ADDIS ABABA UNIVERSITY

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INDUSTRIAL ENGINEERING

MASTER'S DEGREE THESIS

ON

IMPROVEMENT OF OPERATIONAL PRODUCTIVITY OF MAINTENANCE AND ENGINEERING ACTIVITIES THROUGH THE USE OF TOTAL QUALITY MANAGEMENT -A CASE STUDY ON ETHIOPIAN AIRLINES

Submitted to Addis Ababa University, Faculty of Technology, Department of Mechanical Engineering, in Partial Fulfillment for the Award of the Degree of Master of Science in Mechanical Engineering (Industrial Engineering Stream)

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Abstract

Total Quality Management (TQM) has become a frequently used term in the discussions regarding quality. The international and national competitive environment is in a process of constant change by the globalization of markets and increased interdependence of economic agents. This process of change has brought increased demands on the organizations' competitiveness and the customers have gained a central role in the organizations' focus. TQM is considered to be an important management philosophy, which supports the organizations in their efforts to maintain satisfied customers.

The aviation industry is the most safety requiring industry where a single malfunction or fault may lead to the fatal and catastrophic accident of life and property. Organizations engaged in this industry should constantly monitor all tasks in order to assure the safety of flight and to stay as a working unit in the competitive market and serve their customers. This will come true when existing employees in these organizations are trained to acquire all the demands placed on this technology and when they are satisfied with the environment in the organizations to develop the sense of belongingness and inspiration so as to satisfy and exceed their customers' needs and aspirations.

In the aviation industry, operators need to be licensed by regulatory bodies to exist in the industry. However, the major focus of these regulatory bodies is conformance to requirements instead of system wise quality management. Hence a need has come for the airlines to establish total quality achievement to be better competitors in the industry.

This thesis focuses on the improvement of operational productivity of aircraft maintenance and engineering activities in Ethiopian Airlines through the use of TQM. A thorough investigation of TQM implementation is conducted in the maintenance and engineering division of the airline by assessing the accomplishment of the existing quality related activities in relation to TQM philosophies. The results obtained by studying the implementation of TQM in this division indicate that still a lot of effort is required to achieve productivity improvement through TQM. The existing "TQM" department in this division is actually performing quality assurance activities. This is more elaborated in this study and a model TQM implementation is suggested later to actually obtain the benefits of TQM implementation.

List of Tables

List of figures

List of abbreviations

A&P	Airframe & Power plant
ANSI	American National Institute of Standards
ASQC	American Society for Quality Control
ATA	Air Transport Association
B-757	Boeing 757
CAA	Civil Aviation Authority
CASS	Continuing Analysis & Surveillance Systems
CEO	Chief Executive Officer
CFR	Code of Federal Regulation
CMM	Component Maintenance Manual
COO	Chief Operating Officer
EAL, ETHIOPIAN, ETH	Ethiopian Airlines
EASA	European Association of Suppliers Agency
ECAA TD	Ethiopian Civil Aviation Technical Directive
F-50	Fokker 50 Aircraft
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FR	Foreign Repair
HFM	Human Factors in Maintenance
IPM	Inspection Procedure Manual
IOSA	IATA Operational Safety Audit
ISO	International Organization for Standards
MCC	Maintenance Control Center
M&E	Maintenance and Engineering
MPD	Maintenance Planning Data Document
MPE	Maintenance Program Evaluation
NDT/NDI	Non Destructive Test/Inspection
NIST	National Institute of Standards and Technology
OJT	On-Job Training
PDCA	Plan Do Check Act
PFA	Prevention, Appraisal Failure
QC &QA	Quality Control & Quality Assurance
RPM	Reliability Program Manual
SWOT	Strength, Weakness, Opportunity, Threat
TCCA	Transport Canada Civil Aviation
TQC/M	Total Quality Control/Management
TPPM	Technical Policies and Procedures Manual
VP	Vice President

Chapter 1: Introduction

1.1Background

In capturing increased market share, quality has been the main concern of every manufacturer or service giving organization since olden days. Started with the inspection concept, it is moved to the quality control concept, when it was realized that making the inspection department responsible for the quality would be less productive. Concept of quality control emphasizes self-inspection and appropriate systems to assure quality by identifying defectives and eliminating them. Later the concept of quality assurance came in to practice. But the quality movement did not stop with this and the attempt is to continuously improve the quality and assure higher and higher standards of quality, offer better products and services to the customer .It was felt that quality was not only the job of quality control department but also of other departments like sales, procurement, material handling, accounting, industrial relations, design, production, forecasting, marketing, stores and after sales service. Thus quality is the responsibility of all the employees. The workers should run the system; managers should design and improve the system; while the top management should provide leader ship and team spirit. Total Quality Management (TQM) is an approach to the art of management that originated in Japanese industry in the 1950's and has become steadily more popular in the west since the early 1980's. TQM is at first glance seen primarily as a change in an organization's technology of doing work. In the human services, this means the way clients are processed the service delivery methods applied to them and ancillary organizational processes such as paperwork, procurement processes, and other procedures. Next TQM is also a change in an organization's culture , its norms, values, and belief systems that aims to provide, and continue to provide, its customers with products and services that satisfy their needs and even to exceed their expectations. The culture requires quality in all aspects of the company's operations, with things being done right first time, and defects and waste eradicated from operations. And finally, it is a change in an organization's political system, decision-making processes and power bases. For substantive change to occur, changes in these three dimensions must be aligned: TQM as a technological change will not be successful unless cultural and political dimensions are attended as well.

Effective TQM results in greater customer satisfaction, fewer defects, less waste, reduced costs, improved profitability and increased productivity. For the effectiveness of TQM programme a careful analysis of the customer's needs, and an assessment of the extent to

which these needs are currently met, and a suitable plan to fill up the gap between the current level and expectation is necessary. For the success of TQM, top managers must provide vision mission and, reinforce values emphasizing quality, set quality goals, and deploy necessary resources for these quality programs. For this purpose, training and development free flow of information is essential. The top managers must continuously monitor, evaluate, get feedback about TQM program and take necessary steps for its improvement.

Customer satisfaction is one of the most important aspect of TQM .The customer may be external to the organization or maybe inside the organization. Meeting the needs of outside customers depends on meeting the needs of inside customers. Inside customer is an individual or department receiving the output of another individual or department of the concern. From the above we can say that TQM involves effective decision-making, problem solving and integration of quality planning, quality implementation and quality improvement strategies of all the departments of an organization, committed and involved employees, lower costs, higher revenue and higher profit for the organization.

1.2 Statement of the problem

In the modern, global and competitive aviation industry, survival in a market is the result of continuous struggle and strive for delivery of better products and services. Products and services will constantly address the needs and expectations of customers only if an organization is able to manage the quality of its products/services systematically. Though Ethiopian Airlines has longstanding experience in the aviation industry, there are still many problems of quality that need to be addressed through an effective and efficient implementation of TQM. Here are few of them to list:

a) Paying more attention to quality control and conformance to regulatory bodies' requirements but with less achievement in quality assurance activities and total quality management.

b) Considerable flight delays, cancellations and technical incidents which result in customers' dissatisfaction.

c) Huge employee turnover mainly to get a better standard of living in developed countries.

d) Extension/postponding of Maintenance and Engineering tasks over the scheduled time.

e) Lack of most optimum quality management technique for production planning and control tasks in the maintenance and engineering areas.

f) Lack of awareness of quality by most employees and sections in performing their specific tasks.

g) Minimum aircraft utilization, lower dispatch reliability below the objective and higher maintenance man-hour.

h) Minimum commitment to conduct trainings as per training schedules.

1.3 Objective of the thesis

Taking the above problems in to consideration, this thesis attempts to achieve the following objectives:

1.3.1 General objectives

a) To find out the most optimum way of assuring quality of maintenance and engineering activities.

b) To make every employee responsible for quality and continuous improvement.

c) To direct the vision, mission and guiding principles of quality towards TQM.

d) To help attain a potential of satisfying and exceeding internal and external customers' needs.

1.3.2 Specific objectives

a) Deep analysis of problems created by poor quality management systems that lower operational performance.

b) Identifying the causes of quality problems.

c) Suggesting possible solution to improve quality through the use of TQM.

1.4 Scope of the thesis

This thesis entirely focuses on exercising TQM implementation in the M&E division of Ethiopian Airlines. On this basis, a deep investigation and study has been conducted to examine the existing quality related activities currently underway in this division and there by evaluate the actual practice of TQM philosophies and the benefits that can be derived from it. Hence a thorough investigation has been conducted in all those sections under the M&E

division and other related divisions which may serve as inputs to the collection of information and data.

1.5 Methodology

- Literature review: The survey will include about Total Quality Management (TQM).
- Survey of previous relevant works. Review of previously accomplished thesis works, relevant articles and other documents on TQM on ETHIOPIAN and other industries.
- Interview ETHIOPIAN employees and representatives of regulatory bodies.
- Distribution of Questionnaires to ETHIOPIAN employees to gather the necessary information, consultation and personal observation at the ETHIOPIAN.
- Relevant data collection, interpretation and analysis.
- TQM model development and interpretation, and finally conclusion and recommendation.

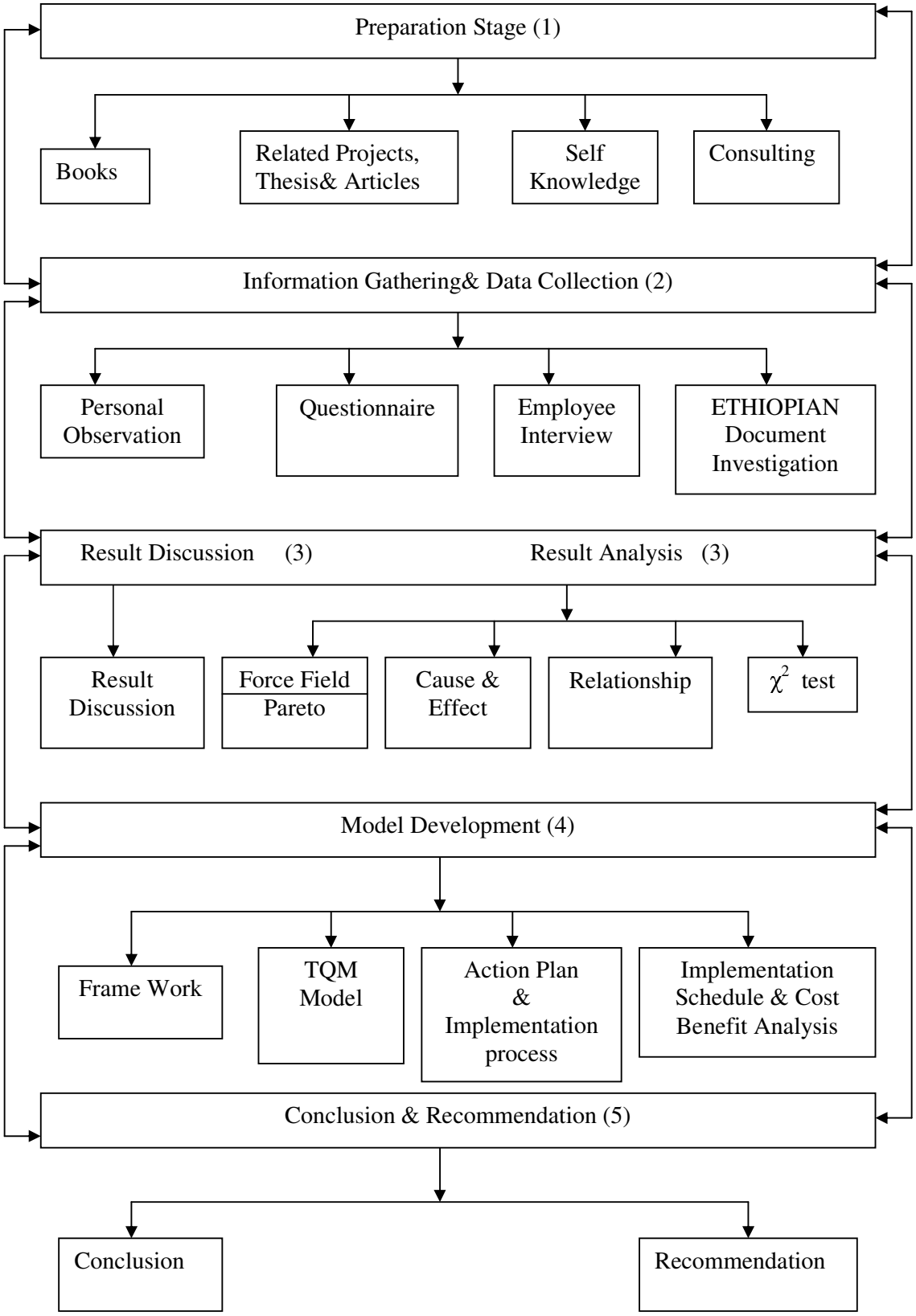
1.6 Application of the thesis results

Ethiopian Airlines (EAL) will benefit from the application of the thesis result in:

- Operational Productivity improvement of maintenance and engineering activities through the actual implementation of TQM.
- Maintaining consistent customer satisfaction and increased market share.
- Creating a conducive environment and changing traditional methods and culture of quality control and quality assurance to a modern way of TQM in the organization.

The result can also be applied with slight modification to other manufacturing and service giving organizations.

Figure 1.1 Organization of the thesis and summery of methodology followed



Chapter 2: Literature review

2.1 Definition of quality

The term quality is a relative term and has different meanings to different people or authors. Some of them are:

According to Garvin. D.A:

**Quality is a multi-dimensional perspective-based concept*: Performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. [12]

According to Deming:

*Quality can be defined only in terms of the *agent*. Who is the judge of quality? Thus, quality may mean different things to different people.

According to Juran:

*Quality is *fitness for use*. Therefore, quality products should meet or exceed *customer* requirements.

According to Crosby:

*Quality is *conformance to requirements*. Thus requirements must be clearly stated so that they cannot be misunderstood [4].

It is also possible to define quality by looking at it from different angles such as:

a) Customer based: Fitness for use, meeting customer expectations.
b) Manufacturing based: Conforming to design, specifications, or requirements. Having no defect.
c) Product based: The product has something that other products don't, that adds value.
d) Value based: The product is the best combination of price and features [6].

2.2 Evolution of quality management

The development of quality management can be defined in four stages:

(a) Quality inspection stage;
(b) Quality control stage;
(c) Quality assurance stage;
(d) Total quality management stage.

2.2.1 Quality inspection stage

Quality management started with simple inspection-based systems. Under such a system, one or more characteristics of a product are examined, measured or tested and compared with specified requirements to assess its conformity. This system is used to appraise incoming products, manufactured components and assemblies at appropriate points in the production process. It is undertaken mainly by staff employed specifically for this purpose. Products which do not conform to specification may be scrapped, reworked or sold as lower quality items. In some cases, inspection is used to grade the finished products. The system is an after-the-fact screening process with no prevention content other than, perhaps, the identification of suppliers, operations or workers manufacturing non-conforming products. Simple inspection-based systems are usually wholly in-house and do not directly involve suppliers or customers [7].

2.2.2 Quality control stage

Under a system of quality control, product testing and documentation control became the ways to ensure greater process control and reduced non-conformance. Typical characteristics of such systems were performance-data collection, feedback to earlier stages in the process, paperwork control, use of basic statistics, basic quality planning, product testing and self-inspection. While screening, inspection was again the main mechanism for preventing products which were outside the specification from being shipped to customers. Quality control measures led to greater process control and a lower incidence of non-conformance. [7].

2.2.3 Quality assurance stage

The quality assurance stage came with the change away from product quality towards system quality. In this stage, an organization sets up a system for controlling what is being done and the system is audited to ensure that it is adequate both in design and use. A major part of this change is the use of both second-party and third-party audits to assess the efficiency of the system. The major characteristics of this stage are the use of quality manuals, procedures, work instructions, quality planning, quality audits, etc. The fundamental difference is that quality assurance is prevention-based while quality control is inspection-based [7].

2.2.4 Total quality management stage

Total quality management stage is the highest level, involving the application of quality management principles to all aspects of the business. Total quality management requires that

the principles of quality management be applied in every branch and at every level in an organization. Typical of an organization going through a total quality process would be a clear and unambiguous vision, few interdepartmental barriers, time spent on training, excellent supplier and customer relations and the realization that quality is not just product quality but also the quality of the whole organization, including sales, finance, personnel and other non-manufacturing functions [7].

2.3 The total quality approach

Total quality is an approach to doing business that attempts to maximize the competitiveness of an organization through the continual improvement of quality of its products, services, people, and environment [8].

2.3.1 How total quality is achieved?

Total quality approach has the following characteristics:

a) Strategically based: Total quality organizations have comprehensive strategic plan that contains at least the following elements: Vision, mission, broad objectives, and activities that must be completed to accomplish the broad objectives. The strategic plan of total quality organization is designed to give it a sustainable competitive advantage in the market place.

b) Customer focus: In a total quality setting, the customer is the deriver. This point applies to both internal and external customers. External customers define the quality of product or service delivered. Internal customers help define the quality of the people, processes, and environment associated with the product or service.

c) Obsession with quality: In a total quality organization, internal and external customers define quality. With quality defined, the organization must then become obsessed with meeting or exceeding this definition. All personnel at all levels approach all aspects of the job from the perspective of "How can we do this better?". When an organization is obsessed with quality, good enough is never good enough.

d) Scientific approach: Although it is true that people skills, involvement and empowerment are important in a total quality setting, they represent only a part of the equation. Another important part is the use of scientific approach in structuring work and decision making and problem solving that relates to the work. This means hard

date is used in establishing benchmarks, monitoring performance and making improvements.

e) Long-term commitment: Organizations that implement management innovations after attending short-term seminars often fail in their initial attempt to adopt the total quality approach. This is because they approach total quality as just another management innovation rather than as a whole new way of doing business that requires a whole new corporate culture.

f) Team work: In traditionally managed organizations, the best competitive efforts are often between departments with in the organization. Internal competition tends to use energy that should be focused on improving quality and in turn, external competitiveness.

g) Continuous process improvement: Products are developed and services are delivered by people using processes with in environments (systems). To continually improve the quality of products or services-which is a fundamental goal in a total quality setting-it is necessary to continually improve systems.

h) Freedom through control: In a quality leadership there is control, yet there is freedom. There is control over the best-known method for any given process. Employees standardize processes and find ways to ensure every one follows the standard procedures. They reduce variation in input by reducing variation in the way work is done. As these changes take hold, they are free to spend time eliminating problems, to discover new markets and to gain greater mastery over processes.

i) Unity of purpose: From the perspective of total quality, who or what is to blame for adversarial management-labor relation is irrelevant. To apply total quality approach, organizations must have unity of purpose. This means that internal politics has no place in a total quality organization. Rather, collaboration should be the norm.

j) Employee involvement and empowerment: This is one of the most misunderstood elements of the total quality approach and one of the most misrepresented by its detractors. It is the recognition that many decisions made in an organization can be made better by soliciting the inputs for those who may be affected by the decision. It is an understanding that people at all levels of an organization possess unique talents, skills, and creativity that can be of significant value if allowed to be expressed. The basis of involving employees is twofold. First, it increases the likelihood of a good decision, a better plan, or a more effective improvement by bringing more minds to bear on the situation-not just any minds, but the minds of the people who are closest to

the work in question. Second, it promotes ownership of decisions by involving the people who will have to implement them. Empowerment means not just involving people but involving them in ways that give them a real voice. The difference between involvement and empowerment is just having input and input that is heard, seriously considered and followed up on whether it is accepted or not [8].

2.4 Leadership and change

2.4.1 Leadership defined

Leadership is the ability to inspire people to make a total, willing and voluntarily commitment to accomplish or exceeding organizational goals. [8]

This definition contains a key concept that makes it particularly applicable in a total quality management: The concept of inspiring people. Inspiring people is a higher order of human interaction than motivating them. *Inspiration* means motivation that has been internalized and therefore comes from within employees, as opposed to motivation that is simply a temporary response to external stimuli. Motivated employees commit to the organization's goals while inspired employees make those goals their own. When employees are inspired, the total, willing and voluntarily commitment described in the definition follows naturally.

2.4.2 Critical things leaders must be able to do

a) Overcome resistance to change: Some people in management positions attempt to do this using power and control .Those who are leaders overcome resistance by achieving a total, willing and voluntary commitment to shared values and goals.
b) Broke the needs of constituency groups inside and outside the organization: When the needs of the company and one of its suppliers appear to conflict, leaders must be able to find ways of bringing the needs of both organizations together without shortchanging either of them.
c) Establish an ethical framework within which all employees and their company as a whole operate: This is best accomplished by setting an example of ethical behavior, choosing ethical people as team members, communicating a sense of purpose for the organization, reinforcing appropriate behaviors with in the organization and outside of it, articulating ethical positions, internally and externally [8].

2.4.3 Leadership versus misleaders

In his book *Managers for the Future: The 1990's and Beyond,* Peter Drucker makes the point that leadership is not a function of charisma. Too many managers have been led to believe that dressing for success and developing a charismatic appearance are the keys to being a good leader. Although there is something to be said to for personal appearance, and charisma is certainly not a negative quality, one shouldn't make the mistake of confusing image with substance. Those who place image above substance and try to lead are misleaders, not leaders. What follows are several criteria Drucker uses to distinguish leaders from misleaders.

a) Leaders define and clearly articulate the organization's mission.
b) Leaders set goals, priorities and standards.
c) Leaders see leadership as a responsibility rather than a privilege or rank.
d) Leaders surround themselves with knowledgeable and strong people who can make a contribution.
e) Leaders earn trust, respect and integrity [8].

2.4.4 Leadership style in TQM

Leadership styles have to be with how people interact with those they need to lead. Leadership styles usually fall in five categories namely, autocratic, democratic, participative, goal-oriented, and situational leadership styles. The appropriate leadership style in TQM is participative leadership taken to a higher level. Whereas participative leadership in the traditional sense involves soliciting employee input, in TQM setting it involves soliciting inputs from empowered employees, listening to that input and acting on it. Collecting employee input is not new. However, collecting input, logging it in, tracking it, acting on it in an appropriate manner, working with employees to improve weak suggestions rather than simply rejecting them and rewarding employees for improvements that result from their input-all of which are normal in TQM setting-extended beyond traditional approach to participative leadership[8].

2.4.5 Leadership characteristics in TQM that build and maintain followership

Leaders build and maintain follower ship by earning the respect of those they lead. Some of their characteristics are:

a) Sense of purpose: Successful leaders know where they fit in the organization and the contributions their areas of responsibility make to the success of the organization.
b) Self-discipline: Through self-discipline, leaders avoid negative self-indulgence, inappropriate displays of emotion such as anger and counterproductive responses to the everyday pressure of the job and they set an example of handling problems and pressures with equilibrium and positive attitude.
c) Honesty: Successful leaders are trusted by their followers. This is because they are open, honest and forthright with other members of the organization and with themselves.
d) Credibility: Successful leaders have credibility. Credibility is established by being knowledgeable, consistent fair and impartial in all human interaction; by setting a positive example; and by adhering to the same standards of performance and behavior expected of others.
e) Common sense: Successful leaders have common sense. They know what is important in a given situation and what is not. They know that applying tact is important when dealing with people. They know when to be flexible and when to be firm.
f) Stamina: Successful leaders must have stamina. Frequently they need to be the first to arrive and the last to leave. Their hours are likely to be longer and the pressures they face more intense pressures than others.
g) Commitment: Successful leaders are committed to the goals of the organization, the people they work with and their own ongoing personal and professional development. They are willing to do every thing within the limits of the law, professional ethics and company policy to help their team succeed.
h) Steadfastness: Successful leaders are steadfast and resolute. People don't follow a person they perceive to be wishy-washy and noncommittal [8].

2.4.6 Pitfalls that can undermine followership

Mangers should also be aware of several common pitfalls that can undermine follower-ship and the respect managers must work so hard to earn. Some are:

a) Trying to be buddy: Positive relations and good rapport are important, but leaders are not the buddies of those they lead. The nature of the relationship doesn't allow it.
b) Having an intimate relationship with an employee: This practice is unwise and unethical. A positive manager-employee relationship can't exist under such

circumstances. Few people can succeed at being the lover of the boss, and few things can damage the morale of the team so quickly and completely.

c) Trying to keep things the same when supervising former peers: The supervisor-employee relationship, no matter how positive, is different from peer-peer relationship. This can be a difficult task to accept and a difficult adjustment to make. But it is an adjustment that must be made if the peer-turned-supervisor is going to succeed as a leader [8].

2.4.7 Leadership versus management

Leadership and management, although both are needed in the modern work place, are not the same thing. According to John P. Kotler, leadership and management are two distinctive and complementary systems of action. Kotler lists the following differences between management and leadership:

a) Management is about copying with complexity; leadership is copying with change.
b) Management is about planning and budgeting with complexity; leadership is about setting the direction for change through the creation of a vision.
c) Management develops the capacity to carryout the plans through organizing and staffing; leadership aligns people to work toward vision.
d) Management ensures the accomplishment of plans through controlling and problem solving; leadership motivates and inspires people to want to accomplish the plan.

Field Marshall Sir Williamk Slim, who led the British Army's brilliant re-conquest of Burma during World War II, made the distinction between leadership and management as:

"Managers are necessary, leaders are essential….Leadership is of the spirit, compounded of personality and vision ….Management is of the mind, more a matter of accurate calculation, statistics, methods, timetables and routine."

In summery:

a) Managers administer; leaders innovate.
b) Managers are copies; leaders are originals.
c) Managers maintain; leaders develop.
d) Managers focus on systems and structures; leaders focus on people.
e) Managers rely on control; leaders inspire.
f) Mangers take the short view; leaders take the long view.
g) Managers ask how and when; leaders ask what and why.

h) Managers accept the status quo; leaders challenge it.
i) Managers do things right; leaders do the right thing [8].

2.5 Total quality management (TQM)

2.5.1 TQM defined

It has come as a reality that customers place a higher value on quality and price is no longer the determining factor in customers' choice. Price has been replaced by quality. Today's business environment is such that managers must plan strategically to maintain a hold on market share, let alone increase it. As quality is the concern of all in an organization in the total quality concept, total quality concepts should be integrated with effective and efficient management/leadership philosophy to yield TQM [18].

TQM is a management philosophy that seeks to integrate all organizational functions (marketing, finance, design, engineering, and production, customer service, etc.) to focus on meeting customer needs and organizational objectives.

TQM views an organization as a collection of processes. It maintains that organizations must strive to continuously improve these processes by incorporating the knowledge and experiences of workers. The simple objective of TQM is "Do the right things, right the first time, every time". TQM is infinitely variable and adaptable. Although originally applied to manufacturing operations, and for a number of years only used in that area, TQM is now becoming recognized as a generic management tool, just as applicable in service and public sector organizations. There are a number of evolutionary strands, with different sectors creating their own versions from the common ancestor [17].

Total Quality Management (TQM)

Total: Quality involves everyone and all activities in the company.

Quality: Conformance to requirements (meeting customer requirements).

Management: Quality can and must be managed.

TQM: A process for managing quality; it must be a continuous way of life; a philosophy of perpetual improvement in everything we do [22].

TQM is the foundation for activities, which include: Commitment by senior management and all employees ,meeting customer requirements ,reducing development cycle times ,just in time/demand flow manufacturing ,improvement teams ,reducing product and service costs ,systems to facilitate improvement ,line management ownership ,employee involvement and empowerment ,recognition and celebration ,challenging quantified goals and benchmarking ,focus on processes / improvement plans ,specific incorporation in strategic planning. This shows that all personnel, in manufacturing, marketing, engineering, R&D, sales, purchasing, HR, etc, must practice TQM in all activities [24].

2.5.2 The benefits of TQM programme

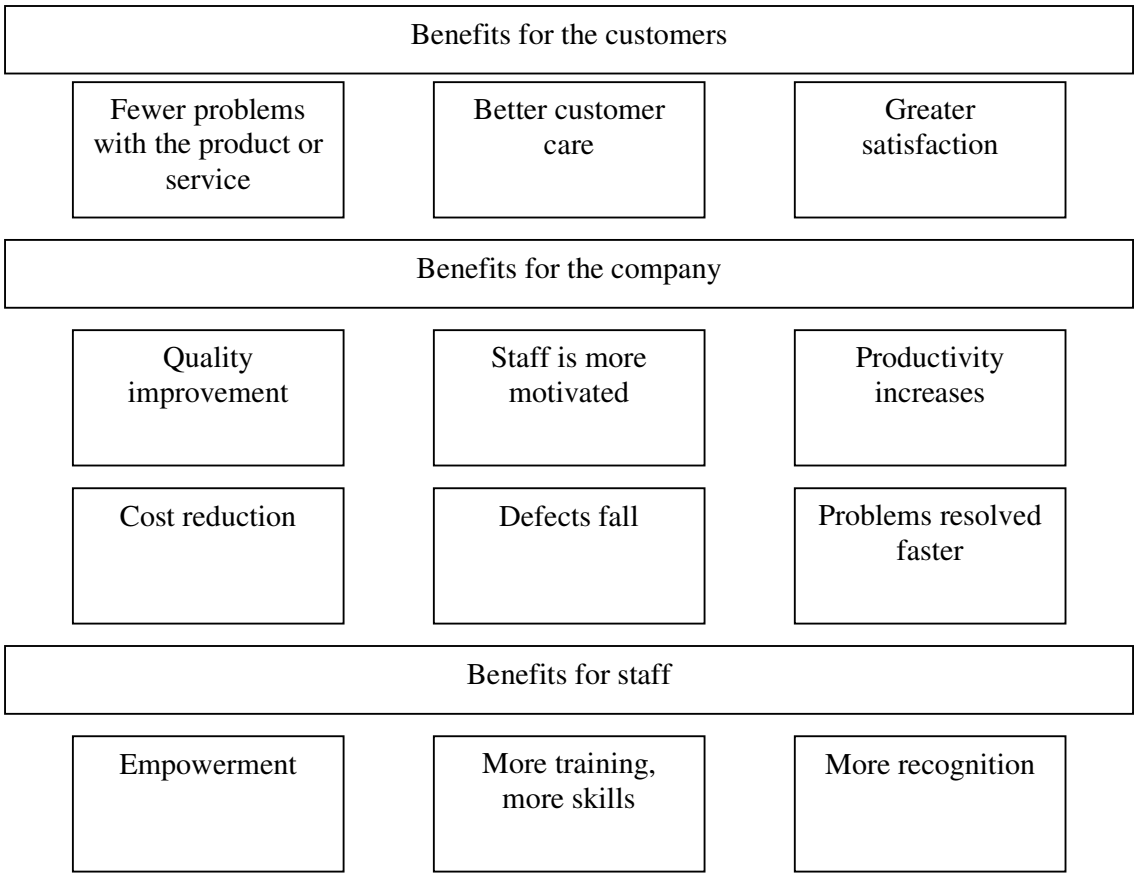


Figure 2.1 Benefits of the TQM programme

Some of these benefits are common to many quality initiatives. Advantages which are unique to TQM are as follows [28]:

› It makes the company a leader, not a follower.

