DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) IN STATISTICAL MODELS

by
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İZMİR

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) IN STATISTICAL MODELS

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We have read the thesis entitled **"FAILURE MODES AND EFFECTS ANALYSIS (FMEA) IN STATISTICAL MODELS"** completed by **ÜMİT KUVVETLİ** under supervision of **Assist. Prof. Dr. ALİ RIZA FİRUZAN** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

In any area and any time of everyday life, there are a services and these services affect directly life quality of people. Accordingly, giving service rightly at fist time and meeting expectations of people by giving this service are as important as giving service.

Measuring service quality is more complex than evaluating quality of manufacturing products. The service that is given intangible and invisible, so service quality is a bit different subject.

FMEA, is a systematic technique that has a goal of defining and preventing the errors before they occur in system, design, process and service subjects. This method, is used to define how the system can be developed to increase reliability and make free from errors.

In this study, the service quality was measured on the passengers that use the lines of ESHOT General Directorate in Karşıyaka region by servqual technique, necessary statistical analysis were done, then a FMEA study example was applied.

Key Words: FMEA, Service Quality, Servqual, Reliability, Public Transport Service

HATA TÜRLERİ VE ETKİLERİ ANALİZİNDE (FMEA) İSTATİSTİKSEL MODELLER

ÖZ

Hizmet, günlük yaşamın her alanında değişik biçimlerde karşımıza çıkmaktadır. Hizmetler doğrudan insanların yaşam kalitesini etkilerken, hizmet vermek kadar hizmeti ilk defada doğru bir şekilde sunmak, bu hizmeti verirken insanların beklentilerini karşılayabilmek kadar önemli bir hale gelmiştir.

Hizmet kalitesinin ölçülmesi, imalat ürünlerinin kalitesinin değerlendirilmesinden daha karmaşıktır. Verilen hizmetin elle tutulamaması, gözle görülememesi gibi özellikler, hizmet kalitesini biraz daha farklı bir konuma getirmektedir.

Hata Türleri ve Etkileri Analizi (FMEA), sistem, tasarım, süreç ve servis konularında, hataları meydana gelmeden tanımlamayı ve önlemeyi amaçlayan sistematik bir tekniktir. Bu yöntem, belirli bir sistemin incelenerek, güvenilirliğinin arttırılabilmesi ve hatalardan arındırılabilmesi için ne şekilde geliştirilebileceğinin belirlenmesi için kullanılır.

Bu çalışmada, İzmir Büyükşehir Belediyesi ESHOT Genel Müdürlüğü' ne bağlı Karşıyaka bölgesindeki hatları kullanan yolcular üzerinde servqual tekniği yardımıyla verilen hizmetin kalitesi ölçülmüş, gerekli istatistiksel analizler yapılmış ve daha sonra örnek bir FMEA çalışması uygulanmıştır.

Anahtar Sözcükler: FMEA, Hizmet Kalitesi, Servqual, Güvenilirlik, Toplu Taşıma Hizmeti

CONTENTS

Page

CHAPTER ONE

INTRODUCTION

Quality is defined as a degree of the customer's expectations from a product or service that he takes. Accordingly, quality is a criteria and judge of qualified or unqualified is directly proportional with how much the product/service answers the expectations of the customer. Say the least of it, quality is the sum of the properties that a product or service provides to the customer. Reliability describes prevention of these during usage or service duration.

Services are more intangible than products and measurement of the services is more difficult. So the term of service quality arose later than the term of product quality. The desire of researchers to do numerical researches aimed at measuring service quality brought forth servqual scale. In servqual scale, service quality was defined as a difference between the service level that the customers perceived and the service level that the customers expected.

Failure Modes and Effects Analysis (FMEA) is an important quality technique aimed at solving the failure as soon as possible at early stages and preventing occurrence of the failure. FMEA is a technique that must be systematically applied in service sector that requires perfectness. Because zero-error philosophy is performed rightly and service continously developes by means of FMEA. In FMEA logic, potential failures are evaluated by means of three criterions, the work start by correcting the most significant failure and this process is replicated continuously.

This study consists of six chapters.

In Chapter 1, related information is given briefly about quality, service quality, servqual and FMEA method.

In Chapter 2, quality and service quality concepts are examined and quality, historical evolution of quality, service quality, gaps in service quality and servqual scale that was developed to measure service quality are defined.

In Chapter 3, the term of reliability, significance of reliability and some definitions that are related with reliability are examined and Quality Function Deployment and Fault Tree Analysis techniques are defined briefly.

In Chapter 4, FMEA, the history of FMEA, the relationship of FMEA with the other quality techniques, types of FMEA, stages of FMEA study, some concepts that are related with FMEA are examined inclusively. An example of servqual and FMEA study that were applied in ESHOT General Directorate where are located in Chapter 5 of this thesis.

In Chapter 5, there are the results of the statistical analyses that are related with the research and the outputs of the FMEA study. In the last chapter, there are conclusions and advices.

CHAPTER TWO

QUALITY

2.1 What is Quality?

Quality may be defined in many ways. Most people have a conceptual understanding of quality as relating to one or more characteristics that a product or service should possess.

According to ANSI/ASQC Standard A3-1987, quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy implied or stated needs. Stated needs are determined by the contact, whereas implied needs are a function of the market and must be identified (Besterfield, 1994).

The quality of a product can be evaluated in several ways. It is often very important to differentiate these different dimensions of quality. Garvin (1987) provides an excellent discussion of eight components or dimensions of quality. These dimensions of quality can be summarized as follows (Montgomery, 2001):

- **Performance** (will the product do the intended job?)
- **Reliability** (how often does the product fail?)
- **Durability** (how long does the product last?)
- **Serviceability** (how easy is it to repair the product?)
- **Aesthetics** (what does the product look like?)
- **Features** (what does the product do?)
- **Perceived Quality** (what is the reputation of the company or its product?)
- **Conformance to Standards** (is the product made exactly as the designer intended?)

These discussions barely demonstrate that quality is indeed a multifaceted entity. Consequently, a simple answer to questions such as “What is quality?” or “What is

quality improvement?" is not easy. The traditional definition of quality is based on the viewpoint that products and services must meet the requirements of those who use them. Quality means fitness for use (Montgomery, 2001)

There are two general aspects of fitness for use: quality of design and quality of conformance. The quality of conformance is how well the product conforms to the specifications required by the design. Quality of conformance is influenced by a number of factors, including the choice of manufacturing processes, the training and supervision of the workforce, the quality- assurance system used (process control, tests, inspection activities, etc.), the extent to which these quality- assurance procedures are followed, and the motivation of the workforce to achieve quality Quality is inversely proportional to variability (Montgomery, 2001).

Furthermore, Soysal (2000), arranged the other definitions related to quality in the following way:

- Quality is the worth of a product or service.
- Quality is conformity to the characteristics that are determined before.
- Quality is conformity to the needs.
- Quality means that satisfy the expectations of the customers and realize more than those.
- Quality means that produce a product or service that continously satisfy the expectations or desires of the customers.
- Quality is prevention; that creates the solutions before the problems arose, adds flawlessness to structures of products or services.
- Quality is productivity, that is obtained by the employees that are trained to achieve the works, supported by the equipments and instructions that they need.
- Quality is a process that includes continuously improving.
- Quality is an investment; to do a job right for the first time in long term is cheaper than to correct the error later.

- Quality is a systematic approach to the understanding that supports flawlessness.

In Japan, the term of quality is defined as everything that can be improved.

2.2 Historical Evoluation of Quality

The term of quality is not a term that has recently arisen. All the historical works of art that has stated from old ages to now are surely quite qualitified. In the years of B.C. 3000 in Babylonia, The Codes of Hammurabi may be accepted as the first reference of the term of quality. One of these codes says “Even if a man builds a house badly, and it falls and kills the owner, the builder is to be slain.”. Although this law is primitive, it barely demonstrates the significance of quality.

After The Industrial Revolution, technology quickly improved and the processes of production became complex. Therefore, products and services that are the outputs of these processes became complex, too. The historical evoluation of quality after The Industrial Revolution can be examined at four different stages (British Quality Foundation, 2007):

Inspection: Inspection involves measuring, examining, and testing products, process and services against specified requirements to determine conformity.

The use of inspection has been evident throughout the history of organized production. In the late Middle Ages, special measures were taken to inspect the work of apprentices and journeymen in order to guard the guild against claims of makeshift or shoddy work.

