state of the aircraft, crew and schedule each time it is solved. They claim this paradigm allows aircraft routes and pairings to be designed based on more up-to-date information. They favor the option of increasing robustness of the resulting schedule by solving an integrated problem. They justify their proposal that by keeping crew and aircraft on the same connections when the connection time is not long can be included in the optimization objective. Besides they claim to have dealt with the tail assignment process which they claim to have been rarely optimized. They further strengthen their argument by stating that no attempts have been made to integrate tail assignment with crew scheduling,which is not surprising since the traditional sequential approach does not allow this due tothe temporal aspect of each stage.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The research was mainly designed to do **assessment on the new scheduling system of crews to flights of the EAL**. As crew scheduling decision is one of the decisions among other operational decisions of the company, the Ethiopian Airlines crew scheduling system was considered and investigated as a case study.

The research attempted to address issues related with crew scheduling such as the process of scheduling, identifying the variables as well as the rules and regulations considered in determining the crew allocation, the methods applied and evaluating the system from these variables. The standard monthly or weekly hours of work from the organization's and other stakeholders' point of view such as labor law, labor unions, collective agreements and international laws such as that of the ILO were planned to be assessed. Only the rules of THE International Civil Aviation Association (ICAA) and that of other countries, specifically, the United States of America were found.

3.2 Population and Sample Design

The population for the research with regard to employees was the list of active cabin crew members currently working in the EAL (since the new scheduling system was introduced). Fifty crew members were selected using systematic random sampling method.

With regard to the schedules, the population was all the schedules prepared using the new schedule system for the crew members. The above mentioned cabin crew members assignments were reviewed for a specific month by taking some recent schedules. A representative of the staff members involved in scheduling tasks was interviewed.

3.3 Data Type, Collection Methods and Procedures

The data for this research were collected from **primary data sources**namely questionnaires and interviews with crew members and representatives of Ethiopian Airlines including the Scheduling Department in order to get adequate information on the current scheduling.

Secondary data sources such as documents including schedules, rules, regulations or procedures followed by the company, collective agreement, labor union and other supporting documents consulted to prepare the current schedule. Some recent schedules were also reviewed with reference to specific cabin crew members. Document analysis method is used to get data from the sources.

3.4 Data Analysis

The data collected from the **interviews** of sample crew members and the representatives of Ethiopian Airlines including the Scheduling Department were analyzed and presented with the use of **theStatistical Package for the Social Sciences (SPSS)**, which is a predictive analytics software, used to predict with confidence what will happen next to make smarter decisions, solve problems and improve outcomes. The sample cabin crew members were used in the analysis for the determination of various factors such as analyzing **duty hours, load, fairness of assignment, quality of the schedule, and also to test the applicability of the different rules affecting schedule preparation**.

The data obtained from **questionnaires and investigation of secondary data sources**were processed and analyzed to see how the new schedule is prepared and to extract the different variables that are used to construct the current schedule.

Collective agreements were also reviewed and other relevant information gathered from different sources to do the document analysis to triangulate the data obtained from interview and questionnaires.

3.5 Ethical Issues

Data obtained from respondents are kept with high degree of confidentiality. Names and identity of respondents will by no means be disclosed to entities within and outside the EAL.

CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

4.1 Presentation of Data

The research used interview, questionnaire and document analysis to get data on scheduling at the Ethiopian Airlines. The data for this research were collected from both **primary data sources and secondary data.**

An Interview was made with a representative of the crew and a representative of the staff members involved in scheduling. The information obtained from the interviews is presented in **section 4.1.1.**

The questionnaire has two sections. These are Demographic Data and Assessment on how employees view the new scheduling system

The questions were both open-ended and close-ended in form. Close-ended questions were formulated using likert scale. Open-ended questions were used to get any additional comments from the respondents that might not be covered by close-ended questions. The questions were designed to obtain information about how employees view the new schedule of the Ethiopian Airlnes cabin crew members. Respondents were asked to rate their opinion using a 5-point Likert scale ranging from 1= Strongly Disagree, 2= Disagree 3= Neutral (Indifferent) 4=Agree, 5=Strongly Agree

Questionnaires were sent to cabin crew members. Hence, mainly quantitative data was used along with qualitative method employing interview as data collection method for validation of the quantitative method. Data was gathered from 51 cabin crew members.