› It fosters team work.

› It makes the company more sensitive to customer needs.

› It makes the company adapt more readily to change.

› It lets staff from different departments meet each other.

2.5.3 How does TQM work?

As shown in Figure 2.2, a TQM programme creates continuous improvement. This reduces waste and improves customer satisfaction. Both these factors lead to more profit [28].

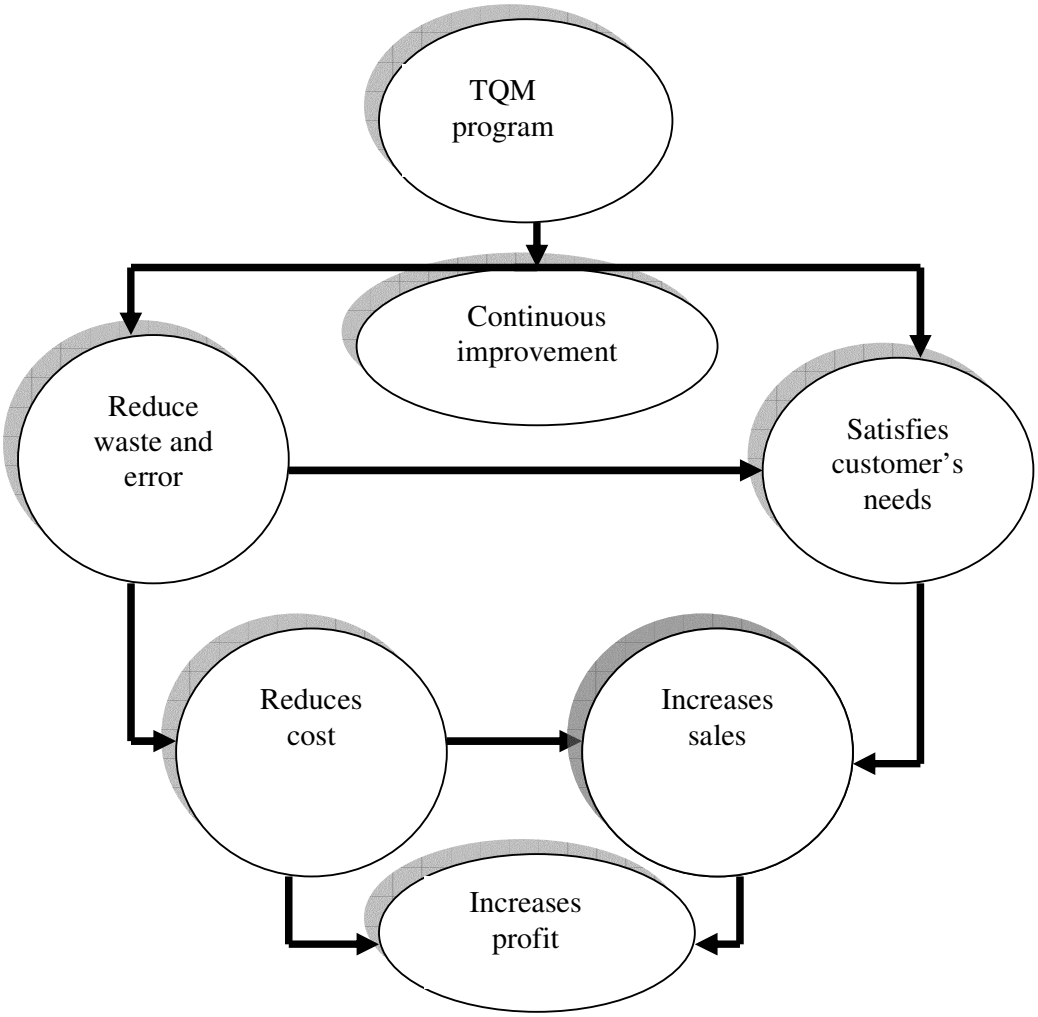


Figure 2.2 How TQM works

2.6 Learning from the quality pioneers

2.6.1. W. Edwards Deming

W. Edwards Deming was born on October 14, 1900 in Sioux, Iowa. Deming graduated with a B.S in physics from the University of Wyoming in 1921, and graduated from Yale with a Ph.D in mathematical physics in 1928. He worked for the U.S Census Bureau during and after World War II. In 1950, Deming went to Japan to help conduct a population census, and lectured to top business leaders on statistical quality control. Deming told the Japanese they could become world -class quality leaders if they followed his advice. Today Deming is generally regarded as the top leader in quality management, and still cited as the founder of the third wave of the industrial revolution (the first wave occurred in the early 19th century with simple automation, the second wave occurred with assembly concepts in the late 19th century, and the third wave is occurring with the information /computer revolution) [16].

Deming has summarized his quality philosophies into 14 steps. These are:

a) Create constancy of purpose towards improvement of product and service.
b) Adopt the new philosophy. Management must learn that it is a new economic age and awaken to the challenge, learn their responsibilities, and take on leadership for change.
c) Cease dependence on mass inspection. Require, instead, statistical evidence that quality is built in.
d) End the practice of awarding contract on the basis of low price.
e) It is management's job to work continually on the system of production and services, to improve quality and productivity, and thus constantly reduce cost.
f) Institute modern methods of training on the job.
g) Institute leadership. The purpose of leadership should be to help people and technology work together.
h) Drive out fear, so that every one may work effectively for the company.
i) Break down barriers between departments so that people can work as a team.
j) Eliminate numerical goals, posters, and slogans for the workforce asking for new levels of productivity without providing methods.
k) Eliminate quotas and management by objectives. Substitute leadership.
l) Eliminate barriers that rob employees of their pride of workman ship.
m) Institute a vigorous program of education and retraining.
n) Make the transformation everyone's job and put everyone to work no it.

Deming's seven deadly diseases

The fourteen points summarize Deming's view on what a company must for a positive transformation from business as usual to world-class quality. The seven deadly diseases summarize the factors that he believes can inhibit such a transformation.

a) Lack of consistency of purpose to plan products and services that have a market sufficient to keep the company in business and provide jobs.
b) Emphasis on short-term profits
c) Personal review systems for managers and management by objectives without providing methods or resources to accomplish objectives.
d) Job hopping by managers.
e) Using only visible data and information in decision-making with little or no consideration given to what is not known or can't be known.
f) Excessive medical costs.
g) Excessive costs of liability driven up by lawyers who work on contingency fees. [8]

The Deming Cycle which means, "Plan - Do - Check - Act " is also known as the control circle or PDCA. It is a four step, never ending process for solving problems, planning, making decisions and process improvement.

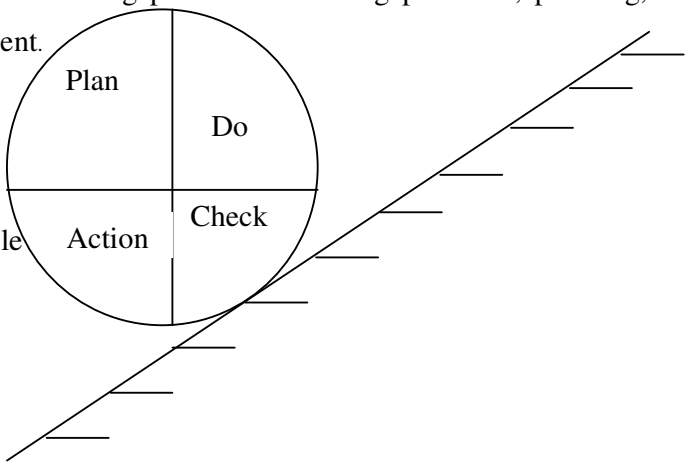


Fig.2.3 The Deming's improvement cycle Cycle

Deming uses the PDCA cycle to unite his seven deadly diseases, fourteen points, and statistical techniques into continuous, never-ending process of TQM. The PDCA cycle provides a model or process for teams. It can be applied to any process including a budget, vacation, company goals, or any correction actions. It is based on the simple premise that to achieve quality one must plan for it, do (implement) it, check (analyze) the results, and act (take action) for improvement [18].

2.6.2 Joseph M. Juran

Joseph M. Juran was born in 1904 in Romania, and came to the United States in 1912. A holder of degree in engineering and law, he advanced to the positions of quality manager at Western Electric Company, government administrator and professor of engineering at New York University before embarking on a consulting career in 1950. Juran is regarded as one of the architects of the quality revolution in Japan, where he lectured and consulted frequently, starting in 1954. In 1979, he founded the Juran institute, which conducts quality training seminars and publishes quality-related works.

Juran's idea of meeting customer's needs was based on five quality characteristics:
Technological (strength); Psychological (beauty); Time oriented (reliability); Contractual (guarantee); and Ethical (sales staff courtesy).
Quality management according to Juran consisted of three basic processes (Juran Trilogy):

a) Quality Planning: - A process, which identifies the customers, their needs, product service features, and the process that will deliver all the right attributes and then facilitate this knowledge through out the organization.
b) Quality Control: - A process where products are examined and evaluated against the original requirements of the customer. And then any corrections needed are made.
c) Quality Improvement: - A process in which a sustaining mechanism for continuous quality improvement are placed. It involves the establishment of permanent structure to pursue quality and maintain the gains already secured.

He also recommended a project-by-project approach for any improvement process, and the selection of project should be based on their estimated return on investment.
Juran was the first to recognize that there are two types of customers in an organization: Internal and external. Internal customers are those that receive products/service with in the organization. External (final, existing) customers are the final consumer of the product/service that is offered by the organization. Internal and external customers are important to the organization and any improvement process must take into account both.
Like Deming, Juran put the cause for any quality problems to management rather than to employees. He also laid out two types of problems, Sporadic and Chronic, and each should be dealt differently. Chronic problems need more of 'breakthrough' principles while sporadic problems need 'Control' principles. He has elaborated the activities for each [16].

Juran has formulated ten steps of quality improvement approach, which are summarized as:

a) Build awareness and conducive environment for change and improvement.
b) Set improvement goals and decide control points.
c) Organize to reach goals - forming diagnostic groups to identify and prioritize goals.
d) Provide training to create understanding of the systematic approach to quality improvement.
e) Carryout problem solving projects .Steering council should guide and track the effects.
f) Report progress .Diagnostic group should analyze problems, propose solution and report progress.
g) Give recognition - public recognition like certificate & plaques.
h) Communicate results in terms of cost of quality.
i) Keep score of the improvements made.
j) Maintain momentum by making annual improvement efforts as part of the regular systems and process of the company [4].

2.6.3 Philip B. Crosby

Philip B. Crosby was born in 1926 in Wheeling, West Virginia. Crosby obtained a degree in podiatry (His father's profession) but decided he did not like it. In 1952 he became a reliability engineer for Crosby Corporation in Richmond, Indiana.

Crosby's name is best known in relations to the concepts of *Do It Right First Time* and *Zero Defects* .He offered fourteen management steps to quality improvement.

Crosby's fourteen steps to quality improvement are:

a) Make it clear that management is committed to quality
b) Form quality improvement teams with representatives from each department.
c) Determine where current and potential quality problems lie.
d) Evaluate the cost of quality and explain its use as a management tool.
e) Raise the quality awareness and personal concern of all employees.
f) Take actions to correct problems identified through previous steps.
g) Establish a committee for the zero defects programme.
h) Train supervisors to actively carry out their part of the quality improvement programme.

i) Hold a 'zero defects day' to let all employees realize that there has been a change.
j) Encourage individuals to establish improvement goals for themselves and their groups.
k) Encourage employees to communicate to management the obstacles they face in attaining their improvement goals.
l) Recognize and appreciate those who participate.
m) Establish quality councils to communicate on a regular basis.
n) Do it all over again to emphasize that the quality improvement programme never ends.

Crosby has four absolutes of quality:

- Definition –conformance to requirements.
- System –prevention.
- Performance standard –zero defects.
- Measurement-price of nonconformance [8].

2.6.4 Armand V. Feigenbaum

Feigenbaum's nineteen steps of quality improvement are:

a) Total quality control defined: TQC may be defined as an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organization so as to enable marketing, engineering, production, and service at the most economical levels which allow for full-customer satisfaction.
b) Quality versus quality: "Big Q" or quality refers to luxurious quality where as "little q" refers to high quality, not necessarily luxury. Regardless of an organization's niche, little q must be closely maintained and improved.
c) Control : In the phrase " quality control" the word control represents a management tool with four steps:
    1. Setting quality standards.
    2. Appraising conformance to these standards.
    3. Acting when the standards are exceeded.
    4. Planning for improvements in the standards.

d) Integration: Quality control requires the integration of often uncoordinated activities into a framework. This framework should place the responsibility for customer-driven quality efforts across all activities of the enterprise.

e) Quality increases profits: Total quality control programs are highly cost effective because of their results in improved levels of customer satisfaction, reduced operating losses and field service costs, and improved utilization of resources.

f) Quality is expected, not desired: Quality begets quality. As one supplier becomes quality oriented, other suppliers must meet or exceed this new standard.

g) Human impact quality: The greatest quality improvements are likely to come from human improving the process, not adding machines.

h) TQC applies to all products and services: No person or department is exempted from supplying quality services and products to its customer.

i) Quality is a total life-cycle consideration: Quality control enters into all phases of the industrial production process, starting with the customer's specification, through design engineering and assembly to shipment of the product and installation.

j) Controlling the process: These controls fall into four natural classifications: New design control, incoming material control, product control, and special process studies.

k) A Total quality system may be defined as the agreed companywide and plant wide operating work structure, documented in effective, integrated technical and managerial procedures for guiding the coordinated actions of the people, the machines, and the information of the company and plant in the best and most practical ways to assure customer quality satisfaction and economical costs of quality.

l) Benefits: Benefits often resulting from total quality programs are improvements in product quality and design, reduction in operating costs and losses, improvements in employee morale, and reduction of production-line bottlenecks.

m) Cost of quality: Quality costs are a means for measuring and optimizing total quality control activities. Operating quality costs are divided into four different classifications: Prevention costs, appraisal costs, internal failure costs, and external failure costs.

n) Organize for quality control: It is necessary to demonstrate that quality is everybody's job. Every organizational component has a quality-related responsibility; for example , marketing for determining customers' quality preferences, engineering for specifying product quality specifications and shop supervision for building into the product.

o) Quality facilitators, not quality cops: The quality control organization acts as a touchstone for communicating new results in the company, providing new techniques,

acting as a facilitator, and in general resembles an internal consultant, rather than a police force of quality inspectors.

p) Continuous commitment: Management must recognize at the outset of its total quality control program that this program is not a temporary quality improvement or quality cost reduction project.
q) Use statistical tools: Statistics are used in an overall quality control program whenever and wherever they may be useful, but statistics are only one part of the total quality control pattern.
r) Automation is not a panacea: Automation is complex and can become an implementation nightmare. But the best human-oriented activities are implemented before being convinced that automation is the answer.
s) Control quality at the source: The creator of the product or the deliver of the service must be able to control the quality of their product or service [16].

2.6.5 Kaoru Ishikawa

Kaoru Ishikawa was born in 1915, and earned a degree in applied chemistry from the University of Tokyo in 1939. Later, he became president of the Musashi Institute of Technology. Until his death in 1989, Dr. Ishikawa was the foremost figure in Japan regarding quality control. He was the first to use the term total quality control, and developed the "seven tools" that he thought any worker could use.

The other contribution that Ishikawa made is the introduction of quality circle concept. He argued that neither workers nor managers know the correct solution to a problem. But by working together they would have a better capacity to solve any problem that may arise. This would also enhance the participation of all employees in quality improvement activities.

Ishikawa's view of quality can be summarized as follow:

a) Quality control (QC) is the responsibility of every body in the company. It is a discipline that combines knowledge with action.
b) Management should put quality at the top of its list, plan for long term benefit and stamp out any sectionalism.
c) TQC management is a team work not an individual act.
d) TQC fails if there is no cooperation among all employees from president to line worker.
e) TQC is a company wide activity and also based on respect for humanity.

f) Middle management will be the focus point in TQC and thus subjected to frequent involvement and criticism.
g) Care should be taken not to confuse objective with means.
h) QC circle activities are part of TQC [5].

2.6.6 Comparison of the three American quality gurus

The three American Gurus: A small group of American quality experts or 'gurus' has been advising industry thorough out the world on how it should manage quality. The approaches of Philip B. Crosby, W. Edwards Deming, and Joseph M. Juran, their similarities and difference, are presented briefly below.

The similarities and differences among Deming, Juran and Crosby are:

- The common elements (similarities) are:
    1. Constant high levels of training and education
    2. Create awareness of opportunity and constant search for improvement-permanence of the process
    3. Error-friendly problem-solving environment
    4. Prevention orientation and attention to detail
    5. Use of self-defined measurement by all employees
    6. Control of suppliers by SPC or auditing
    7. High levels of non-financial recognition of employees
    8. Open communication of results of projects and business performance
    9. Concept of 'internal customer' and management of processes
- Differences are:
    1. Use of Quality Circles-Crosby
    2. Zero defects as a performance standard-Crosby
    3. Hold a zero defects day to celebrate commitment to quality-Crosby
    4. Single sourcing of suppliers-Deming
    5. Eliminate management by objectives and pay linked to output-Deming
    6. Extensive market research-Deming
    7. Use of cross-functional action teams to attack problems on a project by project basis-Juran
    8. Individual goal setting- Crosby and Juran

The other way to compare directly the various approaches of the three American gurus is in tabular form. Table 2.1 shows the differences and similarities, classified under 12 different factors [18].

Table 2-1: The American quality gurus compared

Factor	Crosby	Deming	Juran
Definition of quality	Conformance to requirements	A predictable degree of uniformity and dependability at low cost and suited to the market	Fitness for use
Degree of senior management responsibility	Responsible for quality	Responsible for 94 % of quality problems	Less than 20 % of quality problems are due to workers
Performance standard/motivation	Zero defects	Quality has many 'scales'. Use statistics to measure performance in all areas. Critical of zero defects	Avoid campaigns to 'do perfect work'
General approach	Prevention, not inspection	Reduce variability by continuous improvement. Cease mass inspection	General management approach to quality-especially 'human' elements
Structure	Fourteen steps to quality improvement	Fourteen points for management	Ten steps to quality improvement
Statistical process control (SPC)	Rejects statistically acceptable levels of quality	Statistical methods of quality control must be used.	Recommends SPC but warns that it can lead to 'tool-driven' approach
Improvement basis	A 'process', not a programme. Improvement goals	Continuous to reduce variation. Eliminate goals without methods	Project-by-project team approach

Teamwork	Quality improvement teams. Quality councils	Employee participation in decision-making. Break down barriers between departments	Team and quality circle approach
Costs of quality	Cost of non-conformance. Quality is free	No optimum-continuous improvement	Quality is not free-there is an optimum
Purchasing and goods received	State requirements. Supplier is extension of business. Most faults due to purchasers themselves	Inspection too late-allows defects to enter system through AQLs. Statistical evidence and control charts required	Problems are complex. Carry out formal surveys
Vendor rating	Yes and buyers. Quality audits useless	No-critical of most systems	Yes, but help supplier improve
Single sources of supply		Yes	No-can neglect to sharpen competitive edge

2.7 Organizational change

In a competitive and rapidly changing market place, industrial companies are constantly involved in the development of strategies for keeping up, staying ahead, and setting new directions. Managers do to play a positive role in the process by:

a) Having a clear vision and corresponding goals.

b) Exhibit a strong sense of responsibility.

c) Being effective communicator.

d) Having a higher energy level.

e) Having the will to change.

To respond effectively to the change, organizations must continually apply at least the following strategies:

a) Promote a “we are in this together” attitude toward change.

b) Make sure all employees understand that change is driven by market forces, not management.

c) Involve everyone who will be affected by the change in planning and implementing the response to it [1].

2.8 Culture and Climate

The culture of an organization is the shared values and norms of behavior of the individuals within the organization. Management behavior is the predominant of organization culture and it remains a fact that the nearer the top of the ladder someone is, the more his/her behavior influences the prevailing culture. Culture of an organization can be sensed at three levels .Firstly by the visible artifacts: Physical conditions, receptions areas, organization structure, office layouts and designs. Secondly by stated values: Statements made by senior figures, press reports, annual reports and other publications to represent the organization's attitude toward those with whom it interacts. The stated values may not reflect the reality. The goal of customer satisfaction may be number one in the stated values where as the reality may be far from this. The third means to sense an organization's culture is by the basic assumption, which constitutes the most deeply rooted layer of the organization's culture. They are embedded in the organization's history, its traditions, its geography, the values and beliefs brought to it by its owners, managers and employees over many years. The simplest way of representing these assumptions is "the way we do things around here" [3].

Table 2-2: TQM culture change

From	To
Grapevine and secrecy	Open communication
Control of staff	Empowerment
Inspection and fire fighting	Prevention
Internal focus on rules	External focus on customer
Cost and schedule	Quality of conformance
Stability seeking	Continuous change and improvement
Adversarial relations	Co-operative relations
Allocating blame	Solving problems at their roots

The majority of cultural changes implied above are related to management style and attitude towards employees. Management practices them and employees take over, like in the case of blame allocating. Lack of open communication between managers and their subordinates is among the cultural barriers, the one which needs to be broken down. Employees should be

empowered to contribute their best while control of staff could do almost nothing for the improvement of an organization.

TQM must be carefully implemented to take advantage of the organization strengths and avoid a culture clash, which may lead to culture shock too early. Though changing the culture is partly the purpose of TQM itself, it is also in many cases a necessary prerequisite in an attempt to install TQM [5].

2.9 Costs of quality

Manufacturing a quality product, providing a quality service, or doing a quality job – one with a high degree of customer satisfaction – is not enough. The cost of achieving these goals must be carefully managed, so that the long-term effect of quality costs on the business or organization is a desirable one. These costs are a true measure of the quality effort. A competitive product or service based on a balance between quality and cost factor is the principal goal of responsible management. This objective is best accomplished with the aid of competent analysis of cost of quality (COQ).

The analysis of quality related costs is a significant management tool that provides:
-A method of assessing the effectiveness of the management of quality.
-A means of determining problem areas, opportunities, savings, and action priorities.
The costs of quality are no different from any other costs. Like the cost of maintenance, design, sales, production/ operations, and other activities, they can be budgeted, measured and analyzed [9].

2.9.1 Prevention costs

These are costs of all activities specifically designed to prevent poor quality in products or services. They are associated with the design, implementation, and maintenance of the total quality management system. Prevention costs are planned and are incurred before actual operation. Prevention includes:

a) Product or service requirements: The determination of requirements and the setting of corresponding specifications (which also takes account of process capability) for incoming materials, processes, intermediates, and finished products or services.

b) Quality planning: The action of quality, reliability, and operational production, supervision, process control, inspection and other special plans, e.g. pre- production trials, required to achieve the quality objective.

c) Quality assurance: The creation and maintenance of the quality system.

d) Supplier's/vendor's capability survey: The cost associating the survey made to check the capability of suppliers.

e) Process capability evaluations: The survey made to determine the company's capability.

f) Quality improvement team meetings: Formation of a team for continuous quality improvement.

g) Inspection equipment: The design, development and/or purchase of equipment in inspection work.

h) Training: The development, preparation, and maintenance of training programs for operators/ technicians, supervisors, staff, and managers both to achieve and maintain capability.

i) Miscellaneous: Clerical, travel, supply, shipping, communications and other general office management activities associated with quality. Resources devoted prevention give rise to the cost of "doing it right first time" [18].

2.9.2 Appraisal costs

The costs associated with measuring, evaluating or auditing products or services to assure conformance to quality standards and performance requirements. It includes:

a) Incoming and source inspection/test of purchased material: The inspection/test made on the suppliers facility and on arrival destination.

b) In-process and final inspection/test: Inspection made during intermediate and final stages of a product/operation.

c) Verification: Checking of incoming materials , process set-up , first-offs , running processes , intermediate and final products, services, including product or service performance appraisal against agreed specifications.

d) Quality Audits: To check that the quality system is functioning satisfactorily.

e) Inspection equipment: The calibration and maintenance of equipment used in all inspection activities.

f) Vendor rating: The assessment and approval of all suppliers, foreign repair/maintenance organizations of both products and services. Appraisal activities result in the cost of "checking it is right" [18].

2.9.3 Internal failure costs

These costs occur when the results of work fail to reach designed quality standards prior to delivery or shipment of the product or the furnishing of a service, to the customer takes place. Internal failures include:

a) Waste: The activities associated with doing unnecessary work or holding stocks as the result of errors, poor organization or poor communications, the wrong material, etc.
b) Scrap: Defective product, material or stationery that cannot be repaired, used or sold.
c) Rework or rectification: The correction of defective material or errors to meet the requirements.
d) Re-inspection: The re-examination of products or work that have been rectified.
e) Downgrading: A product that is usable but doesn't meet specifications may be downgraded and sold as a "second quality" at a lower price.
f) Failure analysis: The activity required to establish the causes of internal product or service failure [18].

2.9.4 External failure costs

These costs occur when products or services fail to reach design quality standards but are not detected until after transfer to customer. External failure includes:

a) Repair and servicing: Either of returned products or those in the field.
b) Warranty claims: Failed products that are replaced or service re-performed under some form of guarantee.
c) Complaints: All work and costs associated with handling and servicing of customer's complaints.
d) Returns: The handling and investigation of rejected or recalled products or materials, including transport costs.
e) Liability: The result of product or service liability litigation and other claims, which may include a change of contract.

f) Loss of goodwill: The impact of reputation and image, which impinges directly on future prospects for sale.

External and internal failures produce the "costs of getting it wrong".
Order re-entry, retyping, unnecessary travel and telephone calls, conflict are just few examples of the wastage or failure costs often excluded [18].

2.9.5 Total quality costs

The sum of the above costs: This represents the difference between the actual cost of a product or service and what the reduced cost would be if there were no possibility of substandard service, failure of products or defects in their manufacture.

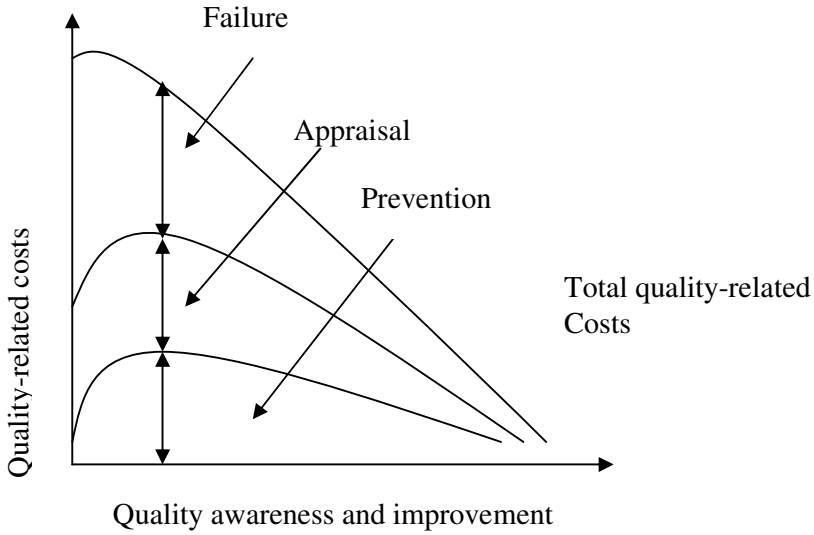


Figure 2.4 Cost of quality

The relationship between the quality related costs of prevention, appraisal, and failure and increasing quality awareness and improvement is shown in figure 2.4. Where the quality awareness is low, the total quality related costs are high, the failure costs predominating. As awareness of the cost to the organization of failure gets off the ground, through initial investment in training, an increasing in appraisal cost usually results. As the increased appraisal leads to investigation and further awareness, further investment in prevention is made to improve design futures, processes and systems. As the prevention action takes effect, the failure and appraisal costs fall the total cost reduces. The P-F-A model suggests that there is an optimum operating level at which the combined costs are the minimum [18].

2.10 ISO 9000 series

The ISO 9000 series contains three guidelines and three standards.

- ISO 8402 defines terms used in the series.
- ISO 9000 provides quality management and quality assurance standards and general guidelines for selection and use. It defines the elements that comprise each standard.
- ISO 9001 covers (external) quality systems and provides a model for quality assurance in design, development, production, installation, and servicing. It is clearly the most comprehensive standard.
- ISO 9002 covers (external) quality systems and provides a model for quality assurance in production, and installation. Eighteen of the elements in 9001 (excluding design and service) are used.
- ISO 9003 covers (external) quality systems and provides a model for quality assurance in final inspection and testing. This standard also has a significantly lower conformance requirement. Registration requires twelve of the twenty elements (excludes contract review, design, control, purchasing, purchaser-supplied product, process control, correction action, internal quality audits, and servicing).
- ISO 9004 covers (internal) quality management and quality system elements of standards 9001 to 9003. It provides specific guidelines for *specific industrial applications*.
- ISO 9004-2 covers (internal) quality management and quality system elements of standards applicable to all forms of services [15].

The ISO 9000 series of standards, and their European equivalent (EN 29000), are derived from the British quality management standard (BS 5750) which was built on a military standard, the UK Ministry of Defense's Def Stan 0521. The quality system requirements of ISO 9001 are aimed at preventing nonconformity at all phases of the product life cycle from design and/or development through servicing. These requirements are complementary to the technical specifications of the product. They do not replace the technical requirements, and are not alternative to them .Increasingly, large companies are insisting that suppliers should be accredited. Dealing with accredited suppliers provides them with a sense of security, and reduces the effort required to control the supplier's products. From the supplier's point of view, accreditation provides a quality image, customer confidence, and access to markets where quality certification is obligatory. In addition, the introduction of a quality management

system may have a major effect on internal performance. The accreditation process usually takes between one and two years.