During the early years of manufacturing, inspection was used to decide whether a worker’s job or a product met the requirements; therefore, acceptable. It was not done in a systematic way, but worked well when the volume of production was

clearly low. However, as organizations became larger, the need for more effective operations became apparent.

In 1911, Frederick W. Taylor helped to satisfy this need. He published 'The Principles of Scientific Management' which provided a framework for the effective use of people in industrial organizations. One of Taylor's concepts was clearly defined tasks performed under standard conditions. Inspection was one of these tasks and (British Quality Foundation, 1993):

- was intended to ensure that no faulty product left the factory or workshop;
- focuses on the product and the detection of problems in the product;
- involves testing every item to ensure that it complies with product specifications;
- is carried out at the end of the production process; and relies on specially trained inspectors.

This movement led to the emergence of a separate inspction department. An important new idea that emerged from this new department was the defect prevention, which led to quality control.

Inspection still has an important role in modern quality practices. However, it is no longer seen as the answer to all quality problems. Rather, it is one tool within a wider array.

Quality Control and Statistical Theory: Quality Control was introduced to detect and fix problems along the production line to prevent the production of faulty products. Statistical theory played an important role in this area. In the 1920s, Dr W. A. Shewhart developed the application of statistical methods to the management of quality. He made the first modern control chart and demonstrated that variation in the production process leads to variation in product. Therefore, eliminating variation in the process leads to a good standard of end products (British Quality Foundation, 1993).

Statistical Quality Control:

- focuses on product and the detection and control of quality problems;
- involves testing samples and statistically infers compliance of all products;
- is carried out at stages through the production process; and
- relies on trained production personnel and quality control professionals.

Shewhart's work was later developed by Deming, Dodge and Roming. However, manufacturing companies did not fully utilize these techniques until the late 1940s.

Total Quality: The term 'total quality' was used for the first time in a paper by Feigenbaum at the first international conference on quality control in Tokyo in 1969. The term referred to wider issues within an organization.

Ishikawa also discussed 'total quality control' in Japan, which is different from the western idea of total quality. According to his explanation, it means 'company-wide quality control' that involves all employees, from top management to the workers, in quality control.

Total Quality Management: In the 1980s to the 1990s, a new phase of quality control and management began. This became known as Total Quality Management (TQM). Having observed Japan's success of employing quality issues, western companies started to introduce their own quality initiatives. TQM, developed as a catchall phrase for the broad spectrum of quality-focused strategies, programmes and techniques during this period, became the centre of focus for western quality movement (British Quality Foundation, 1993).

A typical definition of TQM includes phrases such as: customer focus, the involvement of all employees, continuous improvement and the integration of quality management into the total organization. Although the definitions were all similar, there was confusion. It was not clear what sort of practices, policies, and activities needed to be implemented to fit the TQM definition.

Nowadays, TQM is applicated successfully by a lot of firms, this method is being developed yet more so it builds up a base to new quality methods.

2.3 Service Quality

Service quality is a concept that has aroused considerable interest and debate in the research literature because of the difficulties in both defining it and measuring it with no overall consensus emerging on either (Wisniewski, 2001). There are a number of different "definitions" as to what is meant by service quality. One that is commonly used defines service quality as the extent to which a service meets customers' needs or expectations (Lewis and Mitchell, 1990; Dotchin and Oakland, 1994a; Asubonteng *et al* ., 1996; Wisniewski and Donnelly, 1996). Service quality can thus be defined as the difference between customer expectations of service and perceived service. If expectations are greater than performance, then perceived quality is less than satisfactory and hence customer dissatisfaction occurs (Parasuraman,1985; Lewis and Mitchell, 1990).

Three features of the service delivery activity are critical to the quality perceived by the customer. (Parasuraman,1990)

- The intangibility: The service is usually subjectively perceived and the result is always related to the customer feelings
- The customer participation in the process: The customer presence in the service process introduces an element that is not controlled by the provider and still adds up the need for the customer satisfaction regarding the way the service is delivered.
- Production and consumption are a simultaneous process: There is no way to control the quality before the service is delivered.

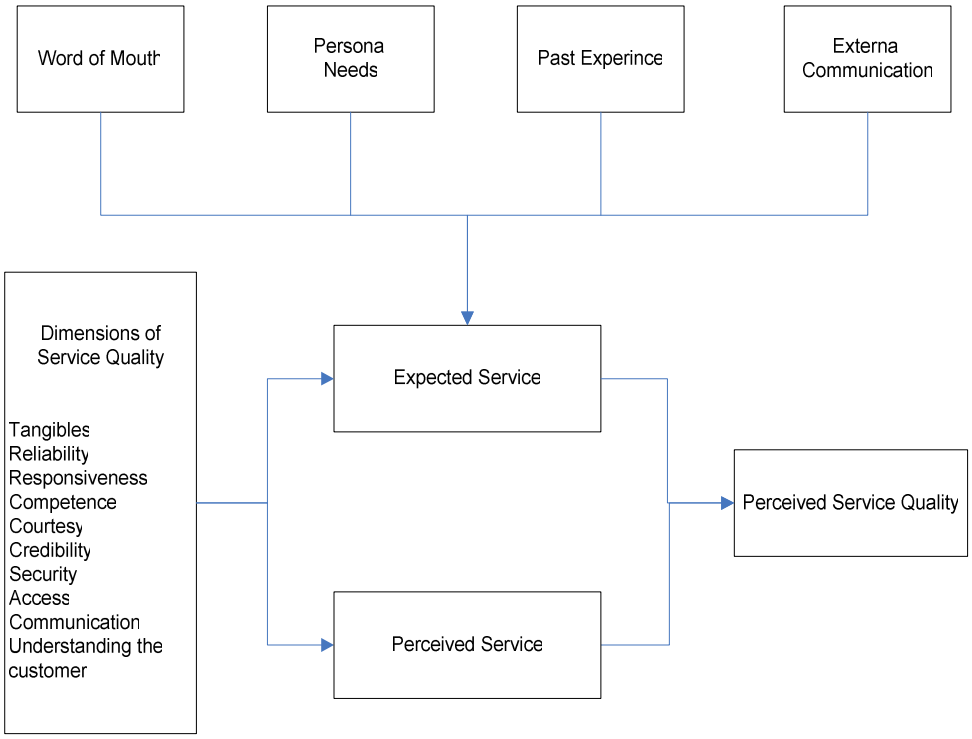


Figure 2.1 Customer assessment of service quality (Zeithaml, Parasuraman, & Berry,1990).

In Figure 2.1, if the expected service level is greater than the perceived service level, non-acceptable quality; if the expected service level is equal to the perceived service level, quality satisfaction; if the expected service level is less than the perceived level, quality surprise occurs.

2.3.1 Dimensions of Service Quality

The services marketing literature has made significant progress exploring fundamental questions regarding service quality. One area that has received significant attention is the multidimensional nature of services. In a seminal research study, Parasuraman, Zeithaml, and Berry identified 10 dimensions of service quality -tangibles, reliability, responsiveness, competence, courtesy, communication, credibility, security, access, and understanding- based upon a series of focus group studies. Since that study, service quality measures have been used to assess a broad variety of services including physician, hospital, educational, banking, and dental (Holdford, Patkar, 2003).

The ten dimensions defined and illustrated in Figure 2.1 are not necessarily independent of one another (Zeithaml, Parasuraman, &Berry,1990):

Tangibles: Appearance of physical facilities, equipment, personnel and communication materials.
Reliability: Ability to perform the promised service dependably and accurately.
Responsiveness: Willingness to help customers and provide prompt service.
Competence: Possession of the required skills and knowledge to perform the service.
Courtesy: Politeness, respect, consideration and friendliness of contact personel.
Credibility: Trustworthiness, believability, honesty of the service provider.
Security: Freedom from danger, risk or doubt.
Access: Approachability and ease of contact.
Communication: Keeping customers informed in language they can understand and listening to them.
Understanding the cunstomer: Making the effort to know customers and their needs.

From that initial research, Parasuraman, Zeithaml, and Berry developed a service quality instrument called servqual, which evaluated consumer perceptions of services. Factor analysis of consumer responses to servqual resulted in a conclusion that there are 5 key dimensions of service quality (Zeithaml, Parasuraman, &Berry,1990):

Tangibles, reliability, responsiveness, empathy and assurance.

Empathy: The degree to which customers are treated as individuals.
Assurance: Ability to inspire trust and confidence.