The study planned to get response from fifty crew member by selecting the sample using systematic random sampling method. Accordingly, fifty six (56) questionnaires were distributed. Fifty three were returned out of which two were wrongly filled-in (with blank answers given to some questions). They were discarded as they may distort the other data. The remaining three were not returned. The result of the response is presented in **section 4.1.2**

The collective agreement between EAL and the labor union of the EAL staff members was analyzed. However; even if the researcher planned to analyze weekly and monthly schedules and rosters of crew members, it was impossible to get. Besides, the rules and policies of the Ethiopian Civil Aviation Authority were not accessible.

The data collected from the **interviews** of sample crew members and the representatives of Ethiopian Airlines including the Scheduling Department were analyzed and presented with the use of **theStatistical Package for the Social Sciences (SPSS)**. The response received from the cabin crew members were used in the analysis of various factors such as analyzing **duty hours, load, fairness of assignment, quality of the schedule.**

The applicability of the different rules affecting schedule preparation were not analyzed as the documents needed for this purpose from the ECAA were not accessible though. The **Collective agreement** between the EAL and the Labor Union was reviewed and other relevant information gathered from different sources to do the document analysis were used to triangulate the data obtained from interview and questionnaires. The result of the document response is presented in **section 4.1.3**

In Summary, both primary and secondary information sources are used. The primary sources of information include people through interview and questionnaire. This was supplemented by document analysis of policies, procedures, agreements and rules. Secondary sources used include research books, research reports and journal articles. The interview, questionnaire and organizational records are thought to triangulate the method.

4.1.1 Interview

International air transport is governed by Bilateral Air Service Agreements (BASAs) between individual countries. BASAs are also referred to as Bilateral Air Transport Agreement (BATAs) and allow air transport services between countries, regulate the airlines that can service specific routes, impose restrictions on traffic rights and approve commercial fares. Ethiopia currently has BASAs with 97 countries – 46 countries in Africa, 22 countries in Europe, 13 countries in the Middle East and Gulf Region, 12 countries in Asia, 2 countries in North America, and 2 countries in Latin America (ECAA 2014).

All air transit activities in Ethiopia are guided by the Ethiopian Civil Aviation Rules and Standards (ECARAS), developed by the ECAA. This document serves as a guideline for all parties in the air transport sector – it addresses policies and procedures, personnel licensing, approved training organizations, aircraft registration and marking, airworthiness, approved maintenance organizations, instruments and equipment, aircraft operations, air operator certification, commercial air transport by foreign air operators within Ethiopia, aerial work and aerodromes (ECAA 2013).

The Ethiopian Airlines transports approximately 4.8 million passengers annually – 76% of the total passengers traveling in Ethiopia (EAL 2013).

The airline also holds an 18% share of all international passenger traffic in Africa (EAL, EAE 2013). Ethiopian transports over 4.6 million internationally passengers annually to and from 79 International destinations – 48 in Africa, 2 in North America, 2 in Latin America, 7 in Europe, 9 in the Middle East and 11 in Asia. EAL generates approximately $1.4 billion USD from international passenger traffic annually (EAL 2013).

The airline operates "the youngest fleet in Africa" with 62 planes, of which 25 are leased. EAL also has an additional 33 aircrafts on order, including 8 additional Boeing 787 Dreamliner jets. With the new order, EAL will operate 13 Dreamliner jets, making the airline the first and most active African operator of the Dreamliner (EAL 2014).

