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SCHOOL OF GRADUATE STUDIES**

**CREW SCHEDULING SYSTEM:
THE CASE OF ETHIOPIAN AIRLINES**

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Acronyms

List of Routes Reached by EAL

ABJ	Abidjan (Coted'ivoire)
ACC	Accra
AMS	Amsterdam
ARN.....	Arlanda (Sweden)
AUH	Abu Dhabi
BAH	Bahrain
BEY	Beirut
BJM	Bujumbura (Burundi)
BKK	Bangkok
BKO	Bamako
BOM	Bombay
BRU.....	Brussels
BZV.....	Brazzaville
CAI	Cairo
CAN	Guan zou (China)
CDG	Charles Digul (Paris)
DAR	Darussalam (Tanzania)
DEL	Delhi
DIR.....	Dire Dawa
DKR	Dakar (Senegal)
DLA	Duala (Cameroon)

DXB Dubai
EBBEntebbe
FCORome
FIHKinshasa
FRAFrankfurt
HKGHonk Gong
HREHarare
IADUSA
JEDJeddah
JIBDjibouti
JNBJohannesburg
JROKilimanjaro
KGLKigali
KRT.....Khartoum
LADLuanda (Angola)
LBVLibreville
LFW.....Lome
LHRLondon
LLWLilongwe (Malawi)
LOS Lagos
LUNLusaka (Zambia)
MQXMekelle
NBONairobi

NDJNdjamena (Chad)

PEK..... Beijing

SAHSana'a

TLVTel Aviv

Other Abbreviations

EAL..... Ethiopian Airlines

FAA..... Federal aviation Authority

IATAInternational Air Transport Association

Abstract

In this paper, Ethiopian airlines crew scheduling system is considered and investigated. A crew scheduling decision is one of the decisions among other operational decisions faced by the Company. The Company has been preparing and distributing the schedules on a weekly basis and it performs the entire function manually. In EAL, the crew scheduling preparation is subjected to different rules, regulations, safety considerations, contractual agreements and conditions of awards and agreements. To check whether these factors are consistently considered or not, 5 recent schedules prepared on May 28, June 4, 11, 18, and 25 were reviewed and assessment was made on these schedules by considering the month of June assignment. In the course of analysis, 20 cabin crew members were randomly selected from these schedules and the data related with them was analyzed on the basis of monthly duty time, days-off incorporation, fairness of the assignment in terms of consistently assigning all available flights to the crew members equitably, and quality (error rates) of the schedule.

With respect to the monthly duty assignment, the Company sets 90 hours monthly duty time for each cabin crew member as a standard and based on this standard 85% of the employees, whose overtime payment ranges from 9% to 77% from their basic obligation, were found working extra hours. Regarding the days-off consideration, each cabin crew member is entitled to receive 6 days guaranteed days-off per month and based on this it is found that 75% of cabin crew members days-off were not considered when the schedule was prepared. In the course of checking the equitability of the system, flight repetition was taken as a variable and it was found that 50% of the cabin crew members were scheduled to attend 1 or two flights repeatedly with in the given month. At last, the quality of the schedules was also

evaluated based on the selected cabin crew members and it was found that 20% of the crew members were scheduled to attend more than 1 flight in the same day.

Chapter - 1

1.1 Introduction

To stay and excel in the market, any business organization needs to have a well designed system that supports the achievement of its objective. Support departments strength and efficacy play a vital role for the achievement of the excellence that any organization desires to achieve. In today's world, the application of management science concepts in real world problems play a vital role in assisting organizations to achieve their objectives by solving complex problems.

Ethiopian Airlines, which this study intends to address, is founded on December 30, 1945 and began operation on April 8, 1946. The Company currently extends its services around 45 different destinations and is using crews (pilots and flight attendants) for each flight to serve its customers. Since these crews are the backbone to its service, it needs the optimum and timely utilization of its crew members to minimize its cost as well as comply with restrictions dictated by the Collective Agreements and the Civil Aviation Authority.

1.2 Project Description

This study is about assessing the current practice of the assignment (scheduling) of crews to flights in Ethiopian Airlines and is intended to address issues related with the crew scheduling such as the process of scheduling, identifying the different variables (rules and regulations as well) considered in determining the crew allocation, the methods applied so far and evaluating the efficiency of the system from different angles.

1.3 Problem Statement

Assignment (scheduling) problems represent a broad range of mathematical programming problems in which a number of tasks are to be performed overtime with a limited amount of resources (crews) (Hanif D. Sherali et al. 1984). Airline crew schedule construction is a difficult and important problem. It is difficult because it gives rise to large-scale problems and because it must deal with the complexity of the collective agreement and other regulations applied in the industry (Michael Gamache et al. 1999). 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. In this regard, the problem considered in this paper is proper investigation and analysis of an airline crew allocation and scheduling system in Ethiopian Airlines. 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.

1.4 Objectives of the study

Having in mind the perspective of commitment to the basic objective of providing safe, reliable, and profitable air transport services and to be competitive Airline in the world and leader in Africa, (See the EAL website: www.answers.com/topic/ethiopian-airlines) Ethiopian Air Lines definitely needs to have a reliable scheduling system which supports its performance in the industry. So the objective of the study includes:

- ✦ Identify the current system to be followed in performing crew scheduling in Ethiopian Airlines and assessing its reliability.
- ✦ Identifying and describing the variables to be considered in scheduling crews to flights and assess their application.
- ✦ To pass 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 so that other interested researchers or the Company under consideration can further use them to study the topic at large for finding solutions in the process of optimum allocation of crew members to flights.

1.5 Significance of the Study

This study is intended to deliver the following significances:

- To motivate other researchers to perform study on the so far untouched areas of management science topics such as scheduling and follow their application in Ethiopian Companies.
- To give insight to other researchers to explore the topic in a more detailed manner.
- In addition to the above points, the Company in which this study bases, can use the study or the recommendations to be included in this paper as a base to improve its operation after carefully evaluating its impact.

1.6 Methodology

1.6.1 Data collection Methods

Data for this research is collected from documents including rules or procedures followed by the Company, union agreements and other supporting documents used to prepare the current schedule. Interview was conducted with employees who work in the section that is in charge of preparing schedules. Besides the interview, ten recent consecutive schedules prepared so far were reviewed.

1.6.2 Sampling size, selection and procedure

Besides the interview conducted with the scheduling section of EAL, ten consecutive schedules prepared so far were reviewed. 20 cabin crew members were selected randomly from the cabin crew members who were on the job for the month of June. The above mentioned cabin crew members assignments were reviewed for the month of June by taking 5 most recent schedules prepared on May 28, June 4, 11, 18 and 25.

1.7 Scope of the Study

This study is basically focuses on proper investigation of Ethiopian Airline crew scheduling system and is specifically concerned with the investigation of cabin crew members. Individual (cabin crew member) responses or reactions to the existing schedule or any event relating to the schedule are not the concern of this paper. It is assumed that the aircraft type to the flight is completed before the crew scheduling decision and crew scheduling will also base the already existed aircraft schedule.

1.8 Limitation of the study

The researcher had different types of limitations in the process of collecting relevant information. The International Air Transportation Association and the Ethiopian Civil

aviation Manual which will add knowledge to understand the international and national rules and regulations concerning cabin crew members were not reviewed only because the Company in which this research addresses was not willing to provide them. The other limitation the researcher encountered during the data collection process was not finding specific information such as which air craft will be assigned to which flight and the name of cabin crew members who were not considered in the preparation of scheduled due to different reasons during the time period in which the received schedule covered.

Due to time limitation, only cabin crew scheduling system is covered in this study. Since access was denied to conduct the interview with all employees collectively, the interview was conducted with only one employee represented from the scheduling section and all his responses are taken as the Company's response.

1.9 Analysis

The data collected through interview or from investigation of different documents was processed and analyzed for being more aware with the current system and to extract the different variables that are used to construct the current schedule. The 20 sample cabin crew members selected 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.

Chapter – 2

Literature Review

2.1. Overview of Crew scheduling

2.1.1 Economics, Definition and Related Concepts

Optimum allocation of limited resources in order to achieve objectives like maximizing the profit or minimizing the cost is a general problem of interest in many real-life situations. Mathematical programming models which include linear programming, non-linear programming, integer programming and others can solve such problems efficiently. But in some cases, the size of the problem and the type of the decision variables make it difficult to solve such problems using the standard algorithms available. Some problems are NP-complete (Nondeterministic Polynomial) and the computational effort to find the optimum solution grows exponentially with the problem size. Heuristics algorithms and approximations with some simplifying assumptions have been employed in such cases (Tom M. Cavalier et al., 1986). The wide use of these operations research (OR) mathematical programming models make the field OR as a way to gaining competitive advantage instead of being seen as a support function (P. C. Bell, 1998).

Any organization using valuable resources and employing a large number of personnel faces the problem of ensuring the efficient and productive utilization of both resources and staff. This 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 prevalent function that is omnipresent throughout many industries and applications. Scheduling involves accomplishing a number of things 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 as cited in Noronha and Sarma, 1991. Guaranteeing the compatibility of the decisions made is the role of constraint propagation. 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 in the literature 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). However, our main concern here is airline crew scheduling.

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).

The scheduling of air crews is a problem that has attracted considerable attention from both airlines and the mathematical community. Air crews are amongst the most valuable of airline resources and efficient utilization of crews is obviously an important consideration in airline

operations. 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).

2.1.2 Terms used in Airline Industry

There are notable terms and definitions in the airlines industry. According to Pamela H. Vance and others (1997), the following terms are frequently used in the industry.

- A *flight leg* or *segment* is a single nonstop flight.
- A *duty* period consists of a sequence of flight legs with short rest periods or *sits* separating them. Also included in a 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 a crew.
- A *pairing* is a sequence of duty periods with overnight rests between them. Each pairing begins and ends at the same *crew base*, which are the cities where crews are stationed. In some cases a pairing includes flights that the crew flies as passengers. 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 (Pamela H. Vance et. al., 1997).

2.1.3 Scheduling Processes

The main business of an airline is to offer and execute flights in such a way that profit is maximized. In order to "produce" such a kind of service, there is a set of underlying scheduling tasks that need to be fulfilled. In general, it is required to determine: which flights are offered, when and how often such flights should take place, which resources are allocated at which scheduling step, and how the schedule execution is controlled and unpredictable events are handled.

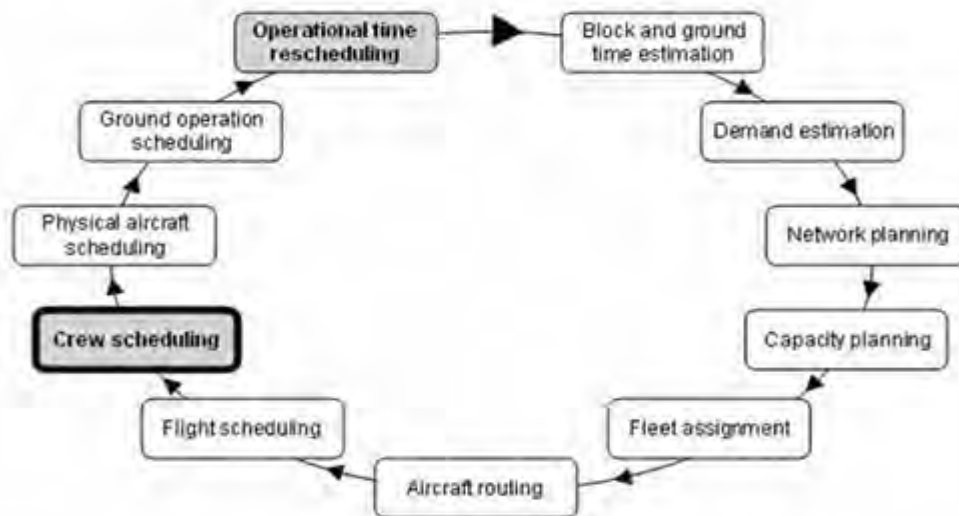


Figure 2.1 Airline scheduling process

In Fig. 2-1 all general scheduling steps at airlines are presented: The first step, *block and ground time estimation*, evaluates the specific time requirements for boarding, loading/unloading, refueling, cleaning, and catering. It may vary by airline, pattern, and

airport. *Demand estimation* examines the market in order to extract the potential needs of the customers while considering, e.g., competitors outside the airline industry. During *network planning*, it is defined whether destinations are approached via a hub-and-spoke or a point-to-point network. *Capacity planning* decides on the required amount of seats as well as the flight's frequency. Subsequent to capacity estimation, *fleet assignment* considers, e.g., capacity, range of aircraft and operational cost (fuel, maintenance, etc.) while covering all requirements defined during earlier steps by selecting the appropriate fleet to each individual flight to be serviced. *Aircraft routing* works at this stage on logical vehicles ensuring that regularly scheduled ground maintenance cycles remain feasible in such a way that the final *flight scheduling* is economically useful and can be published afterwards. *Crew scheduling* enables the execution of all flights by the available flight personnel, whereas *physical aircraft scheduling* assigns dedicated (physical) aircraft to the defined rotations (including vehicle-dependant maintenance requirements). Closely prior to the flight's execution, *ground operation scheduling* determines details like gates, ground personnel, aviation security, catering, etc. *Operational time rescheduling* as the final scheduling step handles all unexpected disruptions of the normal operation by minimizing cost and impact of those events (Markus P.Thiel, 2005).