2.3.2 Gaps In Service Quality

Defining and measuring quality in services might be difficult due to the intangible nature of the service offering. Many of the researches on service quality have been carried out within the framework of widely accepted service quality model (Servqual) developed by extensive research by Parasuraman (1985, 1988, and 1991). Since then, many researchers have used this 22 item scale to study service quality in different sectors of the services industry including financial institutions (Gounaris, 2003; Arasli, 2005).

Basically, the service quality model was derived from the magnitude and directions of five gaps as follows:

- **Gap 1 (Understanding):** the difference between costumer expectations and management perceptions of costumer expectations.
- **Gap 2 (Service standards):** the difference between management perceptions of costumer expectations and service quality specifications.
- **Gap 3 (Service performance):** the difference between service quality specifications and the service actually delivered.
- **Gap 4 (Communications):** the difference between service delivery and what is communicated about the service to costumers.
- **Gap 5 (Service quality):** the difference between customer expectations of service quality and customer perceptions of the organization's performance.

Gaps 1 to 4 affect the way in which service is delivered and these four gaps lead to Gap 5. Therefore, the extent of Gap 5 depends on the size and direction of these four gaps (Gap 1, Gap 2, Gap 3 and Gap 4).

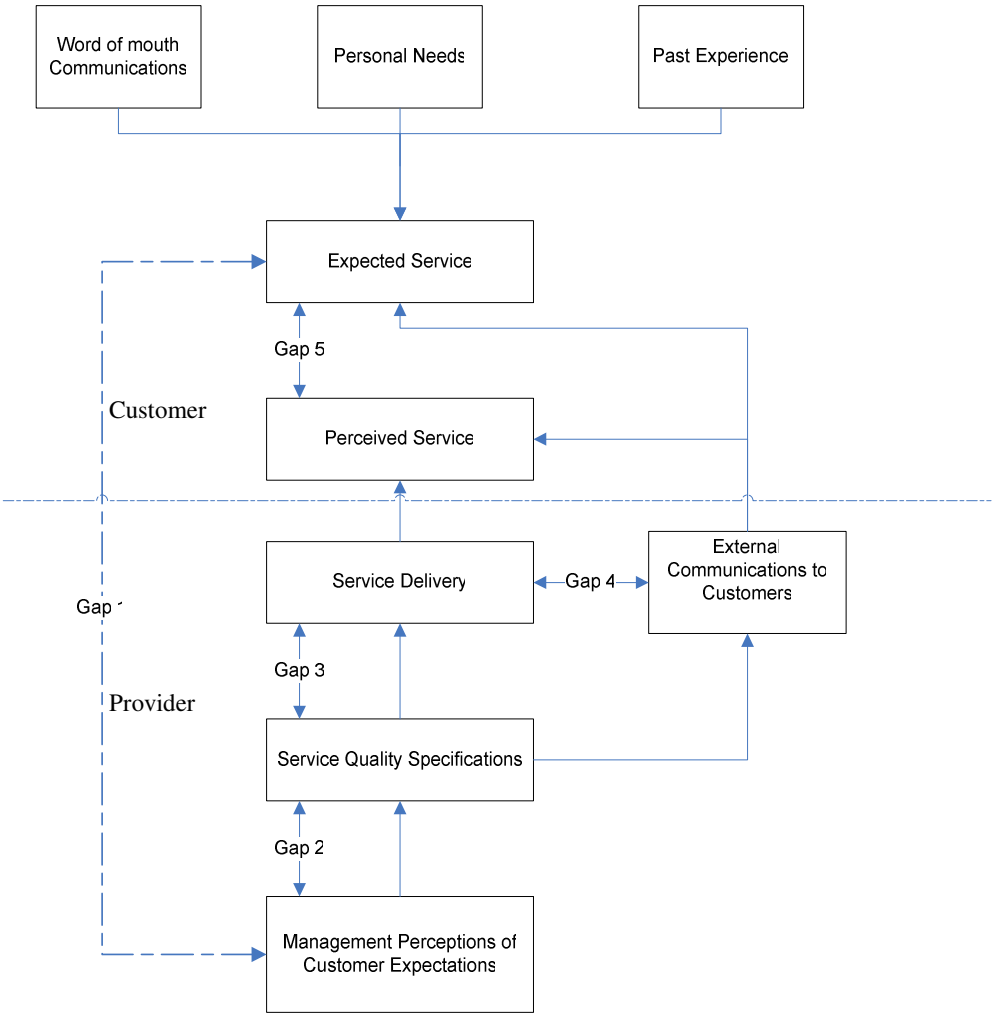


Figure 2.2 Service quality gap model (Zeithaml, Parasuraman, &Berry,1990).

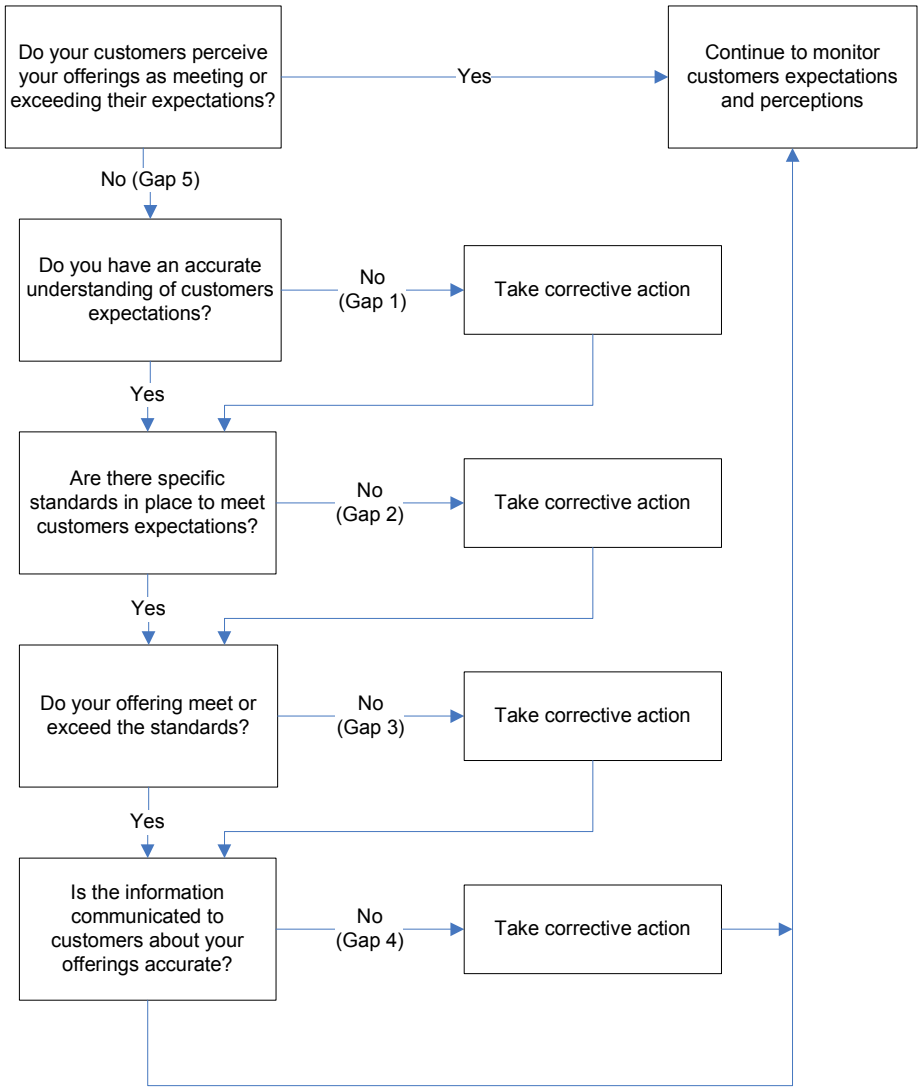


Figure 2.3 Process model for continuous measurement and improvement of service (Zeithaml, Parasuraman, &Berry,1990).

2.4 Measure of Service Quality

Always there exists an important question: why should service quality be measured? Measurement allows for comparison before and after changes, for the location of quality related problems and for the establishment of clear standards for service delivery. Edvardsen (1994) state that, in their experience, the starting point in developing quality in services is analysis and measurement.