Ethiopian Airlines has developed a set of strategic goals known as "Vision 2025." Under Vision 2025, the airline seeks to become the "most competitive and leading aviation group in Africa." The goals include increasing passenger traffic to 18 million passengers and 90 international destinations. EAL plans to reach those goals by relying on cost leadership, delivering 5 star services and the creation of multi-hubs in Africa. The airline's strategy for new routes is based on their "betting on Africa" focus.

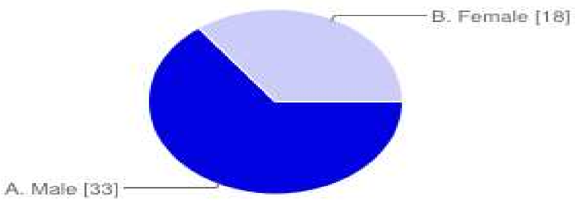
Ethiopia has 19 airports spread across its vast landscape. The domestic routes are serviced mainly by Ethiopian Airlines, the only provider of scheduled domestic flights. Domestic routes account for 6% of EAL's revenue, or approximately $115 million USD (EAL 2012). As domestic travel in Africa is normally prohibitively expensive, EAL introduced a three-tiered pricing model. Non-citizens who travel into Ethiopia with a carrier other than EAL pay the highest rate. Non-citizens who travel into Ethiopia on EAL pay an intermediate rate, and Ethiopians and resident expatriates pay the lowest rate (EAL 2014).

Ethiopian Airlines uses an automated system in scheduling/rostering crews.

4.1.2 Questionnaire

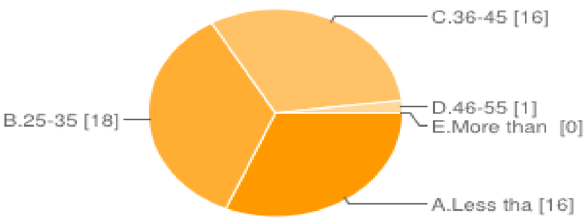
4.1.2.1 Profile of Respondents

1. Gender



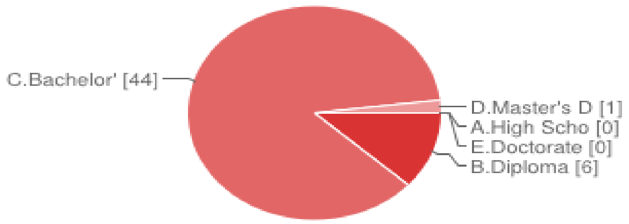
The graph shows that 65% of the respondents are male and 35 percent of the respondents are female.

2. Age



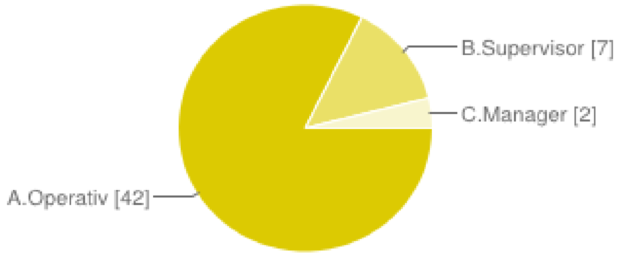
From the graph, the employees aged between 25-35 are 35%, less than 25 are 31%, between 36-45 are also 31%. No cabin crew is aged more than 55 years of age.

3. Highest Level of Education?



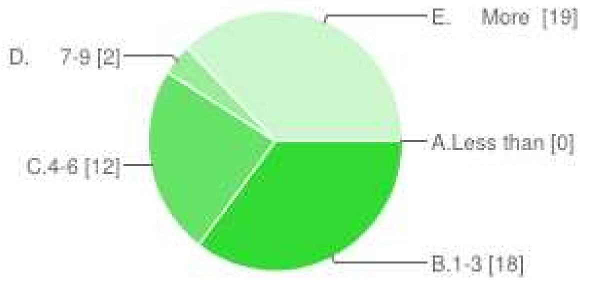
The graph shows that 86 % of the cabin crew members have bachelor's degree followed by diploma (12%) and master's degree (2%). None of them is high school or doctorate graduate.