2.1.4 Problems in Crew Scheduling

From a mathematical point of view the problems of air crew scheduling give rise to a number of challenging problems in combinatorial optimization (David, 1992). Once flight timetable and aircraft schedules have been constructed, an airline has to ensure that each flight is provided with a crew. This stage is generally separated into two problems: planning (crew pairing) and rostering (Paul R. Day and David M. Ryan, 1992).

The first problem, called the Planning or Pairings Problem, involves the construction of sequences of flights or sectors which are variously described as duties (tours of duty) or trips (or pairings or rotations). In some situations these duties or trips can be daily periods of work but in other applications they involve sequences of flights and periods of rest over many days. The important feature of a duty or trip is that it must be 'feasible' with respect to all the rules, regulations and conditions of awards and agreements. While many of these conditions are common to most airlines the details can vary greatly among airlines (David, 1992). The planned duties are generic in the sense that they are not allocated to individual crew members at the planning stage (Paul R. Day and David M. Ryan, 1997).

Most duties or trips originate and terminate at a crew base (hence the term 'rotation'). The underlying objective in the planning problem is to produce a schedule of feasible duties or trips which cover all the timetabled flights in the most efficient manner possible. Efficiency is often measured in terms of the number of duties or trips but there are other obvious criteria such as total duty time and the number of sectors on which crews are positioned (or deadheaded) without working.

The second problem associated with air crew scheduling is referred to as Rostering. The rostering problem involves the allocation of the planned duties or trips from the first stage to individual crew members which links together duties into work schedules (roster lines or lines-of-work) that are allocated to individual crew members over the rostering period. The full Rostering problem can usually be broken into smaller independent sub problems corresponding to groups of crew members of the same rank (David, 1992; Paul R. Day and David M. Ryan, 1997). A satisfactory solution method for the rostering problem is necessary for several reasons. Although the planning problem has obvious cost significance, the

important issue of crew satisfaction in rostering also affects the cost of operating rosters. Crew dissatisfaction can indirectly lead to significant cost increases. The rostering problem also involves a conflict of management and crew objectives: management wish to minimize the number of crew members required, while crew members wish to maximize their satisfaction with the roster. Reducing crew numbers usually adversely affects the feasibility of the rosters and crew member satisfaction with the roster. An ideal rostering system would satisfy both crew and management objectives and minimize roster operating costs in a reduced amount of time (Paul R. Day and David M. Ryan, 1997).

2.1.5 General Methods in Constructing Rosters (Schedules)

Two major approaches to building a roster are **bidding systems or equitability systems**. Bidding systems permit crew members to bid for certain structures in their own work schedule. Bids are then normally satisfied in order of decreasing seniority in the crew rank. **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 that have been created to satisfy regulations and provide adequate staffing for all scheduled flights. For both bidding systems, the roster construction procedure is usually based on simple greedy sequential heuristic methods. Bidding systems inevitably 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.

Equitability systems build rosters that attempt to distribute the work content more evenly or fairly throughout the crew rank. Due to combinatorial complexity, achieving an equitable

roster is difficult. Most airlines requiring equitable rosters use heuristic methods to allocate duties to individual crew members. However, this approach still leads to some in-equitability (or even infeasibility) within the roster, and the crew members will not be used as productively as possible. A set partitioning formulation for the equitability rostering problem offers the possibility of optimizing the equitability of the work allocation while ensuring the construction of a legal and feasible roster (Paul R. Day and David M. Ryan, 1997).

2.1.6 Governmental Work Rules and Union Agreements

Crew schedules have to obey a set of rules and regulations in order to be considered as legal. Those detailed restrictions imposed by the Federal Aviation Authority were created in order to protect the security in air traffic. Additionally, there might also be further agreements among employee unions and the airline which have to be followed. Over all, there are often more than several hundreds of rules to be rigidly fulfilled as *hard constraints*. Apart from this, there are also *soft constraints* which may be violated, although it is in general undesirable to do so. As cited in Kohl and Karisch 2004 such constraints can be classified into *horizontal*, *vertical*, and *artificial rules* as follows.

I. Horizontal rules

The majority of rules are applied only to characteristics of a single roster instead of considering several rosters or a roster combination. Typically, such rules restrict the general compatibility of a crew member, which is based on the task and the time setting for the scheduling in stance examined. Furthermore, it includes regulations, such as rest time between flight legs, flight duties, pre-scheduled activities, etc. Off-day patterns for weekly rest periods

are imposed as well, 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. Besides, accumulated values are commonly used to restrict, e.g., the maximum number of flying hours, working hours or take-offs. Such restrictions are based on the recent individual work history of the employee, e.g., if limitations for yearly or quarterly values have to be maintained.

II. 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 the *crew complement* for a certain flight leg. Even though the crew rostering problem is usually divided up by fleet and crew function some activities may require crew complements with dedicated characteristics, such as (*qualification, type*) constraints. 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).

III. Artificial rules

In addition to the explicitly required constraints, artificial rules may be applied in order to enhance the solution quality. They can ensure aspects like 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).

2.1.7 Mathematical Programming Models and Heuristics in Crew

Scheduling

As mentioned in Bodin et al 1983; much time has been spent by airlines and the operations research community for efficient and effective methods for solving crew scheduling problem and similar scheduling problems. Scheduling aircraft, as cited by Etschmaier and Mathaisel, is the first stage in solving the airline scheduling problem. This involves constructing timetables and allocating aircraft to these timetables to create a flight schedule. The flight schedule takes into account factors such as expected number of passengers, operating costs, airline marketing, and competition (see David, 1992). Finding a good quality solution to this problem is 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 to the problem. Most airlines use simplified manual or heuristic techniques based on only a few of the possible inputs 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. As an example Balakrishnan et al. 1990 and Subramanian et al. 1994 can be cited (Paul R. Day and David M. Ryan, 1997). Dynamic programming, integer programming and linear programming are among the models used to solve crew scheduling problems (Tom M. Cavalier et al., 1986). Most researchers however inclined to use integer programming model while solving problems related with crew scheduling in Airlines and other transportation industry (Kelly Easton et al., Michael Trick, 1999 and Roy E. Marsten et al., 1979).

2.1.7.1 Integer programming and crew scheduling

The formulation of models with distinctive mathematical structures and the development of algorithms to exploit these structures continue to be a productive direction for research in mathematical programming. During the last few years, several similarly structured integer programming models have been developed for a number of diverse applications (G. Terry Ross and Andris A. Zoltners, 1979).

Integer programming has shown itself to be an 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 has been robust and effective enough to play a key role in solving problems in applications such as airline crew scheduling, combinatorial auction winner determination, telecommunications network design, sports scheduling and many other applications.

Despite the practical success of integer programming, initial forays into this area are often full of frustration: seemingly obvious formulations “don’t work”, leading to excessive computation time for even small instances. Success with integer programming seems to be a hit-or-miss proposition, with more misses than hits (Michael Trick).

As it is discussed, in some cases, the size of the problem and the type of the decision variables make it difficult to solve such problems using the standard algorithms available such as linear programming, integer programming and dynamic programming. Some problems are NP-complete (Nondeterministic Polynomial) and the computational effort to find the optimum solution grows exponentially with the problem size. So in such cases, heuristics are widely applied.

2.1.7.2 The Heuristic Approach and Procedures

As early as 300 A.D. Pappas, writing on Euclid, suggested the approach of approximate methods-which are easy to use but which do not guarantee optimality. Through the work of Descartes and Leibniz, the subject became known as *heuristics*. Allied with logic, philosophy and psychology, it has the aim of investigating the methods of invention and discovery. The name itself was derived from the Greek *heuriskein-to* discover. Today the term *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).

A Classification of Heuristics

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

I. The construction strategy

The input for methods based on this strategy is nothing more than 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 and attempting to identify an element which is likely to be a valuable part of a very good final solution. Next, successive additional elements of a solution are added. The better construction heuristics employ some kind of 'look-ahead' mechanism. That is, additions are made, not just because they appear a good idea at the time, but because they are likely to be of genuine value in the complete solution. Once the final solution has been built up, it may be obvious that improvements can be easily effected. Thus the strategy is often applied to the output of the construction method. This

strategy is worthwhile when it is relatively difficult to generate feasible solutions to the problem.

II. The improvement strategy

The input for methods based on this strategy is a solution to the problem. This solution is then progressively improved by the application of a series of modifications. In some instances it may be impossible to make much progress in this way, and yet the final product may still be far from optimality. Because of this, some improvement strategies are far-sighted in the following sense. Some iterations of the 'improvement' process may actually be allowed to bring about 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 best final result chosen. Sometimes the strategy is used to convert an infeasible solution into a feasible one.

III. The component analysis strategy

Some problems are so large or so complicated that the only practical approach is to break them up into manageable portions. Sometimes these portions are then dealt with independently by heuristics or even algorithms. The solutions for the portions are then married to form some master plan. Of course, 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 sort of logical sequence, it usually makes sense to examine them in the same order. This ordering is often based on some time-scale which is an integral part of the problem. For instance, in investment problems a natural sequencing may be to define a

component as one year's activities. The output of the analysis of one component may be a valuable input for the analysis of later components.

IV. The learning strategy

Methods based on this strategy often use a tree-search diagram to chart their progress. That is, the different options which appear at various stages are represented by different branches of a tree. The sequences of choices actually 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. The early termination of a branch and bound search is an example of this strategy (L. R. Foulds, 1983).

2.1.8

Varia

bles considered in Solving Crew Scheduling Problems

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. In this section, some of the types of restrictions that are typical in the industry are outlined below.

- 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 pairings may be composed of up to a maximum number of duty periods called *max-duties*.
- A 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-rest*; 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 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 (Pamela H. Vance et al., 1997).

2.1.9 Approaches Used in Solving Crew Scheduling Problems

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 and others 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. For each day of the month, pairings are assigned to individuals selected from a pool of available crew members. 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. This method makes a single pass over an employee list, generally beginning with those with higher seniority 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. The heuristic aims not only to generate good rosters, but also to construct a constraint matrix that will ease the search for an integer solution. Then the problem is solved on this set of rosters by using specialized integer programming. The specifics of the linear relaxation and branch-and bound method are described as cited in Ryan (1992), and additional details are given in Ryan and Falkner (See 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. Columns are generated by solving, for each employee, a constrained shortest path problem on a

network in which nodes represent pairings, and arcs represent possible links between pairings and rest periods for each employee. The solution method and the sub problem modeling are presented in Gamache and Soumis (See Michel Gamache et al, 1999).

Michel Gamache and others also evaluated the above mentioned approaches as follows. The first four methods have the advantage of being easy to implement, since they are based on well-documented, standard algorithms and heuristics. They also simplify part of the planners' task by computerizing it. Workload is sometimes distributed more evenly over the month when such heuristics are used. In addition, since rostering construction can begin later in the month, problem data is generally of better quality as cited in Marchettini 1980 and Sarra 1988 (See Michel Gamache et al, 1999). Finally, in certain cases, the heuristic leaves fewer uncovered pairings than do manual methods as cited in Tingley 1979. Each of these four methods, which solve the rostering problem by sequentially solving a number of small-scale problems, presents distinct disadvantages. Standard implementation of the first method (a) is difficult to attain because the notion of priority activities varies from one problem to another, depending on the relative scarcity of resources. In the day-by-day assignment method (b), it is hard to take account of potential difficulties on succeeding days. A global view of the problem is essential, especially if, as in the summer and holiday seasons, the month being scheduled includes a high-activity (peak) period. Method (c), which sequentially constructs rosters employee by employee, produces poor quality rosters for the final employees scheduled. The advantage of the combination method (d) is that it can reduce the number of undesirable aspects of each roster and improve the overall solution. It reduces the number of such undesirable aspects; however, it does not eliminate them.

The mathematical model for generalized set partitioning (e) is interesting because, unlike the heuristics just described, it involves a global view of the problem. The approach used for a priori enumeration of a restricted set of rosters could, however, have an impact on solution cost since enumerated ones (say, 200,000 rosters) might represent only a small portion of the (usually) millions of admissible rosters. It is difficult to analyze the impact of this pre-selection since the true optimal solution is not known. The mathematical programming approach using column generation (f), obtains the optimal solution to the linear relaxation of the generalized set partitioning problem by implicitly considering all possible rosters while generating a small number of eligible rosters as needed. Unfortunately, this method cannot accommodate large-scale problems. The number of arcs in each employee graph used to generate new columns is of the order of n^2 , where n represents the number of pairings to be assigned. Such a model is clearly inadequate for very large problems. Moreover, this method has not been designed for problems where pairings must be covered by more than one employee (Michael Gamache et al., 1999).