When an organization's quality system has been assessed against ISO 9001, ISO 9002 or ISO 9003 by an accredited independent certification body, then the quality system is registered, and can be used as evidence of quality assurance in tendering for contracts. Quality systems produced in accordance with these quality system requirements are subject to regular third party assessment based on documented, objective evidence of compliance [19].

2.10.1 TQM compared to ISO 9000

ISO 9000 is a quality system management Standard. TQM is a philosophy of perpetual improvement. The ISO quality standard sets in place a system to deploy policy and verifiable objectives. An ISO implementation is a basis for a total quality management implementation. Where there is an ISO system, about 75 percent of the steps are in place for TQM. The requirements for TQM can be considered ISO plus. . In short, implementing TQM is being proactive concerning quality rather than reactive [21].

Table 2.3 Maintenance requirements compared to ISO series requirements [13]

ISO9000 requirement	9001	9002	9003	Maintenance
Management responsibility	*	*	*	*
Documented quality system	*	*	*	*
Review of customer contracts	*	*		
Implement process controls	*			*
Document control	*	*	*	*
Purchasing control	*	*		*
Supplier control	*	*		*
Product traceability	*	*	*	*
Documented processes	*	*		*
Inspection and testing	*	*	*	*
Calibration of tools and test equipment	*	*	*	*
Inspection and test of products	*	*	*	*
Control of non conforming products	*	*	*	
Document corrective action	*	*		*
Protect parts, etc. from damage, theft, etc.	*	*	*	
Quality records required	*	*	*	*
Internal quality audits	*	*		*
Document training	*	*	*	*
Track servicing	*			*
Use statistical techniques to track quality	*	*	*	*

2.11 Why TQM fails

TQM fails for several reasons such as: Top management sees no reason for change, not concerned for its staff, not committed for TQM programme, loses interest in the programme after a few months, TQM is imposed on the work force, no performance measures set etc.

Chapter 3: Background for the case study

3.1 Focus area of the thesis

Established in 1946, Ethiopian Airlines (EAL) provides domestic and international flights, maintenance and engineering services in specific approved capabilities for local and external customers. To maintain higher performance, availability, excellent competitiveness, and increased market share, it is mandatory to assure continuous improvement of all maintenance and engineering activities through the use of TQM so that every employee will be aware of and responsible for quality of all operations.

3.1.1 Vision

To be Africa's world-class Airline that ensures satisfaction of its customers and other stakeholders.

3.1.2 Mission

-Ethiopian is a business enterprise committed to the basic objective of providing safe, reliable and profitable air transport services for the passenger and cargo as well as other aviation related services.

-The airline renews its pledge to further develop its total network with continued emphasis on interconnecting Africa and linking it with the rest of the world.

-Ethiopian is committed to the provision of quality service to its customers. In order to ensure this, the airline will strive to maintain a highly trained, motivated and dedicated workforce and enhance its internal capacity in various fields.

-Through the use of modern and environmentally friendly technology in all areas, Ethiopian endeavors to play an important role in the well being of the society and equip its employees with a high level of skill through transfer of technology.

-The airline will continue to contribute its share towards the development of trade and tourism in Ethiopia through the provision of essential air transport. It will also strive to maintain its role as a major player in the development of aviation in Africa.

3.1.3 Approved capabilities on the maintenance and engineering division

3.1.3.1 Airframe maintenance

The maintenance base provides complete package maintenance on:

-Boeing Models B767, B757, B737, B727, B707

-Lockheed Model L-100

-ATR Model ATR-42-300

-Bombardier Model DHC-5 and DHC-6

-Fokker Model F-50

3.1.3.2 Engines maintenance

-Complete repair, modification, overhaul and testing

-Modular maintenance

-Engine performance test

-A range of special process shops for parts salvage work and modification

3.1.3.3 Component overhaul/testing

-Repair, overhaul and testing of components fitted on the above-mentioned fleets (refer to the paragraph under "Airframe maintenance")

-The avionics component shop utilizes a state-of-the-art Automatic test Equipment, ATEC 5000, for Avionics components

3.1.3.4 Non-destructive testing (NDT); with specialized inspection

-X-ray
-Radiography
-Eddy current

-Ultrasonic
-Magnetic particles and

- Dye penetrant

3.1.3.5 General engineering support

-Development of

-Major repair/modification

-Engineering orders

-Maintenance programs

-Complete inspection/check work packages

-Operational assistance through

-Aircraft performance analysis

-Engine condition monitoring

-Handling of -technical records keeping, technical planning functions,

Reliability analysis

-Facility evaluation, development plans and recommendation.

-Technical evaluation/damage assessment on aircraft at any location.

3.1.5.6 Line station technical handling

-In addition to the base at Addis Ababa, EAL offers service at various international stations such as, Nairobi, Bombay, Cairo, and Lagos.

3.1.3.7 Mobile technical team and crew secondment:

-Experienced technician and flight crew for a short and long-term assignment upon request.

3.1.3.8 Spare parts inventory

-Exchange/loan of parts for Boeing, Fokker, ATR, De-Havilland & Lockheed aircrafts

-Sale of surplus aircraft parts

-Automated stores and inventory control services [11]

3.2 Organization chart

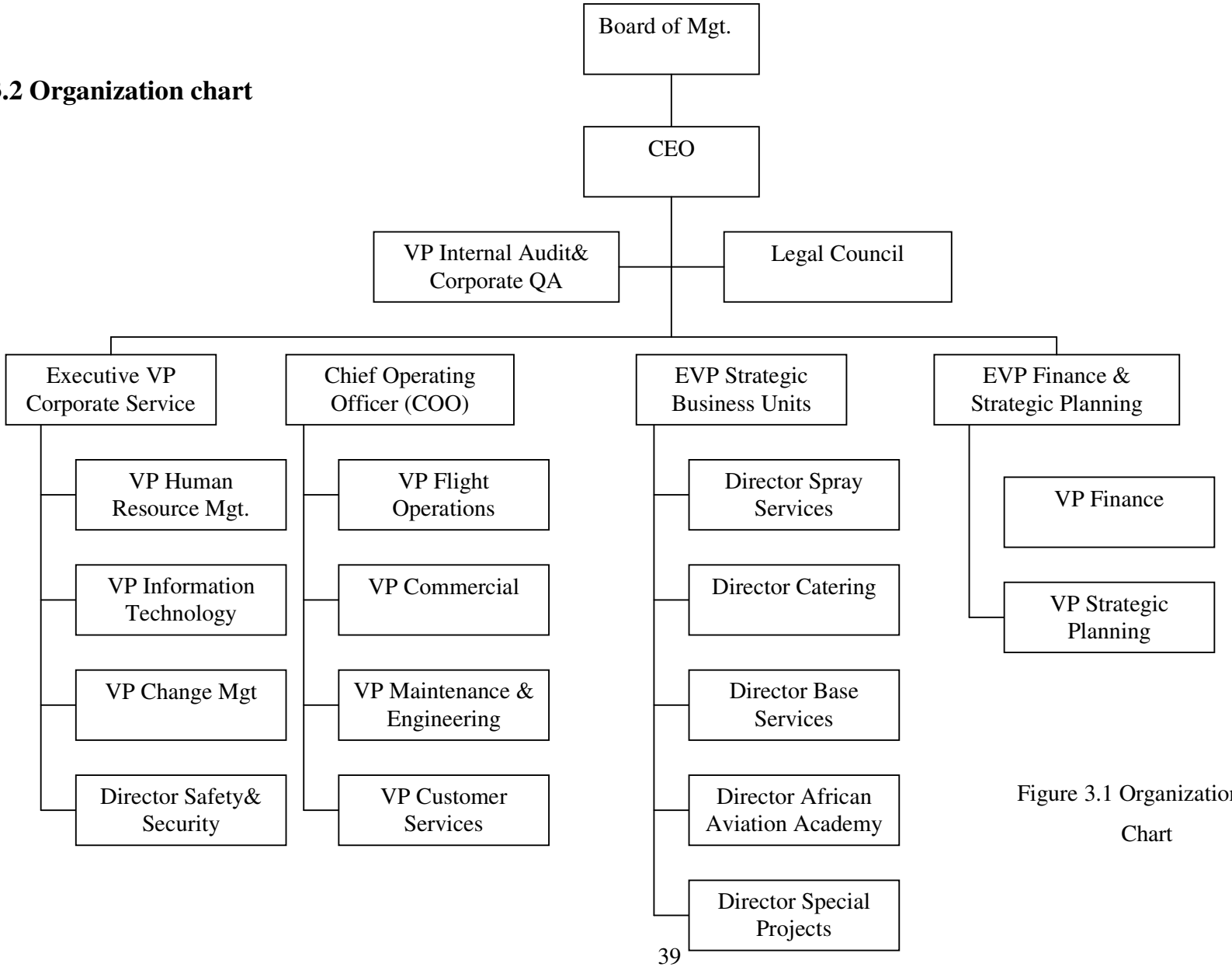


Figure 3.1 Organization Chart

3.3 The maintenance and engineering organization

3.3.1 Organization of maintenance and engineering

The structure for an effective maintenance and engineering organization will vary with the size and type of organization. It may also vary with the management philosophy of the company. But one thing must be kept in mind: organizational structure must allow the company to meet its goals and objectives and each unit within the company must be endowed with sufficient personnel and authority to carry out those objectives and meet those goals.

The following structure was determined, from experience and observation, to be the most efficient and effective one for a mid-sized commercial airline. For application to large or small airlines, this structure will have to be modified; but all of the functions identified here will have to exist separately or in combination to accomplish all the functions and activities identified below [13].

3.3.2 Organization structure

The basic organization structure for a mid-sized airline is shown in Fig.3.1. There are three basic concepts underlying the structure defined. Two of these come from traditional management thinking. These are the concepts of span of control and the grouping of similar functions. The third concept some what unique to aviation: the separation of production activities (maintenance and engineering) from the oversight functions of inspection, control, and monitoring (quality assurance, quality control, reliability and safety) [13].

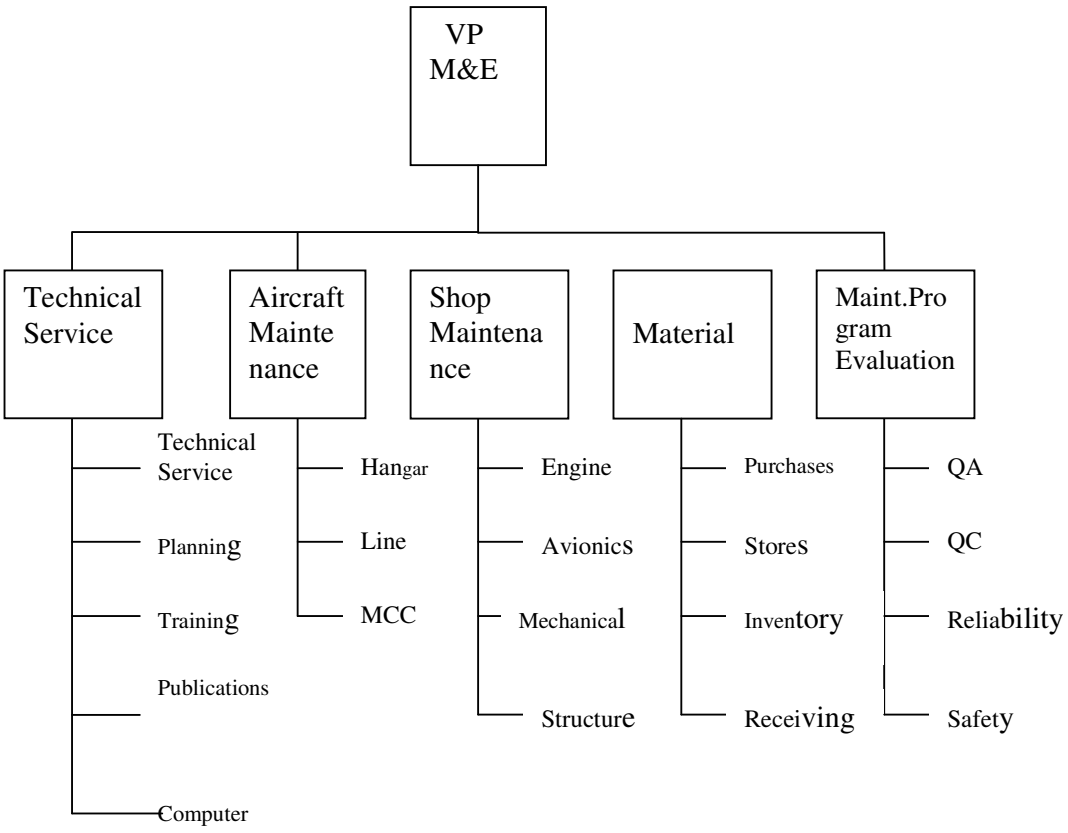


Figure 3.2 Typical maintenance and engineering organization

3.3.2.1 Span of control

The span of control concept may be considered passé to some, but it is still a useful concept. This concept states that a supervisor or manager can effectively supervise or control three to seven people. Any less than three would be ineffective use of time and manpower and any more than seven would spread the boss too thin. In the organizational structure shown in Fig 3.2, we have adhered to this concept. The VP of maintenance and engineering supervises five directors. Each director has the necessary number of managers under him or her to carry out the prescribed functions of the directorate. We find that by limiting the number of people that a manger has to supervise, the organization's work is divided into pieces that are more easily managed without losing the people to-people contact that is so necessary for a happy and efficient work force.

At the lower levels of the organization, where the actual maintenance work is performed by workers with many different skills, the span of control is usually not so narrow. A line or hanger maintenance supervisor may have as many as 20 or 30 of these specialists to supervise. But at the upper management levels, we like to keep the span of control at the lower number. This is not to say that a wider span cannot be utilized, however. All management activities must be organized to work with the available resources and within the current management's capabilities and philosophy.

3.3.2.2 Grouping of similar functions

The second basic concept of the organizational philosophy currently underway is the grouping of similar functions under one director, manager, or supervisor. What this comes down to is that all maintenance activities (line, hangar, and MCC) are under one manager. All maintenance overhaul shops functions (electrical and electronics shops, mechanical shops, hydraulics, etc.) are likewise grouped .All inspection activities whether it is inspecting the company's workers, inspecting parts or inspecting the suppliers of parts are grouped into one organization (maintenance program evaluation functions) .Those handling the purchase of supplies, those performing engineering work, and those doing the planning are also grouped accordingly so that the managers and directors can maintain proper surveillance and control over areas in which they have expertise.

3.3.2.3 Separation of production and oversight functions

A third concept that is applied here may be unique to the maintenance organization. Under the FAA philosophy, an airline receives certification to operate as a commercial air transport company and that authorization is, for all practical purposes, permanent. Some foreign airlines must be recertified by their regulatory authority annually. Under the FAA rules, for and airline to be certificated, it must have certain programs in place including a self –monitoring function to ensure that it is performing according to the rules(its own rules as well as those of the regulator authority). This alleviates the FAA from having to recertify each airline every year. This requirement for self-monitoring is usually in the form of quality assurance (QA), quality control (QC), reliability, etc.. It is recommended, and generally practical that these self-monitoring functions operate separately from the maintenance and engineering functions they are monitoring to prevent any conflict of interest problems. This separation is built into the organizational structure shown in Fig.7-1 and is discussed below by selective grouping [13].

3.3.3 The M&E organizational chart

Figure 3.2 is the basic organizational chart for the maintenance and engineering organization of a "typical" medium sized airline. Following is discussion of each layer and each function. The structure starts with the VP level and continues downward with designations Director, Manager and Supervisor as appropriate.

3.3.3.1 Vice-president of maintenance and engineering

The head of the entire maintenance and engineering function within the airline should be at a relatively high level of the airline's structure. He or she should be directly under the head of the airline or under the head of the company operational activity (President, Chief Operating Officer, or whatever title is used).The VP of M&E position should also be at the same level as the head of flight operations (VP Flight Ops or whatever he or she is called). Flight operations and maintenance are considered to be two sides of the same coin: they complement each other and carry equal weight.

The flight operations department is responsible for conducting the air transportation operations; i.e., the flying. Maintenance and engineering, on the other hand, is responsible for delivering airworthy vehicles to the operations department to meet the flight schedule. The M&E department is responsible for conducting all scheduled maintenance, modification, etc. on the vehicles within the specified limits of the maintenance schedule and still meets the operations department's flight schedule. Without maintenance, flight operations would be quite limited in their activities; without flight operations, maintenance wouldn't have much purpose in maintaining the equipment. They need each other and the airline needs both [13].

3.3.3.2 Directors of major functions

The five major functions shown in Fig. 3.2 are technical services (which includes engineering, planning, training, technical publications, and computing); aircraft maintenance (flight line, hangar, out stations, and maintenance control center);overhaul shops(for off-aircraft maintenance, repair, and overhaul); material services (responsible for ordering and maintaining supplies, handling warranties, and moving repairable and consumable parts through the system); and maintenance program evaluation (the monitoring activity for the organization, its workers and its suppliers).

3.3.3.3. Managers and supervisors

Within each directorate, there are several managers. Each of these managers has a specialized area of responsibility within the overall scope of the directorate's function. Specific activities within each manager's area of responsibility require staffs of specialists with supervision by knowledgeable people. In some large organizations, the supervisor may need additional separation of activities or duties and appoint "leads" or "straw bosses" to decrease his span of control to a workable size. However, for most operators, the span of control can be much wider at this level [13].

3.3.4 Manager level functions-technical services directorate

The technical services directorate contains numerous activities and services that support the maintenance and inspection functions. In the typical setup of Fig. 3.2 various activities for each directorate are identified. Each activity is under the direction of a manager. There may be further echelons of management such as supervisors and leads as necessary.

3.3.4.1 Engineering

The manager of engineering is responsible for all engineering functions of the M&E organization. This includes (a) the development of the initial maintenance program (tasks, intervals, schedules, blocking, etc.); (b) the evaluation of service bulletins; (SBs) and service letters (SLs) for possible inclusion in to the airline's equipment; (c) oversight of the incorporation of those SBs and SLs that they deem beneficial; (d) overseeing the incorporation of airworthiness defectives (ADs), the modifications that are required by the regulatory authority; (e) the evaluation of maintenance problems determined by the reliability program and for problems (if any) resulting from the maintenance checks performed by maintenance; and (f) for establishing the policies and procedures for the M&E organization. The engineering department employs a cadre of engineering specialists, usually enough to cover, with a high degree of expertise, any and all specialties within the aircraft's technical realm: power plant, structures, avionics, aircraft performance, and systems (hydraulic, pneumatic, etc.). These positions are at the supervisor level with several engineers in each group with their own specialties, if required.

The engineering department is also involved in the planning of facilities (new hangars, maintenance shops, storage facilities, buildings, etc.) for the airline, which are to be used by

the M&E organization. Although engineering usually will not actually do the design and engineering work, they will work which the engineering consulting firm or contractor that has responsibility for the project to ensure that the final result meets the airline's requirements.

3.3.4.2 Production planning and control

The manager of production planning and control (PP&C) is responsible for maintenance scheduling and planning. This function must plan and schedule the manpower, parts, facilities, tools, and any special assistance required for all maintenance or modification activities. Included in the functions of PP&C are the following (a) all planning activities related to maintenance and engineering (short, medium, and long term); (b) the establishment of standards for man-hours, materiel, facilities, tools, and equipment; (c) work scheduling;(d) control of hangars; (e) on-airplane maintenance; and (f) monitoring of work program in the support shops.

3.3.4.3 Training

The manager of technical training is responsible for curriculum, course development, administration, and training records for all formal training attended by the M&E unit's employees. The organization coordinates any training required outside the unit (vendor training) and coordinates with line and hangar maintenance personnel for the development of on-the-job training and remedial or one-time training activities. The training section must be able to establish new and special training courses to meet the needs of the airline. These course requirements are often the result of problem investigation by reliability, incorporation of new equipment or modifications, or the addition of aircraft types to the fleet.

3.3.4.4 Technical Publications

The manager of technical publications is responsible for all technical publications used by the M & E organization. Technical publications (or Tech pubs) keeps a current list of all documents received from manufactures and vendors as well as those produced in-house by the airline. Also on record are the numbers of copies, in paper, microfilm, or compact disc (CD) format that each work center should receive. The Tech Pubs organization is also responsible for ensuring that appropriate documents and revisions are distributed to these various work centers. Work centers are responsible for keeping their own documents current, but Tech Pubs usually conducts periodic cheeks to see that this is being done. The pub is also

responsible for maintaining the main technical library and any satellite libraries within the airline's system, including those at out-stations.

3.3.4.5 Computing services

The manager of computing services is responsible for the definition of the M & E organization's computing requirements: (a) selections of software and hardware to be used, with usage information and requirements inputs from the individual units: (b) training of maintenance, inspection, and management personnel on computer usage; and (c) provide continuing support to the using organizations [13].

3.3.5 Manager level functions –aircraft

3.3.5.1 Maintenance Directorate

The aircraft maintenance directorate has responsibility for the major aircraft maintenance activities: maintenance on the flight line and maintenance performed in the hangar. Three managers report to the director of airplane maintenance: hangar, line and MCC managers. For airlines with different model aircraft or with two or more maintenance bases, the number of aircraft maintenance managers many be increased as for the scope of the operation.

3.3.5.2 Hangar Maintenance

The manager of hangar maintenance is responsible for compliance with the airline's polices and procedures relative to all work done on the aircraft in the hangar, such as modifications, engine changes, "C" checks (and higher), corrosion control, painting, etc. The hanger maintenance functions also include various support shops (Welding, seat and interior fabric, composite, etc.) as well as ground support equipment.

3.3.5.3 Line Maintenance

The manger of line maintenance is responsible for compliance with the airline's policies and procedures relative to the work done on the aircraft on the flight line while the aircraft is in servicing, daily checks, short interval checks (less than "A" check interval) and "A" checks. Sometimes, simple modification can be done by line maintenance may also be utilize to perform line maintenance activities but he or she is often part of the home base MCC operation.

3.3.5.4 Maintenance Control Center

The function known as the maintenance control center (MCC) keeps track of all aircraft in flight and at outstations. All maintenance needs of these vehicles are coordinated through the MCC. The MCC also coordinates downtime and schedule changes with the flight department. Some airlines might have a supervisor of line stations to coordinate outstation activities but he or she is often part of the home base MCC operation [13].

3.3.6 Manager level functions – overhaul

3.3.6.1 Shops Directorate

The overhaul shops directorate consists of those maintenance shops that perform maintenance on items removed from the aircraft. These shops include engine shop(s), electrical shop, electronics (or avionics) shop, and various mechanical shops. These may be separate shops or some may be combined for convenience, depending on the operation. Some of these shops may also perform contract work for other airlines.

3.3.6.2 Engine Shops

The manager of the engine overhaul shops is responsible for all maintenance and repair done on the organization's engines and auxiliary power units (APUS). If more than one type engine is used, there may be a separate engine shop for each type performing the work, but these would usually be under or senior manager with a supervisor for each engine type. The engine build up activities would generally come under the engine shop manager.

3.3.6.3 Electrical and electronics (avionics) shops

The manager of electrical/electronics shops is responsible for all off-aircraft maintenances of electrical and electronics components and systems. There are a variety of components and systems in this field with wide variation in the equipment and in the skills needed to address them. There may be several shops (radio, navigation, communications, computers, electric motor-driven components, etc) with separate supervisors. Shops are combined at times, however, to optimize manpower and space and to reduce test equipment inventories.

3.3.6.4 Mechanical components shops

The manager of mechanical component shops has responsibilities similar to those of the manager of avionics shops. The only difference, of course, is that these shops would address mechanical components: actuators hydraulic systems and components aircraft surfaces (flaps, slats, and spoilers), fuel systems, oxygen, pneumatics, etc.

3.3.6.5 Structures

The structures shop is responsible for maintenance and repair of all aircraft structural components. This includes composite material as well as sheet metal and other structural elements [13].

3.3.7 Manager level functions-materiel directorate

The material directorate is responsible for the handling of all parts and supplies for the M&E organization: (a) purchasing; (b) stocking and distribution (stores); (c) inventory control; and (d) shipping and receiving of parts and supplies used by the M&E organization. This includes not only the parts and supplies used in the maintenance, servicing, and engineering of the aircraft but also the supplies used for the administration and management of M&E (i.e., office supplies, uniforms, etc.).

3.3.7.1 Purchasing

The manager of purchasing is responsible for buying parts and supplies and tracking these orders through the system. This begins with the initial issue of parts when a new aircraft is added to the fleet and a continual replenishment of those parts based on usage. The purchasing unit is also responsible for handling warranty claims and contract repairs.

3.3.7.2 Stores

The manager of stores takes responsibility for the storage, handling, and distribution of parts and supplies used by the maintenance personnel in line, hangar, and shop maintenance activities. Stores areas, or parts issue points, are placed near the various work centers to allow mechanics quick access to parts and supplies and minimize time spent in obtaining those parts and supplies.

3.3.7.3 Inventory control

The manager of inventory control is responsible for ensuring that the parts and supplies on hand are sufficient for the normal, expected usage rate without typing up excessive funds in nonmoving items and without running out of stock too soon or too often for commonly used items.

3.3.7.4 Shipping and receiving

Manager of shipping and receiving is responsible for packing, waybill preparation, insurance, customs, etc. for outgoing materials as well as customs clearance, unpacking, receiving inspection, tagging etc. for incoming materials. This includes all parts being shipped into and out of the airline [13].

3.3.8 Manager level functions-maintenance program evaluation directorate

The maintenance program evaluation (MPE) directorate is an organization tasked with the job of monitoring the maintenance and engineering organization. The MPE unit will be responsible for the CASS activities. The unit's functions include quality assurance, quality control, reliability, and safety.

3.3.8.1 Quality assurance

The manager of quality assurance is responsible for assuring that all units of M&E adhere to the company policies and procedures as well as FAA requirement. The manager of QA sets the standards for the M&E operation and the QA auditors ensure compliance to those standards through year audits. Quality assurance is also responsible for auditing outside suppliers and contractors for compliance with the company's, as well as the regulatory authority's rules and regulations.

3.3.8.2 Quality control

The manager of quality control is responsible for conducting routine inspections of maintenance and repair work, certifying maintenance and inspection personnel, and management of the required inspection items (RIIs) program. This latter function involves the identification of RIIs and the certification of specific personnel authorized to inspect and accept the work. The QC organization is also responsible for the calibration of maintenance

tools and test equipment and performs or oversees the nondestructive testing and inspection (NDT/NDI) procedures.

3.3.8.3 Reliability

The manager of reliability is responsible for conducting the organization's reliability program and ensuring that any problem areas are promptly addressed. This responsibility includes data collection and analysis, identification of possible problem areas (which are then addressed in detail by engineering), and publication of the monthly reliability report.

3.3.8.4 Safety

The safety organization is responsible for developing, implementing, and administering the safety and health related activities with in the M&E organization. The safety manager is also responsible for handling all reports and claims regarding M&E safety issues [13].

3.4 Quality related activities in ETHIOPIAN maintenance and engineering division

The major tasks given more attention by ETHIOPIAN in assuring quality of maintenance and engineering activities are presented in this section.

3.4.1 Preparing a document that contains the list of approved foreign maintenance organizations.

Important elements of this document are [11]:

- Distribution list i.e. to which sections it should be distributed.
- Table of contents
- List of effective pages
- Record of revision
- Approved validity period of the document
- Names and addresses of the maintenance organizations
- Effective date of approval
- Expiry date of approval
- Original certificate validity date
- Certification number
- Certifying authority

- Certification validity duration.

3.4.2 Preparing a document that contains list of approved suppliers for parts and materials.

Suppliers of aircraft parts or component should provide a certificate issued by FAA which will be periodically renewed for the confirmation of airworthiness of their parts .Some suppliers provide ISO and ESA (European Suppliers Agency) certificate along with their FAA certificate. A sample approval certificate of a supplier issued by FAA may have the following format [11].

USA Department of Transportation

Federal Aviation Administration

Air Agency Certificate

Number_____

This certificate is issued to

Company X

Whose address is: _____.

Upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an air agency, and is empowered to operate an approved Repair Station

With the following rating:

Limited Air Frame (October 31, 1997)

Limited Engine (November 28, 1998)

Limited Accessories (June 15, 2002)

Limited NDT inspection, Testing and processing (Nov 28, 1998)

This certificate, unless cancelled, suspended or revoked, will continue in effect until October 31, 2007.

Sometimes ratings and limitations of the foreign company are attached with the certificate. For instance the certificate holder is authorized with the following ratings and /or limitations.

Limited ratings	Manufacturer	Make /Model	Limitations
Airframe	Airbus	A-319 All series	Limited to quick change

Moreover the activities that the foreign maintenance organization is authorized and not authorized to do will be described. In some cases foreign maintenance and repair organizations or vendors may provide ISO certificates with the scope of registration.

3.4.3 Preparing certified foreign repair station or vendor capability list

Foreign repair stations and vendors capability lists indicate the authorized tasks that can be accomplished or supplied by them. It is a major criterion to prepare the list of tasks they are able to perform for the safety of flight. Capability list is also a major criterion of ISO standards. A sample capability list for FR stations or Vendors may have the following main elements [11]:

-Reference number and revision date of the list
-Name of the repair station
-Part description (e.g. Igniter plug)
-Part number (e.gAA725)
-ETHIOPIAN part number (R721-1607)
-ATA No (74-22-01)
-FAA rating
-Capability level (repair or overhaul)

3.4.4 Preparing CAA approved ETHIOPIAN capability List

The maintenance tasks that are with in the capability of ETHIOPIAN maintenance and engineering division will be described in this capability list and approved by CAA and later by FAA. The main elements of this list are [11]:
-Reference, revision date and number
-Part name or description of components
-Manufacturing part number

-Ethiopian part number
-Vendor name
-ATA number
-Capability level (or repair overhaul)
-Aircraft type

3.4.5 Quality audits

3.4.5.1 Internal quality audits (first party audits performed by employees of ETHIOPIAN)

As stated in the Technical policy and procedure Manual, the objectives of internal quality audits are [11]:

-To determine conformity or nonconformity of the quality system elements with specified requirements.
-To determine the effectiveness of the implemented quality system in meeting specific requirements.
-As a need for meeting regulatory requirements.
-To afford an opportunity to improve quality system.