4. What is your position level?



From the graph, 82% of the cabin crew members are operational employees, 14 % are supervisors and 4% are managers.

5. How long have you worked at your organization?

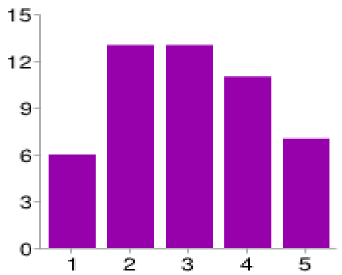


According to the graph, 37% of the cabin crew members studied have worked for more than 10 years. The percentage of employees that worked for the EAL between 1-3 years is 35%. Meanwhile the percentage of those who worked between 7-9 years is 4%.

4.1.2.2 Assessment on how employees view the new scheduling system

Respondents were asked questions that were designed to obtain information about how employees view the new schedule of the Ethiopian Airlines cabin crew members. They were asked to rate their opinion using a 5-point Likert scale ranging from 1= Strongly Disagree, 2= Disagree 3= Neutral (Indifferent) 4=Agree, 5=Strongly Agree. The following is a summary of the responses:

1. **The elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse).**

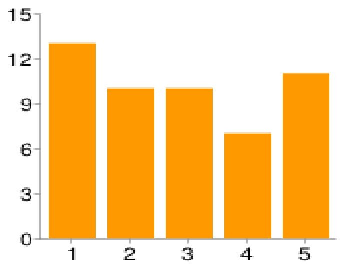


Respondents were asked if the elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse). Out of the total respondents, 26 % disagreed, and again 26% were neutral or indifferent, 22% agreed, 14% strongly agreed and 12% strongly disagreed.

2. **The total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly).**

Cabin crew members were asked their view about the statement: the total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly). 31% strongly disagreed, 14% disagreed, 22% are neutral, 18% agreed and 16% strongly agreed.

3. **Pairing allows flight crew members a minimum number of hours of rest between duties (min-rest).**

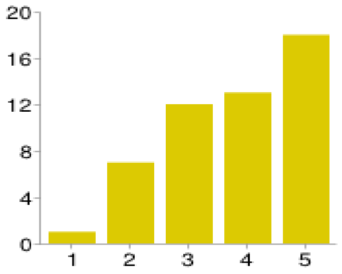


The graph shows that 25% strongly agreed that the pairing allows flight crew members a minimum number of hours of rest between duties (min-rest). Meanwhile, 22% strongly disagreed, 20% agreed, 20% are neutral and 14% agreed.

4. **A longer compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res.**

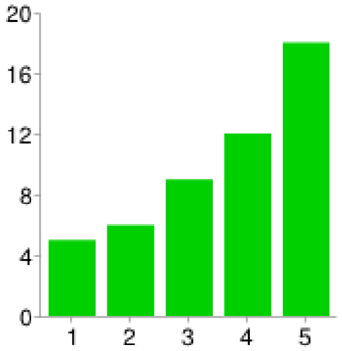
From the graph, only 16% strongly disagreed to the statement a longer compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res. However; 20% disagreed, 20% strongly agreed, 22% agreed and 24% are neutral or indifferent.

5. The total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement).



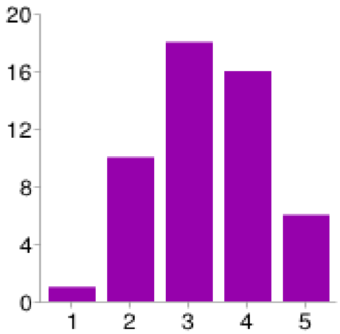
From the graph, only 2% strongly disagreed that the total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement). 35% strongly agreed, 25% agreed, 24% are indifferent or neutral and 13% disagreed.