Hanif D. Sherali and Minerva Rios suggested a general solution for tackling the above two problems: planning (crew pairing) and rostering. They propose three standard steps, called generation, reduction and optimization. The generation step involves the construction of a matrix A in which the rows represent flight legs to be serviced and the columns represent rotations or a set of legs flown by the crews on a round trip which starts and ends at some home base. The entry a_{ij} of the generated matrix takes on a value of 1 if leg i is flown in rotation j , and 0 otherwise. Information such as crew regulations, aircraft schedule for each aircraft, union and federal regulations, safety considerations and contractual agreements are

all used in this stage to construct feasible rotations. Typically, rotations are constructed by sequentially adding legs until the addition of another leg makes the rotation infeasible.

The next step is that of reduction, in which rotations are either forcibly chosen or eliminated based on relative cost considerations, and in which the set of legs still needing to be serviced is updated. Salkin describes the general reduction techniques used for this type of set partitioning problem, and Rubin presents some additional techniques used for airline crew scheduling in particular. In order to reduce overall effort, the generation and reduction steps are sometimes combined and run concurrently (see Hanif D. Sherali and Minerva Rios, 1984).

The final step is that of optimization, in which either exact or heuristic methods are used to select a set of rotations which will collectively serve each leg at minimal total cost. Among the exact techniques employed are Gomory's cutting plane algorithm for the United Air Lines problem, specialized implicit enumerational branch and bound algorithms for several other airlines, including Air Canada, Air France and American Airlines. Usually, however, a majority of the airlines, for example Swiss Air and B.E.A. employ heuristic methods.

Ultimately, after a solution to the above problem is obtained, timetables for planes and crews need to be generated based on realistic considerations such as feasible flight times, passenger volumes and crew working hours.

Nonetheless, the heuristic rules developed for this problem may be applied in the same spirit to other air-crew scheduling problems as well. Hanif D. Sherali and Minerva Rios also proposed two heuristic methods. The first approach, called the Two-Phase Method, is similar in philosophy to the crew scheduling problem in that the sequence of missions to be flown by each plane is fixed in Phase I, and the subsequent scheduling of crews is conducted in Phase

II. The second approach, called the One-Phase Method, attempts to sequence missions and schedule crews concurrently. As one may expect, the former method is less time consuming, whereas the latter method has added flexibility. As it turns out, the Two-Phase Method is preferable for Problem 2, whereas the One-Phase Method is preferable for Problem 1 (Hanif D. Sherali and Minerva Rios, 1984).

Chapter 3

3 Presentation of data, interpretation and analysis

3.1 Data presentation

This chapter deals with the presentation of data, its interpretation and analysis. To collect the data and extract findings, an interview question was prepared and interview was conducted with the Ethiopian Airlines Supervisor- crew scheduling. The interviewer response is taken as the Company's response because the researcher in advance submits the list of interview question and all relevant individuals in the crew scheduling section discussed on the issues and the reply was made on group basis even if the researcher finally discussed the issues with a single respondent. Documents such as collective agreement were also reviewed and relevant information was collected through various means. So the next section presents the data gathered from the Company.

3.1.1 General information

The interview question, which was prepared and presented began with the questions intended to gather general information such as the number of airplanes available, the routes Ethiopian Airlines currently reaches, the number of staff available (used only for flight operation), the number of crew members to be assigned for each flight, and so on. So description of the responses obtained in this regard is presented as follows.

While responding to the questions brought to get information about the number of airplanes used by the Company, the interviewee said that, Ethiopian Airlines currently uses a total of 34

air planes. From these available airplanes, 2 air planes are dedicated to cargo, 8 airplanes are only used for domestic operation, and 24 airplanes are used for the international flights it has been undertaking. By using these 24 planes, the Company has been reaching the following international routes.

Table 3.1 International routes reached by EAL

Ser. No.	Flight No.	Departed at	Departed to	Flight to be attended on							Total flights per week
				MON	TUE	WED	THU	FRI	SAT	SUN	
1	606	0010	BKK/CAN	■		■		■		■	4
2	608	0010	BKK/HKG		■		■		■		3
3	702	0050	FCO/ARN	■		■		■			3
4	712	0050	FCO		■						1
5	500	2215	FCO/IAD	■	■		■	■	■	■	6
6	470	0020	KRT	■		■					2
7	450	0915	KRT/CAI	■		■		■			3
8	452	2215	CAI				■		■		2
9	901	0915	LOS	■	■	■	■	■	■	■	7
10	*917	0140	LOS/ACC	■		■		■			3
11	907	1015	LFW/ACC		■		■		■	■	4
12	610	2140	BOM	■	■	■	■	■	■	■	7
13	809	0900	JNB	■	■	■	■	■	■	■	7
14	851	0930	LAD	■		■		■			3
15	873	0930	LLW/LUN	■		■		■	■		4
16	801	0945	NBO/KGL	■	■	■	■	■	■	■	7
17	831	0945	BZV/FIH	■	■	■	■	■		■	6
18	805	1000	JRO/DAR	■	■	■	■	■	■	■	7
19	909	1000	ABJ/BKO/DKR	■		■		■			3

20	602	1015	DXB	■	■	■	■	■	■	■	7
21	600	2230	DXB	■	■	■	■	■	■	■	7
22	811	1015	EBB/BJM	■	■	■	■	■	■	■	7
23	306	1030	JIB/SAH	■	□	■	□	■	□	■	4
24	700	1200	FCO/LHR	■	□	■	□	■	□	■	3
25	710	0150	FCO/LHR	□	□	□	■	□	■	■	3
26	100	1215	MQX	■	■	■	■	■	■	■	7
27	408	2150	BEY	■	■	■	■	■	■	■	7
28	620	2215	BAH/AUH	■	□	■	□	■	□	■	4
29	704	2335	CDG/BRU	■	□	■	□	■	□	■	3
30	604	2310	DEL/PEK	■	□	■	□	□	■	■	4
31	404	0205	TLV	□	■	□	■	□	■	■	4
32	915	0900	LBV/DLA	□	■	□	□	■	□	□	2
33	905	0900	DLA	□	□	■	□	□	■	□	2
34	871	0915	HRE/LUN	□	■	□	■	□	□	■	3
35	937	2215	NDJ	■	□	□	□	■	□	□	2
36	939	2215	NDJ	□	■	□	■	□	□	■	3
37	706	2320	FRA/AMS	□	■	□	■	□	□	■	3
38	402	0030	JED	□	□	■	□	■	□	■	3
39	206	0800	DIR/JIB	□	□	□	■	□	■	■	3
40	202	0800	DIR/JIB	□	■	□	□	□	□	□	1

N.B. The highlighted cells in the table indicate the flight to be attended on the respective date

Besides the above international routes, the Company also operates in domestic markets. It attends (on average) 9 scheduled flights per day.

Regarding the number of staff available, currently Ethiopian airlines has 125 captains (pilots), 129 co-pilots (flight officers) and 745 cabin crew attendants (flight attendants). Among the flight attendants, 23 hold supervisory positions, 121 hold lead positions, 87 hold senior flight attendant positions, and the remaining 514 holds are flight attendants, junior flight attendants and trainees.

The number of crew members required to perform a certain flight, the respondent replied the number differs from flight to flight. For example, for domestic operation using the small aircraft which can hold a maximum of 17 passengers, only 1 flight attendant, 1 pilot and 1 co-pilot will be assigned. On the other hand, to perform international operation using Boeing 757, which has the capacity to hold around 250 passengers, the airlines will use 1 captain, 1 co-pilot, 7 flight attendants of which 1 will be the supervisor, 1 must be the lead, at least 1 should hold a senior position and the remaining can hold a flight attendant, a junior flight attendant and a trainee position. However, the minimum number of crew member required to perform a flight on average term is a pilot can not be assigned without a co-pilot, and 1 flight attendant (regardless of position) will be assigned for 50 passengers i.e. if the number of passengers in one aircraft is 250, there must be at least 5 flight attendants. The Company assigns a crew to airplanes by considering International Air Transport Association (IATA) requirements. The IATA minimum requirement is as per the number of passengers attended and it obliges all IATA members to assign 1 flight attendant for 50 passengers and 1 pilot and 1 co-pilot for each flight. According to the respondent, Ethiopian airlines also schedules crew members as per the IATA requirement and it prepares schedule as the ratio of 1 flight

attendant for less than 50 passengers and always assigns 1 pilot and 1 co-pilot for each flight. Generally, the assignment also bases the type of aircraft assigned for a particular flight as summarized in the following manner. For Boeing 757, 5 cabin crew members will be assigned as one crew group, for AIF and Boeing 757, 7 cabin crew members will be assigned and for Boeing 767, 8 cabin crew members will be assigned as one crew group. For small airplanes such as Fokker, which has been used for domestic operation, on average two cabin crew attendants will be assigned.

It is also possible to perform a flight with the absence of one or more crew member who was assigned but couldn't attend the flight if the minimum requirement of International Air Transport Association (IATA) is fulfilled.

With respect to the above mentioned positions, a question is raised whether they can be replaceable to one another when there is a shortage of man power or a certain position.

Replacement can be made in the following positions:

- Lead-flight attendant can replace the supervisor-flight attendant position
- Senior-flight attendant can replace the lead flight attendant position
- A flight attendant can replace the senior flight attendant position

The replacement is applicable only to a certain flight and it is also possible to use a crew member with high position (in relative terms) and use it to perform small position assignments i.e. for example a senior flight attendant can be replaced to perform a flight attendant or a junior flight attendant position.

3.1.2 Presentation of scheduling Issues

In this section information collected to be aware of issues such as the scheduling preparation process, the method employed to prepare schedule, and other relevant issues will be presented and interpreted.

With regard to the scheduling process, to begin the process, the section which is responsible for the preparation of schedules will receive the planned routes to be covered/ scheduled flights to be reached in a quarterly basis from marketing department. The flight schedule includes information such as flights to be attended each day, the departure and arrival time, the flight hours (block time), trip time, and layover (the number of hours the assigned crew member will stay at outstation). Based on the information submitted from marketing department, the crew scheduling section will prepare and distribute a weekly printed schedule (which contains weekly information of individual crew member assignment for each flight starting from Monday to Sunday) to crew members' per week basis. The crew scheduling section will distribute the weekly schedule to each crew member on Saturday afternoon through their dedicated boxes.

Revision is made on the weekly schedule in each working day to smooth irregularities encountered in the absence of crew members for any flight for reasons such as sick leave, refusal, or grounding. The information for revision has been regularly obtained from the Company's dispensary (medical center), the Human Resource Department, and the crew member him/herself. Every revision will be communicated to the relevant (affected) crew members through telephone and crew members are expected to appear for duty based on the information it received through telephone. Regarding the number of revisions made per week or day (in average terms), the respondent replied that it is their usual experience and on

average they revise the plan for each flight because one or more crew members may show absenteeism or may be assigned for another flight instead of the scheduled one.

With respect to the method employed in preparing schedule, the Company so far uses manual systems to prepare it. There are around 5 individuals who are dedicated to prepare the weekly printed schedule. In principle the Company assumes to follow equitability method when preparing the schedule. I.e. each crew member will receive a flight which is consistent and equal in load with respect to others during the time horizon. They try to measure equitability in terms of assigning individuals to all available flights in a rotation manner (not assigning repetitively in one flight), hours loaded per month with respect to others, and the assignment of days-off. In their current system, each individual prepares the schedule uses his/her own judgment (subjective point of view) and assign individuals to flight. A question is raised to be aware of whether formal training was given for employees who perform the scheduling task to enable them to execute their daily job in a consistent and efficient manner. While responding to this question, the respondent replied that so far no special training was given and employees assigned to this section have learnt from each other and will be a better performer when they stay in the work for a long period of time and acquire the necessary experience.

The other interesting area to cover here was the basis of assigning individuals to a particular crew group. According to the respondent, the scheduling section basically will look for two things while doing so: the availability of the individual at the particular time and the position required in forming the group.

Concerning the nature of the scheduling job with respect to its simplicity or difficulty, the respondent argue that they classify the job as difficult because they perform it in a manual basis and do not give them guarantee in keeping the consistency and accuracy of the system. Since they try to incorporate the different rules and regulations which are directly related to cabin crew members' assignment, it becomes difficult for them to take in to consideration every relevant rules and regulation for each individual while trying to do the schedule.

In the current system, it is not also possible to measure the accuracy or efficiency of a schedule done by one only because there is no standard measurement criteria applied so far. A schedule done by one is taken for granted as an end and no cross check or any other controlling mechanism is applied. Currently the quality of the scheduling is dependent up on the individual who prepares the schedule.

For the question raised to know whether there were any improvement measure undertaken so far to correct/ improve the system or not, the Company did not attempt to do much to solve the problem from the root which will improve the system. The Company has bought software in the past but couldn't be able to use it. The reason they mentioned for not using the software is the software couldn't support the section who prepares the schedule because the number of employees to be assigned is small in relation to the number of routes to be covered and the software is designed by incorporating all rules and regulations applied in the industry at large while assigning crew members to flights. According to the respondent, they have tried to use it but they found it useless since the number of manpower (cabin crew member) available or input of human resource doesn't match with the marketing/sales/ requirement.