Audit Frequency

-Management ……...bi annually
-Inspection ……...bi annually
-Maintenance (hangars, shop stations & outstations)…….....bi annually
-Stores……...bi annually
-Support shops……..bi annually
-Training program……bi annually
-Records……...bi annually

For instance a sample audit check list prepared for component maintenance shops has the following elements:

1. References used to prepare the audit check list
   -Ethiopian Civil Aviation Authority (ECAA) approved inspection procedure manual
   -ECAA Technical Directive (ECAA TD) Chapter 4
   -Code of Federal Aviation Administration (CFR) Part 145

2. Areas of audit

-Human resource/manpower (number, currency of licenses, on job trainings, qualification record of each technician)

-Housing, facilities & house-keeping (space adequacy and suitability for machines& tools, suitability of assembly space, sealing of floor, adequacy of light and ventilation for the shop , availability of compressed air & water, racks, shelves, arrangement and cleaning of shops, controlling temperature and humidity of shops CFR145.35)

-Equipment and tools (regular maintenance and calibration of tools IPM 07-01-1, approval of equivalent equipment or test apparatus CFR part 43.13 &part 145.109& IPM 07-05-1,toolbox check as per IPM 07-03-2, replacement of tools with in a reasonable period of time IPM 07-03-7)

-Safety (abut fire control organization , inspectors' report on unsafe practices and poor housing conditions, first aid kits, protective equipment such as safety goggles and glasses, emergency exits etc.)

-Availability, current status, revision, proper signing and filing of documents manuals and records [11]:

3.4.5.2 Third party audit conducted by FAA to renew ETHIOPIAN certificate.

3.4.5.3 Extrinsic quality audits

Suppliers and approved foreign maintenance organizations or FR are audited by ETHIOPIAN every three years. As per ISO the important elements to be considered are:

-Audit plan (check list)

-Supplier quality system audit report

-Audit discrepancies report

-Corrective action request.

The audit checklist of ETHIOPIAN includes primary points and secondary points under each primary point. Major points included are: [11]

-Certification of the supplier or foreign repair station.

-Quality control status

-Inspection status

-Technical data

-Safety/Security/Fire protection

-Work processing

-Scraped parts

–Shelf life program

_Tools and test equipment

_Training

_Housing and facilities

_Storage

_Shipping

3.4.5 Receiving and inspection

The airline may need to send aircraft or engine components/parts to a foreign repair station or may need to buy new equipment or parts form vendors. Upon receiving, inspection is performed. Foreign repair stations or vendors will attach authorized release certificate along with the repaired components or with the materials being purchased. Currently ETHIOPIAN accepts mainly 3 types of release forms. These are the following:

1. Authorized release certificate approved by TCCA
2. Authorized release certificate approved by EASA
3. FAA form 8130-3

Major elements of these forms include: [11]

-Description of the item (e.g. Oxygen mask)
-Part number
-Quantity
-Serial/Batch number of component
- Status /work performed (e.g. overhauled, repaired, new)
-Remarks (e.g. this article was overhauled & inspected in accordance with ZODIAC CMM 35-13-63 with revision date)
-Approving Authority (e.g. FAA)
-Approved organization name
-Form tracking number
-Work order /Contract/invoice
-Address of the company
-Authorized signature
-Date, Name& signature of responsible person

Ethiopia batch tag will be attached with the authorized release certificate of the foreign company. This batch tag will indicate the person who received and inspected the item, the shelf life, receiving date, expiry date, stamp etc. Once the release certificate is attached with the incoming material and when the FR station or vendor is commonly known, only visual inspection will be done on the item. Detail inspection will be done for a new FR station or vendor item. The material receipt form will accompany the item until the production/maintenance process is over.

3.4.7 Rejection of non-conforming parts/items/FR delivery

When purchased/repaired parts or components coming from FR stations are nonconforming (for reasons such as release certificate is not original, “bogus parts”, part number change, not as purchase order etc.) the unit will be rejected and will be kept in Quarantine until it gets

decision with the vendor or FR station. A unit rejection form contains the description of the part, manufacturing date, ETH part number, serial number, quantity and reason for rejection. Quarantine slip which is used for rejection contains the following major elements [11]:

- Manufacturer part No & ETH part No
-Serial No (may or may not be applicable)
-Purchase order /repair work order
-Document No, quarantine quantity
-Quarantine reason (such as order not in data base, part No/ serial No unmatched, part No not on file, over shipment, short shipment, Item with out approved/wrong certificate, item in unserviceable condition, incomplete kits/ assembly etc.)
-Quarantine remark
-Disposition (such as accept to store, functional test, repair/ modify/rework, return to vendor for replacement or without replacement, scrap with or without replacement from supplier etc.).The procedure of rejection of non-conforming items is matched to the ISO requirement.

3.4.8 Control of inspection, measurement and test equipment

To ensure the repeatability and accuracy of special tools, jigs, equipment, and instruments, they must be periodically checked, inspected, adjusted, modified, and repaired. This action is called calibration. The three international quality standards all require some level of control over calibrated tooling. ANSI/ASQC Q9001 and ANSI/ASQC Q 9002 are identical in their requirements for calibrated tooling. ANSI/ASQC Q9003 is very close to the other two international quality standards in its requirement for calibration ,except that the emphasis is only on the control of final inspection, measuring and test equipment .The FARs are not as clear as the international quality standards when identifying the requirements for calibration system. With the exception of FAR part 145, for repair stations, professional interpretation may be needed. The quality system requirements for a repair station have a very clear description of the requirements for a calibration system. FAR sub part 145.47(b) states that:

"The repair station shall ensure that all inspection and test equipment is tested at regular intervals to ensure correct calibration to a standard derived from the National Institute of Standards and Technology (NIST) or to a standard provided by the equipment manufacturer." [23]

The company has a calibration center which calibrates test and measuring instruments found in different sections. Each month calibration due date reminder is prepared for all technical sections using computer software. This reminder indicates due month or year of all measuring and test equipment in each section/ department including serial/tag number, description of the item, frequency of calibration, the person who did the calibration and the first date of calibration.

3.4.9 Purchasing

To select appropriate supplier or FR/Maintenance organization, assessment or evaluation will be conducted. This evaluation consists of two major parts:

1. Document evaluation (pre assessment)

   Document evaluation (pre assessment): This assessment is performed at the beginning of the contact. Factors mainly focused are [11]:

   A. Financial aspects

   -Labor rate at supplier/FR station e.g. $45/hr

   -Free on board (FOB) point i.e. delivery destination after job completion e.g. Dubai, Addis Ababa etc.

   - Terms of payment (on cash or loan), if loan, how many days?

   -Parts price mark-up e.g. 7%, 3%, N/A etc

   -Sub contract mark-up 7%, 3%, N/A etc

   -Labor escalation rate e.g. 3%, 0%, N/A etc.

2. Physical audit (post assessment) at the supplier's site (Extrinsic /third party audit).Auditors assigned from "TQM" department conduct evaluation at the suppliers or FR stations' base every three years.

3.4.10 Training

The company conducts training activities in its recurrent training center although the rate is not to a satisfactory level. The recurrent training center releases annual training schedule for maintenance personnel to participate in various training activities. However, the willingness from departments to send their staff to the training center is not encouraging. This problem seems to be partially solved after the audit conducted by IOSA. To substantiate this fact the training record of trainees participated on various training activities obtained from the center is presented next [11]:

2002-2003: 462 maintenance personnel including 31 customer trainees participated on trainings.

2003-2004: 408 maintenance personnel including 39 customer trainees participated on trainings.

2004-2005: 464 maintenance personnel including 121 customer trainees participated on trainings.

2005-2006 beginning of June: 764 maintenance personnel including 48 customer trainees participated on trainings. (i.e. after the remark made by IOSA).

2006(June – September): Regulation 157 trainees, human factors 240 trainees and 113 trainees for different courses, a total of 510 trainees with in four months were registered. The improvement in training activities is the result of the remark made by IOSA. Although the participants of trainees have increased after the audit made by IOSA, still some 50% of maintenance personnel are not included in the training activities.

3.4.11 The corporate quality manual

One major and important decision made in the recent time is the effort underway to establish a quality management system and to emphasize on the management's accountability for quality. This is described in the corporate quality manual of company. The corporate quality manual of ETHIOPIAN was issued first on July 13, 2006. It has the following major elements [11]:

a) Record of revision pages
b) Revision to this quality manual
c) Chapter 0: Procedures to control the original issuance of the corporate quality manual and subsequent revisions made now and then to insure that those persons who are issued receive revisions.
d) Chapter 1: Quality policy.
e) Chapter 2: ETHIOPIAN quality management structure.
f) Chapter 3: Quality management system.
g) Chapter 4: Internal evaluation
h) Chapter 5: Quality and safety oversight
i) Chapter 6: Monitoring and corrective action
j) Chapter 7: Quality audit
k) Chapter 8: Quality system training and chapter 9 is about Quality audit forms (compatible to the current forms required by ISO)

Audit subjects	Hangar	Line	Shops	Contractors	Vendors	Fuel	Tech.Lib	Logbooks	Checks	Material	Tools	Training
1. Adequacy & Upkeep of Facilities	*	*	*	*						*	*	*
2. Adequacy & Serviceability Of GSE	*	*										
3. Serviceability & calibration of tools &test Equipment	*	*	*	*							*	
4. Use of technical Manuals	*	*	*	*								
5. Availability of Skilled &qualified Personnel	*	*	*	*					*			*
6. Paper work Handling	*	*	*	*	*				*			
7. Required inspection Items handling	*	*		*								
8. Personnel records	*	*	*	*								
9. Parts: availability Handling, control	*	*	*	*						*		

Audit subjects	Hangar	Line	Shops	Contractors	Vendors	Fuel	Tech.Lib	Logbooks	Checks	Material	Tools	Training
10. Fuel &Oil: Dispensing &storage		*				*						
11. Dicing Chemicals Dispensing &Storage		*										
12. Compliance with Airline Requirements				*	*							
13. Capabilities				*	*							
14. Cleanness Quality Of fuel						*						
15. Periodic Test &inspection of Fuel Facilities						*						
16. Fuel handling equipment						*						
17. Fueling procedures		*				*						
18. Revision status of Manuals							*					
19. Distribution procedure Of manuals							*					
20. Proper Revision Sign Off							*					
21. Currency &Completeness	*	*	*	*			*					

Audit subjects	Hangar	Line	Shops	Contractors	Vendors	Fuel	Tech.Lab	Logbooks	Checks	Material	Tools	Training
22. Completeness of Logbooks								*				
23. Proper Sign Off of Discrepancies								*	*			
24. Transfer of Data to Tracking System								*				
25. Improper Maintenance Write-ups in Logbook		*						*				
26. Completeness of Check Packages									*			
27. Inspection Stamp Usage	*	*							*			
28. Airplanes Identified									*			
29. Receiving Inspections										*		
30. Serviceable Tag Sign Off										*		
31. Shop finding reports			*	*	*					*		
32. Quarantine Areas										*		
33. Shelf life control (store)										*		
34. Separation of serviceable From unserviceable										*		
35. Currency of Calibration Stickers											*	
36. Re-Calibration control System											*	
37. Traceability of Standards (NIST)											*	

Audit subjects	Hangar	Line	Shops	Contractors	Vendors	Fuel	Tech.Lib	Logbooks	Checks	Material	Tools	O_2	Training	Safety
38. Cleanness of Tools, Work areas, Parts											*	*		
40. Proper Storage of O_2 Bottles												*		
41. Quality of oxygen												*		
42. Availability of safety Equipment	*	*	*											*
43. Safety training														*
44. Accident/incident Reporting	*	*	*											
45. Identification of 'No smoking areas'	*	*	*			*								*
46. Hazardous materials Labeling& handling	*	*	*											*
48. Training course Syllabus													*	
49. Maintenance of training Records													*	
50. Processing warranty Claims										*				

Table 3.1 Various areas of quality audits for a medium size airline [13].

3.5 Technical training

An airline is responsible for the proper training of its personnel. This includes flight crews, cabin crews, and ground handling crews, maintenance mechanics, and technicians, inspectors, auditors, managers, computer operators, and administrative personnel. A significant portion of their training –especially for flight crews, cabin crews, and maintenance personnel- is usually accomplished prior to hiring in to the airline. This involves, formal, specialized training sanctioned by the FAA and the issuance of an FAA license for the particular specialty [13].

3.5.1 Training for aviation maintenance

A) Formal training: It is usually accomplished before the mechanic is hired. Airframe and power plant (A&P) or avionics mechanics and technicians may come from FAA approved A&P schools, from technical/trade schools with appropriate aviation curricula, or from military services. The FAA approved schools usually graduate students with the appropriate licenses. The other sources of training require that the applicant arrange with the FAA or national civil aviation authority such as CAA to take the necessary tests for attending the desired license.

B) Organizational training: This training is developed and conducted by the airline organization itself and covers the airline's basic policies and procedures, papers, work, and specific aviation systems and equipment in use at the airline. These curricula could include full courses for a particular airframe and its systems or could involve only the difference between the airline's equipment and that for which the mechanic has current experience. All training courses should address the safety and human factors issue as applicable.

C) Manufacturer or vendor training: Airframe, engine, and aircraft equipment manufacturers often offer specialized training on their products or on special activities related to their products either at their facilities or at the airline. The airline training department makes all arrangements and monitors the activity.

D) Quality training: Quality assurance auditors require training in auditing procedures and techniques as well as refresher training on regulations and airline policies; quality control inspectors need to be trained on inspection techniques and on tool and equipment calibration.

Mechanics authorized to perform required inspection items (RIIs) must receive special training from the airline or an outside organization in inspection techniques.

E) On-job training (OJT): It involves special procedure that can't be covered completely or effectively in classrooms sessions and those that can only be accomplished by hands-on experience on the job.

F) Upgrade training: It is required when new equipment is incorporated in the unit's vehicles or fleet or when new procedures are implemented in the maintenance activities. Other upgrade training classes may be conducted (on- or off-site) to permit mechanics to upgrade their licenses or their work status.

g) Refresher training: It is required whenever it is noted that the mechanic or technician is "rusty" and needs to review or re-verify certain skills. This may occur because the mechanic has extended periods of time where he/she wasn't exposed to the equipment or maintenance activities. Upgrade and refresher trainings are usually developed by the organization and are done "as necessary" basis.

h) Maintenance resource management: Considerable interest has developed recently in the subject of human factors in maintenance. In the 1990s efforts begun to identify and correct errors in the maintenance activities that contribute to aircraft accidents and incidents. This activity-human factors in maintenance (HFM)-has developed in to the maintenance resource management (MRM) program. The FAA has issued Advisory Circular AC 120-72, maintenance resource management training to outline the requirements for this type of training

i) Airframe manufacturers training: When an airline buys one or more aircraft from the airframe manufacturers (Boeing, Lockheed, Airbus, etc.) they usually get, as a part of the purchase price, a certain number of training slots for the manufacturer's training classes on that model. This would include courses on airframe, power plant and avionics equipment installed. Airframe, engine and equipment manufacturers may provide a variety of "onetime" program at the airline venue. This might include training on extended range operations with two engine airplane(ETOPS), corrosion protection and control program(CPCP), maintenance error detection program(MEDA), non-destructive test and inspection techniques(NDT/NDI), aviation safety, reliability programs and the like [13].

3.6 Reliability in broad sense

Reliability is one of the major tools currently underway in the aviation industry to continually evaluate quality and performance. Military standard defined reliability as "The probability that an item will perform a required function without failure under stated conditions for a stated period of time."

In this part, reliability has a special approach in aviation. There are two main approaches to the concept of reliability in aviation industry [13].

1. One looks essentially at the whole airline operation or the maintenance and engineering operation with in the whole. This is the case with EAL.
2. The other looks at the maintenance program in particular.

The first approach is measured by dispatch reliability i.e. how often the airline achieves an on-time departure of its scheduled flights. An on-time departure means that the aircraft has been "pushed back" from the gate with in 15 minutes of the scheduled departure time. Airlines using this approach track delay. Very often airlines using this approach to reliability overlook any maintenance problems (personnel or equipment related) that don't cause delays and track and investigate only those problems that cause delay. The second approach is to consider reliability as a program specifically designed to address the problems of maintenance whether or not they cause delay –and provide analysis of and corrective actions for those items to improve the overall reliability of the equipment. This contributes to the dispatch reliability as well as the overall operation.

3.6.1 Types of reliability

There are four types of reliability one can talk about related to maintenance activity [13].

3.6.1.1 Statistical Reliability: It is based upon collection of and analysis of failure, removal, and repair rates of systems or components. These various maintenance actions are called events. Event rates are calculated on the basis of events per 1000 flight hours or events per 100 flight cycles. This is used for the purpose of the analysis. It is recommended to use this approach in airlines with more number of aircrafts (>30) in order for the statistical calculations to be very significant. Moreover, this approach may not indicate reliability of components which are engaged in work for a smaller duration .For instance whether radars may be engaged only for two months in a year and there will be scarcity of data.

3.6.1.2 Historical Reliability: It is simply comparison of current event rates with those of past experience. It can be used in the case when there is no sufficient data to perform statistical analysis. It is just looking at the last year's data for the same equipment, same period of time. If current rates compare favorably with past experience, then it is okay; if there is significant difference in data from one year to the next that would be an indication of a possible problem.

3.6.1.3 Event oriented reliability: It is concerned with one time events such as bird strikes, hard landings, in-flight shutdowns, lightening strikes, or other accidents or incidents. These are events that don't occur on a regular basis and therefore produce no usable statistical or historical data. Nevertheless, they do occur from time to time, and each occurrence must be investigated to determine the cause and to prevent or reduce the possibility of recurrence of the problem.

3.6.1.4 Dispatch reliability: It is a measure of the overall effectiveness of the airline operation with respect to the on-time departure. It receives considerable attention from regulatory authorities as well as from airlines and passengers. If there are 4 delays and cancellations in 100 flights this means a 4% delay rate. A 4% delay rate would translate in to a 96% dispatch rate. In other words, the airline dispatched 96% of its flights on time.

The use of dispatch reliability at the airlines is, at times, misinterpreted. The passengers are concerned with timely dispatch for obvious reason. To respond to FAA & Aircraft manufacturers pressures on dispatch rate, airlines often react. Some airlines maintenance reliability program (such as ETHIOPIAN) track only dispatch reliability; that, they only track and investigate problems that result in a delay or cancellation of a flight. But this is only part of an effective program and dispatch reliability involves more than just maintenance. An example will bear this out.

An aircraft pilot in a command is 2 hours from his arrival station when he experiences a problem with the rudder controls. He writes up the problem in the aircraft logbook and reports it by radio to the flight following unit at the base. Up on arrival at the base, the maintenance crew meets the plane and checks the log for discrepancies. They find the rudder control write-up and begin troubleshooting and repair actions. The repair takes a little longer than the scheduled turnaround time and, therefore, causes a delay. Since maintenance at the work and the rudder is the problem, the delay is charged to maintenance and the rudder system would be investigated for the cause of the delay. This is an improper response. Did maintenance cause the delay? Did the rudder equipment cause the delay? Or was the delay caused by poor

airline procedures? To put in to another way: could a change of airline procedures eliminate the delay? Let the events remain as they are happened .It is possible to change them for the better.

If the pilot and the flight operation organization knew about the problem 2 hours before landing, why wasn't maintenance informed at the same time? If they had been informed, they could have spent the time prior to landing in studying the problem and performing some troubleshooting analysis. It is quite possible, then, that when the airplane landed, maintenance could have met it with a fix in mind. Thus, this delay could have been prevented by procedural changes. The procedure should be changed to avoid such delays in the future.

While maintenance organizations and the airline could benefit form this advance warning system, it will not always eliminate delays. The important thing to remember is that if a delay is caused by procedure, it should be attributed to procedure and it should be avoided in the future by altering the procedure. That is what a reliability program is about: detecting where the problems are and correcting them, regardless of who or what is to blame.

Another fallacy in over emphasizing dispatch delay is that some airlines will investigate each delay (as they should) but an equipment problem is involved, the investigation may or may not take in to account other similar failures that did not cause delays. For example, if there are 12 write-ups of rudder problems during the month and only one of these caused a delay, there are actually two problems to investigate: (a) the delay, which could be caused by problems other than the rudder equipment and (b) the 12 rudder write-ups that may, in fact, be related to underlying maintenance problem. One must understand that dispatch delays constitute one problem and the rudder system malfunction constitutes the other. They may indeed overlap but they are two different problems. The delay is an event oriented reliability problem that must be investigated on its own; the 12 rudder problems (as this constitutes a higher failure rate) should be addressed by the statistical (or historical) reliability program. The investigation of the dispatch delays should look at the whole operation. Equipment problems- whether or not they caused delays- should be investigated separately [13].

Table 3.2 Inputs to determine dispatch reliability

A/C type	767-300		767-200		737-700		757-PAX		7575-CAR		737-260		DH-6		F-50		L-100-30	
	T(hr)	Lnd	T(hr)	Lnd	T(hr)	Lnd	T(hr)	Lnd										
Flt.hr& Lnd.	426.28 424.3 446.55 413.68 421.95 405.82	89 89 106 92 95 101	 260.4	 88	239.17 258.45 373.12 246.03 251.15	115 112 145 86 120	230.55 119.03 328.15 314.48 289.7	58 43 82 101 83	 158.2	 40	 90.83	 62	 62.55 49.07	 57 50	201.15 202.43 163.43 145.12 196.02	257 247 201 172 212	 -- --	 -- --
Total Hrs(A)	2538.6	572	260.4	88	1367.9	578	1281.9	367	158.2	40	90.83	62	111.62	107	906.15	1089		
A/C days in the month	31*6=186		31*1=31		31*5=155		31*1=31		31*1=31		31*1=31		31*2=62		31*5=155		--	
Service days(B)	186		13		155		31		31		31		62		155			
A/C in service	6		1		5		5		1		1		2		5		--	
Daily utilization(C) A/B	13.6		8.4		8.8		8.3		5.1		2.9		1.8		5.8		--	
Average sector time=A/Lnd	4.4		3		2.5		3.7		4		1.5		1.04		0.9			
No of delay Or cancellation	5		4		5		2		0		0		0		13			
Dispatch reliability %	99.1		95.5		99.1		99.4		100		100		100		98.7			

*Dispatch reliability= (Total No of landing with out delay or cancellation/ Total No of landing or departure)*100%
For instance for B-767 D.R = ((574-4)/572)*100%=99.1% [11]

3.6.2 Alert status determination for aircraft systems

Sample example for Boeing 767-300, ATA No 2150(Cabin Cooling)
Data used for alert value calculation is from year 2005.

Table 3.3 Inputs to determine alert status [11]

Month	J	F	M	A	M	J	J	A	S	O	N	D	$\sum X$	$\bar{x}$	$\sum(X_i-\bar{x})^2$
X_i	0.5	1.1	1.7	5	1.8	4.7	1.7	2.1	2.3	1.3	0.4	1.6	24.2	2.02	
$(X_i-\bar{x})^2$	2.3	0.8	0.1	8.8	0.04	7.2	0.1	0.006	0.07	0.5	2.60	0.2			22.9

$\delta=\sqrt{\sum (X_i-\bar{x})^2/n-1} = 1.44$

$U_{CL}=\bar{x} + 2.5\ \delta=5.62$

X_i refers to monthly event rate in 1000 flight hours for the previous 12 months excluding the three months from the current month.

To determine the value of X_i:
-Revenue flight hour for the particular month under consideration will be recorded for all aircrafts in the fleet. Revenue flight hour is the total flight hour of the fleet excluding training and other non revenue generating flights.

-Number of failures of the specific component in that month will also be registered.
X_i = (1000*Number of failures)/Revenue flight hours.

For Boeing 767-300 fleet the revenue flight hour in May 2006 was 2538.58
Three pilot writ-ups were registered for cabin pressure control whose ATA No is 2130.
Hence its rate for 1000 flight hours will be
X_i = (1000*3)/2538.58=1.18

Three month rate: Is average of the event rates for the last three months including the current month. This is done for every three months on a rolling basis.

Reliability status:

-Clear, if 3 months average is < U_{CL}

-Alert, if 3 months average is > U_{CL}

-Remains in alert if two or more consecutive 3 months rates > U_{CL}.

-If monthly rate falls below U_{CL}, status returns to clear even if 3 months rate remains above U_{CL}.

Investigation of the alert items by engineering often results in the need to change the maintenance program. This may result in:

a) Adjustment in the interval at which maintenance tasks are performed.
b) Change in the maintenance process (HT, OC, CM) to which components are assigned.

A change in the task may mean rewriting maintenance and/or test procedures or in implementing new, more effective procedures.

Chapter 4: Problem identification

Nowadays survival and competitiveness of a business company in a market is highly dependant on the quality of products or services that it provides to customers. Although advanced technology contributes a lot for quality outputs, this is nothing without an efficient quality management of those tasks being accomplished. Though Ethiopian Airlines has secured longstanding tradition and experience in transport aircraft maintenance and engineering tasks, there are also big issues of quality that need to be addressed by implementing and experiencing TQM. Some of these problems are:

4.1 Flight cancellation

Table 4.1 Flight cancellation rate [11]

	Aircraft type				
Year	B767	B757	B737	DH6	F50
1999	1	2	1	6	4
2000	5	3	3	5	9
2001	4	11	1	12	15
2002	7	4	3	5	10
2003	5	7	6	6	24
2004	3	4	5	4	21
2005	5	6	2	1	13

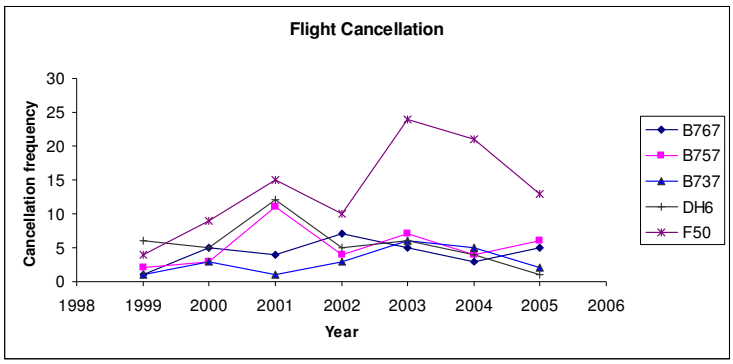


Figure 4.1 Flight cancellation run chart

As it can be seen from the graph, the highest rate of flight cancellation is observed on F-50 fleet. This is the major cause of customer dissatisfaction in the local flight. Although the trend

indicates that the rate of flight cancellation decreased recently, F-50 fleet is the still showing the largest flight cancellation rate compared to other fleets. So far the highest flight cancellation scored in one year is 24 in the F-50 fleet. The other fleets have also shown considerable cancellation rate. Specially, the B-757 and DH-6 had high rate in the year 2001. In the recent times, the cancellation rate seems to be declining for the F-50, B-737and DH-6 fleets while increasing for the B-767 and B-757 fleets.

4.2 Flight delay

Table 4.2 Flight delay frequency [11]

	Aircraft type				
Year	B767	B757	B737	DH6	F50
1999	107	121	25	65	65
2000	130	160	29	81	96
2001	120	113	55	87	105
2002	112	94	65	52	109
2003	72	121	83	27	109
2004	89	145	77	19	155
2005	146	137	49	34	168

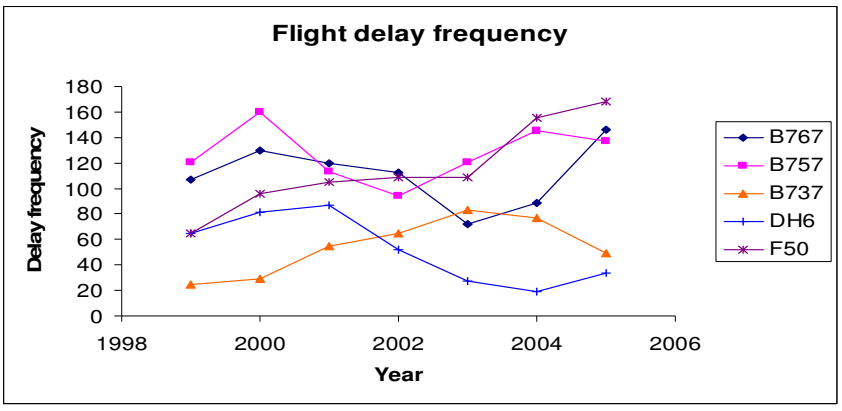


Figure 4.2 Flight delay run chart

4.3 Total hours delayed

Table 4.3 Flight total hours delay [1] [11]

	Aircraft Type				
Year	B767	B757	B737	DH6	F50
1999	318.2	280.76	73.7	197.14	158.7
2000	303.16	262.36	57.6	257.38	281.3
2001	147.13	201.23	65.6	167.7	163.4
2002	236.37	109.32	91.91	90.65	191.92
2003	125.45	198.04	367.07	50.14	252.27
2004	187.91	202.88	140.07	22.16	313.02
2005	311.9	242.62	133.1	137.36	421.59

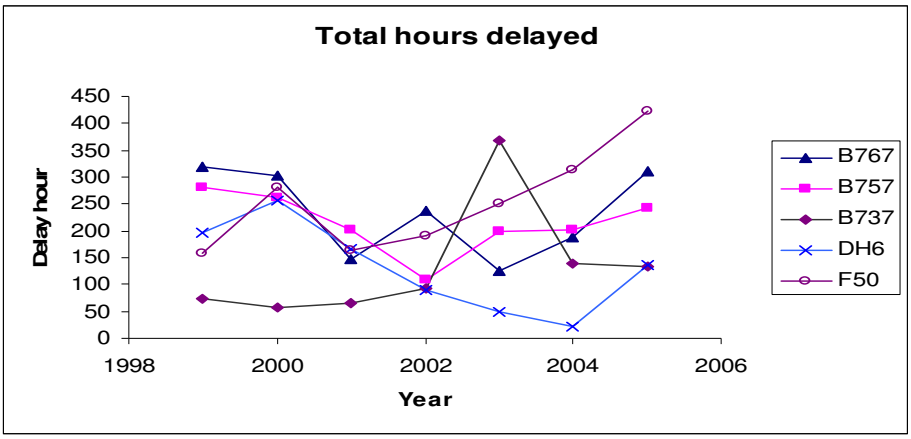


Figure 4.3 Total hours delay run chart

The flight delay frequency and delay hour are important parameters to show the effectiveness of the airline to evaluate the performance of its aircraft fleet in order to obtain the highest dispatch reliability. The trend of total delay hour has increased since 2001, 2002 and 2003 for the fleets F-50, B-757, B-767 respectively. The highest total flight hour delay is observed in the F-50 fleet in the year 2005. The B-757 and B-767 fleets which are engaged in the international flight service are also subjected to increasing delay hours. The cumulative effects of these circumstances are dissatisfaction of both internal and external customers, compensation that should be made for customers such as covering hotel rent along with other services, and the delay of the next scheduled flight.