6. **The total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints.**



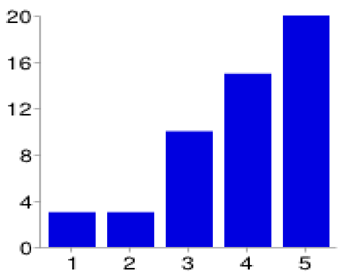
From the graph, 36% strongly agreed that the total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints. 24% agreed, 18% are neutral, 12% disagree and only 10% strongly disagree.

7. Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions.



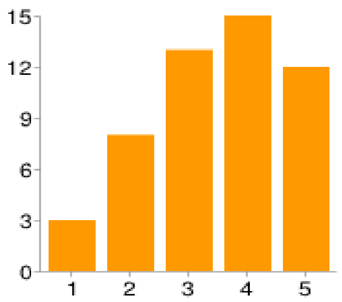
From the graph, only 2% strongly disagreed that Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions. 35% are indifferent, 31% agree, 12% strongly agree, and 20% disagree.

8. Each employee is entitled to a certain monthly (weekly) rest period.



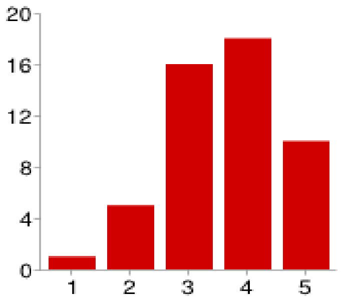
From the graph, 39% strongly agree that each employee is entitled to a certain monthly (weekly) rest period. Only 6% strongly disagree, 6% disagree, 20% are neutral and 29% agree.

9. Each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it.



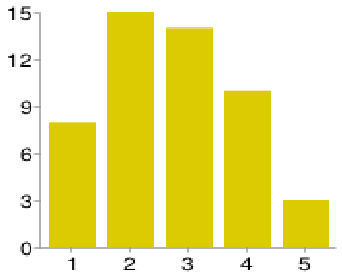
From the graph, only 6% strongly disagree that each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it. 29% agree, 24% strongly agree, 25% are neutral and 16% disagree.

10. The duty hours are convenient and acceptable.



From the graph, only 2% strongly disagree that the duty hours are convenient and acceptable. 36% agree, 32% are neutral, 20% strongly agree and only 10% disagree.

11. The load is acceptable.

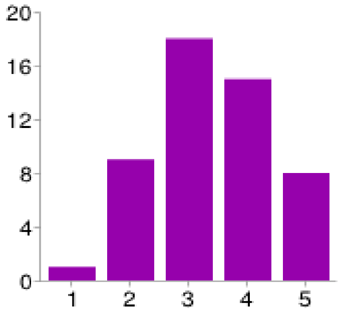


From the graph, 30% disagree that the load is acceptable. Only 6% strongly agree, 20% agree, 28% are neutral and 16% strongly disagree.

12. The scheduling/assignment is fair.

Respondents were asked if the scheduling/assignment is fair. Only 2% strongly disagreed, 8% disagreed, 27% are neutral, 33% agree and 29% strongly agree.

13. The quality of the schedule is good.



From the graph, only 2% strongly disagreed that the quality of the schedule is good. 18% disagreed, 35% are neutral, 29% agreed and 16% strongly agreed.

4.1.3 Document Analysis

4.1.3.1 Collective Agreement of the Ethiopian Airlines and the Ethiopian Airlines Basic Trade Union

According to the 10th Collective Agreement of the Ethiopian Airlines and the Ethiopian Airlines Basic Trade Union, the following provisions are stated with regard to work and pay (Only the relevant parts of the provisions are stated):

Article 8 Overtime Work

8.1 Its Scope & Employees Entitled For Overtime Pay

1. "Overtime Work" shall mean the actual time worked in excess of the regular working hour as defined in Article 6.1 above or the average eighty (80) hours distributed for two weeks' period.