The basic methods that are used to measure service quality are arranged as below. Each of these methods use different dimensions to measure service quality, but servqual method is generally favored to determine the expected and perceived service quality in the application stage by all of these methods(Aydın, n.d) :

- Benchmarking
- Total Quality Index
- Statistical Methods
- Servperf
- Servqual
- Service Barometer of Linjefly
- Group Interview Method
- Critical Events Method (CEM)

2.4.1 Servqual Method

The Servqual method that is developed by Zeithaml, Parasuraman and Berry, is the factor analysis of 22 item scale that is applicated after reducing 10 determinative factor to 5 factor, is developed in industrial applications and focus groups (Cronin and Taylor,1992).

Servqual is an omnibus method that is used by the firms to understand better the expectations of customer and perceptions, has good reliability and high validation (Zeithaml, Parasuraman,& Berry,1990).

Service Quality Evoluation in Servqual logic is based on the difference between "expectation-perception" pairs. Servqual score can be computed as below after the factors are obtained:

Servqual score = Perception score- Expectation score

Mean servqual score for each dimension is computed by using servqual scores. Mean servqual scores are obtained at 2 stage (Zeithaml, Parasuraman,& Berry,1990):

1. For each customer, the servqual scores that are given for statements of related dimensions are summed and then these are divided by the count of statement that build up the dimension.
2. For N customer, the numbers that are obtained at the first stage are summed and then this is divided by N.

The scores that are computed for 5 dimensions are summed and then are divided by 5 to obtain total service quality score. As a result of this, the value that is found is unweighted servqual score. This value is not affected by the significance that the customers give.

Weighted score is obtained as below (Zeithaml, Parasuraman,& Berry,1990):

1. For each customer, mean servqual score is computed for each five dimensions.
2. For each customer, the servqual score for each dimension is producted by the magnitude of signifance that the customer gives that dimension.
3. For each customer, unweighted servqual scores are summed by summing five dimensions.
4. The scores of the customer that are obtained at stage 3 are summed and divided by N.

CHAPTER THREE

RELIABILITY

3.1 Definition of Reliability and Reliability in Services

Reliability is one of the important characteristics of the quality applicable for products, systems and services. In our day, the quality in the product or the service has become much more important than its price. Good quality and high reliability, especially in the competitive sectors of the market, is known to be more important than the price.

Simply stated, reliability is quality over the long run. Quality is the condition of the product during production or immediately afterward, whereas reliability is the ability of the product to perform its intended function over a period of time. A product that "works" for a long period of time is a reliable one. Since all units of a product will fail at different times, reliability is a probability (Besterfield, 1994).

A more precise definition is: Reliability is the probability that a product will perform its intended function satisfactorily for a prescribed life under certain stated environmental conditions (Besterfield, 1994).

Quality and reliability are not free, but poor quality and reliability usually cost much more than good quality and reliability. Warranties, liabilities, recalls and repairs cost millions of dollars each year because quality and reliability were not given enough emphasis during the design, manufacture and use stages of product development to attain customer satisfaction. Just as in medicine, the cost of preventing poor quality and reliability is usually much less than the resulting costs of inferior quality and reliability (Ireson, Coombs, &Mess, 1996).

Starting in the early 1950s, the word reliability acquired a highly specialized technical meaning in relation to the control of quality of manufactured product.

Many formal definitions have been proposed that are similar in the general intent but differ a bit in their exact phrasing. Three of these are as follows (Grant, Leavenworth, 1996):

- "Reliability is the probability of a device performing its purpose adequately for the period of time intended under the operating conditions encountered."
- "The reliability of a (system, device etc.) is the probability that it will give satisfactory performance for a specified period of time under specified operating conditions."
- "Failure is the inability of an equipment to perform its required function, and reliability is the probability of no failure through a prescribed operating period."

Bazovsky states the modern concept of reliability in popular language as follows: "Reliability is the capability of an equipment not to break down in operation."

Even though a product has a reliable design, when the product is manufactured and used in the field, its reliability may be unsatisfactory. The reason for this low reliability may be that the product was poorly manufactured. So, even though the product has a reliable design, it is effectively unreliable when fielded that is by actually the result of a substandard manufacturing process. As an example, cold solder joints could pass initial testing at the manufacturer, but fail in the field as the result of thermal cycling or vibration. This type of failure did not occur because of an improper design, but rather it is the result of an inferior manufacturing process. So while this product may have a reliable design, its quality is unacceptable because of the manufacturing process (http://www.relex.com/resources).

Just like a chain is only as strong as its weakest link, a highly reliable product is only as good as the inherent reliability of the product and the quality of the manufacturing process.

Reliability can be considered for mechanical systems whose performances could be measured in quantity as well as service companies whose performances are measured in efficiency criteria.

Service companies are structurally made of processes. All their subsystems are therefore processes. Because of this, the reliability of the service companies can be measured with the reliability of the proceses it contains. The service processes also meet the reliability definitions. But it has a difference in measuring and calculating of performance.

In service companies reliability requires some practices. For example, service must have realiable design, reliable tools, reliable service providers, reliable supervisory program, reliable data analysis, reliable informational feedback and accurate procedure. As a consequence, reliability has an important role in designing, production and operation phases of a system.

3.2 Importance of Reliability

There are a number of reasons why product reliability is an important product attribute, including (http://www.relex.com/resources):

Reputation: A company's reputation is very closely related to the reliability of their products. The more reliable a product is, the more likely the company is to have a favourable reputation.

Customer Satisfaction: While a reliable product may not dramatically affect customer satisfaction in a positive manner, an unreliable product will negatively affect customer satisfaction severely. Thus high reliability is a mandatory requirement for customer satisfaction.

Warranty Costs: If a product fails to perform its function within the warranty period, the replacement and repair costs will negatively affect profits, as well as gain

unwanted negative attention. Introducing reliability analyses is an important step in taking corrective action, ultimately leading to a product that is more reliable.

Repeat Business: A concentrated effort towards improved reliability shows existing customers that a manufacturer is serious about their product, and committed to customer satisfaction. This type of attitude has a positive impact on future business.

Cost Analysis: Manufacturers may take reliability data and combine it with other cost information to illustrate the cost-effectiveness of their products. This life cycle cost analysis can prove that although the initial cost of their product might be higher, the overall lifetime cost is lower than a competitor's because their product requires fewer repairs or less maintenance.

Competitive Advantage: Many companies will publish their predicted reliability numbers to help gain an advantage over their competition who either does not publish their numbers or has lower numbers.

3.3 Reliability Function and Some Definitions in Reliability

3.3.1 Reliability Function

Looking broadly at the concept of reliability, it is seen that reliability is a probability and so it can be explained in terms of probability. The numerical value of reliability is the probability that failure of the product or service will not occur during a particular time. Thus, a value of 0.93 would represent the probability that 93 of 100 products would function during a prescribed period of time and 7 products would fail before the prescribed period of time (Besterfield,1993). This degree of flexibility makes the reliability function a much better reliability specification than the MTTF (Mean Time To Failure), which represents only one point along the entire reliability function.

When lifetime is considered as a random variable, the cumulative distribution function of the random variable is closely related to the reliability of a component or the system and is called life distribution. Probability of failure when taken as a function of time can be defined as below:

$$P(T \leq t) = F(t) \qquad t \geq 0$$

Here $F(t)$ is the component's or the system's probability of failure, not being able to carry out its function as desired in time interval t. This is called "Failure Distribution Function".

"Reliability Function" $R(t)$ is the component or system's success to be able to carry out its function as desired in time interval t, so component or the system's probability of success as below:

$$R(t) = P(T > t) = 1 - F(t)$$

By the help of probability distribution which is defined according to the failure time, predictions are made.

Estimating with certain levels of significance is very much dependent on correct determination of the number of parameters. For example, first of all it is important to choose the appropriate distribution for the data. If not, the results will not be reliable. Confidence, dependent on the sample size, should be convenient for right decision making. On its own, the component of failure rate is dependent on an adequate amount of population and its ability to mirror the present situation correctly. Although used in practical forms, reliability engineering today can be summarized as containing statistics excessively (Ireson, Coombs,& Mess, 1996).

3.3.2 Some Definitons in Reliability

Failure: System's lack of ability to carry out one or more of its performance criteria. For example, not to be able to accomplish the cleaning consitions in hospital or deficiency of municipal services is a failure. Failures can be divided as critical or noncritical failures. The critical failures are failures that cause to become significant errors, to bring damage to alives. The failures that are not critical are failures that materialize when the performance criteria can not be provided. For example, dishing distored eatable to the customers is a critical failure, but carrying the meals late can be an example of noncritical failure. The critical failures can change according to the structure of the system.