[1] Technical delays of 15 minutes and above are only considered

4.4 Revenue departure (Flight departure to generate income excluding training and other flights.)

Table 4.4 Number of revenue departures [11]

	Aircraft Type				
Year	B767	B757	B737	DH6	F50
1999	5327	6532	953	4267	8055
2000	5483	6682	1051	3809	10119
2001	5110	6219	2654	3197	11169
2002	6264	6132	2479	2509	11614
2003	4172	6404	3268	2032	10691
2004	5826	6530	5301	1695	10871
2005	6632	5765	6632	1551	10647

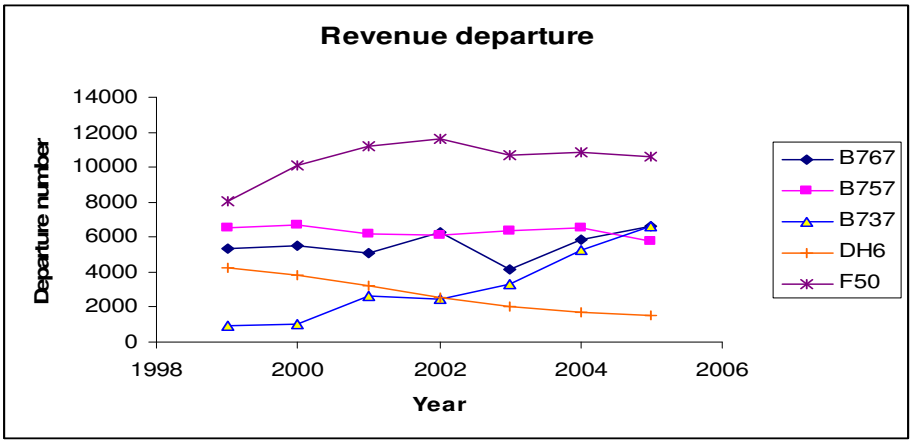


Figure 4.4 Revenue departure run chart

The revenue departure measures the number of departures made by the airline fleet to generate income. It will not include departures made for other purposes such as training, flight test etc. It can serve as one means of measuring the performance of the airline since it may indicate the increase of flight routes or the increase of flight departure frequency in the existing flight lines. As it can be seen from the plot, the revenue departure is more or less constant for the B-575 fleet, increasing and then coming to a constant level for the F-50 fleet, increasing for the B-737 and B-767 fleets and totally declining for the DH-6 fleet.

4.5 Average dispatch reliability

Table 4.5 Average% dispatch reliability [11]

		Aircraft type				
Year		B767	B757	B737	DH6	F50
1999	Planned	98.6	98.6	98.6	97	97
	Actual	98	97.7	97.5	98.5	99.24
2000	Planned	98.6	98.6	98.6	97	97
	Actual	97.53	96.97	98.6	97.88	98.96
2001	Planned	98.6	98.6	98.6	97	97
	Actual	97.8	97.4	97.86	97	98.93
2002	Planned	98.6	98.6	98.6	97	97
	Actual	97.8	98.24	97.23	97.74	98.96
2003	Planned	98.6	98.6	98.6	97	97
	Actual	98.2	97.6	97.3	98.33	98.7
2004	Planned	98.6	98.6	98.6	97	98.6
	Actual	98.4	97.9	96.7	98.66	98.4
2005	Planned	98.6	98.6	98.6	97	98.6
	Actual	95.3	97.2	99.25	97.75	98.3

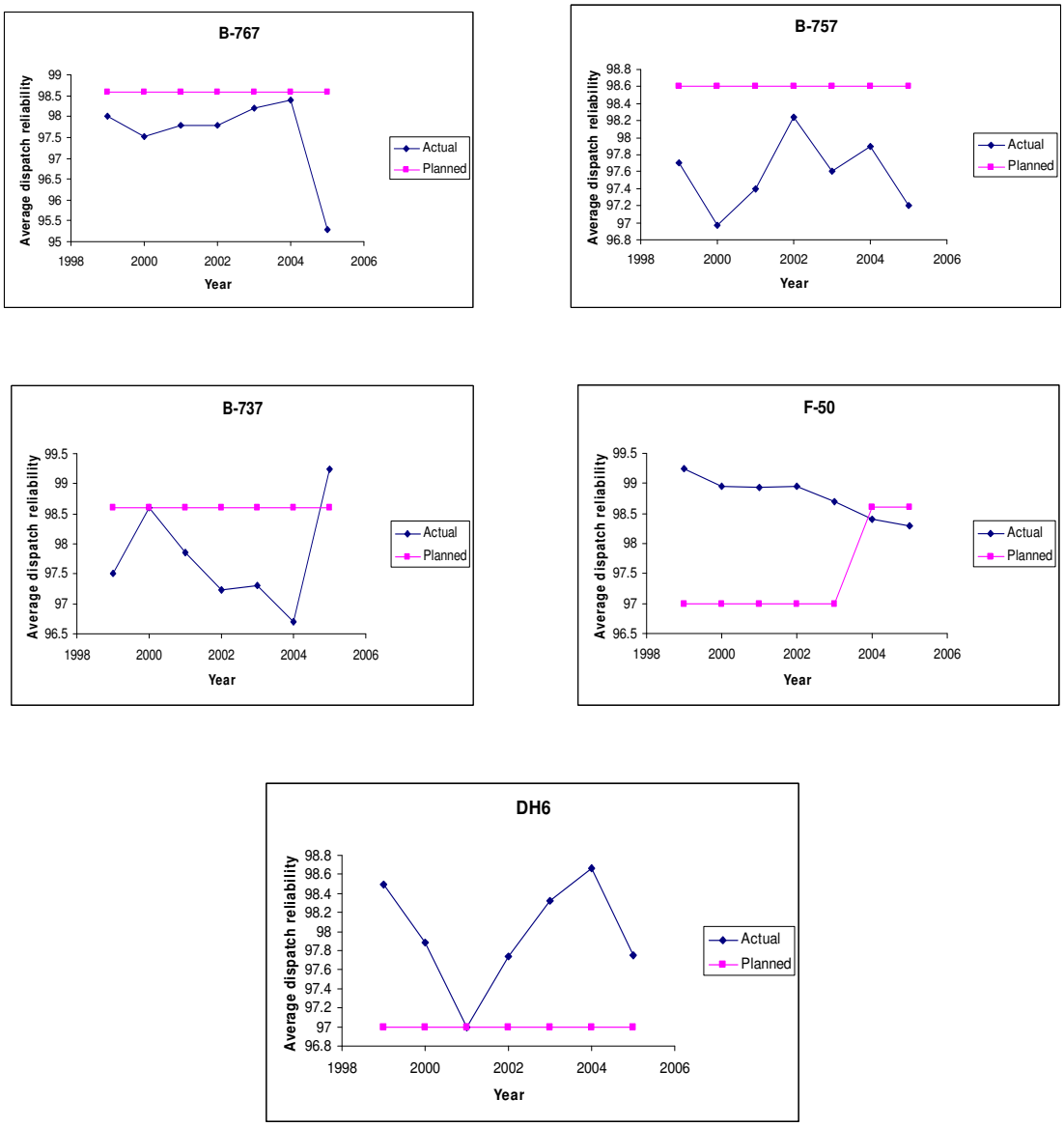


Figure 4.5 Dispatch reliability run chart

Dispatch reliability measures the capability of an airline to achieve an on-time departure of its scheduled flights. As it can be seen for the graph plotted, B-767 fleet had lower dispatch reliability than the planned one for the past seven consecutive years. The variance had even grown to larger value in the year 2005. In the same manner the B-757 fleet had dispatch reliability lower than the planned one for the same period. Unlike the B-767 and B-757 fleet, the DH-6 fleet had actual dispatch reliability greater than the planned value for this duration. The actual dispatch reliability of B-737 and F-50 was below the planned value for considerable consecutive years, though the situation was improved later.

4.6 Technical incidents

Table 4.6 Frequency of technical incidents [11]

	Aircraft Type				
Year	B767	B757	B737	DH6	F50
1999	5	13	5	19	10
2000	7	15	2	16	22
2001	10	9	2	25	27
2002	20	7	9	15	30
2003	5	12	15	7	52
2004	10	20	12	4	40
2005	12	12	7	10	42

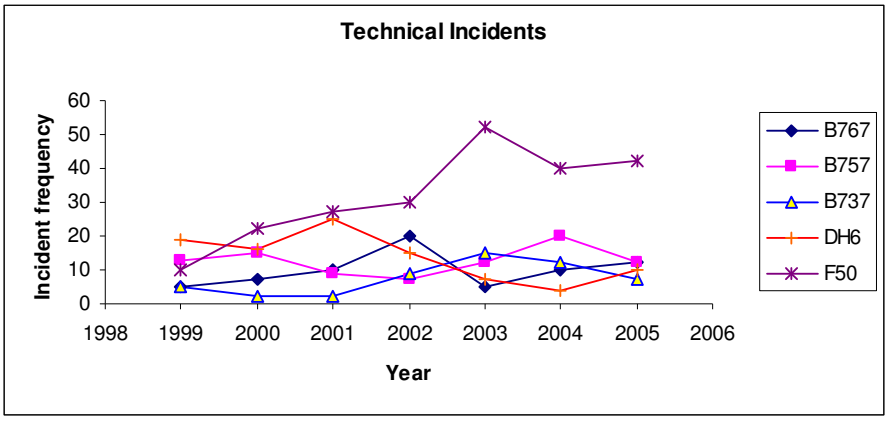


Figure 4.6 Technical incidents run chart

Technical Incidents include:

-Return from taxi-way

-Return from flight

-Return from take-off block

-Engine in-flight shutdown

-Aborted take-off

-Fire warning

-Diversion due to mechanical problem only

4.7 Employee turnover

Employee turnover is a critical cost deriving for any business organization. The cost of recruiting and filling vacancies, lost productivity from vacant jobs, and the cost of training

new employees increases operating cost, reduces out put and declines profit. Based on the five years executive summery of employee turnover, the following data is provided.

Table 4.7 Yearly employee turnover [11]

Fiscal year	Average No of employee	No of labor turnover	Turnover %
2000/2001	3848	156	4.1
2001/2002	3970	170	4.3
2002/2003	4129	227	5.5
2003/2004	4487	206	4.6
2004/2005	4610	199	4.3
Average	4210	192	4.6

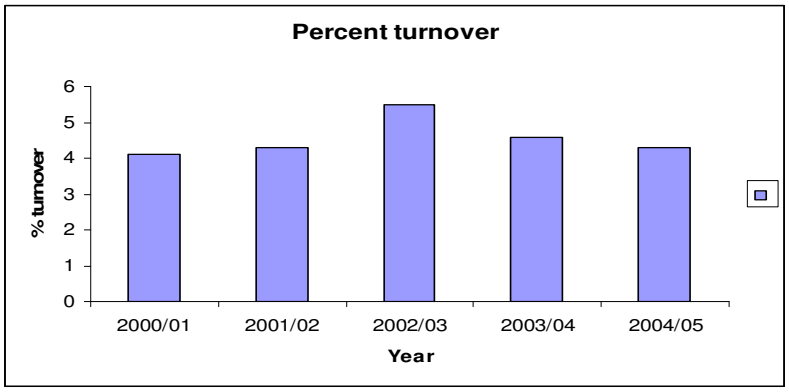


Figure 4.7 Histogram of employee turnover

4.7.1 Turnover by profession

During 2003/2004 and 2004/2005 1 chief executive, 19 Pilots , 83 marketing personnel , 16 financial personnel, 51 technicians, 39 cabin crew, 7 engineers , 10 IT personnel, and 179 other different personnel left the company due to various reasons.

4.7.2 Causes of turnover

1. Economic reason (main reason) and pursuit of a better life in developed countries.

2. Threats from Middle East countries in taking more pilots and aircraft technicians of EAL. This situation is expected to continue since these countries are expanding airline business.

Improvements undertaken to minimize employee turnover

1. Salary scale adjustment

2. Recently ETHIOPIAN has taken initiatives to facilitate the process for employees to have their own house.

However, considerable employees point out that the performance appraisal payment technique and the variable payment technique are not equally rewarding employees' effort. The latter is used for mechanics, pilots& cabin crew while the former is used for office workers and other staff members. In variable payment technique, measurement is time. It compares the standard man hour and the actual time taken to complete a certain task. For instance if a mechanic finishes a task 3 hours earlier than the standard man hour, it will be registered for him. Like wise the hours will be accumulated in a month and a payment in addition to his salary will be made. But in case of performance appraisal payment, monthly activity report of workers will be collected and a certain performance level will be given to the workers .The problem is that in giving a higher performance level it requires justification to be made by bosses or higher managers. Usually bosses and higher managers are not willing for this justification and they put a performance level just below the higher required value for additional payment and as a result a higher extra payment may not be achieved.

4.8 Training

Though the company conducts training activities, still a lot effort is required to strictly adhere to the schedules released by the training centers. Many departments still hold their staff members from participating on training activities. The reason they put forward for this is that lack of man power will happen if they allow their staff members to participate on training activities. This situation has shown a little improvement after the audit conducted by IOSA.

4.9 Quality assurance

The major aspect of quality assurance in aviation industry is the internal audit performed with in the company and external audit performed on the site of suppliers/vendors and foreign repair stations. This audit practice of ETHIOPIAN was non systematic and inferior to the audit requirements of ISO. There were no standard corrective action request system, audit

discrepancies record system and audit follow-up system. This problem has been solved quite recently to some extent after the audit conducted by IOSA.

4.10 Major emphasis to quality control

In order to continue in the airline business, EAL has to be evaluated by the Ethiopian Civil Aviation Authority and the Federal Aviation Administration (FAA). FAA is the responsible organization to renew ETHIOPIAN operating certificate after periodic evaluation by its representatives. The evaluation of these regulatory bodies mainly emphasizes on conformance to requirements outlined by FAA. The evaluation scheme doesn't pay much attention to standard quality assurance systems or total quality management philosophies. It is up to the organization to develop a standard quality management system and apply the philosophies of TQM. The researcher noticed that although there was TQM department under the maintenance and engineering division, implementation of TQM was by far below the requirement. The quality control aspect has been well practiced while the quality assurance practice has remained traditional and non standard until very recent time. The quality assurance practice has exhibited improvement after the audit activities made against ETHIOPIAN by IOSA.

As far as its operating certificate is renewed by FAA, ETHIOPIAN has the right to continue operation for the approved duration. To renew the certificate of the maintenance organization, designated representatives of FAA perform the following major evaluations:

1. Checking calibration of measuring and test instruments such as gauges, meters etc.

2. Checking of qualification of technicians, operators etc.

3. Checking documents (revision dates, stamps, approvals of inspection works etc.)

4. Checking performance of instruments or equipment and counterchecking capability of operators by requesting operators to conduct a certain practical operation or inspection task.

5. Checking the existence of standards, work procedures, manuals, and materials to perform a certain inspection or other task.

6. Checking sample of tasks performed if they are within the capability list of the airline.

7. Other quality control oriented evaluations.

4.11 Aircraft ground time and man hours

More than 90% of the maintenance activities are performed with actual aircraft ground time below the scheduled one. However, more man-hours have been utilized than the standard one. The reason for this is that, because of lower technology employed by ETHIOPIAN compared to the airlines in the developed countries, the man-hour is increased by a factor of 2 to 2.5.But the adverse effect of this is increase of maintenance cost.

4.12 Ignored costs

Estimating quality costs and maintenance costs would indicate the performance of ETHIOPIAN from time to time. However, these costs are ignored. From the interview conducted, the reason for ignoring these costs is to eliminate the consequences of a negative image on the company that may come from the government, donators such as European Countries, and other partners. But delays, cancellations etc. are causing extra costs on the company such as for renting rooms for passengers, other services, and even delay of the next flight.

Chapter 5: Collection of data, discussion and analysis of results

5.1 Data collection procedure

Information gathering and data collection are made by:

1. Interviewing ETHIOPIAN employees and representative of regulatory bodies such as CAA, FAA, and IOSA.
2. Conducting personal observation at the work places.
3. Distributing questionnaires to sample of employees in different departments.
4. Looking at Technical Policies and Procedures Manual (TPPM), Inspection and Procedures Manual (IPM), Reliability Program Manual (RPM), Corporate Quality Manual (CQM), Maintenance Program Documents (MPD), Quality Audit Reports, etc.

The distribution of questionnaires is made to the departments listed below and the selected sample employees in these departments are given ample time to respond to the questions during their free time or by taking the questionnaire paper to their home. As a result, the researcher believes that productivity was unaffected.

List of departments considered for the questionnaire:

1. Repair shops
2. Power plant inspection
3. Hangar maintenance
4. Hangar inspection
5. Component overhaul
6. Structure maintenance
7. “Total quality management”
8. Planning
9. Engineering
10. Maintenance program methods development
11. Store

On average four to five employees at different posts (director, manager, supervisor, foreman, senior mechanic, lead mechanic, junior mechanic, etc.) are randomly selected from each department .They are requested to respond to the questions frankly and to forward further elaborations so that the out come is to overcome the existing problems and thereby enhance

the competitiveness of the company in the global market. The points included in the questionnaires are believed to be critical factors that need to be considered while implementing total quality management in the airline industry. The total number of papers distributed was 50 and the one collected was 36.

5.2 Discussion of results

5.2.1 Summery of questionnaire results

Table 5.1 Summary of data collected

Grade	A		B		C		D		E		F		G		H	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
1	12	2.54	8	7.9	1	0.7	11	5	0	0	1	0.4	11	2.54	25	8.68
2	55	11.7	17	17.8	22	15.38	49	22.7	24	22.2	16	6.32	63	14.6	58	20.14
3	129	27.04	28	27.7	46	32.2	54	25	32	29.6	43	17	151	34.5	79	27.4
4	136	28.9	28	27.7	29	20.28	55	25.5	32	29.6	62	24.5	138	31.9	63	21.9
5	137	29.1	18	17.8	19	13.28	30	13.9	18	16.6	125	49.4	45	10.4	53	18.4
6	2	0.42	2	2	26	18.2	17	7.8	2	1.85	6	2.37	24	5.56	10	3.47
Total	471		101		143		216		108		253		432		288	

Grade 1: Excellent/extremely high

2: Very good/very high

3: Good/high

4: Average

5: Poor/below required

6: Not applicable

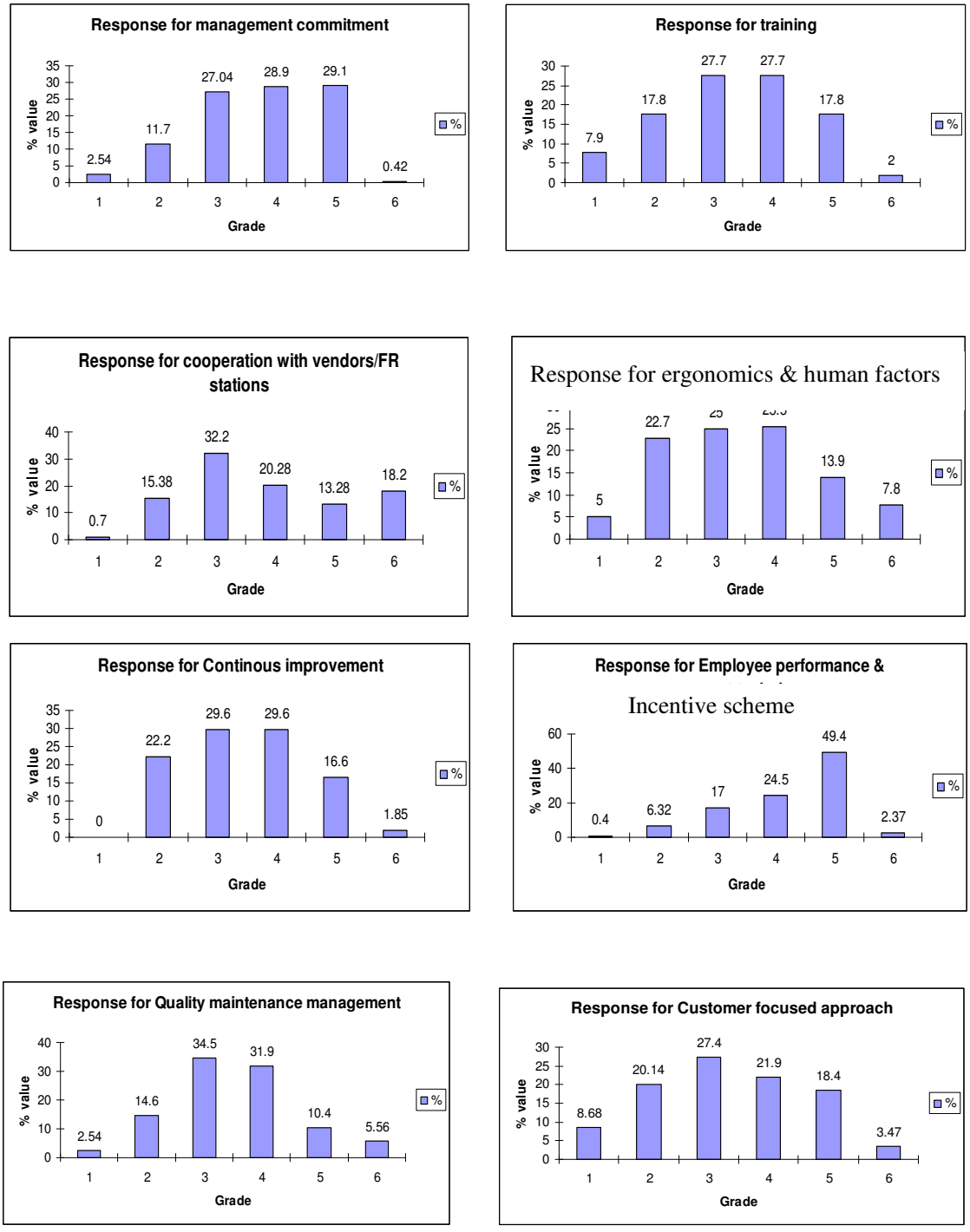


Figure 5.1 Graphical display of questionnaire results

a) Commitment of the management/Leadership

As it can be seen for the Figure 5.1, 28.9% of the respondents replied that the commitment of the management was average while 29.1% responded that the management commitment was below the requirement. On the other hand, 85.46% of the respondents replied that the commitment of the management regarding continuous improvement, willingness for important changes, motivation and recognition of employees' effort, transparent leadership, listening to employees' dissatisfaction or addressing their enquiries etc. should be improved (responses 3, 4, 5).

b) Training

From Figure 5.1, 27.7% respondents pointed out that the training activities undergoing in the company were good. On the other hand the same number of respondents replied that the commitment of conducting training as per schedules and the willingness of departments to send their staffs for training was average. Other considerable respondents (17.8%) indicated that the commitment to run trainings smoothly according to the plan was below the requirement and should be improved. While the researcher was conducting personal investigation of training records, he noticed that the effort made in this requirement was below the required until the very recent audit conducted by external auditing organizations.

c) Cooperation with vendors or foreign repair stations

32.2% of the respondents replied that the cooperation and commitment of vendors and foreign repair stations in giving trainings, in delivering spares/ repaired component etc. on time and in taking immediate corrective actions were good while another 20.28% replied that this cooperation and commitment was average , and still another 13.8% point out that the effort was still below the requirement. However, some other 15.38% were in favor of the willingness of these foreign organizations' cooperation and commitment.

d) Ergonomics and human factors

Ergonomics and human factors are becoming now major criteria of the global airline industry, airline auditing organizations and regulatory bodies.25% of the respondents replied that the availability of auxiliary equipment to support maintenance; the clarity, understandability and accessibility of manuals and documents maintained; the design of maintenance programs with

the capability, skills and endurance of the work crew as required; and trainings regarding human factors were good. Other 25.5% replied that the effort made in this regard was average but another 13.9% said it was below the requirement. On the other hand 27.7% were in favor of the achievement of this requirement.

e) Continuous improvement

In evaluating the continuous improvement of maintenance and engineering activities with the aim to improve demand and supply generation, technology, operations and people capability, 22.2% of the respondents indicated that the effort made in this regard was very good while another 29.6% said it was good and still another 29.6% replied it was average. A considerable number of respondents (16.6%) replied that the effort was still below the requirement.

f) Employee performance versus incentive schemes

Currently ETHIOPIAN uses two kinds of incentive schemes namely, variably payment and performance appraisal payment to motivate employees. In evaluating the fairness maintained with these schemes to reward all employees as per their effort and performance; the effectiveness of these schemes in motivating hard working employees, in accounting for quality of work and complexity and difficulty of tasks ,in allowing participation of employees in setting these methods, 49.4% of the respondents replied that the techniques were poor in satisfying employees and in achieving stated objectives while 24.5% pointed out that they were average and some 17% indicated that they were good and other 6.32% replied they were very good.

g) Quality maintenance management

In assessing the level of quality problems around maintenance and engineering areas, the repetition of failures, delays and cancellations, the efficiency and effectiveness of maintenance activities in addressing maintenance problems, the dispatch reliability in competing with that of other airliners and in satisfying the global requirement, the maintenance costs, the strength of the link among the ETHIOPIAN maintenance procedures, maintenance engineers and line/shop/hangar maintenance personnel to solve problems or alerts as fast as possible , the practical contribution of engineers in providing effective troubleshooting, the clarity and understandability of drawings, maintenance packages, EOs,

ERs, etc. , 34.5% replied 'good', 31.94% replied 'average', 14.58% replied 'very good'10.4% replied 'poor', 5.56% replied 'not applicable' and 2.54% replied 'excellent'.

h) Customer focused approach

In evaluating how employees in one department consider employees in other departments as their customers, the mechanisms employed to assess customers satisfaction/dissatisfaction, the rate of replying / performing customers' enquires/tasks; involvement of employees in setting performance and payment standards, the effort made to recognize, initiate and reward higher performance achievements, interdepartmental relationships, satisfaction and proudness of employees by their work, 27.4% replied 'good', 21.9% replied 'average', 20.14% replied 'very good', 18.4% replied 'poor',8.68% replied 'excellent' and 3.47% replied 'not applicable'.

In addition to this, 97.2% of the respondents believed that they were contributing for the quality of maintenance and engineering activities, 66.7% recommended the change of the management, 86.1% provided job related opinions to their supervisors and managers, while 64% believed that their supervisors and managers didn't listen to their comments and didn't take the necessary action. Regarding empowerment of employees, 86.1% pointed out that they didn't have the power and authority to take actions by their own.

5.3 Analysis of results

5.3.1 Force field analysis

Force Field Analysis is a simple but powerful technique for building an understanding of the forces that will drive and resist a proposed change. It consists of a two columns, with driving forces listed in the first column, and restraining forces in the second. A force field diagram is used to analyze these opposing forces and set the stage for making change possible. Change will not occur when either the driving forces and restraining forces are equal, or the restraining forces are stronger than the driving forces. For change to be possible, the driving forces must overcome the restraining forces. Usually, the most effective way to do this it to diminish or remove restraining forces. It can be tempting to try strengthening the driving forces instead, but this tends to intensify the opposition at the same time. Table 5.2 shows the force field analysis.

Table 5.2: What factors affect ETHIOPIAN in improving quality and implementing TQM?				
Driving Forces				Restraining Forces
1	Global competition and growth of airlines' industry quality systems World wide.	→	←	Stagnation to old quality procedures& techniques.
2	Aviation safety and maintenance rules became stronger recently.	→	←	Maintenance procedures and safety rules are as before.
3	Strong and practical decisions of competitors in implementing standard quality management systems.	→	←	Strictly adhere to conformance of regulatory authority's requirements, infant quality management systems, and no ISO certification.
4	The acceptance of international aviation quality audit organizations	→	←	Non standard quality audit and quality assurance techniques.
5	Repetitive quality remarks from certifying & audit organizations.	→	←	Paying more attention to quality especially during audit time & unprepared in advance of audit schedules.
6	Qualified personnel if trained properly can easily achieve quality improvement.	→	←	Dissatisfied employees for no participation in setting policies, procedures, bonus/incentives schemes.
7	Good reputation, long time experience in the industry.	→	←	High employee turnover, increase of highly equipped and economically strong competitors.
8	Customer focused mission, vision and values.	→	←	Lack of motivation, recognition, and reward of employees. Lack of effective maintenance management causing flight delays & cancellations.