3. Overtime pay to be paid in accordance with this Article shall not be applicable to the cockpit crew and cabin crew members. In addition, except Cabin Crew and Cock-Pit Crew, no employee shall be entitled to overtime pay for business travel time either by air or by any other means of transportation.

4. Where an employee is required to return from abroad on his day-off while on the Undertaking's business spending more than 8 hours flight time and where the next day is his working day, his arrival date shall be considered as his day off. Again, where an employee is

required to travel on his day off for company business, he shall be given a compensating time-off for the first day only.

5. An employee who leaves after carrying out his work on night shift shall not be required work overtime. However,, where the employee is required to work on two consecutive shifts due to reasons beyond control and under the instructions of the Undertaking, he shall be given commensurate rest /day-off on the next day in addition to the overtime pay for the excess hours he worked for.

8.2. Conditions for Overtime Work

2. The hours of overtime work for reasons stated in Article 8.2 (1) (a) above shall not exceed two (2) hours in any single twenty four (24) hours period or twenty (20) hours in any one month and one hundred (100) hours in any given year. However, the overtime to be worked under conditions stated in Article 8.2. (1) (b), (c), and (d) may exceed such limits.

Article 9 Weekly Rest Period (Days Off)

An employee shall be entitled to forty eight (48) consecutive hours days off in Seven (7) days. However, where the nature of the shift work does not permit such days off or if the employee so requests, he shall be granted two different days-off within that same week.

25.2. Monthly Flight Time

25.2.1. The regular monthly duty hours required of a cabin crew member shall be eighty (80) flight hours in one calendar month.

25.2.2. The total monthly flight time provided under sub-article 1. above shall include all the flight block hours during the month, the three hours per day a cabin crew member is credited to take her physical check-ups, or recurrent trainings and document renewal upon being grounded for such purposes in addition to the block hours. It shall also include all deadheading assignments in full and the standby duty hours credited in accordance with Article 25.8 and 25.9 herein under.

25.3. Duty Time Limitations

A. 14 hours for day flights and 13 hours for night flights shall constitute the maximum duty time within 24 consecutive hours. This shall include the flight time counted from the scheduled reporting time or actual reporting time up to the release time after the aircraft's landing. For a single set of cabin crew, the duty time of 14 hours may not exceed a flight time of 10 hours when the flight consists more than one landing.

25.4. Delay at Home

Cabin crew members who are informed of delay shall be credited 1:4 for delays at home.

4.1.3.2 The Ethiopian Labor Proclamation

According to the Ethiopia Labour Proclamation No. 377 – 2003, normal hours of work shall not exceed eight (8) hours a day or forty-eight (48) hours a week. However; other provision in the proclamation on collective agreements, reduction of normal hours of work, arrangement of weekly hours of work, averaging of normal hours of work and exclusion give the ground for the violation of the aforesaid maximum daily or weekly hours of work.

4.1.3.3 The IATA - International Air Transport Association Best Practices

The IATA - International Air Transport Association 2013- 25, IATA-Cabin-Operations-Safety-Best-Practices-Guide states details of number and composition of cabin crew member in section 2.25. Accordingly, the Airlines civil aviation regulations will specify the minimum number of Cabin Crew applicable to either passengers on board or to passenger seats. Where this specification is not stipulated it is recommended that there is a minimum of one fully qualified Cabin Crew for every 50 passengers, or passenger seats, installed on the same deck of an aircraft.

4.2 Data Analysis

1. **The elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse).**

Respondents were asked if they agreed with the statement elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse). 38% disagreed and 36% agreed and 26% were neutral.

2. **The total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly).**

Cabin crew members were asked their view about the statement: the total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly). 45% disagreed, 34% agreed and 22% were neutral.

3. **Pairing allows flight crew members a minimum number of hours of rest between duties (min-rest).**

Respondents were asked if they agreed with the statement that the pairing allows flight crew members a minimum number of hours of rest between duties (min-rest). 34% agreed, 46% disagreed and 20% are neutral.