The other interest of this study was also to know the driving objective of preparing schedules. According to the respondent, the driving objective behind the preparation of schedules is simply to fill the flight requirement (operational requirement) at any cost or completion of a certain flight. The section will prepare schedules to enable a certain flight to be attended for which it receives the flight schedule from marketing department. However, while responding to the question “what will happen to the Company if schedule is not done at all?” the supervisor responded crises will happen and the Company cannot perform its basic business i.e. providing air transport services at all and everything will be messed up. Simply put “no flight”.

A question was raised to get awareness about the view of the scheduling section regarding what efficient scheduling system will look like and they respond to this question that the following benefit can be achieved by having efficient scheduling system.

- Cost saving (minimum or no overtime)
- No loophole in operation
- Minimization of crew dissatisfaction
- Time saving (Devoted to prepare a schedule)
- Better utilization of crew resources
- Provision of quality service
- Fast response

Responding to the measurement criteria they have applied so far to measure the efficiency of the scheduling system at all, they said that the Company/the section doesn't employ any system that will be used to measure the efficiency or accuracy of the system.

It was also the researchers' interest to investigate whether the schedule incorporates reserve members for each flight or at a specified time period. While responding to this question, for each flight a reserve crew member and stand-by crew member scheduled and a weekly printed schedule also incorporates this. If it doesn't incorporate, the relevant crew member will be notified through telephone. The scheduling of reserve crew can be at a stand by basis (in the work station) or at home basis (at crew members home). The relevant rules applied for reserve crew scheduling which is extracted from the collective agreement are presented as follows:

Standby at the Airport

- Stand by at the airport shall not be for more than for 4 hours
- A cabin crew member assigned on standby at airport may be assigned on flight provided the duty time does not exceed 14 hours including the stand-by time for long range flights and 13 hours for other flights.
- A cabin crew member who has been on stand by at airport for 4 consecutive hours shall not be assigned on stand by for the next 12 consecutive hours.

Standby at home

- A cabin crew member who is standby at home may be assigned on any flight. A stand by at home shall not be for more than 6 consecutive hours.
- A stand by at home cabin crew member shall report for work if so requested within the standby time.
- A cabin crew member assigned on stand by at home for six hours will not be assigned on stand by at home for the next 12 hours.

Both groups of reserved cabin crew members can be assigned to any flight within the time they are on standby basis.

Regarding the Civil Aviation Authority rules and regulations to be considered in the preparation of schedule, the Company considers the International Air Transport Association (IATA) and the Ethiopian Civil Aviation Authority rules and regulations passed in relation to cabin crew on matters such as duty time, rest period, flight time, minimum qualification (license), physical fitness, various trainings, and endorsed documents. To refer both documents in detail and being familiar with the rules and regulations, it becomes impossible to find the documents because the Company considered it as a confidential document and was not willing to show.

Also questions were raised to understand what kind of mechanism the Company was using if a scheduled crew member is absent to attend a specific flight and to know whether the Company had any bad experience of cancelling flights because of the shortage of crew members or not. While responding to these questions, since standby crews are always scheduled for each flight, they will be used as a substitute to attend a certain flight when absenteeism occurred. However, if the absentees of a particular flight are more in number (such as two, three or above) and also is not possible to substitute the absentees only by the standby and reserve crews, the Company will cancel the flight. The respondent also revealed that the Company had a number of experiences of cancelling flights as a result of facing the shortage of crew members not only because of absentees but also as a result of shortage of manpower.

According to the respondent, based on the international industry requirement as well as national aviation requirement, the Company designs its own work rules for the cabin crew members. The collective agreement signed between Ethiopian Airlines and the labor union of the Company incorporated the rights and obligations of cabin crew members including the duty time, flight time, rest period, day-off etc. The relevant rules and regulations to be considered in the preparation of schedule and incorporated in the collective agreement are presented as follows.

Monthly Duty Time

- 90 hours shall be the normal duty time of each cabin crew member within a month.

Duty Time Limitation

- 13 hours shall constitute the maximum duty time within 24 consecutive hours. This shall include the period from reporting time until release time.

Required Reporting Time

- For international flights reporting at home base shall be one hour and 30 minutes before scheduled departed time.
- For international locations (outstations) reporting time shall be one hour before scheduled departure time.
- For domestic flight the reporting time shall be one hour before the planned departure time.

Long Range Flight

- 14 hours shall constitute the maximum duty time in 24 consecutive hours in any long range (non-stop) flight.

Local Night Rest

- A local night rest of 24 consecutive hours shall be granted at home base in addition to the minimum crew rest after each long-range flight.

Trip Time

- The trip time shall mean all the elapsed time from reporting time at Addis Ababa Airport (1:30 hours before departure) to completion of the full route including the 30 minutes release time at Addis Ababa.

Crew Rest at Home Base

- Cabin crew member shall be entitled to 20 hours rest after each international flight that takes more than 4 hours. For international flights taking less than 4 hours, a crew rest of 12 hours shall be granted after each flight. For domestic flight the crew rest shall be 12 hours.

Rest Period at Outstations

A rest period at outstations shall mean uninterrupted period granted to cabin crew members at their hotel after destination. Such rest period shall be 8 consecutive hours or double the flight time which ever is higher.

Days off in a month

- Guaranteed days off shall mean 6 guaranteed days given to cabin crew members in a month at Addis Ababa. The undertaking shall not assign a cabin crew member who is on his guaranteed days-off at any flight.
- Cabin crew shall be granted three consecutive guaranteed days-off and a further two (2) consecutive and one days-off per month.
- The Company shall not issue the name of crew members under guaranteed day-off in its weekly published-schedule.
- During guaranteed days-off the Company shall not oblige the crew members to call to the Flight Control Department. However, Flight Control can call and leave message. Guaranteed days off shall count after the utilization of the rest period (guaranteed after duty return).

Sickness

- If a cabin crew falls ill away from his/her domicile, he/she will not be made to fly back to Addis Ababa if the doctor treating him/her certifies that the employee's health will deteriorate as a result of flying.

Also the questions regarding the duty time was investigated. When responding to the question “what will you do if the crew member completes its duty time before the flight completes”, the respondent said the Company will do its best to schedule crew according to the regulations specified in the collective agreement and will replace other crew members in outstations. However, if it is impossible to replace the crew at that specific flight, the crew member will be obliged to do beyond the maximum requirement.

A question was raised to get awareness about whether there is a limit on the number of flights per a certain period and it is found that there is no limit (either minimum or maximum) for the

number of flights to be undertaken by any crew member and the general limitation exists not on the number of flights basis but on the basis of the number of hours per month as stated above.

Interview question was also administered concerning whether all crew members are eligible to undertake any flight (any route) to know if there is any limitation on a certain flight or not. Responding to this question, from the 745 available crew members, all are eligible to undertake the routes found in the domestic, Africa, Europe, and Asia countries. However, from the total 745 crew members (currently available), around 700 are eligible to fly to US route and the remaining 45 are not eligible because they didn't fulfill the criteria required to undertake flights to US. The eligibility criteria to be fulfilled to fly a certain flight are related more with the qualification such as attending a certain training, license, and visa.

For the interview question raised to get awareness about whether the Company faces any overtime or other compensation only because the crew member was worked beyond the limit. When responding to this question, it is a long time trend and also the Company is familiar to pay extra hours payments and other specified benefits every month almost for each crew member because almost always every crew member was working beyond the limited time specified above. However, the Company was not willing to provide the actual cost data paid so far as extra payment. As per the information obtained from the Company, the following cost compositions are included or incurred for the cabin crew member.

- Fixed salary cost (vary as per the seniority of crew members)
- Hotel accommodation cost
- Perdiem payment in outstations

- Overtime payment

Another area of interest was the investigation of whether the Company has a cost center on flight basis to be able to determine the cost of each flight especially with regard to the cost incurred during the assignment of crew members. It is found that currently the Company has no separate cost record for each flight with regard to crew members and the Company is using the monthly crew members' payrolls to look for the expenses it incurred within a particular period.

Regarding the kind of controlling mechanism that the Company applied so far to control the efficiency of the crew scheduling system, the respondent replied no controlling mechanism is applied so far except checking the payment of crew members every month and looking the trend of the payment whether it increases or decreases. Based on the resulting figure, no special measure was taken to reduce it when it increases or to keep it up when it shows decreases.

To have a general view of the assignment of employees to flights, 10 schedules (prepared for domestic as well as international flights) were received from the section who prepares the schedule. The following table shows 20 crew members' assignments for the month of June (extracted from the schedules prepared on May 28 and June 04, 11, 18 and 25, 2007) selected randomly from the available crew members included in the schedule. To make the presentation more meaningful, an attempt was made to find the list of individuals who were not considered in the schedule for any reason within the ten schedules periods received. However, since they didn't keep the record in an organized way it becomes impossible to find and consider it for the analysis. So the analysis to be made on such data will base the partial

Information received. To keep the anonymity of cabin crew members', the name of individuals is assigned with a number denoted by 1-20.

Table3.2 Sample list of cabin crew members schedule for the month of June

Cabin	Date	ACC	Flight	Departur	13Returning	Duty	Total
Cabin crew No.	Date (Departure)	Departed to	Flight No.	Departur e time	Date Return	Time	Duty Time
Crew No.	Departure	to	No.	time	Date	time	Time
1	Wed 05 June	NDJ	939	1030	05 June	2000	11:30
	Fri 08 June	BZV	831	0945	10 JUNE	2035	12:20
	Fri 08 June	LOS/ACC	917	0140	JUNE	2030	16:25
	Mon 12 June	BAA/AMS	6206	2320	15 JUNE	0625	32:20
	Wed 13 June	DEL	604	2310	20 JUNE	0625	32:45
	Wed 25 June	LOS/ACC	6047	0340	29 JUNE	0625	32:45
	Thu 21 June	NDJ	939	1030	JUNE	2000	11:30
	Fri 29 June	EBB/BJM	811	0900	29 June	2030	12:15
	Sat 23 June	CAI/KRT	452	2215	24 JUNE	2040	12:15
	Sat 30 June	FCO	600	2205	2 JUNE	0815	32:25
5	Wed 03 June	FRH/LON	700	0900	29 June	2030	12:35
	Wed 06 July	EBB/BJM	811	0935	6 JUNE	2020	12:55
2	Mon 11 June	LOS/ACC	917	0140	13	0715	16:00
	Fri 08 June	LOS/ACC	917	0140	10 JUNE	0715	16:00
	Fri 15 June	DXB	602	1015	15 June	2045	12:30
	Tue 12	NDJ	939	1030	12 JUNE	2000	11:30
	Sun 7	BEY	408	2150	9 June	0805	13:00
	Thu 4	BZV	831	0945	15 JUNE	2035	12:20
	Wed 20	CDG/BRU	704	2335	24 June	0720	20:50
	Sun 7	BOM	610	2140	10 JUNE	0820	13:20
	June 26	LFW/ACC	907	1015	27 June	2030	16:25
	Wed 20	JNB	809	0900	24 JUNE	2100	14:35
3	Mon 04	FCO/LHR	700	1200	07 June	0725	18:45
	Mon 25	EBB/BJM	811	1015	25 JUNE	2030	12:15
	Sat 09 June	BEY	408	2150	June	0805	13:00
	Tue 26	DXB	600	2230	27 JUNE	0730	11:00

	June				June			
	Sun 1 July	HRE/LUN	871	0915	2 July	2010	12:55	
6	Fri 01 June	LOS/ACC	917	0140	3 June	0715	16:00	158:40
	Mon 04 June	JNB	809	0900	05 June	2100	14:35	
	Thu 07 June	LFW/ACC	907	1015	08 June	2030	16:25	
	Sun 10 June	FRA/AMS	706	2320	14 June	0725	20:20	
	Fri 15 June	NBO/KGL	801	0945	15 June	2010	12:25	
	Mon 18 June	BZV	831	0945	20 June	2035	12:20	
	Thu 21 June	DXB	600	2230	22 June	0730	11:00	
	Fri 22 June	EBB/BJM	811	1015	22 June	2030	12:15	
	Sat 23 June	MQX	100	1215	23 June	1455	4:00	
	Sun 24 June	EBB/BJM	811	1015	25 June	2030	12:15	
	Fri 29 June	LAD	851	0930	29 June	2025	12:55	
	Sat 30 June	FCO	500	2215	7 July	0815	37:25	
	Cabin crew No.	Date (Departure	Depart ed to	Flight No.	Departur e time	Returning Date Time		
7	Mon 11 June	DXB	600	2230	12 June	0730	11:00	94:10
	Mon 18 June	BAH	620	2215	19 July	0815	12:00	
	Fri 22 June	MQX	100	1215	22	1455	4:00	