5.3.2 Relationship analysis: It indicates the relationship among different factors.

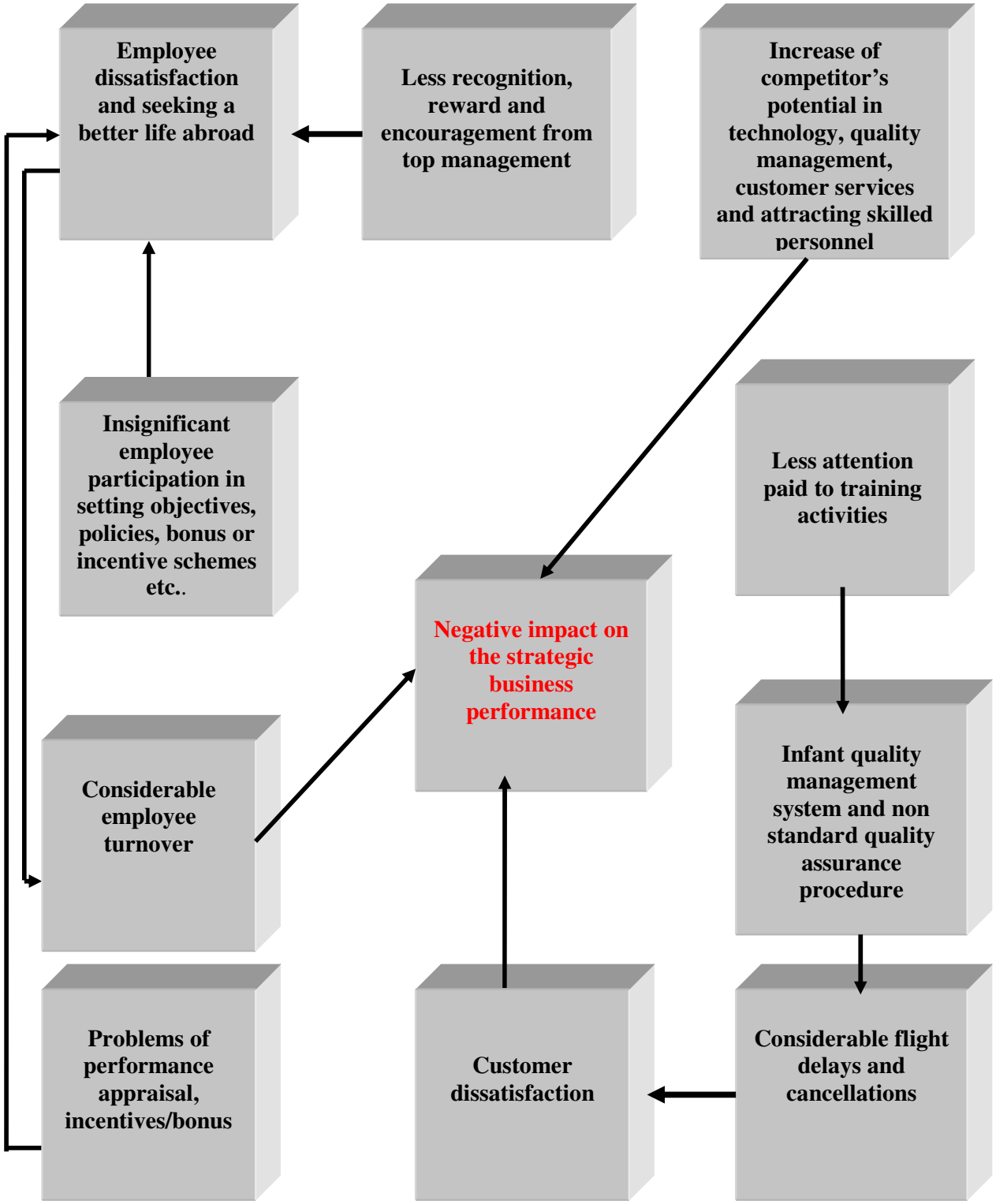


Figure 5.2 Relations diagram

5.3.3 Pareto analysis

Pareto chart: To develop Pareto analysis, the percentage response of "poor' in each reply is converted in to 100% since this reply indicates the existence of problem.

Table 5.3 Result conversion

	Problem area	% response of "poor" from 169%	Converted to 100%
1	Employee evaluation versus incentives/bonus	49.4%	29.4%
2	Leadership	29.1%	17.8%
3	Customer focus approach	18.4%	10.8%
4	Training	17.8%	10.6%
5	Continuous improvement	16.6%	9.95%
6	Ergonomics/human factor	13.9%	8.33%
7	Supplier partnership	13.28%	7.95%
8	Quality maintenance management	10.4%	6.23%
	Total	169%	100%

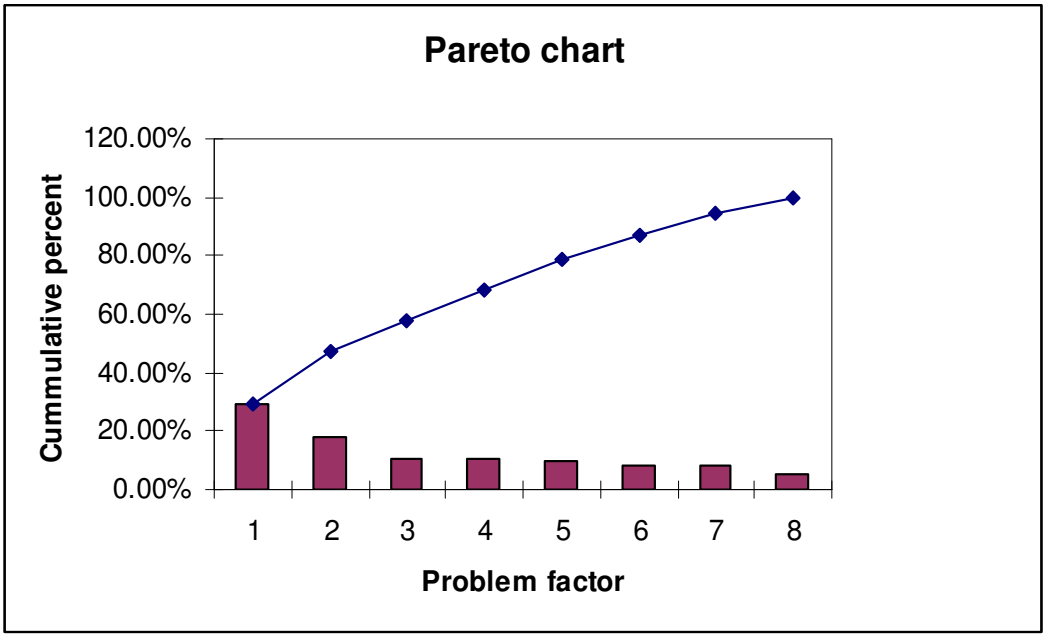


Figure 5.3 Pareto chart

From the chart eliminating the problems in employee evaluation versus incentives/ bonus schemes, leadership and customer focus approach, will eliminate some 60% of the total problems.

5.3.4 Statistical hypothesis testing (χ^2 test analysis for independence) [2]

χ^2 test is used to investigate association between attributes. For instance it is used to investigate if there is any association between good management commitment and good continuous improvement in ETHIOPIAN by using the questionnaire results.

Before proceeding to this it is recommended to change Table 5.1 in to frequency table.

Table 5.4 Frequency table

	Attribute							
Grade	A	B	C	D	E	F	G	H
1	1	3	0	2	0	0	1	3
2	4	7	6	8	8	3	5	8
3	10	10	12	9	11	6	12	10
4	10	10	7	9	11	9	12	8
5	11	6	5	5	6	18	4	7
6	0	0	6	3	0	0	2	0
Total	36	36	36	36	36	36	36	36

Attribute A refers to management commitment/leadership, B refers to training and so on as per Table 5.1. The column total refers to the total number of sample employees. Grades are similar to those in section 5.2.1. Here in this section the responses in the category 1, 2, 3&4 are grouped in good category while responses in grade 5 are categorized in the poor category for the purpose of the χ^2 test analysis.

A **null hypothesis**, denoted by H_0, is an assertion about one or more population parameters. This is the assertion we hold as true until we have sufficient statistical evidence to conclude otherwise.

The **alternative hypothesis**, denoted by H_1, is the assertion of all situations *not* covered by the null hypothesis.

A **test statistic** is a sample statistic computed from the data. The value of the test statistic is used in determining whether or not we may reject the null hypothesis.

The **decision rule** of a statistic hypothesis test is a rule that specifies the conditions under which the null hypothesis may be rejected.

State of Nature

Decision		H_0	H_1
	H_0	Correct decision	Type II error
	H_1	Type I error	Correct decision

Figure 5.4 Decision alternatives

The probability of committing type I error is denoted by α while the probability of committing type II error is denoted by β. This means, when the state of nature is H_0 and decision is H_0, the decision is correct. However, when the state of nature is H_0 but the decision made is H_1, an error made is called type I error.

$$\alpha = P \text{ (Reject } H_0 \text{ when } H_0 \text{ is true)}$$
$$\beta = P \text{ (Not reject } H_0 \text{ when } H_0 \text{ is false)}$$

Usually we will be presented with a null hypothesis, a statistical assertion, which we will try to reject. Before carrying the actual test, we know the probability that we will make type I error. This probability, α, is preset to a small number, say 0.05. Knowing that we have a small probability of committing type I error (reject a true null hypothesis) makes our rejection of a null hypothesis a *strong conclusion*. The probability of committing type I error, α, is also called the level of **statistical significance.** In fact, statistical hypothesis testing is often called *significant testing.* A statistical result is considered significant at level α if it leads us to reject a given null hypothesis. In this test the null and alternative hypothesis are tested for independence as follows:

H_0: The two classification variables are independent of each other.

H_1: The two classification variables are not independent.

The philosophy of chi-square test is to assume that H_0 is true and to use this assumption in determining the distribution of the test statistic. Then we try to show that the result is unlikely under H_0 and thus reject the null hypothesis.

Now to investigate if there is dependency between good management commitment and good customer focused approach:

Let H_0: Good management commitment and good customer focused approach are independent.

H_1: Good management commitment and good customer focused approach are not independent.

Table 5.5 RxC Observed value for customer focus approach & management commitment

	Good Customer Approach	Poor Customer Approach	Total
Good Mgt. Commit.	25	0	25
Poor Mgt.Commit.	4	7	11
Total	29	7	36

Assuming that the two classification variables are independent, let us derive expected counts in all cells. Looking at a particular cell in raw i and column j with the probability of occurrence of event i and event j, the expected count in cell (i, j) is $E_{ij}=n^* p (i \cap j)$. By the law of independence of events, $p (i \cap j) = P (i)^* p (j)$.

From the raw totals, $P (i) = R_i/n$. Similarly from the column total, $P (j) = C_j/n$.

Hence $E_{ij}= \{R_i^* C_j\}/n$. These along with the observed cell counts, are used to compute the values of a chi-square statistic, which leads us to a decision to about the null hypothesis of independence.

The chi-square test statistic for independence is:

$$\chi^2 = \Sigma \text{ all cells of } \{(O_{ij}-E_{ij})^2\}/n$$

To produce table of expected frequencies using the contingency table 5.3:

$$E_{11}= (R_1C_1)/n$$

$$E_{12}= (R_1C_2)/n$$

$$E_{21}= (R_2C_1)/n$$

$$E_{22}= (R_2C_2)/n$$

Table 5.6 Expected frequency table

20.13	4.87	25
8.87	2.13	11
29	7	36

Table 5.7 $\chi^2_{calculated}$ value

Observed (O)	Expected (E)	$(O-E)^2$	$\chi^2_{calculated}=\{(O-E)^2\}/E$
25	20.13	23.71	1.17
4	8.87	23.71	2.67
0	4.87	23.71	4.86
7	2.13	32.71	11.13
Total			19.88

For degree of freedom (υ) = (r-1)*(c-1) = (2-1)*(2-1) =1, at a level of significance α=0.05, $\chi^2_{0.05}$ (from table on appendix II) is 3.84. But calculated χ^2 (i.e. 19.88) is greater than tabulated χ^2 (i.e. 3.84) .Hence the null hypothesis is rejected. We therefore conclude that good management commitment and good customer focused approach are not independent, i.e. they are related.

Again it is possible to check the dependency between good employee performance measurement techniques and good customer satisfaction. The null and alternative hypotheses are:

H_0: Good employee performance measurement techniques and good customer satisfaction are independent.

H_1: Good employee performance measurement techniques and good customer satisfaction are not independent.

Table 5.8 RxC Observed value for employee performance measurement & customer focus

	Good Customer Approach	Poor Customer Approach	Total
Good Employee Performance Measurement Techniques	18	0	18
Poor Employee Performance Measurement Techniques	11	7	18
Total	29	7	36

Table 5.9 Expected frequency

20.13	4.87	25
8.87	2.13	11
29	7	36

Table 5.10 $\chi^2_{calculated}$ value

Observed (O)	Expected (E)	$(O-E)^2$	$\chi^2_{calculated}=\{(O-E)^2\}/E$
18	14.5	12.25	0.84
11	14.5	12.25	0.84
0	3.5	12.25	3.5
7	3.5	12.25	3.5
Total			8.68

For degree of freedom (υ) = (r-1)*(c-1) = (2-1)*(2-1) =1, at a level of significance α=0.05, $\chi^2_{0.05}$ from table (on appendix) is 3.84. But calculated χ^2 (i.e. 8.68) is greater than tabulated χ^2 (i.e. 3.84) .Hence the null hypothesis is rejected. We therefore conclude that Good employee performance measurement techniques and good customer satisfaction are not independent, i.e. they are related. This approach leads us to the following important decision about the dependency of the attributes as shown next.

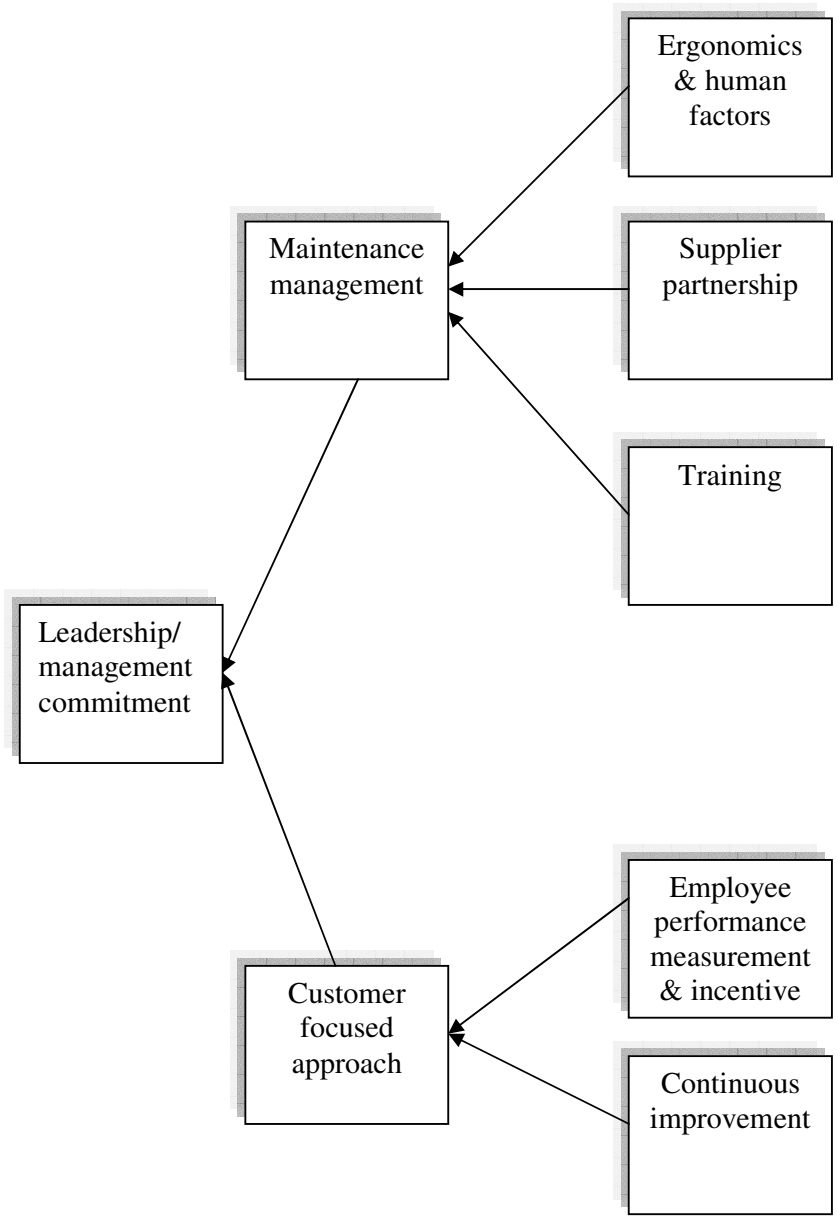
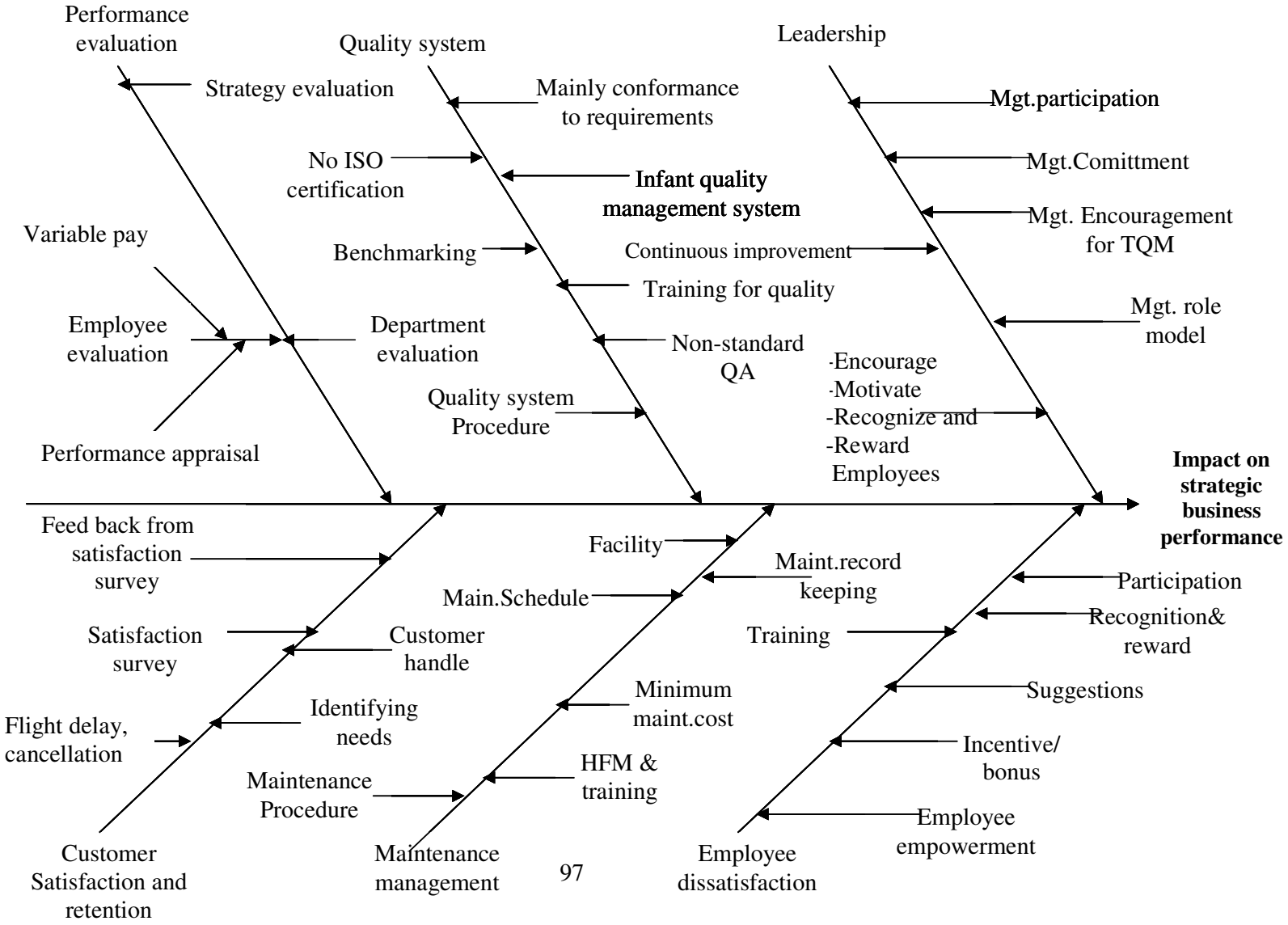


Figure 5.5 Relationship among TQM elements based on $\chi 2$ test

5.3.4 Cause and effect analysis



Chapter 6: Development of a TQM implementation model

6.1 Introduction

This chapter presents the development of a TQM implementation model for ETHIOPIAN maintenance and engineering facility. The development of this model is based on the TQM literature review, the structured interviews conducted in ETHIOPIAN, the questionnaire findings from ETHIOPIAN employees, and the general characteristics of the airline. The model can assist in evaluating the strengths and weaknesses of the TQM implementation, targeting improvement areas, setting up an action plan for improvements, and tailoring a special part to the needs of the airline. The TQM implementation model developed in this study consists of:

a) A framework of TQM that consists of the 11 elements of TQM and the four elements of overall business performance.
b) A set of TQM implementation practices.
c) A set of indicators of overall business performance.
d) Processes of using this TQM implementation model in practice.
e) Practical guidance providing guidelines to assist user in selecting and/or formulating the most effective TQM implementation plans.

6. 2 Framework of TQM

The framework of TQM was formulated on the basis of the theoretical model of TQM implementation and overall business performance. The combination of the elements of TQM and overall business performance is the framework of TQM, which is displayed in Figure 6.1. Thus, the framework of TQM consists of the 11 elements of TQM and the four elements of overall business performance. This framework is based on the hypothesis that TQM implementation has effects on employee satisfaction, maintenance service quality, customer satisfaction, and strategic business performance. These hypotheses were confirmed by the questionnaire survey data. Of the 11 TQM elements leadership is the most important, a finding obtained from the structured interviews and questionnaire in ETHIOPIAN. Of the four elements of overall business performance, employee satisfaction has effects on maintenance service quality and customer satisfaction; it also has an indirect effect on strategic business performance through maintenance service quality and customer satisfaction.

Maintenance service quality has effects on customer satisfaction and strategic business performance. As discussed previously, in the long run, customer satisfaction may have positive effects on strategic business performance. In this framework of TQM, the 11 TQM elements as a whole are regarded as enablers that can lead to improvements of overall business performance. In other words, overall business performance is the result of TQM implementation. [32]*[2]

6.3 TQM implementation practices

A set of TQM implementation practices and their explanations are presented in this section. In fact, implementing TQM is to implement the 11 TQM elements. There is a set of TQM implementation practices supporting the implementation of each element. Based on the literature review and the results obtained from the structured questionnaire interviews and observation in ETHIOPIAN, a number of TQM implementation practices were considered important. These practices are presented in Figure 6.2.

6.3.1 Leadership

6.3.1.1 Top Management Commitment

Top management commitment is the first step and prerequisite for TQM implementation efforts. Lack of management commitment is one of the reasons for the failure of TQM efforts (Brown 1994). Top managers need to demonstrate their commitment through their actions rather than words. Top management commitment can positively affect employees' commitment to TQM and culturally change people involved [3].

6.3.1.2 Top Management Participation

It is very difficult to improve product/service quality and quality management if top managers do not lead and participate. Quality improvement involves making decisions and creates something that did not exist before. It is not sufficient for top managers to stand on the sidelines and shout "improve maintenance service quality and intensify quality management". Top management participation is crucial to the company's quality improvement efforts; it obviously helps in spreading quality consciousness throughout the company [3].

[2] Modified and incorporated from the reference mentioned

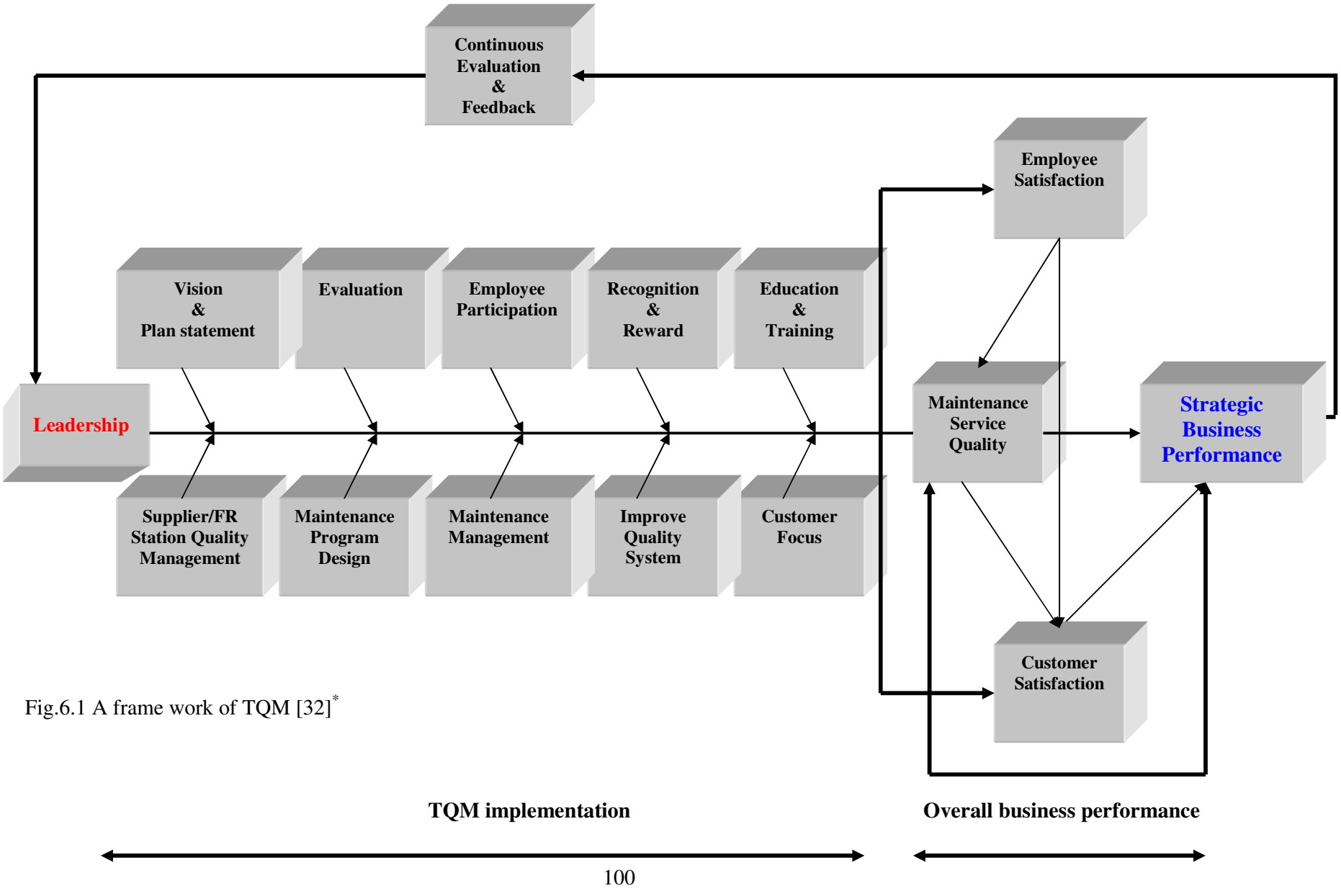


Fig.6.1 A frame work of TQM [32]*

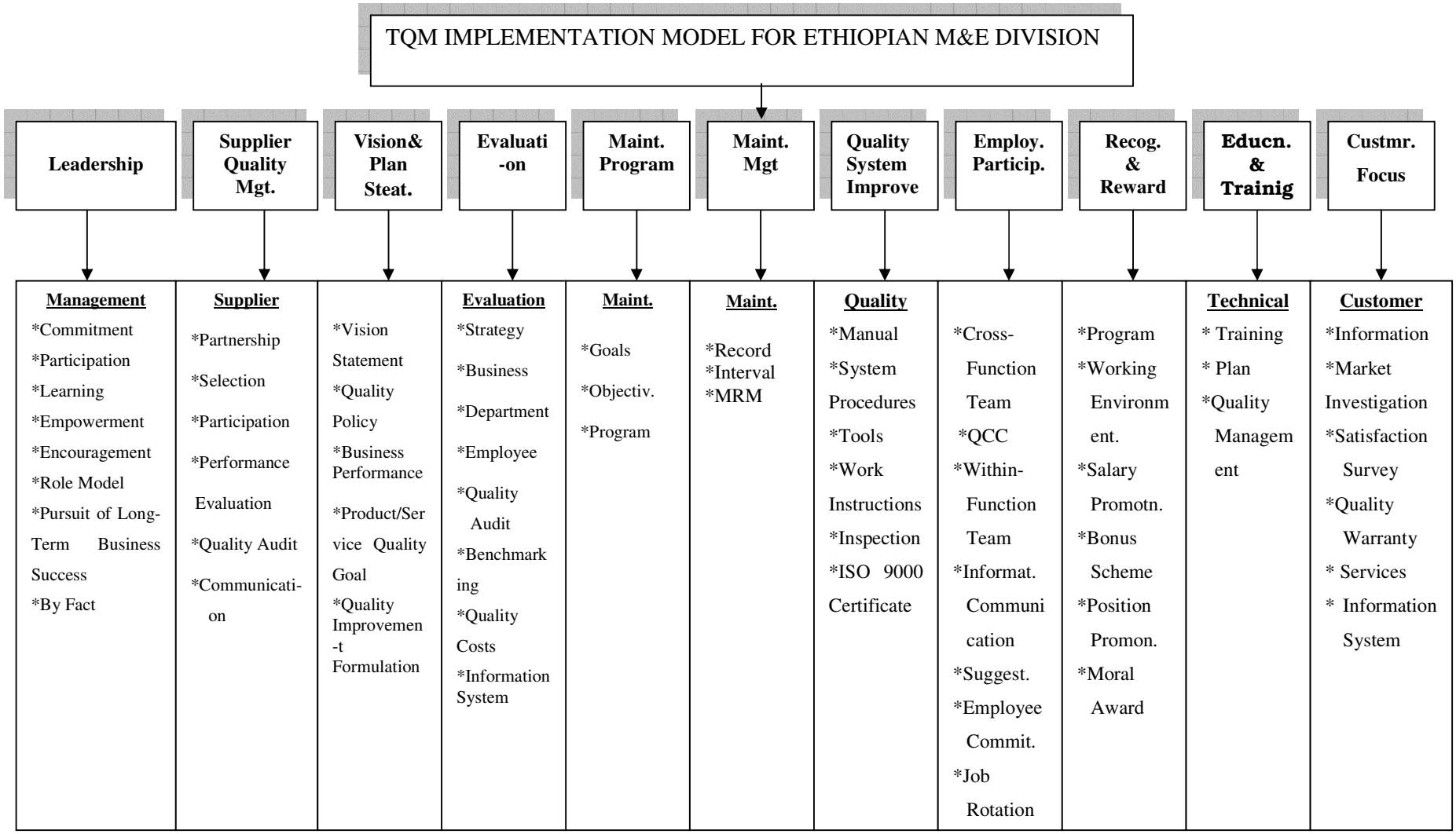


Figure 6.2 A Model of TQM Implementation Practices [32]*

6.3.1.3 Top Management Learning

Top managers need to improve their managerial abilities through continuous learning. To implement TQM, they must first know what it is. Learning TQM is an important step toward implementing it. Top managers should be modest enough to learn from their employees and value the ability of their creativity. Top managers also need to learn from other airliners' successful and unsuccessful experiences and should combine these insights into an approach that fits the specific conditions, problems, and challenges of their own company [32]*.

6.3.1.4 Top Management Empowerment

Empowerment means giving permission to the workforce to unleash, develop, and utilize their skills and knowledge to their fullest potential for the company. Empowerment has many benefits such as increasing employees' motivation to reduce mistakes, increasing the opportunity for creativity and innovation, improving employee loyalty, and allowing top and middle management more time for strategic planning. Top management needs to empower employees to solve various problems and should rely on employees wholeheartedly [32].