4. **A longer compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res.**

34% disagreedto the statement a longer compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res, 42% agreed and 24% are neutral.

5. **The total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement).**

16% disagreed, 60% agreed and 24% are indifferent to the statement that the total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement).

6. **The total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints.**

From the graph, 60% agreed that the total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints. 22% disagreed and 18% are neutral.

7. **Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions.**

From the graph, only 22% disagreed that Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions. 43% agreed and 35% are indifferent.

8. **Each employee is entitled to a certain monthly (weekly) rest period.**

68% agree that each employee is entitled to a certain monthly (weekly) rest period. Only 12% strongly disagree, and 20% are neutral.

9. Each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it.

Only 22% disagree that each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it. 53% agree and 25% are neutral.

10. The duty hours are convenient and acceptable.

Only 12% disagree to the statement that the duty hours are convenient and acceptable. 56% agree, and 32% are neutral.

11. The load is acceptable.

46% disagree to the statement that the load is acceptable. Only 26% agree, and 28% are neutral.

12. The scheduling/assignment is fair.

Only 10% disagreed to the statement that the scheduling/assignment is faire. 63% agreed and 28% are neutral.

13. The quality of the schedule is good.

20% disagreed to the statement that the quality of the schedule is good. 35% are neutral and 45% agreed.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

The following are summary of the findings:

- The number of employees who agree with the view that the elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse) is almost equal to the number who disagree with the same statement.
- More cabin crew members disagree with the statement that the total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly) than those who disagree.
- Close to half of the employees are of the view that pairing doesn't allow flight crew members a minimum number of hours of rest between duties (min-rest).
- Staff members with a view that compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res is greater than those who don't believe so. But the number is not that far apart.
- More than 60% of the cabin crew believe that the total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement).
- More than 60% of cabin crew members who participate in the study agreed they are of the view that that the total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints.

- More employees believe that Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions. The number of those who disagree is not that far from the ones who agree.
- More than two third of the staff are of the view that each employee is entitled to a certain monthly (weekly) rest period.
- More than half of the staff are of the view that each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it.
- More than half of the staff believe that the duty hours are convenient and acceptable. Few disagree.
- The number of employees who disagree with the statement that the load is acceptable is almost double those who believe otherwise.
- More than two third of the cabin crew agree with the statement that the scheduling/assignment is fair.
- Close to half of the staff believes that the quality of the schedule is good. But the number of those who are indifferent is not that much different from those who believe so.
- The Ethiopian Airlines doesn't follow the integrated system.

5.2 Conclusions

The following are conclusions:

- Opinion is divided with regard to the elapsed time.
- Most staffs believe the total number of hours of actual flying time is not greater than the maximum value.
- More than two third of the cabin crew see the scheduling/assignment as fair.

- The view of the staff on the pairing system could be a reflection of the inefficiency and ineffectiveness in pairing.
- Opinion is divided on the issue that compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res is greater than those who don't believe so.

5.3 Recommendations

The Airline needs to work on the following:

- The fact that more than half of the cabin crew believe that the total flying is divided among the flight crews at different crew bases (as per the Contractual obligations requirement) is a positive sign. EAL should work more and capitalize on its strength.
- The fact that close to two third of cabin crew members who participate in the study agreed they are of the view that that the total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints. This is a good sign. EAL should capitalize on this strength.
- The fact that the number of employees who disagree with the statement that the load is acceptable is almost double those who believe otherwise is a symptom of a problem. EAL needs to work on this to change this view.
- EAL needs to check state of the art scheduling and follow the trend as software is not a solution for everything. In particular, literature review of the trend and paradigm in crew scheduling show that more integrated airline planning approaches are employed to deal with all the three aspects at once i.e.aircraft routing, crew pairing, and tail assignment. EAL needs

to be proactive in following the trend and exploring options to integrate the aforesaid areas to be robust in planning.