	Sun 24	TLV	404	0205	25	0545	12:45	
	Sat 23 June	BOM	3610	1030	24		13:20	
	Wed 27	BKK	606	0200	30	0545	27:50	
	Thu 28	LFW/ACC	907	1015	29	2030	16:25	
10	Sun 03	NBO/KGL	801	0945	03	2010	12:25	119
	Tue 05	BY/DLA	815	0900	9	0805	14:45	
	Sat 30 June	FCO	500	2215	20	0815	37:25	
8	Mon 11	LOS/ACC	917	0140	13	0715	16:00	146:15
	Thu 31 May	BEY	408	2150	23	0805	13:00	
	Mon 18	FCO	500	2215	25	0815	37:25	
	Mon 04	NBO/KGL	801	0945	4	2010	12:25	
	Wed 27	DXB	602	1015	27	2045	12:30	
	Fri 29 June	LOS	901	0915	30	2100	14:05	
	Sun 05 July	BAM/AUH	408	2150	3	0805	12:00	
	June							
	Mon 11	LOS	901	0915	12	2100	14:05	
	June				June			
	Thu 14	FCO	500	2215	20	0815	37:25	
	June				June			
	Sat 23 June	BKK	608	0010	26	0545	27:50	
	Wed 27	DXB	602	1015	27	2045	12:30	
	June				June			
	Fri 29 June	LOS/ACC	917	0140	1	0715	16:00	
9	Mon 04	NBO/KGL	801	0945	4	2010	12:25	116
	June							
	Wed 06	DXB	600	2230	7	0730	11:00	
	June							
	Fri 08 June	BAH	620	2215	10	0815	12:00	
	June				June			
	Sun 17	JNB	809	0900	18	2100	14:35	
	June				June			
	Tue 19	BEY	408	2150	21	0805	13:00	
	June				June			
	Fri 22 June	DXB	602	1015	22	2045	12:30	
	June				June			

	Fri 29 June	CDG/BRU	704	2335	4 JULY	0720	20:50	
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Cabin crew No.	Date (Departure)	Departed to	Flight No.	Departure time	Returning		Duty Time	Total Duty Time
					Date	Time		
11	Fri 01 June	FCO	702	0050	07	0515	37:25	146
	Sat 09 June	BOM	610	2140	11	0820	13:20	
	Wed 13	LOS/ACC	901	0915	14	2100	14:05	
	Fri 15 June	NDJ (RT)	937	2215	16	07:15	11:00	
	Sun 17	DEL	604	2310	23	0625	32:45	
	Tue 26	JRO/DAR	805	1000	26	2020	12:20	
	Thu 28	HRE/LUN	871	0915	29	2010	12:55	
	Sun 1 July	NBO/KGL	801	0945	1 JULY	2010	12:25	
12	Thu 31 May	FCO/LHR	710	0150	2 JUNE	0725	20:15	76:35
	Wed 06	ABJ	909	1000	7 JUNE	2100	16:05	
	Sun 10	DXB	600	2230	11	0730	11:00	
	Mon 25	MQX	100	1215	25	1455	4:00	
	Wed 27	DLA	905	0900	29	2100	12:55	
	Sun 1 July	JRO/DAR	805	1000	1 JULY	2020	12:20	
13	Thu 31 May	BZV	831	0945	1 JUNE	2035	12:20	137
	Thu 07	BKK	608	0010	10	0545	27:50	
	Mon 11	FCO/LHR	700	1200	14	0725	20:15	
	Fri 15 June	JRO/DAR	805	1000	15	2020	12:20	
	Sun 17	LOS	901	0915	18	2100	14:05	
	Wed 20	LLW/LUN	873	0930	21	2010	12:15	
	Mon 25	BEY	408	2150	27	0805	13:00	
	Thu 28	DXB	602	1015	28	20:45	12:30	
	Sun 1 July	NBO/KGL	801	0945	1 JULY	2010	12:25	
14	Sat 02 June	TLV	404	0205	03	0545	12:45	140:20
	Mon 04	NDJ	937	2215	05	0715	11:00	
	Wed 06	DEL	604	2355	13	0625	32:45	
	Thu 14	HRE/LUN	871	0915	15	2010	12:55	
	Sat 16 June	BEY	408	2150	18	0800	13:00	
	Tue 19	LOS	901	0915	20	2100	14:05	
	Fri 22 June	DXB	600	2230	23	0730	11:00	
	Wed 27	BAH	620	2215	28	0515	12:00	

Cabin crew No.	Date (Departure)	Departed to	Flight No.	Departure time	Returning		Duty Time	Total Duty Time
					Date	Time		
15	Tue 05	LBV/DLA	915	0900	6 June	2100	14:45	133
	Fri 08 June	JNB	809	0900	9 June	2100	14:35	
	Mon 11	BKK	606	0010	14	0545	27:50	
	Wed 20	BOM	610	2140	22	0820	13:20	
	Sun 24	LFW/ACC	907	1015	25	2030	16:55	
	Fri 29 June	LAD	851	0930	29	2025	12:55	
	Sun 1 July	DEL	604	2310	7 July	0625	32:45	
16	Sat 02 June	NBO/ KGL	801	0945	02	2010	12:25	103
	Mon 04	DXB	602	1015	4 June	2045	12:30	
	Tue 05	BOM	610	2140	7 June	0820	13:20	
	Wed 20	DXB	600	2230	21	0730	11:00	
	Fri 22 June	EBB/BJM	811	1015	22	2030	12:15	
	Sun 24	JED	402	0030	25	0700	8:30	
	Tue 26	FRA/AMS	706	2320	30	0725	20:20	
	Sun 1 July	EBB/BJM	811	1015	1 July	2030	12:15	
17	Fri 01 June	LAD	851	0930	June	2025	12:55	128
	Mon 4 June	LOS	901	0915	5 June	2100	14:05	
	Fri 08 June	FCO/LHR	700	1200	11	0820	20:35	
	Mon 18	EBB/BJM	811	1015	18	2030	12:15	
	Wed 20	JNB	809	0900	21	2100	14:35	
	Fri 22 June	BEY	408	2150	24	0805	13:00	
	TUE 26	TLV	404	0205	27	0545	12:45	
	THU 28	DXB	600	2230	29	0730	11:00	
	SAT 30	LFW/ACC	907	1015	1 July	2030	16:55	

Cabin crew No.	Date	Departed	Flight No.	Departure time	Returning Date	Time	Total Duty Time
	(Departure)	to			June	Time	
18	Thu 25 June	DWB MQX	873 100	0930 1215	26 June	2010 1455	4:40
18	Sat 30 June	DWB DXB	602 602	0915 0915	03 July	2006 2006	12:06
20	Sun 03 June	NDJ NDJ	939 939	1030 1030	03 June	2000 2000	11:30
	Mon 04 June	BOM BOM	610 610	2140 2140	06 June	0820 0820	13:20
	Thu 07 June	EBB/BJM EBB/BJM	811 811	1015 1015	07 June	2030 2030	12:15
	Fri 08 June	DXB DXB	600 600	2230 2230	08 June	0730 0730	11:00
	Wed 03 June	CDG/BRU CDG/BRU	704 704	2335 2335	04 June	0720 0720	20:50
	Fri 15 June	DXB DXB	602 602	1015 1015	20 June	2045 2045	12:30
	Fri 22 June	HRR/KGL HRR/KGL	886 886	0940 0940	22 June	0945 0945	27:35
	Wed 27 June	JIB/SAH JIB/SAH	306 306	1030 1030	30 June	1945 1945	11:15
	Sun 01 July	BOM BOM	610 610	2140 2140	01 July	0820 0820	13:20
Thu 14 June	BOM BOM	610 610	2140 2140	16 June	0820 0820	13:20	
Mon 18 June	JIB/SAH JIB/SAH	306 306	1030 1030	18 June	1945 1945	11:15	
Tue 19 June	HRE/LUN HRE/LUN	871 871	0915 0915	20 June	2010 2010	12:55	
Thu 21 June	CAI CAI	452 452	2215 2215	22 June	2040 2040	12:15	
Tue 26 June	EBB/BJM EBB/BJM	811 811	1015 1015	26 June	2030 2030	12:15	
Sun 1 July	LOS LOS	901 901	0915 0915	2 July	2100 2100	14:05	
19	Fri 01 June	CDG/BRU CDG/BRU	704 704	2335 2335	06 June	0720 0720	20:50
	Fri 08 June	DXB DXB	602 602	1015 1015	08 June	2045 2045	12:30
	Sun 10 June	LOS/ACC LOS/ACC	917 917	0140 0140	12 June	0715 0715	16:00
	Wed 13 June	BKK BKK	606 606	0010 0010	16 June	0545 0545	27:50
	Sun 17 June	MQX MQX	100 100	1215 1215	17 June	1455 1455	4:40

3.2 Analysis of Data and Presentation of Findings

In this section the data interpretation, analysis and presentation of findings will be addressed. The analysis will be conducted on each major issues and table 2, presented in the data presentation part, will be used intensively (when appropriate) to make sense out of it. This part also borrows most ideas from the previous sections mainly from the articles extracted from the Collective Agreement.

As it is indicated in the above section, after the Company prepares the weekly printed schedule and distributes it to each crew member, revision is made on each working day to smooth irregularities if encountered. In general, revision of plans is necessary and important if it is used for coming up with a good plan or matching the plan with the reality. However, when we come to the Company practice, daily revision for each flight is their usual experience. This situation raises a big question on the purpose why the schedule is done and its applicability. Also the schedule may not get the necessary trust or confidence from the part of the cabin crew members because the revision will give them uncertainty regarding their assignment. In general, the reliability of the schedule will put under question if the trend is revising it daily/ too frequently and assigning employees without strictly following the already prepared schedule. On the other hand, if the trend continues like this, it may give space to the individuals who are involved in the preparation of schedule to be reluctant in committing more errors or reduce their sensitivity to errors because they already know that there is a window to correct the already distributed schedule at any time.

The other important point with regard to the revision is that the means of communicating it is through telephone and crew members are expected to appear for duty based on the telephone

call. The reliability of the means of communication is also a big question. If the required cabin crew member telephone is not working by any reason, the Company couldn't find such individual. The other thing is even after the cabin crew member notified through telephone, if he/she intentionally misses the flight and denies the fact that he/she didn't receive the information, the Company has no legal ground to make the individual responsible.

When we come to the methods employed in the preparation of schedule, in principle the Company assumes to follow equitability method. I.e. each crew member will receive a flight which is consistent and equal in load with respect to others during the defined time horizon (a week or a month). They also try to measure equitability in terms of assigning individuals to all available flights in a rotation manner (not assigning repetitively in one flight), hours loaded per month with respect to others, and the assignment of days-off. Since there is no consistent method of doing the schedule and it has been prepared by different individuals, it will be difficult to come up with a reliable system which assigns flights to individuals on equitability basis. To measure whether equitability exists or not as they viewed the two dimensions flights repetition and the assigned duty times, for the month of June is taken from table 2 and summarized and presented as follows:

Table3.3 Scheduled total duty time for the month of June 2007

Cabin Crew No. (A)	No. of flights Assigned (B)	No. of repeated Flight(s)	Frequency of Repetition	Total repetition (E)=C*D	% of total repetition (F)=E/B	Duty Time (G)	% of Loaded duty time
1	7	1	2	2	28.5	117:15	130
2	5	-	-	-	-	79	87.77
3	9	1	2	2	22.2	154	171.11
4	6	-	-	-	-	98	109
5	10	1	2	2	20	117	130
6	12	1	2	2	16.67	159	176.67
7	6	-	-	-	-	57	63.33
8	8	2	2	4	50	146	162
9	8	1	2	2	25	116	129
10	7	1	2	2	28.5	107	119
11	8	-	-	-	-	146	162
12	6					77	85.55
13	9					137	152.22
14	9					130	144.44
15	7					100	111
16	8	2	2	4	50	103	114.44
17	9					128	142.22
18	10					138	153.33
19	8	2	2	4	50	111	123.33
20	9	1	2	2	22.2	133	147.77

Assumptions on preparing the above table:

- For comparison purpose, 90 hours duty time is taken as a base because the collective agreement stated, as indicated in the data presentation part, 90 hours shall be the normal duty time of each cabin crew member within a month.
- While calculating the total number of duty hours assigned, when double assignment is found in a particular date, the prior assignment is taken and the other one is excluded from the calculation to avoid double counting.
- The duty time is calculated from the table presented in the previous section by looking to a particular flight departure and arrival time in Addis Ababa. All the relevant rules are incorporated while calculating it.