Fault: It is a situation that has a component which is defective to accomplish the desired function. It differs from failure. Because failure is an event, fault is an situation. At first the fault arises, then the failure can become because of this fault. For instance, blight of the products that are in stocks is a fault, but bringing in these products to the customers is a failure.

Failure Rate: Rate of failing units in the whole unit.
Failure Rate= Number of failure/ Number of total functioning units.

Bathtub Curve: Shows typical lifetime of a complicated systems.

Reliability specialists often describe the lifetime of a population of products using a graphical representation called the bathtub curve. The bathtub curve consists of three periods: an infant mortality period with a decreasing failure rate followed by a normal life period (also known as "useful life") with a low, relatively constant failure rate and concluding with a wear-out period that exhibits an increasing failure rate.

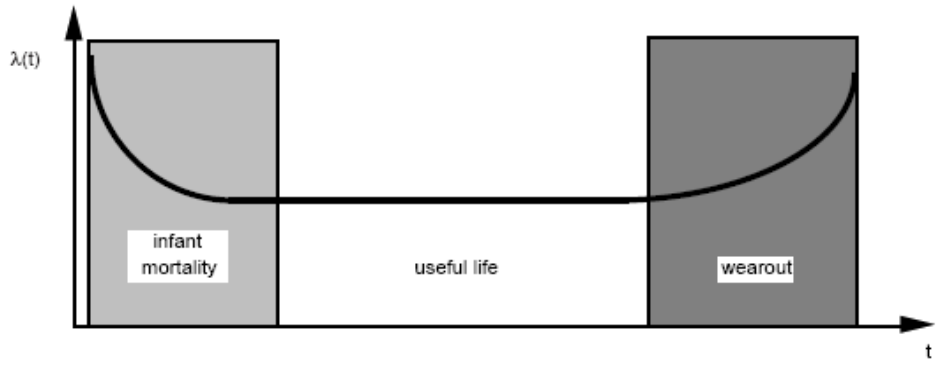


Figure 3.1 Bathtub curve (Bonnefoi,1990).

The initial high-failure region, known as “infant deaths.” This region is where a large number of products fail just after manufacture; it demonstrates problems in manufacturing. Much engineering work takes place in both the product design and the manufacturing process to reduce these failures. Companies recognize these problems and offer warranties to replace defective goods in this initial period to maintain customer confidence.(Amerasekera & Campbell, 1987).

The middle region is the region where very few products fail. This is the carefree life of the product. In this period, the components reach the minimum level of failure rate. These failures are the ones that occur in the duration of the product or the service at various time intervals.

The final high-failure region, known as “old age deaths.” This region is where the product has come to the end of its useful life. The failure rate increases in this period. Most products are designed to endure until the end of useful life period. t_2 is defined as the end of useful life period or the beginning of wear out period. Failure rate increases rapidly from this point. Compared to failures in the other periods, failures that occur in this stage are mostly inevitable. These failures occur due to the change in the expected performance criteria in time and the system’s wearing out, and because of physical and chemical causes (Dhillon, Reiche,1985).

3.4 Choice of the Model in Service Process

To determine the reliability of a service process, the performance criteria, as the process that confront all the needs and the process that doesn't improperness, that are expected from the process must be determined. The requirements that must be confronted by the process are determined by Quality Function Deployment (QFD), as for the faults that can arise are determined by Failure Modes and Effects Analysis (FMEA). A process that can not confront any needs is a failure. Failure rates and reliability values in time can be computed by evaluating and following these faults (Taşpınar, 1999).

3.5 Analysis Using for Design and Improvement of Reliability

All performance criteria must be determined for a service process to able to determine its reliability. QFD is used in determining the performance criteria and FMEA is used in preventing potential failures of the process. With these two methods the failures in the process are detected and failure rates can be estimated. Fault Tree Analysis (FTA) is also one of methods that are used in reliability analysis of the systems.

QFD and FTA are mentioned below. FMEA is observed in detail in the following section.

3.5.1 Quality Function Deployment

Quality Function Deployment is a well-known quality improvement technique for customer focused design of the products, services or the processes. QFD simply focuses on "what" the customer wants and "how" the organization will achieve this aim.

QFD is the systematic translation of the "voice of the customer" to actions of the supplier required to meet the customers' desires, based on a matrix comparing what

the customer wants to how the supplier plans to provide them. This basic matrix can be expanded to provide additional insight to the supplier, and cascaded to identify process parameters that must be controlled to meet the customer requirements. There are many varieties of QFD, and many variations of the charts used.

QFD was conceived in Japan in the late 1960s, during an are when Japanese industries broke from their post-World War II mode of product development through imitation and copying and moved to product development based on originality. QFD was born in this environment as a method or concept for new product development under the umbrella of Total Quality Control. The subtitle "An Approach to Total Quality Control" added to *Quality Function Deployment*, the first book on the topic of QFD written by Dr. Shigeru Mizuno and Yoji Akao (Akao,1997).

The QFD process involves constructing one or more matrices (sometimes called quality tables). The first of these matrices called the "House of Quality" (HOQ). It displays the customer's wants and needs along the top. The matrices consist of several sections or sub matrices joined together in various ways, each of them containing information related to the others.

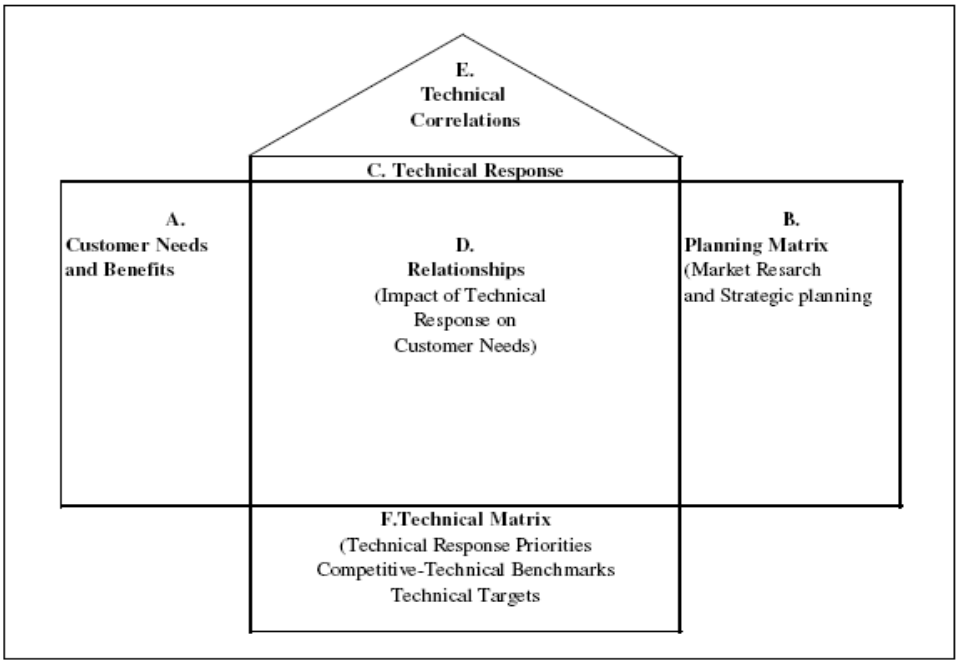


Figure 3.2 House of quality.

Each of the labeled sections, A through F, is a structured, systematic expression of a product or process development team's understanding of an aspect of the overall planning process for a new product, service, or process. The lettering sequence suggests one logical sequence for filling in the matrix.

The construction of this matrix is a step by step process. These steps can be listed below (Şen, Deveci, Yenginol & Gürkaynak,1999):

- Plan, determine the purposes and the necessary data,
- Collect the data,
- Use QFD to form information; analyze and understand the data,
- Spread the information in the organization,
- Use the information in decision making,
- Evaulate the information and the process,
- Improve the process.

Service companies attempt to learn about the customer satisfaction and they can improve the present service or designing a new service and estimate the requests of the customer before the customer gets the service, thus provide quality service and high customer satisfaction.

3.5.2 Fault Tree Analysis (FTA)

Fault Tree Analysis is a tool for analysis, visually displaying and evaluating failure paths in a system. Many people and corporations are already familiar with this tool and use it on a regular basis for safety and reliability evaluations. In some fields it is required for product certification (Ericson,1999).