- EAL should work on pairing to come up with a pairing that suits more staff members.
- EAL should work hard to close the gap in Opinion divided on the issue that compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res is greater than those who don’t believe so.
- Ethiopian Airlines should follow the integrated approach to schedule

Appendix I

Interview to Manager:

- What is the general overview of the Ethiopian Airlines as to the number of aircrafts, international routes etc.
- What is the new crew scheduling system followed by Ethiopian Airlines, is it manual or automated?
- If not automated, what are the challenges to use automated system?
- Do you feel that the new crew scheduling system followed by Ethiopian Airlines is reliable and efficient?
- Is your schedule weekly or monthly? How do you compromise when a staff over works at one period?
- How do you go about scheduling or what is the scheduling method used by the company?
- What variables and rules and regulations do you consider in the process of scheduling? (Could you get me a copy of any documents you consult for scheduling purposes).
- Have you ever tried to see how other airlines go about it as far as best practices are concerned?
- How do you evaluate the reliability of the new system compared with the available options and the best practice in the airline industry compared with the available options and the best practice in the airline industry?
- How do you evaluate the efficiency of the new system?
- How do you see the effectiveness of the new system when compared with previous methods used?
- What are the opportunities and challenges faced by Ethiopian Airlines and its crew members from the introduction of the new scheduling system?

Appendix II

<u>QUESTIONNAIRE</u>

Dear respondent,

You are required to fill the entire questionnaire with utmost trust and confidence. The study will only be used for academic research purpose and it will not affect your career in any way. Thank you in advance for your full cooperation.

The researcher

<u>SECTION 1: Demographic Data</u>

1. Gender

   A. Female ☐

   B. Male ☐

2. Age

   A. Less than 25 ☐

   B. 25-35 ☐

   C. 36-45 ☐

   D. 46-55 ☐

   E. More than 55 ☐

3. What is your highest level of education?

   A. High school ☐

   B. Diploma ☐

C. Bachelors degree ☐

D. Master's degree ☐

E. Doctorate ☐

4. What is your position level?

A. Operative employee ☐

B. Supervisor ☐

C. Manager ☐

5. How long have you worked at your organization?

A. Less than one year ☐

B. 1-3 ☐

C. 4-6 ☐

D. 7-9 ☐

E. More than 10 years ☐

Section 2: Assessment on how employees view the new scheduling system

Please indicate how strongly you agree or disagree with the statements.

1= Strongly Disagree, 2= Disagree 3= Neutral (Indifferent) 4=Agree, 5=Strongly Agree

		Strength of Agreement/Disagreement				
		1	**2**	**3**	**4**	**5**
1	The elapsed time of a duty period of flight crew members including the brief and debrief periods (elapse) are less than a maximum allowable value (max-elapse).					
2	The total number of hours of actual flying time (fly in a duty period) of flight crew members is greater than a maximum value (max-fly).					
3	Pairing allows flight crew members a minimum number of hours of rest between duties (min-rest).					
4	A longer compensatory rest is offered to flight crew members when a duty violates max-fly or a previous rest was shorter than min-res.					
5	The total flying is divided among the flight crews at					

	different crew bases (as per the Contractual obligations requirement).					
6	The total amount of flying in hours assigned to crews from a given crew base is within a specified interval as per the requirement of the crew base constraints.					
7	Crews at the various bases all have the opportunity to receive credit for approximately the same number of hours of work of each month as per the restrictions.					
8	Each employee is entitled to a certain monthly (weekly) rest period.					
9	Each employee is entitled to a certain monthly (weekly) rest period and the schedule allows employees to exercise it.					
10	The duty hours are convenient and acceptable.					
11	The load is acceptable.					
12	The scheduling/assignment is fair.					
13	The quality of the schedule is good.					

14. If you have any additional comment, please state it here:

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____

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THANK YOU

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