As clearly shown in the above table, 10 out of 20 individuals have received the same flight one or two times. From those who received repeated flights, 30% received two different flights repeatedly for two times and the other 70% received one flight for two times. When the repetition is compared with the total number of flights, 3 individuals are assigned with 50% of their flights as a repetition, 6 individuals are assigned with more than 20% of their assignments as a repetition, and one individual is assigned with 16.67% repetition from the total assigned flights. Since the number of available routes also determines repeating the same flight, it is better to look in to it. As it is put in the previous section, it is found that around 40 international routes are available without considering the domestic routes. Also as it is shown in the above table the number of flights assigned for an individual crew member in the given month (June) ranges from 5 to 12. If we take this range and divide the number of routes available by the boundaries (5 and 12), it gives us the time interval (in months) in which a certain cabin crew member may be assigned to a particular flight or may able to address all the scheduled flights. In our case, as per the calculation, it takes a crew member 3.5 to 8

months to attend all the available routes. So, by looking to all the above interpretations, it can be said that equitability method is not implemented (in absolute terms) when one considers flight repetition as a variable of interest.

The other measurement criteria taken to analyze the equitability of the scheduling system is the number of hours (duty time) assigned for each sample crew members as shown in the above table. When we come to the interpretation, it is found that the Company has assigned 3 out of 20 (15%) employees below the minimum requirement while assigning the rest 17 (85%) employees above the minimum requirement. The over utilization rate ranges from the minimum 8 hours to the maximum 69 hours or 9% to 77%. By looking to these figures, one can deduct that the Company is not keeping the rules and regulations specified in the collective agreement with respect to duty time limitation. The information received from the Company indicated that, the collective agreement is created by incorporating the international flight industry requirements and the number of hours is also adopted from the policy manual of International Air Transport Association (IATA). It is the researcher's strong believe that, when such institutions limit requirements such as the number of working hours, there is a big reason underlying it with regard to factors such as the health of the employee and the quality of the service to be provided. So having more and more over utilization of the specific employee for flight may adversely affect the health of the employee as well as the service quality the Company expected to provide. Also important to consider here is that the Company has been incurring overtime payments continuously and its extra hour payments, which ranges up to 77%, may justify the recruitment of additional manpower instead of enjoying such higher rates of overtime payments.

On the other hand, when we see the under utilization rate, it ranges from 63.33% to 85.5%. Relatively the underutilization is small in number with respect to the possible reasons that can be associated with it such as vacation, sick leave and grounded due to any reasons. Since there is no data for the possible justifications, it becomes impossible to make further analysis.

So having said this much about the number of hours worked, it can be said that the Company is not using its employees in a proper manner because on the one hand under utilization and on the other hand overutilization is observed.

The other interesting point to address is that the Company is trying to incorporate the different rules and regulations applied to crew members while preparing the schedule. However, there is no tracing mechanism applied so far to control whether those rules and regulations such as duty times and days-off are consistently incorporated while preparing the schedule or not. To help the analysis, the following chart is constructed which shows their assigned and non-assigned days in the month of June for the 20 selected cabin crew members to critically evaluate their assignments and days-off allocations. Table No 4 is also constructed based on the following chart to make analysis on days-off. To differentiate different assignments or routes assigned for an individual cabin crew member, different types of shading (patterns) are used in the following figure.

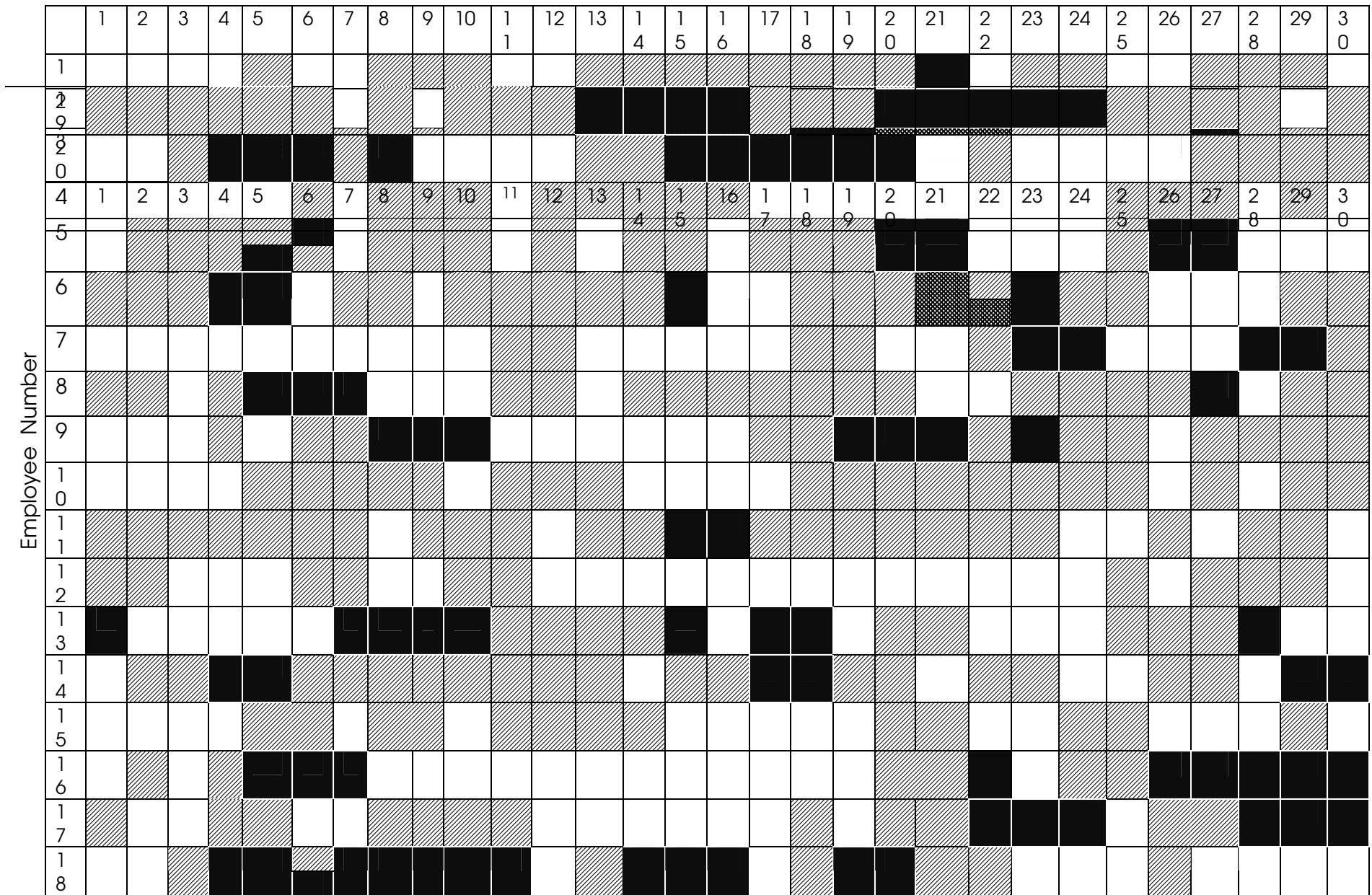
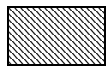


Figure 3.2 Duty assigned and unassigned days of the Month of June

Days in the month of June



Duty assigned days



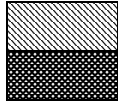
Duty unassigned days



Duty assigned days



Double duty assigned days (any combination of the two patterns)



Double duty assigned days (any combination of the two patterns)

Employee No.	Total No. of unassigned days	Days to be taken as rest period	Days available for guaranteed days-off	Possible Assignment of days-off based on the rule			Not assigned category
				3 days	2 days	1 day	
1	12	5	7	4	-	3	2
2	16	4	12	10	-	2	2
3	6	3	3	3	-	-	2 & 1
4	17	5	12	5	7	-	1
5	11	6	5	-	2	3	3
6	7	4	3	-	2	1	3
7	20	3	17	10	6	1	-
8	8	5	3	-	2	1	3
9	11	3	8	3	5	-	1
10	11	4	7	4	3	-	1
11	6	5	1	-	--	1	3 & 2
12	20	5	15	13	2	-	1
13	12	5	7	4	2	1	-
14	6	4		-	-	2	3 & 2
15	16	6	10	4	4	3	-
16	15	3	12	11	-	1	2
17	12	4	8	5	-	3	2
18	11	5	6	3	2	1	-
19	11	5	6	6	-	-	2 & 1
20	11	3	8	3	3	2	-
Total number of employees unassigned with day-offs				5	8	6	15

Table 3.4 Days-off analysis table

Assumptions made on preparing the above table:

- The 6 guaranteed day offs can be assigned in any sequence but by keeping the three categories separately i.e. 3 consecutive days, 2 consecutive days and one day.
- The assignment of days-off is based on the number of consecutive days available and starts from the maximum possible days to be assigned.
- Cabin crew members are assumed to take a one day rest period after completing each flight (20 hours as per the collective agreement) before any day-off is beginning.

As stated in the data presentation part, a cabin crew member is entitled to receive 6 guaranteed days in a month at Addis Ababa. The undertaking shall not assign a cabin crew member who is on his guaranteed days-off at any flight. And the application is three consecutive guaranteed days-off and a further two (2) consecutive days-off and one days-off per month. Guaranteed days-off shall count after the utilization of the rest period.

Based on the above table, a separate as well as combined interpretation of guaranteed days-off assignment is made. When we see the case individually, out of the total 20 employees, the schedule does not consider the 5 (25%) cabin crew members 3 days guaranteed days-off, 8 (40 %) cabin crew members 2 days guaranteed days-off, and 6 (30%) cabin crew members one day guaranteed day-off as clearly stated in the collective agreement or as the Company views. When we see the case in combination with one-another, a total of 15 employees (75%) are not considered to receive a complete day-off in the preparation of the schedule i.e. 6 days per month. Out of the total 15 employees who are supposed to receive incomplete days-off, 4 (20 %) of them are not scheduled to receive 2 categories days-off and 11 (55%) are not scheduled to receive a one category days-off.

When we see the above interpretation, the figures shown for unassigned days-off is very high and brings big questions on the reliability or efficiency of the schedule and whether there really exist consideration of the various rules and regulations while preparing schedule as they view. Because, as clearly shown in the literature review part, one way to measure the compatibility of a schedule is its consideration of the different rules and regulations applied in the industry. Regarding this it can be said that the Company has got a big problem for respecting the different rules and it also shows that most cabin crew members (75% of the crew members) are working without having enough rest they are entitled to receive as per the Collective Agreement and it may bring negative effects on the service of the Company as well as other factors such as the motivation the cabin crew members should have to work.

To evaluate the quality of the schedule, besides looking for the number of days-off and overtime payment, the error rate was also evaluated. As it can be seen in the chart, employee No. 3, 5, 6, and 18 are assigned for two or more flights for the same day. Employee no. 3 is assigned three times for 7 days, employee no. 5 is assigned one time for 2 days, employee no. 6 is assigned 1 time for 2 days and employee no. 18 is assigned 1 time for one day. By looking to this figure it can be said that the current system is not the one to be relied confidently in communicating cabin crew members' assignments. A cabin crew member who receives double assignments on the same day will not have any mechanism to differentiate which assignment is exactly his or her.

When we come to the method employed in preparing a schedule, the Company is preparing it manually and the reason the schedule section put for the application of manual method is that the software could not perform the scheduling system properly because it requires to strictly incorporating all the rules and regulations governing scheduling of cabin crew members. It is

a very surprising justification and shows the Company's non-readiness for improving the method and also its readiness to violate the different rules such as the collective agreement it has signed with the labor union. At the bottom of this section, analysis is made to check whether the current manpower is enough to meet the flight requirements or not.

It is also stated that the most driving objective of the scheduling function of the Company is meeting crew requirements for each flight regardless of the cost as well as the satisfaction of employees. As it is stated in the literature review part, crew members cost is the second largest expense in airlines industry next to fuel cost. Most airlines took the initiative to improve their scheduling system and have been reducing their costs dramatically. So having this in mind, when we come to Ethiopian Airlines, the crew cost has been given no attention in the process of preparing the schedule. This argument can be supported by the overtime payment shown under the analysis following table no.3 which shows 85% of the cabin crew members were working overtime in the month of June. This all shows cost has got very minimal attention by the Company. The other point to be raised here is that the Company not only ignores cost but also the crew members as well as the service quality while preparing the schedule. As it is seen in the underlying objective viewed by the Company, it can be inferred that it takes quality service as granted if the scheduling function supports in meeting the number of cabin crew members required to attend a particular flight regardless of other things such as the assigned crew members motivation which can be adversely affected by not respecting the rules and regulations governing the crew member such as violation of entitled days-off. From this it can be said that the Company has forgotten to incorporate the sensitivity of the most element "cabin crew members" while designing its scheduling objective. It can also be said that, since the current scheduling system only focuses on attending a particular

flight, it is inescapable that individual crew members rights will be violated in areas such as not respecting the granted days-off, loading more duties, and unfair assignment. Table 4, which shows the days-off analysis, can be brought here to support this argument.

In the same token, it is indicated that the scheduling function is essential to the Company and if it is disrupted or stop at all, the Company will not attend any flight. From this it can be deducted that the scheduling function is very important and a backbone for the existence of the Company even if the Company doesn't give much attention to support the system.