FTA is a graphical representation of the major faults or critical failures associated with a product, the causes for the faults, and potential counter measures. The tool helps identify areas of concern for new product design or for improvement of

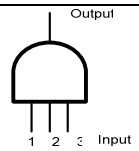
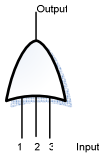
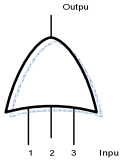
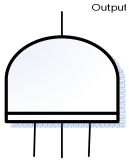
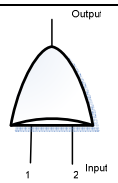
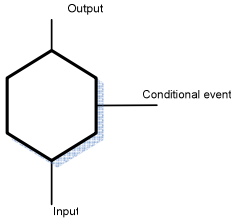
existing products. It also helps identify corrective actions to correct or mitigate problems.

The fundamental concept of FTA is the translation of the failure behavior of a physical system into a visual diagram and logic model. The diagram segment provides a visual model that very easily portrays system relationships and root causes fault paths. The logic segment of the model provides a mechanism for qualitative and quantitative evaluation. FTA is based on reliability theory, Boolean algebra and probability theory. A very simple set of rules and symbols provides mechanism for analyzing vey complex systems, and complex relationship between hardware, software and humans (Ericson,1999).

FTA is useful both in designing new products/services or in dealing with identified problems in existing products/services. In the quality planning process, the analysis can be used to optimize process features and goals and to design for critical factors and human error. As a part of process improvement, it can be used to help identify root causes of trouble and to design remedies and countermeasures.

The AND and OR combinations are also called gates. These gates and the other Gates in the FTA diagram are shown in Table 3.1.

Table 3.1 FTA symbols (Stamatis, 2003)

Name of Gate	Symbol of Gate	Input-Output relationship
AND Gate		The output event occurs if all of the n input events occur.
OR Gate		The output event occurs if at least one of the n input events occurs.
m-out of-n voiting gate		The output event occurs if m or more out of n input events occurs.
Priority AND Gate		The output event occurs if all input events occur in a certain order.
Exclusive OR Gate		The output event occurs if only one of the input events occurs.
Inhibit Gate		The input event causes the output event only if the conditional event occurs.

CHAPTER FOUR

FAILURE MODES AND EFFECTS ANALYSIS

4.1 What is Failure Modes and Effects Analysis?

Failure Modes and Effects Analysis is a systematic and analytic quality planning tool that is of use to determine the probable potential failures which can be occur in a product during the production of a product or till the last use of the person who purchase the product, in the production and the design of process stages (Aldridge, Dale, 1991).

FMEA is an engineering technique used to define, identify and eliminate known and/or potential failures, problems, errors, and so on from system, design, process, and/or service before they reach the customer (Omdahl,1988;ASQC,1983).

"FMEA is an analytic technique that is formed by determining the failures that is known or can be occured in a product or a process by using previous experiences or technology and planning that is used for these failures not to occur." (Besterfield,1999).

It is an efficient tool that is used to prevent the failures in the design and development stages. (Mizuna, Akao,1994).

Ownership quality is the customer's perspective of quality during the use of the product. Reliability, maintainability and serviceability are essential attributes of ownership quality and customer satisfaction. Probabilistic methods for reliability assessment have been a mainstay of engineering systems development for many years. Product development teams need to build in reliability at the early stages of design and FMEA can help adress this challenge (Kmenta, 1998).

FMEA is important technique for a reliability assurance program. It can be applied to a wide range of problems which may occur in technical systems and can be carried out in varying degrees of depth or modified to suit a particular purpose. The analysis is carried out in a limited way during the conception, planning and definition phases and more fully in the design and development phase. It is however important to remember that the FMEA is only part of a reliability and maintainability programme which requires many different tasks and activies. FMEA is an inductive method of performing a qualitative system reliability or safety analysis from a low to a high level (British Standards Institution [BSI], 1991).

FMEA is a technique practised by those companies that have adopted the philosophy of "Total Quality Management". This technique identifies potential problems and oppurtunities for early corrective action. FMEA will lead to a better product or service and improved customer satifaction (SMMT,1989).

Figure 4. 1 The place of FMEA in TQM (SMMT,1989)

Reliability according to the description in the standards; "The probability of a system to have the ability to provide the expected functions in specified conditions." (BS,4778). FMEA that is set correctly presents useful informations that provide to reduce the risks in the system, design, process or service to the person that applies.

Therefore, FMEA is a technique that provide the reliability assurance (Şen Ali, 1999).

In short, FMEA is an analysis that is conducted systematically to prevent all modes of failure effects that can occur in a product, service or process and is based on the design or process. This analysis can lead to predict the serious failures and to preventive activities by directing the inadequate resources on hand to the concerns that is more significant than the others.

History of FMEA

FMEAs have been around for a very long time. Before any documented format was developed, inventors and process experts would try to anticipate what could go wrong with a design or process before it was developed or tried. The trial and error and learning from each failure was both costly and time consuming. For example, each individual iteration of an invention might fail without a through thought experiment by a group of engineers or inventors and take advantage of their collective knowledge to reduce the likelihood of failure.

FMEA discipline is developed in the US army. The Military Procedure MIL-P-1629 that is called The Procedures on Failure Mode and Effects Analysis has been put in progress on November 9th 1949. It is used as a reliable evaluation technique for specifying effects of the system and hardware failures. The failures are classified according to mission succcess and effects on the personnel/hardware safety.

FMEA was used on 1960 by NASA in US Apollo Space Program. After its ten years of use in confidentiality, it has begun to be used in industrial field. Its first use in industry was in a Japanese computer firm NEC in 1975, then on 1980 FORD, 1985 FIAT SPA, has also used the technique.

FMEA is a technique that has recently been common in use. It has been begun, at first in the automotive sector, then food (Scipioni,2002), metal (Meidert, Hansel,

2000) and software (Zalewski,2003) sectors follow this, to use for preventing the failures in the various areas.

4.1.2 The Relationship Between FMEA and the Other Quality Techniques

The studies that are done in the quality area since the early 1980's, focus on the techniques that determine and eliminate the problems that can occur at each stages of comprising system, product or service, so that both increase the reliability and provide the continous improving. Continous improvement comes true by learning the problems that occured in the past and preventing these failures to occur in the future again. FMEA is a very important quality tool that is used for this objective. Controlling is important in TQM, but to find the failure by control never provides the success that is wanted. Instead of this, searching for the causes of the failures and trying to prevent these causes to occur is a more accurate approach. FMEA that is based on this approach, has an important function in TQM (Stamatis, 2003).

FMEA has an important mission in all of the quality systems. The relationship between FMEA and the other quality techniques is presented in Figure 4.2.

The relationship between some techniques in the figure and FMEA is summarized below.

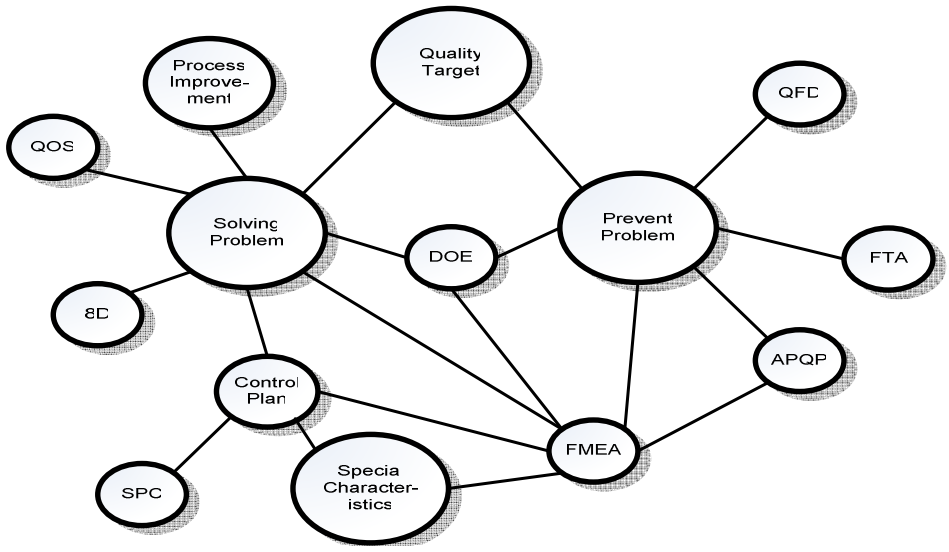


Figure 4.2 The Relationship between FMEA and other quality techniques (www.fmeca.com).