6.3.1.5 Top Management Encouragement

Top managers should strongly encourage employee involvement in quality management and improvement activities, appreciate employees' suggestions, take responsibility for employees' and be open and willing to listen to the voices of employees. They should trust employees and believe that they can do things better, as well as encourage them to list the company's shortcomings and report their own working problems. Such employees should be praised instead of criticized [30].

6.3.1.6 Top Management's Role Model

Top managers need to act as role models, leading by example. Employees always look to top managers for a standard of correct behavior. The manner in which top managers conduct themselves is more influential than any instructions they may give or any discipline they may impose. Their model role can positively affect employees' commitment, satisfaction, participation, confidence, initiatives, and creativity (obtained from the interviews) [21].

6.3.1.7 Pursuit of Long-Term Business Success

Top managers should pursue long-term business success instead of short-term benefits. They should focus on maintenance service quality rather than yields. TQM requires long-term

commitment and endurance; there are no quick fixes. TQM implementation requires investment. In return, it can lead to an impressive increase of overall business performance. Top management must realize that improvement takes time [19].

6.3.1.8 Management by Fact

One of the most important jobs of top management is to make decisions. It is impossible to make good decisions without suitable information; it is extremely important to have a decision-supporting information system to assist managers in making decisions. It is also vital to have an information system that can provide past, present, and future information appropriate for planning, organizing, and controlling the operations of a functional area in the company [27].

6.3.2 Supplier quality management

6.3.2.1 Partnership with Suppliers/Vendors

Supplier partnership can be defined as a mutual, ongoing relationship between a buying company and a supplying company involving a commitment over an extended time period, and entailing a sharing of information as well as a sharing of the risks and rewards of the relationship. In this regard, companies should try their best to establish long-term partnership relations with their suppliers. The basic purchasing policy should place priority on mutual trust and understanding, and aim at long-term stable business relationships on the basis of mutual survival and prosperity [28].

6.3.2.2 Supplier Selection Criteria

The Company must obtain from its suppliers information sufficient to judge whether they have the capability to provide products and services that meet all fitness-for-use requirements. The selection of suppliers must be based on the reputation of the supplier, the investigation of its manufacturing facility, and other relevant information about the supplier. Product quality should be regarded as one of the most important factors in selecting suppliers. Total costs (e.g., incoming inspection, internal and external failure costs) should be taken into account during the selection process. In the end, only those suppliers who can compete on quality, price, and close working relationships with a firm can be kept in its supplier list [16].

6.3.2.3 Participation in Suppliers/FR Stations

ETHIOPIAN is recommended to participate in suppliers'/FR stations' activities related to quality improvement. These activities may include, for example, supplier/FR station training and quality improvement projects. Through participation with suppliers/FR stations, the quality of suppliers'/FR stations' products and services can be improved. Thus, non-value added incoming inspection activities can be reduced or avoided [20].

6.3.2.4 Supplier Performance Evaluation

The company should frequently evaluate the performance of products and services that it receives from suppliers, and give feedback on the performance of suppliers' products and services. In order to conduct supplier performance evaluation, the company should have a supplier information system that stores detailed performance information such as product quality, service quality and delivery performance, etc [26].

6.3.2.5 Supplier/FR Station Quality Audit

Supplier/FR station quality audit is an assessment of a supplier's/FR station's product and service quality, quality control capability, manufacturing practice, and quality assurance system in order to ensure that products and services received from the supplier can meet requirements. An audit consists of a visit to the supplier's/FR station's facility by a team of examiners from different departments such as quality, technology, production, purchasing, and R&D [18].

6.3.2.6 Supplier Communication

The company should keep its suppliers informed of any change that it may make in terms of design and operation. Failure to provide adequate design change information to suppliers has been a distinct obstacle to supplier's quality management. Setting up multiple channels of communication can solve such problems [32].

6.3.3 Vision and plan statement

6.3.3.1 Vision Statement

A vision statement comprises a detailed visualization of the desired future state of the overall business and serves as the target or objective for which all strategies, goals and standards are established. A vision statement should be clear, concise and should satisfy three fundamental

criteria: It must address all levels, be stated in such a way that everyone believes in it, and be aggressive and growth-orientated [32].

6.3.3.2 Quality Policy

A quality policy is overall intentions and direction of an organization with regard to quality, as formally expressed by top management (ISO 8402, 1994). The quality policy involves statements that should be brief, clear, and believable. It can be used as a touchstone for all employees to gauge whether actions are in conformance with the standards and values of the company's quality policy [24].

6.3.3.3 Overall Business Performance Plan

A company should have overall business performance plans that describe its goals and objectives. Two kinds of overall business performance plans exist: Long-term and annual. In fact, long-term performance plans are formed based on a vision statement, whereas annual performance plans are formed based on long-range performance plans and are the sum of different departmental annual targets and goals. Overall business performance plans achieve nothing if the company doesn't have suitable strategies to realize them; they should be set in such a way that they are achievable [32].

6.3.3.4 Product/Service Quality Goal

In order to improve maintenance service quality, ETHIOPIAN should have detailed quality goals. Quality goals are statements of the desired quality results to be achieved within a specified time. Tactical goals are short range (e.g., 1 year) and strategic goals are long range (e.g. 5 years). Quality goals may include, for example, performance, reliability, durability, conformity rate, defect rate, internal failure costs, and external failure costs [24].

6.3.3.5 Quality Improvement Plan

Quality improvement plans are activities that establish the objectives and requirements for quality and the application of quality system elements (ISO 8402, 1994). The plans should be made in such a way that they can be implemented in practice, and should focus on eliminating the major problem areas. When quality improvement plans are drawn up, how to implement them should be well developed [24].

6.3.3.6 Formulation of Vision and Plan

A successful process of formulating visions and plans demands a holistic and cross functional approach. The alignment of visions, strategies, plans, policies, objectives, measurements, and performance assessment at all levels is considered essential. Visions and plans cannot be formulated by imagination; the fuel for their formulation is the abundance, richness and quality of information available. Employees from different levels should be involved in making visions, strategies, policies and plans [32].

6.3.4 Evaluation

6.3.4.1 Evaluation of Strategy

A strategy is the total pattern of the decisions and actions that position the company in its environment and are intended to achieve its long-term goals. Strategies specify how the vision statement will be accomplished. Normally, there are three levels in the strategy hierarchy: corporate, business, and department strategies. Various decision-supporting systems and relevant information available are essential to strategy evaluation. More importantly, the company should adjust its strategies on the basis of the result of strategy evaluation, thus, keeping competitive advantages in the marketplace [18].

6.3.4.2 Evaluation of Overall Business Performance

The objective of implementing TQM is to improve ETHIOPIAN's overall business performance. Therefore, overall business performance should be evaluated regularly. Otherwise, the effects of implementing TQM remain unclear and more effective TQM implementation approaches cannot be formulated. The analysis and investigation of overall business performance can provide adequate input for TQM implementation, identification of improvement areas, and areas caused attention. ETHIOPIAN can use the latest information on overall business performance to compare its previous performance or planned objectives with its competitors and with the best practices in the same industry [18].

6.3.4.3 Evaluation of Departments' Performance

The realization of organizational overall objectives is highly dependent on different functional departments. Therefore, ETHIOPIAN needs to regularly evaluate different departments' performance in order to seek opportunities to improve organizational health. It is important to note that the major aim of departmental evaluation is to seek improvement opportunities rather than criticism [18].

6.3.4.4 Evaluation of Employee Performance

Employee performance evaluation is a process by which a company establishes measures (targets) and evaluates an individual employee's behavior and accomplishments against set target within a finite time period. The results of employee performance evaluation can serve as input for employees' recognition, reward, dismissal, education, and training. Such information is also valuable for recruiting new employees and improving overall human resource management [18].

6.3.4.5 Quality Audit

A quality audit is a systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives (ISO 8402, 1994). One purpose of a quality audit is to evaluate the need for improvement or corrective action. Through quality audits, problem areas are identified and necessary measures can then be taken to solve them [18].

6.3.4.6 Benchmarking

Benchmarking is the process of understanding one's practice and performance, comparing them against that of competitors or best-in-class firms, learning how they practice and perform, and using that information to improve one's own practice and performance. It is an effective catalyst for change and an effective tool for continuous improvement. Benchmarking can stimulate creativity and provide a stimulus that enables operations to better understand how they should be serving their customers [18].

6.3.4.7 Quality Costs

ETHIOPIAN needs to collect the data of quality-related costs, which it can use to seek improvement opportunities. It should be noted that to have data on quality-related costs is not enough. Without carefully investigating the data of quality costs, actions cannot be effective and chronic quality problems cannot be eliminated. Through analyzing quality costs, more improvement opportunities can be identified [18].

6.3.4.8 Information System

A company should have an inter-integrated computerized information system, which collects, stores, analyzes, and disseminates information for various specific purposes. Such an

information system can manage large amounts of information and provide sufficient information for management to make decisions. Additionally, different departments can share resources through the information network. Thus, communication barriers between different departments are reduced. ETHIOPIAN has good practice in IT [18].

6.3.5 Effective maintenance program design

In a typical TPPM, maintenance is defined as "Those actions required for restoring or maintaining an item in a serviceable condition, including servicing, repair, modification, overhaul, inspection, and determination of condition." where as FAA defined maintenance as "Inspection, overhaul, repair, preservation, and replacement of parts." and Dr. Harry Kinnison defined it as "The process of ensuring that a system continually performs its intended function at its designed-in level of reliability and safety." [13]

6.3.5.1 Maintenance Goals

The goals of an airline maintenance program should basically be:

a) To deliver airworthy vehicles to the flight department in time to meet the flight schedule.

b) To deliver these vehicles with all necessary maintenance actions completed or properly deferred [13].

6.3.5.2 Objectives of Maintenance Program

The objectives of an airline in-service maintenance program should basically be:

a) To ensure the realization of the inherent safety and reliability levels of the equipment.

b) To restore safety and reliability to their inherent levels when deterioration has occurred.

c) To obtain the information necessary for adjustment and optimization of the maintenance program when these inherent levels aren't met.

d) To obtain the information necessary for design improvement of those items whose inherent reliability proves inadequate.

e) To accomplish these objectives at a minimum total cost, including the cost of maintenance and the cost of residual failures [13].

6.3.5.3 Aircraft Maintenance Program Content

The maintenance program should basically be consist of two groups of tasks. These are:

a) Groups of scheduled tasks to be accomplished at specific intervals.

b) A group of non-scheduled tasks which result from conducting the scheduled tasks, from report of malfunctions, and from data analysis.

An efficient maintenance program is one which schedules only those tasks necessary to meet the stated objectives. It doesn't schedule additional tasks which will increase maintenance costs without a corresponding increase in reliability protection. Thus, a maintenance program consists of scheduled maintenance tasks to keep equipment and systems in top operating condition (objective a); unscheduled maintenance tasks to address in-service failures (objective b); a continuing analysis and surveillance activity to optimize the total maintenance effort by improving the maintenance program (objective c) or by requesting redesign of equipment (objective d); and an effort to minimize maintenance cost (objective e) [13].

6.3.6 Maintenance management

The aviation industry has developed three management techniques for addressing the in-service interruptions created by the items that must be operated to failure before maintenance can be done. These are equipment redundancy, line replaceable units and minimum dispatch requirements.

The concept of redundancy of certain components or systems is quite common in engineering design of systems where a high reliability is desired. In this case of redundant units-usually called primary and backup units-if one fails, the other is available to takeover the function. For example most commercial aircrafts have two high-frequency radios. Only one is needed for communication but the second one is there for backup in case the first one fails.

Line replaceable unit (LRU) is a component or system that has been designed in such a manner that the parts that most commonly fail can quickly be removed and replaced on the aircraft. This allows the aircraft to be returned to scheduled service without undue delay for maintenance. The failed part, then, can either be discarded or repaired in the shop as necessary without further delaying the flight.

The minimum equipment list (MEL) allows an aircraft to be dispatched in to service with certain items inoperative provided that the loss of function doesn't affect the safety and operation of the flight. The manufacturer issues master minimum equipment list (MMEL) for each aircraft model. The airline then tailors the document to its own configuration to produce MEL.

6.3.6.1 Maintenance Record Keeping

It is an airline's responsibility to keep its aircrafts in an airworthy condition. To ensure that this is accomplished, the FAA requires the operator to keep accurate records of maintenance

and alteration activities. Two types of records are required: Summery information and airworthiness status information. Other records, in various forms, must also be kept to conduct a successful program. One of these is the maintenance logbook. This book is maintained in the aircraft and includes flight information relative to each leg of the flight and includes flight times, fuel and oil uplift, crew data etc. It also provides a place for the flight crews to identify any maintenance related problems they encountered during flight. Other records such as mechanical reliability report (MRR), mechanical interruption summery (MIS) and reports of major alterations and repair must be maintained.

6.3.6.2 Changing Basic Maintenance Intervals

Operational conditions will often require that an operator change the basic maintenance program to better address the organizational needs. For instance, operation in hot humid climates may require that corrosion control tasks be performed more often than the maintenance review board (MRB) report indicates while operating the same aircraft in a dry, desert climate may reduce the need frequency for these tasks. In the latter situation, however, items sensitive to sand and dust will need increased attention in the maintenance program. It is expected that an operator will change the original maintenance intervals for certain tasks or entire letter checks whenever in-service experience dictates. However, to do this, the operator must have proof that a change is warranted. The accepted proof for such maintenance intervals change is in the form of data collected through the operator's condition monitoring program or reliability program.

6.3.6.3 Maintenance Resource Management (MRM)

The overall objective of MRM is to decrease accidents and incidents while increasing professionalism and safety. It is a look into the human side of maintenance and the things to be done to help prevent human error in aircraft maintenance operations. To achieve this goal, attention must be paid to the individual and the team contributions, as well as necessary individual and team improvements. Attention must also be given to resources in the industry that can help reach the desired goal. These include operational integrity, situational awareness, communication skills, maintenance briefings and communications, synergy and team concept, leadership, conflict resolution and decision making [13].

6.3.7 Quality system improvement

6.3.7.1 Quality Manual

A quality manual is a document stating the quality policy and describing the quality system of a company (ISO 8402, 1994). It includes the company's quality policy and addresses each of the requirements of ISO 9000 in broad terms related to the activities of the company. In drawing up a quality manual, various people in the company should be involved and relevant ISO 9000 standards referenced. Prior to issuing the manual, it should be subjected to review by responsible individuals to ensure clarity, accuracy, suitability, and proper structure. Finally, it must be reviewed and approved by the top management [14].

6.3.7.2 Quality System Procedures

Documented quality system procedures describe the activities of individual functional units needed to implement the quality system elements. Thus, responsibilities and authorities of different functional departments are clearly defined by system procedures. To define quality system procedures, it is important to solve the interface issues among different departments. Quality system procedure should describe the responsibilities, authorities, and interrelationships of the personnel who manage, perform, verify or review work affecting quality, how the different activities are to be performed, and the documentation to be used and the controls to be applied. As a rule, documented procedures should not enter into purely technical details of the type normally documented in detailed work instructions [14].

6.3.7.3 Use of Quality Tools

Quality tools play a key role in an organization-wide approach to continuous improvement. The seven QC tools are Pareto analysis, cause and effect analysis, stratification analysis, scatter diagram, check sheet, histogram, and process control chart. The seven new tools are relations diagram, affinity diagram, systematic diagram, matrix diagram, matrix data analysis, process decision program chart, and arrow diagram. Statistical process control (SPC) is the application of statistical methods to the measurement and analysis of variations in a process, and can judge the quality of processes [25], [2].

6.3.7.4 Work Instructions

Work instructions consist of detailed work documents such as instructions for performing the job. A company should develop various work instructions so that all tasks can be conducted in a consistent manner. Work instructions are referred to in the procedures and give precise

details of how individual operations are to be carried out to enable them to be performed to the required quality [10].

6.3.7.5 Inspection

Inspection refers to activities such as measuring, examining, testing and gauging one or more characteristics of a product or service and comparing these with specified requirements to determine conformity (ISO 8402, 1994). Note that inspection actually does not build quality; quality is built into the process. Inspection itself is not a value-adding process, but a waste of human resources and cause of extra cost. If quality can be ensured, it is not necessary to implement inspections [10].

6.3.7.6 ISO 9000 Certification

After the quality system documents have been established, the company should implement its quality systems. In order to understand whether these documents can be effectively implemented, the company should conduct quality audits and management review, thoroughly assessing its quality systems. Such an assessment can identify the suitability of the quality systems to the company and their conformance to the requirements of the ISO 9000 standard (e.g., ISO 9001, 2, or 3). As a result, the quality systems can be improved. Finally, the company may prepare and plan for ISO 9000 certification [26].

6.3.8 Employee participation

6.3.8.1 Cross-Functional Team

A cross-functional team aims to solve or investigate cross-functional problems or improvement opportunities associated with many functions or departments. Sometimes people from external organizations, such as suppliers and customers, also participate. Top management usually delegates the team and is therefore committed to assigning it sufficient resources in the forms of time, money, and personnel. The team is normally disbanded after its task is finished [29].

6.3.8.2 Quality Control (QC) Circle

A QC circle is a small group of employees, usually from the same department, who volunteer to meet regularly (on working time or their own time) to discuss ways of improving the quality of their work. QC participants need to accept training for problem-solving techniques. The benefits of QC circles include improvements of products, processes, and working

environments, improved communication within work groups and between workers and supervisory layers of the company, increased employee commitment and motivation, and employees' enhanced understanding of the difficulties faced by the company [29].

6.3.8.3 Within-Functional Team

A within-functional team aims to solve or investigate problems/opportunities within the same department and is normally disbanded after its task is complete. Within-functional teams are different from QC circles, dealing with certain important issues or urgent problems. The major objective of such a team is to discuss and identify problems encountered, obtain facts and data regarding these problems, and develop feasible solutions. Problems may relate to quality, productivity, safety, and so on [29].

6.3.8.4 Information Communication

In order to stimulate employee participation, a company should have effective information communication channel. Information communication is a means by which employees share ideas, clarify thinking and create a common understanding. Communication can be conducted between different departments, top management and employees, supervisors and employees, and employees themselves. The company needs to communicate its vision, strategies, policies, and business plans to its employees. Various means can be used to communicate, such as regular meetings, internets, newsletters, posters, videos, and broadcasting [29].

6.3.8.5 Employee Suggestions

It is easier for employees to identify their working problems, find the causes of the problems, and develop solutions. Therefore, employees should be encouraged to submit their suggestions, which should be listened to and valued by the management. After evaluation, some suggestions should be practically implemented. Care must be taken that negative comments, attitudes and feedback from the management can quickly kill the interest and enthusiasm of employees. In addition, it is also important to recognize and financially reward employees who submit good suggestions [29].

6.3.8.6 Improving Employee Commitment

The aim of improving employee commitment is to encourage employees to make more contributions to the success of the company. Employee commitment can be established only on the basis of confidence among employees and management. Top management and supervisors should encourage and motivate employees to develop and utilize their full

potential, trust and care for employees, encourage and support employees in job and career related development/learning objectives, respect and value employees' talents and creativity, and treat employees as valuable resources of the company [29].

6.3.8.7 Job Rotation

Job rotation means periodically moving individuals between different sets of tasks to provide some variety in their activities. Job rotation can increase skill flexibility and make a contribution to reducing job monotony. Through job rotation, employees can learn more work skills, know more processes, and understand more about the importance of their current jobs. As a result, the workforce becomes more diversified and multi-skilled [29].

6.3.9 Recognition and Reward

7.3.9.1 Recognition and Reward Program

ETHIOPIAN should institute a serious recognition and reward program. First, the recognition and reward must be consistent with organizational values and objectives. If individual or team efforts cannot contribute to the realization of the overall organizational objectives, they cannot be recognized and rewarded. Therefore, objectives of individuals or teams need to be continuously reviewed and updated. Second, criteria should be objective and measurable; otherwise, it is not easy to ensure that the recognition and reward can be conducted fairly. Third, the recognition and reward should be meaningful and fit the organizational culture. Finally, recognition and reward can be provided at several levels: Individual, team or department level [6].

6.3.9.2 Working Environment Improvement

ETHIOPIAN needs to continuously improve working conditions in order to recognize employee quality improvement efforts. It also needs to maintain a work environment conducive to the wellbeing, morale, and growth of all employees. The company should improve workplace health, safety, and ergonomic factors; consider each person as an individual, a resource to benefit from rather than a commodity to be used. The company should try its best to reduce employees' working strains and protect their health by providing suitable equipment, devices, or tools [17].

6.3.9.3 Salary Promotion

Salary level is an important factor affecting employees satisfaction and contribution. The salary range should be sufficiently wide to allow for adequate differentiation of salary based on performance. The most important requirement for an effective merit pay incentive program is to measure performance against clearly defined objectives. However, other aspects of employees' performance should also be considered, such as attendance, positive work attitudes, or initiatives. ETHIOPIAN should pay more for employees who have demonstrated knowledge, skills, and performance. Highly skilled employees must have high salaries; otherwise, their potential cannot be fully exercised. Salary promotion should be fair and rational. In a word, the company should carry out diverse distribution forms with "to each according to his/her work" as the main goal, and establish an effective incentive mechanism [8].

6.3.9.4 Bonus Scheme

In order to encourage employees (teams, departments, or business units) to make more contributions to the company, a bonus scheme should be implemented. A bonus scheme offers monetary rewards to employees for meeting set targets. To ensure an effective bonus scheme, it is very essential to set up targets for different employees (teams, departments, or business units). These targets may be related to quality, productivity, customer satisfaction, profits, and other performance measures. Such defined targets should be aligned with the overall organizational business objectives. The success or failure of a bonus scheme is highly dependent on the defined targets. The company should move toward a more performance-oriented pay. The principle of "distribution according to work" should be thoroughly implemented [8].

6.3.9.5 Position Promotion

Position promotion must be based on, for example, employees' capabilities, skills, performance, and contributions to the company, and must not be based on the employees' personal relationships with the directors/managers of the company. An effective, rational, equal competition and fair position promotion mechanism should be established. If position holders cannot fulfill their duties due to lack of skills, capabilities, performance, or support from their colleagues, more qualified personnel should take over. Every employee in the company can see the hope of promotion opportunities if he or she performs well. Thus, employees' enthusiasm, creativity, and active participation are encouraged [32].

6.3.9.6 Moral Award

Moral award can be used to recognize the quality performance of employees or teams. It may take the form of thank-you note, oral praise, a letter of praise, sending an employee to a seminar or a conference, presentation of individual or team achievements, award certification, award ceremony, etc [32].

6.3.10 Education and training

6.3.10.1 Technical training

Trainings for aviation maintenance which include formal training, organizational training, manufacturer or vendor training, quality training, on-job-training (OJT), upgrade training, refresher training, maintenance resource management, airframe manufacturers training help increase the skills and potential of aviation maintenance personnel. Details of these trainings are presented in section 3.5 [13].

6.3.10.2 Education and Training Plan

The company's education and training plan should be drawn up in line with its strategies, objectives, available resources, current employees' skills, and employees' job requirements. ETHIOPIAN needs to identify its short- and long-term training needs, design training programs that address technical and behavioral issues, and have an evaluation system in place to check whether the training and development programs meet its objectives [5].

6.3.10.3 Training for Quality Management Knowledge

Employees need to accept education and training on quality management knowledge. This includes, for example, TQM, ISO 9000, the seven QC tools, the seven management tools, statistical process control, quality function deployment, and experimental design. To achieve a good training result, the training program should be well designed. The aim of training is to apply quality management knowledge in quality improvement activities [5].

6.3.11 Customer focus

6.3.11.1 Customer Complaint Information

Customer complaint information is valuable for the company in pursuing quality improvement and customer satisfaction. ETHIOPIAN needs to collect various pieces of complaint information from customers extensively, as well as create a central complaint registration system, which registers various complaints from customers. Customer complaints

should be resolved effectively and promptly. All complaints received need to be aggregated and analyzed for use in improvement. The company should see complaints as opportunities to improve the quality of products and services. After customer complaints are received, the company needs to identify the "vital few" serious complaints that demand in-depth study to discover their basic causes and to remedy those causes [8].

6.3.11.2 Market Investigation

Market investigation can help the company ensure that there is a demand for its service/product and that the requirements and expectations of the customers can be met. Market investigation can obtain various suggestions for improving the quality of the company's services. It is also essential to anticipate future customer requirements and expectations in order to develop such products or services in advance. ETHIOPIAN should be sensitive to changing and emerging customer and market requirements, competitors' offerings, and the factors that drive customer satisfaction and retention. Through market investigation, the strengths and weaknesses of the services of the company and its competitors can be identified. Such information can be used for benchmarking so as to determine the improvement areas of the company. Obtaining valuable information through market investigation is vital to the success of the company [8].

6.3.11.3 Customer Satisfaction Survey

The aim of the customer satisfaction survey is to obtain the customer satisfaction level with the products/services that the company provides. Methods used to conduct the customer satisfaction survey include questionnaire surveys, formal and informal feedback from customers, personal interviews, telephone surveys, and seminars. Regular customer satisfaction surveys can track customer perceptions of the quality of a company and its competitors. This information can be used to improve the quality of products, services, and processes [8].

6.3.11.4 Quality Warranty

A quality warranty is a form of assurance that a product/maintenance service or any other service is fit for use or, failing this, that the user can receive some kind of compensation-for example, free repair, replacement or return, or monetary compensation. In fact, the commitment to quality warranty reflects the quality of the company's products or services [8].

6.3.11.5 Customer Services

ETHIOPIAN needs to provide necessary assistance for the customers before supplying, during the process of supplying, and after supplying of services. In order to improve sales efficiency and customer service quality, it is crucial that the company computerizes its sales/service system and establishes its service standards. It is also important to improve the skills of sales and service personnel. Service quality is increasingly becoming a more important factor affecting customer satisfaction, customer retention, and customer loyalty [8].

6.3.11.6 Customer Information System

ETHIOPIAN should cater to the market and make timely adjustments in accordance with the customers' needs and wants. To do so, it needs a continuous flow of information on customer requirements and expectations. Information about existing and potential customers is critical to success. Therefore, a customer information system should be established. Such a system can be mainly used for several purposes: Collecting data on customers, preferences, collecting and storing customer feedback from sales/service visits, reports, customer satisfaction surveys, customer complaints, etc [8].

6.4 Overall business performance

6.4.1 Employee satisfaction

ETHIOPIAN should regularly evaluate its employee satisfaction level in order to seek the solution to improving employee satisfaction, commitment, and motivation. There are two ways to measure employee satisfaction. One is to obtain direct information from the employees. Thus, the company should develop a measurement instrument that can be used for obtaining employee satisfaction information directly. In order to obtain relatively accurate information, employees should be asked to fill in survey questionnaires anonymously. The alternative way of assessing employee satisfaction can be conducted by a group of people from the top management team and different functional departments within the company. These people can assess employee satisfaction according to their perceptions. These two methods of assessing employee satisfaction are based on a set of facets that may affect employee satisfaction in the company. Through obtaining employee satisfaction data, areas with which employees are not satisfied can be identified. Such information can be used to improve the company's TQM implementation efforts. Many factors may affect employee satisfaction such as annual income (e.g. salary, bonus), equity, fairness, equal opportunities

,recognition and reward schemes, job security, democratic management (e.g. involvement in setting the company's policies, strategies, and plans), leadership style and ability, top managers' and supervisors' conduct relationships , top managers and supervisors relationships with coworkers, promotion opportunities, nature of jobs (e.g. work loads, job content), career development (e.g. training, retraining, and target setting),working conditions (e.g. safety, noise, and pollution) [32].

6.4.2 Maintenance service quality

To test the theoretical models, employee satisfaction approach is adopted since this study examines employee satisfaction in relation to other variables such as maintenance service quality, customer satisfaction, strategic business performance, and TQM implementation. There are two ways to measure maintenance quality. The first is to measure relative quality in terms of comparing the company's own maintenance quality with other maintenance quality provided by other companies in the same industrial sector. The second way is to merely measure absolute maintenance quality in terms of the some indicators listed below. Through the analysis of maintenance quality, the company can understand its maintenance service quality status by comparing with its competitors, identify problem areas, and determine a solution to improve quality. The following indices can be used to measure the maintenance quality in ETHIOPIAN:

a) Performance of maintenance activities
b) Maintained equipment or airplane reliability
c) Delivery of maintained equipment or airplane (e.g. on time delivery, lead time, etc.)
d) Complaints(e.g. complaint response time, effective resolution, time to resolve complaints, percent of complaints resolved first contact, complaint levels, total number of complaints)
e) Warranty and guarantee provisions
f) Support (maintenance sales support, technical support, training, spare part availability)
g) Transportation (e.g. logistics information, packing for delivery).
h) Internal defect rates (during maintenance process)
i) Internal failure costs as a percentage of annual output value
j) External failure costs as a percentage of annual maintenance sales service (e.g. warranty costs and claims costs) [13].

6.4.3 Customer satisfaction

Customer satisfaction can be measured by comparing product quality and service quality with those in other company in the same industrial sector. Use of customer satisfaction information can provide a focus and direction for continuous improvement throughout the entire company. Such information can be used to improve TQM implementation efforts, seek opportunities to improve product and service quality, and study the time dimension of TQM implementation. The measures of product quality include performance, reliability, durability, and conformity. The measures of service quality have been listed above.

6.4.4 Strategic business performance

Strategic business performance is the highest level of the company's business performance, reflecting the company's efforts in implementing TQM, enhancing employee satisfaction, improving product/service quality, and increasing customer satisfaction. As described previously, typical measures of strategic business performance in ETHIOPIAN M&E division are as follows:

a) Annual maintenance service activities/sales

b) Annual maintenance service activities/sales growth

c) Profits

d) Market share [32]

6.5 Action plan and processes of TQM model implementation

This section provides processes of using the TQM implementation model in practice. Figure 6.3 shows the action plan for the TQM implementation process. Later the implementation progress will be checked with the action plan. Figure 6.4 displays the primary processes of implementing TQM, consisting of seven steps. First, in order to have an effective TQM implementation, top management should be committed to implementing this model. Second, based on top management commitment, a team should be established to steer the TQM implementation in the company. Third, the current TQM implementation practices and overall business performance must be evaluated according to the TQM implementation practices presented in Section 6.3 and major indicators of overall business performance presented in Section 6.4**.** Fourth, a PDCA cycle should begin. The cycle starts with the Plan stage, which involves an evaluation of the company's current TQM implementation and overall business performance. This stage includes collecting and analyzing data so as to formulate a plan of action intended to improve TQM implementation and overall business performance. Fifth,

once a plan for improvement has been agreed on the next step is the Do stage, during which the plan is implemented in practice. This stage may itself involve a mini-PDCA cycle as the problems of implementation are resolved. Sixth comes to the Check stage. In this stage, the effects of implementing the improvement plan are measured and used to compare with the plan. The goal of the firm's overall business performance is used to confirm the effects of implementing the improvement plan. Seventh, things move to the Act stage, during which the change is consolidated or standardized if it has been successful. Alternatively, if the change has not been successful, the lessons learned from the "trial" are formalized before the cycle starts again. Such information is used by top management and the TQM implementation team in formulating further improvement plans. Finally, it is essential to restart the PDCA cycle, which is the most important part of implementation. Implementing TQM is like the PDCA cycle – never-ending! [32].