One extreme view which is contrary to the above stated points was found when the scheduling section mentioned the benefits to be gained by having a good/efficient scheduling system. Points such as cost saving, minimizing crew members dissatisfaction, better utilization of crew resources, and provision of quality service are raised as an advantage. From this it can be inferred that the section is more aware of the benefits to be gained by having a good scheduling system but doesn't take the initiative to bring it. As discussed in the previous pages, almost in all areas such as cost, quality of the schedule, and satisfaction of cabin crew members, weaknesses are observed in the current system because the current system doesn't give much attention to incorporate these components. .

The other point is that the Company doesn't have any measurement criteria or controlling mechanism to measure the efficiency of the system. In today's world, it is unlikely to obtain such a big Company which does not design a controlling mechanism to measure its performance. It is the researches strong believe that it is not that much difficult to create performance measurement criteria. Factors such as percentage of flights covered, overtime/other payments incurred, cost incurred for a certain flight (with respect to crew cost)

and no. of revisions made on the issued schedule per day or per week can be easily obtained and incorporated to design the performance measurement criteria.

When we come to the incorporation of reserve crews, the Company has been including reserve and stand-by crew members while preparing the schedule. It shows its preparation in meeting incidental requirements of crew members if the already scheduled ones are absent due to different reasons. It is a good practice and will help the scheduling section to meet what is required from them and will increase the probability of attending all flights. On the other hand it was also shown that the Company has past experiences in cancelling flights only because of the shortage of crew members even if it keeps reserves. To check the existence of the shortage of manpower, it is possible to look in to the extra hour's payments and the assignment of days-off. When looking to the overtime payment and the assigned days-off, more than 85% of crew members were working beyond the limited duty hours and 75% of the cabin crew members did not receive all the guaranteed days-off they are entitled for. In addition to these findings, further analysis was made to check the need for overtime payment or the existence of a real shortage of manpower, by taking the following data which shows the scheduled flights of the week.

Table 3.5: List of weekly scheduled flights

Date															
Monday				Tuesday				Wednesday				Thursday			
Flight No.	Departed		Duty time	Flight No.	Departed		Duty time	Flight No.	Departed		duty time	Flight No.	Departed		Duty time
	Time	To			Time	To			Time	To			Time	To	
606	0010	BKK	27.50	608	0010	BKK	27.50	606	0200	BKK	27.50	608	0010	BKK	27.5
470	0020	KRT	7.55	712	0050	FCO	15.35	470	0020	KRT	7.55	710	0150	FCO/LHR	20.15
702	0050	FCO	21.30	404	0205	TLV	12.45	402	0030	JED	8.30	809	0900	JNB	14.35
*917	0140	LOS/ACC	16.00	809	0900	JNB	14.35	702	0050	FCO	21.30	871	0915	HRE/LUN	12.55
809	0900	JNB	14.35	915	0900	LBV/DLA	14.45	809	0900	JNB	14.35	901	0915	LOS	14.05
450	0915	KRT/CAI	12.15	871	0915	HRE/LUN	12.55	905	0900	DLA	12.55	801	0945	NRO/KGL	12.25
901	0915	LOS	14.05	901	0915	LOS	14.05	450	0915	KRT/CAI	11.40	831	0945	BZV	12.20
851	0930	LAD	12.55	801	0945	NBO/KGL	12.25	901	0915	LOS	14.05	805	1000	JRO/DAR	12.20
873	0930	LLW/LUN	12.15	805	1000	JRO/DAR	12.20	851	0930	LAD	12.55	602	1015	DXB	12.30
801	0945	NBO/KGL	12.25	831	1000	FIH	12.00	873	0930	LLW/LUN	12.15	811	1015	EBB/BJM	12.30
831	0945	BZV	12.20	602	1015	DXB	12.30	801	0945	NBO/KGL	12.25	907	1015	LFW/ACC	16.25
805	1000	JRO/DAR	12.20	811	1015	EBB/BJM	12.30	831	0945	BZV	12.20	939	1030	NDJ	11.30
909	1000	ABJ	40.05	907	1015	LFW/ACC	16.25	805	1000	JRO/DAR	12.20	100	1215	MQX	4.40
602	1015	DXB	12.30	939	2215	NDJ	11.30	909	1000	ABJ	16.05	610	2140	BOM	13.20
811	1015	EBB/BJM	12.30	100	1215	MQX	4.40	602	1015	DXB	12.30	408	2150	BEY	13.00
306	1030	JIB/SAH	11.15	610	2140	BOM	13.20	811	1015	EBB/BJM	12.30	452	2215	CAI	12.15
700	1200	FCO/LHR	20.15	408	2150	BEY	13.00	306	1030	JIB/SAH	11.15	500	2215	FCO	37.25
100	1215	MQX	4.40	500	2215	FCO	37.25	700	1200	FCO/LHR	20.35	600	2230	DXB	11.00
610	2140	BOM	13.20	600	2230	DXB	11.00	100	1215	MQX	4.40	706	2320	FRA/AMS	20.20
408	2150	BEY	13.00	706	2320	FRA/AMS	20.20	610	2140	BOM	13.20				
500	2215	FCO	37.25					408	2150	BEY	13.00				
620	2215	BAH	12.00					620	2215	BAH	12.00				
937	2215	NDJ	11.00					600	2230	DXB	11.00				
600	2230	DXB	11.00					704	2335	CDG/BRU	20.50				
704	2335	CDG/BRU	20.50					604	2310	DEL	32.45				
604	2310	DEL	32.45												
Total Duty Time of the day			429:00	Total Duty Time of the day			302:00	Total Duty Time of the day			361:45	Total Duty Time of the day			291:40

Date											
Friday				Saturday				Sunday			
Flight No.	Departed		Duty time	Flight No.	Departed		Duty time	Flight No.	Departed		Duty time
	Time	To			Time	To			Time	To	
606	0010	BKK	27.50	608	0010	BKK	27.50	606	0200	BKK	27.50
402	0030	JED	8.30	710	0035	FCO/LHR	20.35	402	0030	JED	8.30
702	0050	FCO	21.30	404	0205	TLV	12.45	710	0035	FCO/LHR	20.15
* 917	0140	LOS/ACC	16.25	809	0900	JNB	14.35	404	0205	TLV	12.45
809	0900	JNB	14.35	905	0900	DLA	12.55	809	0900	JNB	14.35
915	0900	LBV/DLA	14.45	901	0915	LOS	14.05	871	0915	HRE/LUN	12.55
450	0915	KRT/CAI	12.15	873	0930	LLW/LUN	12.15	901	0915	LOS	14.05
901	0915	LOS	14.05	801	0945	NBO/ KGL	12.25	801	0945	NBO/KGL	12.25
851	0930	LAD	12.55	805	1000	JRO/DAR	12.20	831	0945	BZV	12.20
873	0930	LLW/LUN	12.15	602	1015	DXB	12.30	805	1000	JRO/DAR	12.20
801	0945	NBO/KGL	12.25	811	1015	EBB/BJM	12.30	602	1015	DXB	12.30
831	0945	BZV	12.20	907	1015	LFW/ACC	16.00	811	1015	EBB/BJM	12.30
805	1000	JRO/DAR	12.20	100	1215	MQX	4.40	*907	1015	LFW/ACC	16.55
909	1000	ABJ	16.05	610	2140	BOM	13.20	306	1030	JIB/SAH	11.15
602	1015	DXB	12.30	408	2150	BEY	13.00	939	1030	NDJ	11.30
811	1015	EBB/BJM	12.30	452	2215	CAI/KRT	12.15	100	1215	MQX	4.40
306	1030	JIB/SAH	11.15	500	2215	FCO	37.25	610	2140	BOM	13.20
700	1200	FCO/LHR	20.35	600	2230	DXB	11.00	408	2150	BEY	13.00
100	1215	MQX	4.40	604	2310	DEL	32.45	500	2215	FCO	37.25
610	2140	BOM	13.20					620	2215	BAH/AUH	12.00
408	2150	BEY	13.00					600	2230	DXB	11.00
500	2215	FCO	37.25					604	2310	DEL	32.45
620	2215	BAH	12.00					706	2320	FRA/AMS	20.20
937	2215	NDJ (RT)	11.00								
600	2230	DXB	11.00								
704	2335	CDG/BRU	20.50								
Total Duty Time of the day			388.20	Total Duty Time of the day			305:10	Total Duty Time of the day			357:10

Table 3.5 List of weekly scheduled flights

As shown in the above table, the Company needs a total duty time of 429 hours on Monday, 302 on Tuesday, 361:45 on Wednesday, 291:40 on Thursday, 388:20 on Friday, 305:10 on Saturday, and 357:10 on Sunday. So based on this, the Company needs a total of 2435 hours per week. When we multiply it by 4, we get a 4 weeks total duty time as 9740 hours. By adding the two days (Monday and Tuesday) total duty hours on this figure, we can obtain the monthly total duty hours of 10,471.

It is learned from the weekly printed schedule taken from the Company and the interview conducted, the Company assigns 5 to 8 crew members as one crew group for international flights. Based on the above calculated total duty times of each day, a rough analysis is made to check whether the available crew members are enough to undertake all the scheduled flights or not by allowing them to work only the normal time specified in the collective agreement. During the course of analysis the following assumptions are made.

- 30 days of duty time is taken as the total duty time of the month by starting from Monday as day 1.
- From the total 745 cabin crew attendants, since some of them should attend domestic flights, it is assumed that 45 of them are assigned to these routes.
- Three different scenarios are assumed concerning those who couldn't attend flights for reasons such as sick leave and refusal. The 1st one is no absenteeism, 2nd one is 5% non-attendants and 3rd one is 10% non-attendants with in a given month.
- Only scheduled flights are to be attended (no extra flight) and there is no irregularity that will occur in the scheduled flights.
- No reserve or stand-by cabin crew member is assumed in the calculation

Based on the above assumption, the following tables are constructed to investigate whether the Company has enough cabin crew attendants or not.

1st scenario: No absenteeism of cabin crew member (optimistic assumption)

No of cabin crew member available =700

	Number of cabin crew members in one			
	5	6	7	8
Number of possible crew groups	140	117	100	88
Total No. of normal Duty hours available	12600*	10500*	9000*	7875
Total duty hours needed	10471	10471	10471	10471
Extra hours needed	2129.00	29.00	(1471.00)	(2596.00)
<i>Additional cabin crew members needed</i>	0	0	114	231

Table3. 6 Duty hour's analysis table

2nd scenario: 5% non-attendants

No. of crew members available 663

	Number of cabin crew members in one			
	5	6	7	8
Number of possible crew groups	133	111	95	83
Total No. of normal Duty hours available	11934	9945	8524	7459
Total duty hours needed	10471	10471	10471	10471
Extra hours needed	1463	(526)	(1947)	(3012)
Additional cabin crew members needed	0	35	130	201

Table 3.7 Duty hour's analysis table

3rd scenario: 10% non-attendants

No. of cabin crew members available 625

	Number of cabin crew members in one			
	5	6	7	8
Number of possible crew groups	125	104	89	78
Total No. of normal Duty hours available	11250	9375	8036	7031
Total duty hours needed	10471	10471	10471	10471
Extra hours needed	779	(1096)	(2435)	(3440)
Additional cabin crew members needed	0	73	190	306

Table 3.8 Duty hour's analysis table

Number of Possible crew groups

=No. of crew members available/Number of crew members to be included in one group

Total No. of normal duty hours available

=Number of Possible crew groups *90

The additional cabin crew members

= (Extra hours needed/90)*crew group size

As it is shown clearly under the table which takes the 1st scenario, when the crew group is composed of 5 or 6 cabin crew members and no absenteeism occurs, the Company can meet the scheduled flights with the existing manpower's available at hand. When the group size

grows to 7 and 8 individuals, the Company needs to have 1471 and 2596 additional hours respectively or 114 and 231 additional cabin crew members.

Referring to the table under scenario 2, which assumes 5% (37) non-attendants, the Company does not need any additional manpower or extra hours from the existing cabin crew members only when the group size is formed by 5 cabin crew members. The table also shows a need of extra hours of 526, 1947, and 3012 or additional cabin crew members of 35, 130, and 201 if the crew group is formed by 6, 7, and 8 cabin crew members respectively.

When we consider the table constructed under scenario 3, which assumes 10% (75) non-attendants, the Company does not need any additional manpower or extra hours from the existing cabin crew members only when the group size is formed by 5 cabin crew members. However, when the crew members' size required to form a crew goes up and becomes 6, 7, and 8, the Company needs to have additional 1096, 2435, and 3440 extra hour performers or 73, 190, and 306 cabin crew members. Under all the three scenarios, the Company is in safe position not to incur extra hour payments if the crew group is formed by 5 cabin crew members.