FTA graphically and logically presents the combination of the effects of the normal and probable erroneous events. FTA can be used in FMEA studies by finding the causes of failures and the probabilities of these.

The plan of control is a written summary of quality planning activities of the producer for a specified product, process or service. The process parameters and design characteristics that is important for the customer and require special prevention are listed in this plan. FMEA determines critical and significance characteristics and builds up a starting point for control plan (Stamatis, 2003).

Desgin of Experiments (DOE) is used in reliability testing and can identify the primary factors causing an undesired event. The optimum use of DOE in FMEA application is when there is a concern about several independent variables and/or an interaction effect of the causal factors (Stamatis, 2003).

The relationship between the various levels of the specified independent variable and the dependent variable is determined by the help of DOE. DOE is used to determine the compound effect of several independent variables and the cause of effects in FMEA studies.

QFD is the systematic translation of the “voice of the customer” to actions of the supplier required to meet the customer’s desires, based on a matrix comparing what the customer wants to how the supplier plans to provide it.

QFD is systematic methodology that brings together the various factions within the corporation (in a planned manner) and causes them to focus on the voice of the customer (Stamatis, 2003).

QFD and FMEA have a lot in common. They both aim at continual improvement; they both focus on elimination of failures; they both look for satisfied customers. Bacause of this overlap, one may think that they may be used interchangeably. That

is not so. QFD must be performed first and based on the results, the system FMEA will follow and so forth (Stamatis,2003).

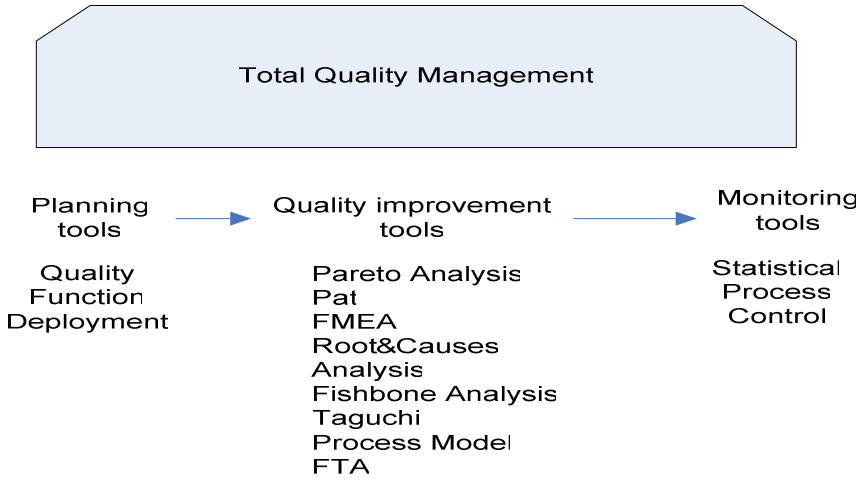


Figure 4.3 QFD-The impetus for planning (Stamatis,2003).

Statistical Process Control, is used to decide the risk of failures occuring and determine the failures after the failures occured in FMEA studies.

Additionally, FMEA can be used to determine the starting point of process improving.

4.1.3 The Subjects Related to FMEA

Every discipline has its own special language. This section addresses the specific words used in FMEA and their special meaning that the methodology of the FMEA that is used by the employs to communicate (Stamatis,2003):

Function: The task that the system, design, process, component, subsystem, service must perform. This function is very important in an understanding the entire FMEA process. It has to be communicated in a way that is concise, exact and easy to understand.

Failure: The problem**,** concern, error, challenge. The inability of the system, design, process, service or subsystem to perform based on the design intent. The designed intent usually comes from an analysis and an evaluation of the needs, wants or expectations of customer. The tool for such an analysis is QFD.

Failure Mode: This is the physical description of the manner in which a failure occurs. A failure mode may have more than one level depending on the complexity of the defined function. Example of failure modes include the following (Stamatis, 2003):

Open circuit	Cracked	Warped	Hole missing
Leak	Brittle	Blistered	Rough
Hot surface	Broken	Corroded	Short/Long
Wrong involve	Dirty	Grounded	Misaligned
Bent	Eccentric	Discolored	Omitted
Over/undersize	Melted	Burred	Binding

Causes of Failure: What is root cause of the listed failure. The more focused one is on the root cause, the more successful one will be in eliminating failures. When addresing the issue of a failure, be careful not to be too eager for a solution. A quick solution may result in becoming a victim of symptoms and short-term remedies, rather than complete elimination of the real problems.

Effects of Failure: The outcome of the failure on the system, design, process or service. In essence the effects of the failure have to do with the questions of: What happens when a failure occurs? What is (are) the consequence(s) of the failure? The effects of the failure must be addressed from two points of view. The first viewpoint is local, in which the failure is isolated and does not affect anything else. The second viewpoint is global, in which the failure can and does affect other functions and/or components. It has domino effect. Generally speaking, the failure with a global effect is more serious than one of a local nature. The effect of the failure has a direct

relationship with severity. So, if the effect is serious, the severity will be high (Stamatis,2003).

Process Validation: Controls that exist now, to prevent the cause(s) of the failure from occuring and the validate repeatability for certain process (Example: Validate the process for certain, C_{pk}).

Current Controls: Controls that exist to prevent the cause(s) of the failure from occuring in the design, process or service (Example: any SPC tool, DOE).

Data: System installation and checkout procedures, operating and maintenance instructions, inspections, calibration procedures, modifications, drawing, specifications and all performance items related to the system of operation (Ford Motor Company,2000).

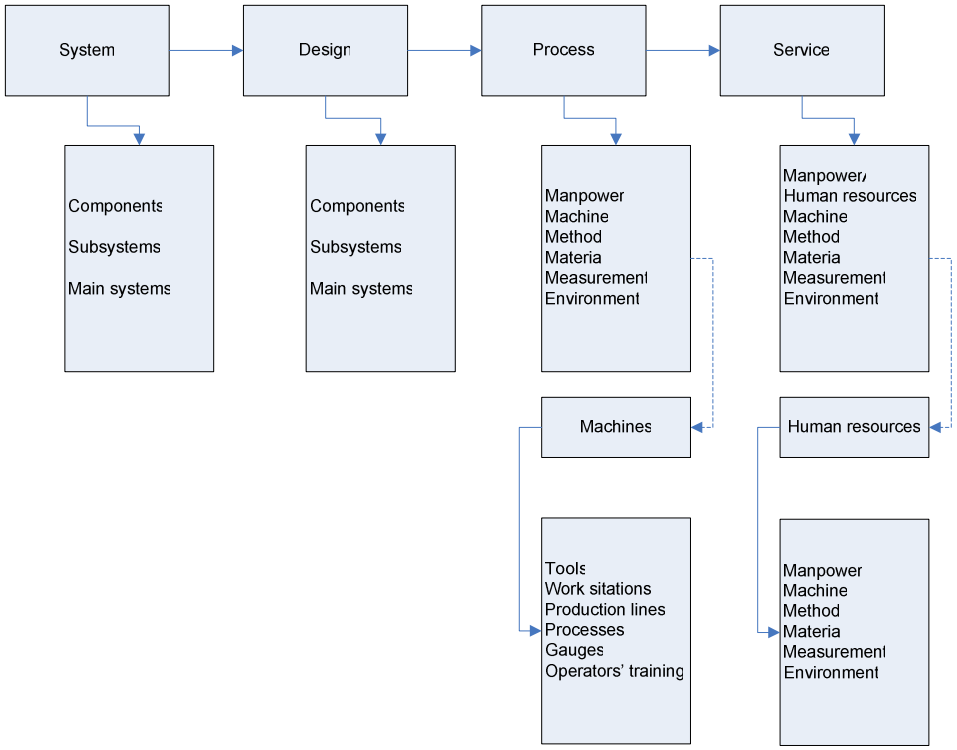
Failure Rate: The rate at which failures occur in a specified time interval (Omdahl,1988).

4.2 Types of FMEA

Generally, it is accepted that there are four types of FMEAs. In Figure 4.4, the relationships of the four FMEAs are shown with their respective focus and objective.

The four types are:

- System FMEA
- Design FMEA
- Process FMEA
- Service FMEA



Focus: Minimize failure effects on the system.	**Focus:** Minimize failure effects on the design.	**Focus:** Minimize failure effects on the total process (system)	**Focus:** Minimize failure effects on the total organization
Objective/goal: Maximize system quality, reliability, cost and maintainability	**Objective/goal:** Maximize design quality, reliability, cost and maintainability	**Objective/goal:** Maximize the total process (system) quality, reliability, cost, maintainability and productivity	**Objective/goal:** Maximize the customer satisfaction through quality reliability and service.