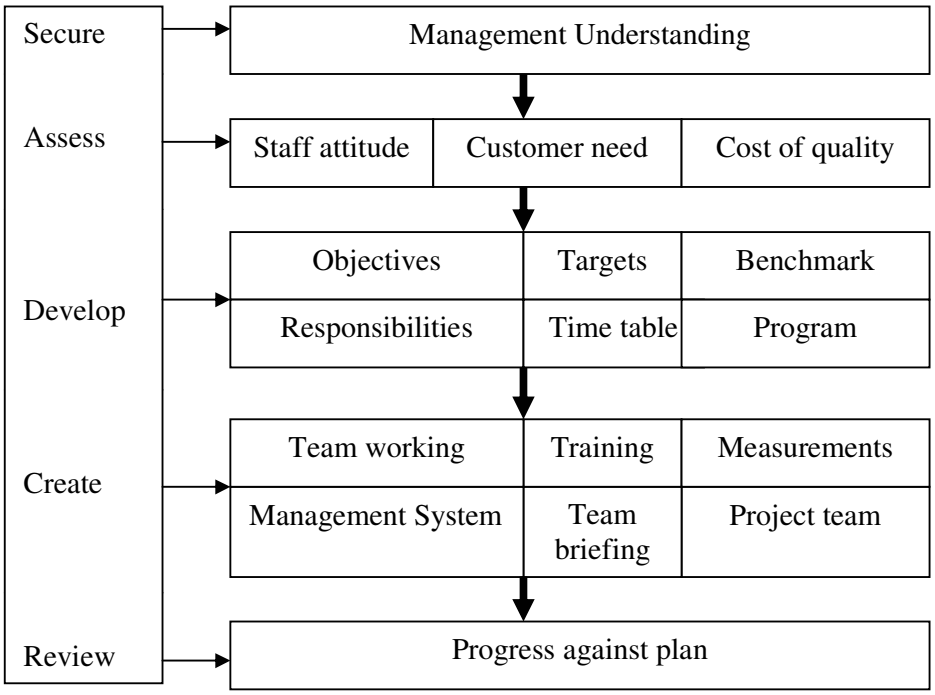


Figure 6.3 Implementation action plan [28]

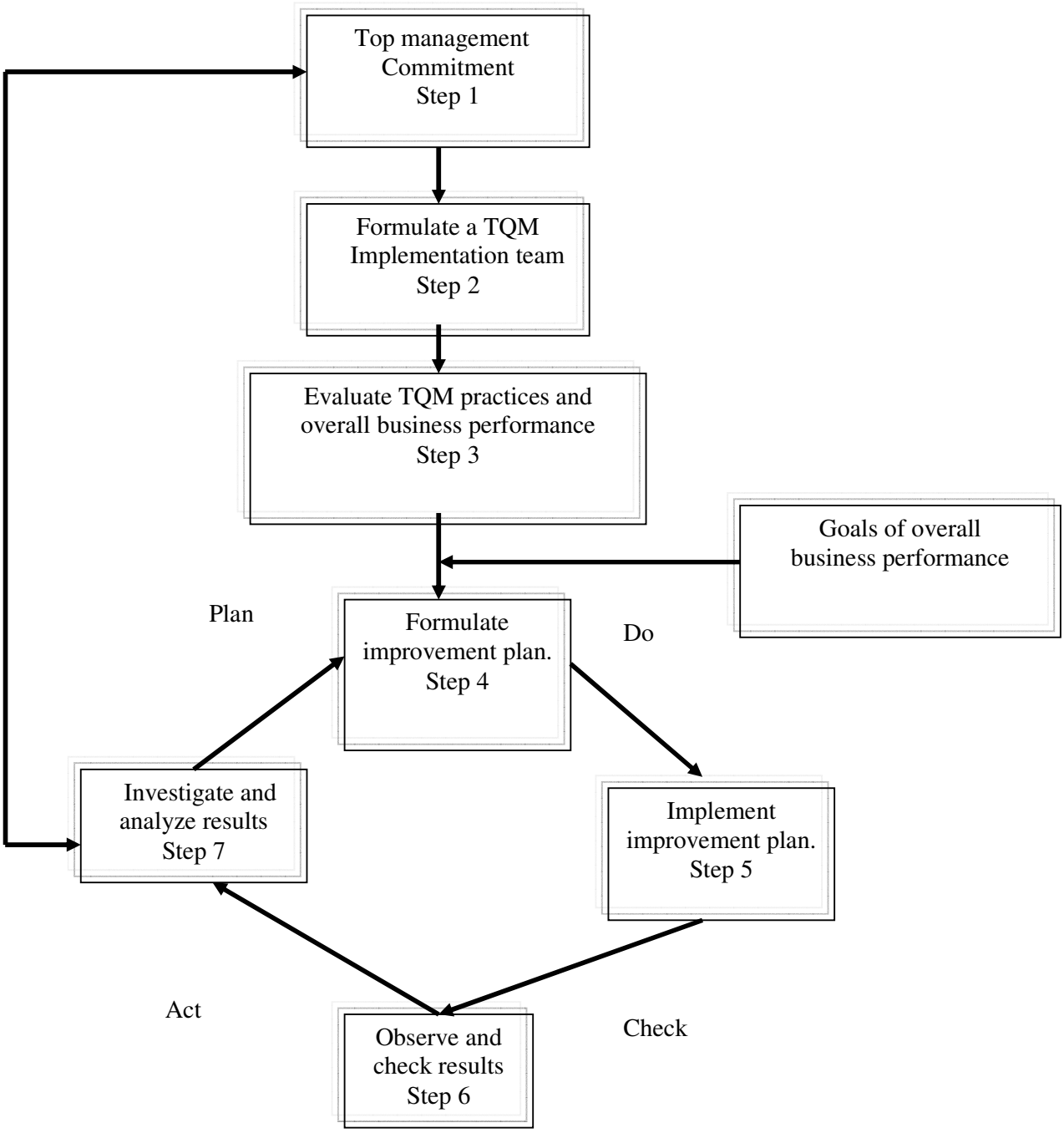


Figure 6.4 TQM Implementation Processes with the Deming's PDCA cycle

6.6 TQM implementation schedule and cost benefit analysis

Table 6.1 TQM implementation and cost estimation

S.No	Description	Duration	Duration	Duration	Duration	Estimated Cost
1	**Preparation Phase** Top management team attending 6-days workshop on TQM (by outside consultant)	1 month				Training cost 30,000, lost time of 40 persons @80 Birr per person per day Total=196,000 Birr
2	Formation of TQM steering committee from TOP management team.					
3	TQM attitude survey (profile of organization, quality costs, organization strength/weakness, advocators & resistors.					
4	**Planning Phase** Strategic planning workshop and other activities (TQM steering committee): Create vision, guiding principles, set broad strategic objectives, develop quality policy, identify critical success factors& critical processes, baseline employee satisfaction and customer satisfaction.		2 months			Workshop running (15,000birr)+ lost time of 40 persons @80 Birr per person per day, =207,000 Birr
5	Plan the implementation approach (PDCA)					
6	**Execution Phase** Formation of quality teams/site steering committees from each department and identify team facilitators.			8 months		Lost time of employees, managers etc@50 Birr per person per day on average, training costs, lost services because of inefficiency during first months, 1.5million Birr
7	Specific training and team-forming workshops for site steering committees.					
8	Companywide awareness on customer/ supplier interfaces					
9	Company-wide implementation/improvement projects for quality policy deployment (quality costing, customer/supplier frame work, systems and techniques).					
10	Modify infrastructures as necessary (procedures/processes, organizational structure, reward/recognition system, union rules etc.)					
11	**Evaluation Phase** Feedback/ follow-up workshops , meetings etc.				1 month	30,000 Birr
				Total	1 year	1,833,000 Birr

Table 6.2 TQM monetary benefit

S.No	Benefit obtained form TQM	Estimated value obtained(Birr/year)
1	Elimination of flight delay and cancellation	200,000
2	Improved customer service and retention	100,000
3	Better employee satisfaction and decreased turnover	200,000
4	Better employee participation and communication	100,000
5	Increased revenue generation	300,000
6	Improved ability to manage maintenance and flight services	100,000
Total		1,000,000

Total benefit obtained is about 1,000,000 Birr per year
Total cost required to implement TQM is 1,833,000 Birr
Payback period is 1,833,000/1,000,000= 1.833 years, approximately 22 months

6.7 Summary

This model shows that the application of TQM practices in combination can lead to improvements in overall business performance. In order to assist ETHIOPIAN in applying this model in practice, the action plan and the processes of its use are presented. The company should set targeted goals, formulate effective improvement plans, get the pilot projects up and running, and get the people involved and motivated. It then should measure the results, compare them to the benchmarks, and start all over again – all of this as fast as possible. Doing it is the key to truly instilling a new set of values and attitudes into the heart of the company. Implementing TQM is a never-ending process. It is important to note that investing in TQM implementation does pay off, though it often implies a choice for a long-term effort that requires a great deal of energy, management attention, money, patience, and tenacity. Although this model is developed for ETHIOPIAN M&E division, different companies can also use it as reference since the existing quality management knowledge is used in its development. Therefore, some principles and practices presented in this model can be used for other companies. This is possible since the basic philosophy of TQM is applicable to any type of organization.

Chapter 7: Conclusions and recommendations

7.1 Conclusions

In chapter three , section 3.4 attempts have been made to investigate the major quality related activities currently underway in ETHIOPIAN, in chapter four the existing major problems which are against the TQM philosophies and which are affecting the strategic business performance of the company have been identified and in chapter five analysis of the questionnaire results is made. While the research was carried out in the company, the researcher noted that there was a department entitled "TQM" under the maintenance and engineering division of the company. As the questionnaire, interview and observation results indicate, the company has come to a standard quality assurance stage recently upon the remarks made by external auditors. Though there has been TQM department since many years before, the company was mainly practicing quality control activities for several years instead of TQM. Moreover, many problems have been observed in the quality assurance procedures of the company such as in training, costs of quality, quality audits etc. To reach to the TQM stage, first it requires practicing all the requirements of standard quality assurance procedures. Then only the understanding of a better quality achievement will come in to picture. The overall research indicates that for several years in the history of the company major emphasis was given to quality control and conformance to requirements of regulatory bodies such as FAA and CAA. If the company would have implemented the actual TQM, the existing problems could have been solved. Therefore it is believed that this thesis will help a lot for the company in achieving a true TQM implementation to be the best competitor in the aviation industry.

7.2 Recommendations

The outcome of the result analysis in chapter five serves in developing the TQM model presented in chapter six. This analysis is made by using different TQM tools and by looking at different corners. As a result of this, the research outcome and the model developed are used as the base line for the recommendations made next. To better understand the recommendations and to implement them, it is strongly advised to know the existing problems in the company, the analysis used in this research work, and the model developed so as to

maintain a consistent flow. This will help create a clear image of the current situation of the company as seen with TQM mirror.

1. It has been tried to show systematically how different elements of TQM related to the commitment of management or leadership (chapter five). In a TQM implementation process, leaders who can inspire their followers are needed. The leader is the central processing unit in TQM and in the model developed in this thesis as well. Therefore ETHIOPIAN needs to create committed leaders and managers to bring the company to a new era of change to the TQM environment.
2. Suggestions/comments regarding the wrong directions or inefficiency of managers should be openly forwarded to them instead of rumoring. At the same time, managers should positively accept these comments and put their effort to rectify their actual shortcomings.
3. The company should identify the basic elements of TQM with their image or appearance to the aviation industry. There are clear distinctions on the stages of quality management evolution. Being at a quality control or quality assurance stage but called by the name "TQM" are entirely different things. Therefore the company should identify those specific activities in each stages of the quality management. Moreover, the existing "TQM" department should act as a facilitator but the philosophies of TQM should be in the minds of all employees. TQM can't be limited in one department.
4. Apart from the strive made to conform to the requirements of regulatory bodies, to stay as a world class competitor in the global aviation industry, there must be an equal strive for continuous improvement to exceed the needs of both internal and external customers. The negative impact of sticking to regulatory bodies' rule alone is that it leads to finding a stable state instead of continuous improvement. Especially the situation is so contradicting with TQM that the effort for meeting conformance of these regulatory bodies is high during audit time. It is better to plan for continuous improvement to be confident at any time.
5. As gold is tested on fire, international quality management techniques have been tested for business achievement not only in the aviation industry but in many industries as well. The ISO series and other international quality management techniques have been proved for effectiveness in many industries. Exercising these quality management techniques will lead ETHIOPIAN many steps ahead to TQM implementation. It is important to note that it is up to the company to worry about its

quality management system. Regulatory bodies follow-up mainly whether or not the company meets their specific requirements. However, these requirements are not substitutes but subsets of TQM.

6. One important and critical factor in strategic business is maintaining satisfied employee in the company. Apart from motivating and inspiring them, their work contribution and performance should be evaluated by fair and acceptable mechanism. The results of the research indicate that the current performance appraisal practice underway in the company is not rewarding employees as their actual performance. One of the most critical and decisive factors that should be possessed by leaders/managers of the ETHIOPIAN is that they should at least involve or at most empower employees of the company in decision making specially when these decisions affect employees directly. However, the results indicate that while setting the current performance appraisal practice, there were little or no such opportunities facilitated by the top management. This situation will cause employees to loose the sense of belongingness of the company, while creates the reverse situation for those who implemented this appraisal practice. It is important to note that the image of the company will be reflected through the satisfaction of its employees. (There are several kinds of performance appraisal techniques. Some are listed out in appendix I. The company can identify the one that best fits to its existing working situation and implement it).
7. An important means that ETHIOPIAN should focus on to achieve a team culture is creating competition among departments. Departments can compute for best performance achievement. This competition can take place once in a month, annually/semiannually. The competition criteria should be in-line with the strategic objectives of the company. Then some three departments can be awarded for best achievement at a time. It is important to note that all departments have equal contribution for the company, but not all of them can achieve equal performance in a given time. Again within these departments not all employees will have equal performance, hence it is possible recognize and reward those employees whose performance is higher.
8. In making TQM implementation practical, training plays the major role. The aviation industry requires conducting different training activities (some are listed in section 3.5). In this research, the status of training activities of the company has been indicated in section 3.4.10. It has been found that different departments did not strictly

follow training activities although the training centers released their schedules. A partial improvement has been noticed in this regard after the remarks put by external auditors. Employees also should accept training on how to use quality improvement tools in order to increase their quality awareness. To be successful in implementing TQM, due attention should be given to all elements of TQM.

9. An organization's internal situation is defined by its strength and weakness. Continuous identification of strength and weakness of the company should be made so as to develop the strengths and to minimize the weaknesses. Especially these weaknesses which could be in the technical aspect such as obsolete facilities and processes, in the quality improvement direction, in customer handling process etc. should be eliminated as much as possible and those strengths should be maintained and even developed more for the good reputation of the company in the market place. The external situation is defined by opportunities and threats that exist in the business environment. The important tool for analyzing this is to conduct the SWOT analysis.
10. Estimating the costs of quality is one means to measure the level of quality in satisfying customers' requirements. It is important tool that need to be adopted in a TQM implementation. However, this technique hasn't yet been utilized in ETHIOPIAN. It is essential to analyze what achievements and discrepancies have been noted in the current year, what future plans are available for elimination of these discrepancies in the coming year etc.
11. Partnering should begin at home. This means it is essential to intensify management-to-employee partnership, team-to-team partnership, and employee-to-employee partnership. The overall purpose of internal partnership is to harness the full potential of the workforce and focus it on the continuous improvement of quality. Internal partnering creates an environment and establishes a mechanism within that brings managers and employees, teams and individual employees together in mutually supportive alliance that maximizes the human resource of the organization. However, this internal partnership in ETHIOPIAN is not sufficient enough to implement TQM at this stage. A lot of effort is still required to bring the existing situation to the required level.
12. Usually relationships between an organization and its vendors have been traditionally characterized by adversarial activities such as the low-bid process which leads one and often both parties to lose. Rather than working together to find ways for both to win, buyers force vendors to absorb costs to win the low bid, and vendors look for ways to

minimize their losses by barely meeting the buyer specification. Such relationship will not help either party succeed in the long run in a competitive marketplace. The goal of partnering with vendors is to create and maintain a loyal, trusting, reliable relationship that will allow both parties to win, while promoting the continuous improvement of quality, productivity, and competitiveness.[1] . Not all suppliers can participate in such relationships. ETHIOPIAN needs to identify those suppliers which qualify for this strong relationship so as to achieve the optimal deal not only in price but also in features, loyalty, quality, delivery issue, training activities and long-term mutual benefit.

13. Effective benchmarking should be conducted in order to understand competitors' potential and offerings. Such information will be valuable for ETHIOPIAN to improve its service qualities and stay as a competitor in the market.
14. In-depth market investigation should be made so as to obtain customers' real expectations and potential needs. It is valuable to obtain customer satisfaction information on the quality of services from the company's competitors. Such information can be used for designing improved service quality.
15. Continuous assessment regarding business environment, organizational dominant values, culture role models such as organizational rites, rituals, and customs, behaviors and norms based on people interaction should be made in order to develop their positive outcomes for conducive organizational climate. These are important elements if governed properly can help achieve the implementation of successful of TQM.
16. An important characteristic of organizational culture is its nature to allow close link between managers and employees. Gathering or meeting of employees with supervisors, managers, directors etc. and sharing their success stories, challenges they faced, their efforts for the accomplishment of the company's mission are valuable in creating a strong link among all in the company. However, this tradition is not usually observed in the company. Instead, employees at the same level of post create groups and spend their free time together. Still a gap is seen between those at the management level and the other employees.
17. In ETHIOPIAN it seems there is a fear culture in which employees fear for their jobs. This is because they don't openly comment on the management, instead they rumor. This culture doesn't foster a TQM spirit. Employees should openly comment on the management and the management should appreciate these comments to take immediate measures.

18. TQM is based on fairness. It requires the company to satisfy its customers, and to be honest and open with its employees. That means the company has to be ethical. Before a TQM programme starts, the company should carryout an ethics audit, and drew up an ethics policy. The ethics policy should cover relationships with the government, customers, suppliers, staff, and the environment.
19. ETHIOPIAN needs to publish a staff news letter which contains TQM achievements, future plans, list of the contributions made by employees and the corresponding reward or recognition made by the company. This will enhance the efforts made by employees and they will strive for further achievements. Other employees will also follow their footsteps.
20. Let employees own 5%-10% of the company's equity. Their sense of belongingness to the company will be improved more. This will increase employees' motivation, inspiration and active participation in the company.
21. Sufficient time should be given for TQM to work. Not only will managers and employees need to spend on the programme, but also they will have to wait several years to see any results. People may get despondent when they don't see immediate results. But this will lead to the loss of interest in TQM and failure of the program. Moreover, sufficient investment should be allotted for the TQM programme such as for trainings and seminars, consultancy, for giving away certificates, prints etc.
22. ETHIOPIAN should measure the benefits obtained by implementing TQM. Employees, managers, and other staff have to see the achievements from TQM. Moreover, continuous evaluation of TQM is necessary for filling any gap which might arise later in the process.

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Appendix I: Performance Appraisal [31]

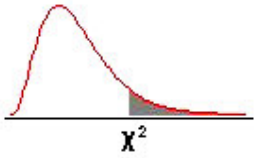
It is systematic evaluation of the performance of employees by an expert of immediate supervisor. It is important to help the management take decision about salary increase of employee, to improve the quality of an employee in job performance, minimizes the communication gap between employee and employer, to transfer person to the right place if his current place doesn't fit, to improve job satisfaction and etc.

Limitations: Can be unreliable, may not be correct if an employee has close relation to employer or boss, some qualities may not be appraised by performance appraisal, non uniform standards may not be followed by supervisors/bosses etc.

Types of performance appraisal

1. Ranking method: Employees are ranked one against the other in their working group as 1, 2, 3 etc.
2. Paired comparison method: Each employee is compared with other employees taking only one at a time. The evaluator compares two employees and put a thick mark against a better employee .In the same way an employee is compared with all other employees. The one who gets maximum ticks is considered as the best employee.
3. Forced distribution method: Group wise rating is done under this method. For example the rater can rate 15% of workers as superior, 35% as at or above average, 35% below average, 15% as poor. This method is suitable to large organization.
4. Grading: Certain categories of abilities or performance of employees are defined well in advance to fall in certain grades such as very good, good, average, poor and very poor. Unlike forced distribution, here individual traits and characteristics are identified.
5. Check list: It is the appraisal of the ability of an employee through getting answers for a number of questions prepared by personnel department. Questions can be about satisfaction of job, finishing job accurately, readiness to accept responsibility or orders.
6. Critical incident method: Measuring performance on the basis of incidents such as refusing to cooperate, unwilling to attend training, got angry over work, refuse to obey.
7. Field review method: performing employee's performance through an interview between the rater and the employee's immediate superior/supervisor.

Appendix II: Chi-Square (χ^2) probabilities



The areas given across the top are the areas to the right of the critical value. To look up an area on the left, subtract it from one, and then look it up (i.e. 0.05 on the left is 0.95 on the right)

υ	**0.995**	**0.99**	**0.975**	**0.95**	**0.90**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.300
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.041	30.813	33.924	36.781	40.289	42.796
23	9.260	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.195	46.963	49.645

Appendix III: Questionnaire

Indicate your current position in ETHIOPIAN. Don't write your name.
Position (Mechanic, Lead mechanic, Foreman, Supervisor, Manager, Director, Vice-President, Other please specify).
Gender_____
Rate or grade the following questions based on your fair and frank judgment. It is possible to include further explanations next to each question if you need to do so.
Ratings: 1= Excellent/ extremely high, 2= Very good/very high, 3= Good/ high, 4= Average,
5= Poor/below required, 6= Not applicable

A. Management Commitment/Leadership

1. How do you rate the commitment of top management for continuous improvement?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

2. Equal treatment of employees by the existing managers can be rated as

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

3. How do you rate the recognition /reward of your effort by the middle/top managers?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

4. Rate the willingness of middle/top managers, directors, VPs or your immediate boss to let you improve your skills and knowledge with the aid of recurrent, refresher or other trainings?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

5. How do you rate the willingness of middle or top managers to incorporate new and improved methods to accomplish tasks/

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

6. How ready are middle/top managers, directors, VPs for important changes?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

7. How do you rate the transparency of managers' activities to employees under their supervision?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

8. How sooth is the relationship of the management with the labor union?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

9. How willing are middle /top managers & VPs to listen to employees' dissatisfaction, to solve their problems, encourage/motivate employees and allow to get what they deserve?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

10. How effective are middle/top managers& VPs to control employees and to exhibit strong discipline?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

11. How do you rate middle and top managers to create a team work atmosphere, harmony, job satisfaction & feeling of belongingness in every employee's mind?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

12. How effective are middle/top managers, directors and VPs in directing/supporting, task managing, delegating and decision making?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

13. How do rate the commitment of middle/top managers, directors& VPs to Total Quality Process /use of quality deliver process/ TQM system, quality improvement projects, application of problem solving process?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

B. Training

14. On which of the following training activities have you participated? Indicate how may times you have been trained.
□ Formal training: Trainings given in Airframe& Power plant & Avionics schools before hired in EAL.

□ Organizational training: About policies and procedures, paper work and specific aviation systems & equipment in use at the airline.

□ Manufacturer or vendor training

□ Quality training

□ OJT

□ Upgrade (recurrent training): When new equipment is incorporated, new procedures are implemented

□ Refresher training: When mechanics/technicians etc. are rusty& to review or re-verify certain skills.

□Special trainings: Training not available in house such as NDT/NDI procedures, calibration procedures, engine operations (run-up, boroscope inspection etc.)

15. How do you rate the usefulness of the trainings you have taken for the actual maintenance or paper work?
□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

16. How do you evaluate the implementation of training activities as per the schedules?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6
17. How do you rate the strategy, time schedule and selection criteria of trainings?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6
18. How effective is the practical implementation of training activities regarding quality aspects?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6
19. How is your ability to interpret & effectively utilize maintenance and policy /procedure manuals such as AMM, CMM, and IPM etc.?
□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

C. Cooperation with Vendors or Foreign Repair/Maintenance Organizations

20. How do you rate the cooperation of vendors/FR stations regarding training aspects?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6
21. How effective is the on time delivery made by vendors/FR stations?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

22. How fast are vendors/FR stations to take corrective actions for any discrepancy?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6
23. Is there an agreed quality policy between ETHIOPIAN and vendors/FR stations?

□ Yes □ No
24. If yes, how do you rate the completeness of this policy to address any quality issue?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

D. Ergonomics and Human Factors

25. How do you rate the availability of auxiliary equipment (GSE, tools /special tools, test equipment, etc.) & written materials to perform the required maintenance on an aircraft?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

26. What can be said about the attention paid while designing maintenance programs with the mechanics capabilities & limitations taken in to consideration?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

27. Rate the clarity, understandability, accuracy and accessibility of manuals and other documents.

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

28. How effective is the maintenance program adjustment/change to be in line with human capabilities & requirements concerning work schedule, endurance& skill makeup of the work crew to avoid overwork, fatigue etc.?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

29. How do you rate the training regarding human factors in maintenance to reduce the chances of human errors in maintenance?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

30. How is the implementation of training regarding "human factors in maintenance" in the ETHIOPIAN?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

E. Continuous Improvement

31. How do you compare the level of quality in performing maintenance and engineering activities of Ethiopian at the present time from that of the past five years?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

32. How do you evaluate the effort made to improve results and capabilities to produce better results in the future?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

33. How do you rate the effort to improve demand generation, supply generation, technology, operations and people capability?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

F. Employee Performance Versus Incentive Scheme

34. How do you rate the balance between employee performance payment and the variable payment methods?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

35. How do you evaluate the accuracy, unbiased approach & factual evaluations made regarding employees' performance payment & variable payment technique so that all employees deserve as per their effort?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

36. What can be said about the performance measurement techniques currently underway in the company?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

37. How do you rate the acceptance & the standard of man-hour for the jobs currently underway?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

38. How do you evaluate the participation of employees while formulating and implementing the performance &variable payment techniques?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

39. How effective is the performance & variable payment techniques in rewarding hardworking employees& in accounting quality of work, complexity and difficulty of jobs?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

40. How do you rate the employee awards and motivating activities currently under way in encouraging or motivating employees?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

G. Quality Maintenance Management System

41. Rate the quality problems in all maintenance and engineering areas.

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

42. How do you evaluate the repetition of failures, delays& cancellations?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

43. How effective and efficient are maintenance activities implemented to address problems registered on pilot write up, component unscheduled removals etc.?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

44. How do you rate the turnaround time& maintenance costs?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

45. How effective is the dispatch reliability of ETHIOPIAN in competing with other airliners and in satisfying the global requirement?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

46. How do you rate the airline procedure in achieving the planed dispatch reliability?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

47. How strong, effective and understandable is the link of the Airline Maintenance Procedure &Maintenance Engineers with line/shop maintenance personnel to solve problems or alerts as fast as possible?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

48. How do you rate the practical contribution of maintenance engineers in providing effective troubleshooting for maintenance problems?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

49. How effective and efficient are maintenance managers in leading the maintenance personnel towards a quality achieved performance?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

50. How do you evaluate the rational allocation of maintenance task cards?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

51. How do you see the influence of running towards larger duration maintenance task cards on quality of maintenance activities?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

52. How would you rate the clarity and understandability of drawings, maintenance packages, EO, ER etc coming to the mechanic form the responsible sections developing the packages?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

H. Customer Focused Approach (Both Internal & External Customers)

53. How would you regard other departments /other department employees as customer to you?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

54. How would you regard the mechanism or channel used to assess or evaluate employee satisfaction/dissatisfaction?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

55. How fast do you reply to /perform customer's enquiries/ tasks?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

56. How do you rate the effort made to handle customer's complaints and satisfy their needs?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

57. How do you evaluate the involvement of all employees in setting standards for performance measurement criteria and payment techniques?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

58. Rate the effort under way to initiate, recognize & reward for higher performance achievement.

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

59. How would you rate the inter-departmental relationship in the company?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

60. How satisfied/proud are you with your job?

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

Appendix IV: Glossary

A Check: A maintenance check performed approximately every month (e.g. every 3000 flight hrs)

AC: Advisory Circular- Information issued by the FAA to identify ways in which an operator can meet the requirements of certain aviation regulations.

AD: Airworthiness Directive- A document issued by the FAA whenever an unsafe condition exists in an aviation product. AD may prescribe inspections, modifications, conditions or limitations under which the product may continue in operation. Incorporation of AD is mandatory.

APU: Auxiliary Power Unit- A turbine engine used to generate electrical power on the ground when aircraft engines are not operating. Sometimes used in flight when one engine is out (ETOPS) to replace the inactive engine driven generator.

CFR: Code of Federal Regulation- A codification of general and permanent rules published by executive departments and agencies of the U.S. government

CASS: Continuing Analysis & Surveillance Systems- A program established by the operator to ensure that the maintenance and inspection programs of the carrier's operation specification are effective.

C check: A maintenance check performed approximately every 12 to 18 months (e.g. every 4000 flight hrs).

EO: Engineering Order- Issuance of maintenance work which isn't not covered in the standard maintenance plan.

FOB: Free Onboard: Delivery destination after job completion.

SL: Service Letter- Documents issued by manufacturers to identify maintenance tips or new procedures. Incorporation is optional.

SB: Service Bulletin- Document issued by manufacturers to modify or improve operation of an aircraft component or system. Could include substitution of parts, special inspection or checks, or a change in life limit. Incorporation is optional.