As it is indicated in the data presentation part, the size of a cabin crew group being assigned to a certain flight depends up on the type of aircraft assigned to a particular flight. So from the 4 types of aircrafts used by the Company to attend the international flights, only in one aircraft type (Boeing 737) 5 cabin crew members will be assigned as a cabin crew group. In the remaining three aircraft types (AIF, Boeing 757 and 767) a cabin crew group will be composed of 7 or 8 cabin crew members. This information implies that the Company mostly needs 7 or 8 cabin crew members to form a group for more flights than it needs 5 cabin crew

members. When the average number of 7 crew members is taken to form the group, the number of additional cabin crew members needed ranges from 114 in the first scenario (uses optimistic assumption) to 190 cabin crew members in the 3rd scenario. The number of additional manpower needed will definitely increase from this number if reserve and stand by crew members are included in the calculation and if any extra flight is scheduled. So by looking to this information, it can be said that the Company needs additional cabin crew members to work by respecting the normal duty hours as stated in the collective agreement.

Chapter - 4

4 Summary, Conclusion and Recommendation

4.1 Summary

The first purpose of this study is to properly investigate and describe the current crew scheduling system to be followed in Ethiopian Airlines and pass recommendations (if found to be appropriate) which will help to improve the system. By having this purpose in mind, investigation was made with regard to the methods and techniques employed to prepare the schedule, the various factors to be considered while preparing the schedule, and the basis of assigning cabin crew member to a particular crew group. In the process of finding the required information, interview questions are prepared and interview is conducted with the representative of the section which is responsible for the preparation of crew schedule. The following main questions (among others) were raised during the interview to assess the system properly:

- What are the driving objectives (to be minimized or maximized) in preparing the schedule?
- What is the impact that the preparation of schedule has on the Company's performance?
- What methods do you employ to prepare the schedule? Do individuals have power over the prepared schedule or is it a programmable decision?
- What are the controlling mechanisms exist to measure the efficiency of the prepared schedule and the system at large?

- At what time interval is schedule is prepared and communicated and do you consider any revision in the schedule after it is distributed? If revision is made, how do you communicate the revised employee?
- What are the factors that affect the preparation of a schedule?

During the discussion, satisfactory answers are found for almost all the questions raised and most of the required information is gathered. So the major findings of this study are summarized and presented as follows.

- In preparing crew schedule, the section who is responsible for this considers various factors. Following are the major factors to be considered adopted from the collective agreement of EAL and applicable to cabin crew members.
 - 13 consecutive hours is the maximum duty time within 24 consecutive hours.
 - A cabin crew member is entitled to 20 hours rest after each international flight that takes more than 4 hours. For international flights that take less than 4 hours and for any domestic flight, the rest time is 12 hours. For long-range flight, a local night rest of 24 consecutive hours shall be granted at home base in addition to the minimum crew rest.
 - The cabin crew member normal duty time within a month is 90 hours.
 - A cabin crew member is entitled to 6 guaranteed days-off within a month in Addis Ababa. The days-off will be arranged in the manner 3consecutive days, 2 consecutive days, and one day.

- Around 94 % of cabin crew members are eligible to attend any flight. And the different positions exist among the cabin crew members can be substitutable with each other.
- The schedule is performed and distributed to all cabin crew members on a weekly basis. The schedule is subjected to change every day and the revision will be communicated to all concerned parties through telephone.
- The Company uses manual methods to perform the scheduling function and it imposes difficulty in performing their daily tasks.
- During the course of checking the quality of the schedule prepared, errors such as assigning one employee for different flights on the same day is found while checking the scheduled prepared so far.
- Individuals involved in the preparation of schedules use their own judgment and their capacity and willingness greatly determines the quality of the schedule. Besides no checking mechanism or standard exists to check individuals work.
- Individuals involved in the preparation of schedules don't take any formal training in relation to the job they are doing. They perform it with the skills they possess through experience.
- In the course of checking the performance measurement standard or criteria applied so far used in controlling the output of the scheduler, it is found that there exists no standard or criteria exists used to control individuals output or to evaluate one's work.
- It is found that the driving objective behind the preparation of crew schedule preparation is meeting the manpower requirement necessary to attend a certain flight.

- The base to assign individuals to a particular crew member to a certain crew group is by looking to the availability of the individual at the particular time and the position required in forming the group.
- In the process of checking the total duty hours' assignment of an employee, 85% of the cabin crew members included in the sample are found working extra hours beyond the normal hours specified in the collective agreement. It is also found that there is a need to have additional manpower to avoid the extra hours.
- From the analysis made to investigate whether the schedule considers days-off or not when it is being prepared, it is found that the schedule doesn't consider the days-off of 75% of the cabin crew members included as a sample group.
- Reserve and stand-by crew members are included in the preparation of schedule.
- The Company doesn't keep a separate record of cost for each flight or doesn't consider each flight as a cost center.
- The Company has past experiences in missing flights because of shortage of available cabin crew members.
- It is found that the scheduling function is very important to the Company and if it is disrupted or stop at all, the Company will not attend any flight.

4.2 Conclusion

Based on the findings presented in the previous section, the following conclusions are drawn.

- By looking to the dimension such as the days-off consideration and the 90 hours time limitation, 85% of cabin crew members are working overtime and 75% of the cabin crew members are not granted with the guaranteed days-off as specified in the collective agreement. So based on this it can be concluded that the schedule prepared so far doesn't strictly consider the different rules and regulations affecting each cabin crew members.
- It is a well known fact that the very purpose of preparing a schedule is to communicate the information to all the concerned parties in advance so that they can perform their own part based on the information. When we come to the schedule prepared to cabin crew members, it is used as a means to communicate their assignments prior to the actual work so that they make themselves ready for the job. While examining the practice of the Company in relation to the revision made on the weekly schedule, the Company has been adopting a daily revision on the schedule which becomes almost the major part of their daily job and alterations have been made on the schedule on each flight (on average). When the schedule is revised (changed), it is the inescapable fact that it manufactures irregularities on the already developed schedules. So based on this frequent revision and the irregularities it imposes on the prepared schedule, it can be concluded that the current revision decreases the dependability or the trust that the schedule should obtain from the part of cabin crew members.

- Much of the work of the Company is performed by getting the cabin crew members to work for extra hours. Looking to the figures 85% of cabin crew members are working overtime and 75% of the cabin crew members are not considered to take their days-off when the schedule is prepared, it can be concluded that if the cabin crew members demand their rights and strict themselves to the 90 hours duty time and the 6 days guaranteed days-off as stated in the collective agreement, the Company obviously could not escape cancellation of more flights.
- To have a check on a certain system or to measure the out put a certain system delivers, it is necessary to have a representative standard or criteria. It is also a well known fact that performance measurement is necessary to improve a certain system. When we come to the Company under consideration, there is no controlling mechanism to check individual scheduler's task or the total system. Moreover individuals involved in the preparation of schedules use their own judgment (capacity and willingness) to produce a certain schedule. Based on this fact it can be concluded that the quality of the schedule to be produced is dependent more up on the individual judgment instead of the system. By bringing the fact that the existence of lack of measurement criteria in controlling/checking individual or system output, it can also be concluded that the Company didn't do anything to measure the output and improve the system.
- As it is indicated, there are two general methods used to solve scheduling problems: Mathematical models and heuristics. When we see the Company's practice, there are no written procedures or steps or methods used to follow during the preparation of the schedule. Individual schedulers are dominating the outcome of the schedule. As it is

also, revealed in the data presentation part, the Company did nothing to improve the system. So from this, it can be concluded that, the Company did not attempt anything special to systematize the scheduling function by adopting a clear procedure which will avoid or minimize the individual dominance observed in the current system.

- To achieve the very purpose of preparing schedule, the schedule should be prepared and communicated to all those concerned without including any ambiguity in it. When we come to the current practice of the scheduling system in EAL, it has been shown that 4 out of 20 employees have received one or more assignments on the same date. By looking to these error rates it can be generalized that the current scheduling system is not clearly communicating the assignments of cabin crew members as it has to be.
- As it is stated previously, scheduling function is very important to the Company and if it is disrupted or stops at all, the Company will not attend any flight. But on the other hand, by looking to the findings related to the system employed and the justification forwarded not to use the already acquired software (the software is not functional because of shortage of cabin crew members to be scheduled, its requirement of the different rules and regulations to be incorporated), the so far existed extra hours payments, non-existence of provision of formal training to the schedulers, the systems dependence on individuals, lack of performance measurement criteria (for the whole system as well as the individual output), violation of the different rules the Company accepts to be governed by, it can be concluded that the Company does not give attention for the scheduling function as it deserves.
- When looking to the different factors and rules governing the preparation of schedule, such as the method employed, performance measurement criteria, the quality of the

schedules, the rules governing days-off and the total duty time, all of these can be controlled by the Company. However, when we see the above factors, in all the areas mentioned above the Company showed a remarkable weakness in respecting the rules, keeping the quality of the schedules, establishing performance measurement criteria to control the output of the system or the individual schedulers, and designing reliable systems. So from this it can be concluded that the Company's management does not give much attention to the scheduling function or it is not capable of understanding the problem and to pass possible solution.

- By looking to the fact that the Company has been incurring extra hours payments in a regular manner (85% of cabin crew members are found working extra hours which ranges up to 77%), the Company's experience in missing flights due to shortage of manpower, and the findings that justifies the need for extra hours when one crew group comprising 7 or 8 crew members, it can be concluded that the Company's current cabin crew attendants are not enough to meet the scheduled flights by keeping all the rules and regulations stated in the collective agreement and without incurring any extra hours payments.
- By looking to the finding which showed the non-existence of separate record of cost incurred for cabin crew members with respect to each flight and the extra hour payments the Company has been incurring, it can be concluded that the Company is not sensitive or doesn't give much attention for the minimization of its operational cost incurred for cabin crew members which ranks second only next to fuel costs in the industry at large.

- When we look the various rules and regulations governing scheduling such as the duty times and days-off, the advance knowledge of the flights to be attended, the air craft assigned for each flight, the number of cabin crew members needed to make the crew group for each flight, the total number of existing manpower, and other airlines experience in the area, it can be concluded that the scheduling function can be a programmable decision and the individual dominance can be minimized.

4.3 Recommendations

Based on the findings and the conclusions drawn in the previous sections, the following recommendations are forwarded.

- Air crews are amongst the most valuable of airline resources and efficient utilization of crews is obviously an important consideration in airline operations. Next to fuel costs, crew expense represents the largest expense component to an airline. Therefore, it is recommended that EAL should better understand the economics to be gained from efficient scheduling system and should take the initiatives to improve the deficiencies surrounded the current system.
- Although the scheduling problem has obvious cost significance, the important issue of crew satisfaction in scheduling also affects the cost of operating schedules. Crew dissatisfaction can indirectly lead to significant cost increases. The scheduling problem also involves a conflict of management and crew objectives: management wish to minimize the number of crew members required, while crew members wish to maximize their satisfaction with the schedule. Reducing crew numbers usually adversely affects the feasibility of the schedules and crew member satisfaction with the schedule. An ideal scheduling system would satisfy both crew and management objectives and minimize schedule operating costs in a reduced amount of time. Based on this, it is recommended that the Company should thoroughly consider the crew member satisfaction while preparing the schedules instead of being one sided

(inclined to satisfying management objectives) which is observed in the current system.

- Performance evaluation of an individual as well as any system is necessary to measure the deliverables and to improve the system if any weakness is observed. As the Company under consideration doesn't have any performance measurement criteria to control the output of the individual schedulers as well as the scheduling system at all, it is the researcher recommendation that the Company should design performance measurement criteria to assess the individuals and system performance. Also recommended is, the Company should consider factors such as percentage of flights covered, overtime/other extra payments incurred, cost incurred for a certain flight (with respect to crew cost) and no. of revisions made on the issued schedule per day or per week as a performance measurement criteria
- The underlying objective in scheduling is to produce a schedule of feasible duties or trips which cover all the timetabled flights in the most efficient manner possible in terms of factors such as the number of duties or trips and total duty time that must be 'feasible' with respect to all the rules, regulations, safety considerations, contractual agreements and conditions of awards and agreements. Therefore, the Company should respect all the rules and regulations affecting crew members which it currently ignored in the process of covering all the time tabled flights.
- To properly perform the scheduling function and create an efficient system there are conditions to be satisfied such as enough manpower, capable

schedulers, and functional system. As it is shown in the analysis and findings of this study, the Company under consideration did not have enough manpower to attend the scheduled flights without forcing the existing cabin crew members to work extra hours and also the schedulers did not attend any formal training which will enable them to work in the system in a consistent manner. Therefore, the Company is recommended to incorporate additional cabin crew members and also to provide training to its schedulers for the betterment of the system. Also important to recommend here is that the Company should reconsider the use of the software already available at hand by fulfilling all the requirements.

- Mathematical models such as integer programming, dynamic programming, and linear programming can solve scheduling problems successfully. To suggest a mathematical programming model in the current system of Ethiopian Airlines it becomes difficult because the Company doesn't have a specific objective to be maximized or minimized such as revenue and cost which should be reflected on the objective function. However, with the current system also, it is the researcher's recommendation for the Company at least to clearly set its objective in a measurable manner in terms of cost, profit, or revenue and also it should immediately implement performance measurement criterion to minimize individual scheduler's dominance observed in the current system.