Figure 4.4 Types of FMEA.

4.2.1 *System FMEA*

The system FMEA is the highest FMEA that can be performed. It is used to identify and prevent failures that are related to systems or subsystems in early design concept stages. The system FMEA is performed to validate the system design specifications minimize the risk of functional failure during operation. Benefits and objectives of the system FMEA (Ireson, 1995):

- It identifies potential systemic failure modes caused by system interaction with other systems and/or by subsystem interactions, including those that may adversely affect safety or compliance with goverment regulations.
- It identifies potential system design parameters that may include deficiencies before hardware and/or software is released to production.
- It helps in selecting the optimum system design alternative.
- It enables actions to ensure that customer wants/ expectations are satisfied to be initiated as early as possible in the development cycle and quality planning phases of the system design.
- It acts as the basis for developing system diagnostic and system fault management techniques.
- It provides an organized, systematic approach to identifying all potential effects of subsystem, assembly and part failure modes for inclusion in design FMEAs.
- It servers as historical record of the thought processes and the action taken in product development efforts.
- It helps engineers to focus on eliminating product concerns and minimizing the probability of poorly performing products reaching the customer.
- It helps in determining, evaluating and improving the system design verification (SV) test programs.
- It helps in generating the failure mode occurrence ratings that can be estimate a particular system design alternative's reliability target.
- It helps in determining if hardware redundancy is required in order to meet the reliability requirements.

4.2.2 *Design FMEA*

The design FMEA is used as a tool to help identify and prevent product failures that are related to the product design. This FMEA can be performed upon a system, subsystem or component design proposal and is intended to validate the design parameters selected for a given functional performance requirement. Benefits and objectives of the design FMEA (Ireson,1995):

- It identifies potential design related failure modes at a system, subsystem or component level that may adversely effect safety or compliance with goverment requlations in early stages (prior to hardware release) so that design actions to eliminate or mitigate the concerns can be identified.
- It increases the probability that potential failure modes and their effects on vehicle/system performance have been considered in the design/development process.
- It identifies key critical and significant characteristics of a design.
- It enables actions to ensure that customer wants/expectations are satisfied to be initiated as early as possible in the product development cycle and quality planning phases of the product design.
- It aids in the objective evaluation of design requirements and design alternatives and provides a reference to aid in analyzing field concerns to develop advanced designs in future.
- It provides an organized, systematic approach to criticality reduction and risk reduction and establishes a priority for design improvement actions.
- It servers as a historical record of the thought processes and the action taken in product development efforts.
- It documents the rationale behind product design changes to quide the development of future product design.
- It helps engineers focus on eliminating product concerns and minimizing the probability of poorly performing products reaching the customer.
- It helps in determining, evaluating and improving design verification (DV) test programs by providing information to help plan a thorough product design verification test program.
- It assists in the evaluation of product design requirements and alternatives.
- It enhances organizational learning by serving as a depository for valuable “lessons learned” to help organizations avoid making the same error repeatedly.

4.2.3 *Process FMEA*

The process FMEA is used to identify and prevent failures that are related to the manufacturing or assembly process for a specific component/assembly or for a family of components/assemblies. Benefits and objectives of the process FMEA (Ireson, 1995):

- It identifies potential process failure modes at a system, subsystems or operation level that may adversely affect safety or compliance with government regulations so that actions can be taken to eliminate the concern or mitigate its effects.
- It identifies key process critical and significant characteristics and aids in the development of through control plans.
- It identifies potential process deficiencies early in the process planning cycle, enabling engineers to focus on control that will reduce the incidence of unacceptable products and the use of unacceptable methods and increase detection capability well before production begins.
- It enables actions to ensure that customer wants/expectations are satisfied to be initiated as early as possible in the process development cycle and quality planning phases of the process design.
- It eliminates or reduces product criticality through manufacturing and/or assembly process design improvements.
- It provides an organized, systematic approach to process change and process update prioritization.
- It establishes priorities for process improvement actions.
- It serves as a historical record of the thought processes and the action taken in process development efforts.
- It helps engineers focus on eliminating product concerns caused by the manufactoring or assembly process, thus minimizing the probability of poorly performing products reaching the customer.
- It helps in determining, evaluating and improving the produciton verification (PV) test programs.

- It documents the rationale behind process changes to quide the development of future manufacturing/assembly processes.

4.2.4 *Service FMEA*

The service FMEA is used to analyze services before they reach customer. A service FMEA focuses on failure modes (tasks, errors, mistakes) caused by system or process deficiencies. The benefits of service FMEA are that it (Stamatis,2003):

- Assists in the analysis of job flow.
- Assists in the analysis of the service and/or process.
- Identifies task deficiencies.
- Identifies critical or significant tasks and helps in the development of control plans.
- Establishes a priority for improvement actions.
- Documents the rationale for changes.

4.2.5 *Failure Mode, Effects and Criticality Analysis*

Failure Mode, Effects and Criticality Analysis (FMECA) is an enhancement of the FMEA methodology in which a criticality analysis is performed. Criticality analysis involves assigning a frequency to each failure mode and a severity to each failure effect. Criticality is a function of the severity of the effect and the frequency with which it is expected to occur. The purpose of this analysis is to rank each potential failure mode identified in the FMEA study according to the combined influence of severity classification and its probability of occurrence (http://www.dyadem.com/engineering/reliability_management/engineering_services/fmeca/).

4.3 FMEA Method

Generally in FMEA analysis, probable errors in the working system are determined, these errors eliminated by analyzing the reasons and the risks of these errors and the effects of these reasons.

Here, the important point is the time that FMEA studies are necessary to begin. Because of that the purpose of FMEA is to determine the known and potential problems before they reached the customer and to take precautions, FMEA studies must be began as early as possible.

Some situations that FMEA studies can be began are stated below (Stamatis,2003):

- While new systems, designs, processes or services is being formed,
- While the present system, design, product, process or service is being changed,
- While new applications are being found for the system, design, product, process or service that is in the present conditions,
- When the improvement for the system, design, product, process or services that are in the present conditions is decided.

FMEA studies continue as long as system, design, product, process or services continue. Only if the system, design, product, process or service end, FMEA studies finish.

Some conditions that FMEA studies will finish are stated below (Stamatis,2003):

- System FMEA, at the point that all the hardware and the design are decided.
- Design FMEA, at the point that the absolut date of production start is decided.
- Process FMEA, at the point that all the process are decided, evaluated and all of the critical and significant characteristies are moved to control plans.

- Service FMEA, can be finished at the point that the system design and personal missions are defined, are evaluated and significant characteristics are moved to control plans.

There isn't any standard application process for FMEA studies. Each company generally forms an application process with respect to its own organization structure and desires (Stamatis,2003).

FMEA steps can be generally arranged as below (Kaiser, 2002):

Step 1. Determination of FMEA scope
Step 2. Set of FMEA team
Step 3. Inspection/Examination of the process
Step 4. Determination of the probable error modes by brain storming
Step 5. Determination of potential reasons for each error mode
Step 6. Determination of potential error effects
Step 7. Assigment of the risk codes
Step 8. Taking precautions to decrease the risks by determining the priorities early
Step 9. After the forecasted precations, assigment of target risk codes
Step 10. Determination of responsibles for forecasted activies
Step 11. Observation of the activities and risk condition.

FMEA studies can be generally at 5 steps:

- Initial studies
- Determination of present controls to determine the errors
- Determination of Risk Priority Number (RPN)
- Determination of the errors and the precautions that are taken
- Application of the the precautions and computation of the new RPN values.

In this study, FMEA method will be examined at this 5 steps.

4.3.1 *Initial Studies*

This stage is formed by the preparations that have to be done before the start of FMEA applications. This stage can be summarized at three steps.

4.3.1.1 Determination of the Scope

At the beginning of the study, the goal and the limits of FMEA must be determined. By turning this to a written document, the informations about the system, design or process that will be examined can be added to this. While the scope is being determined, FMEA team and the responsibilities of this team must be determined, too (Kaiser,2002).

The point that must be payed attention is to divide the application area to small parts rather than very big parts. Therefore, beter results will be obtained. Another point that will be paid attention is numeric definition of the present situation and targets. This provides easiness and will also provide taking objective decisions.

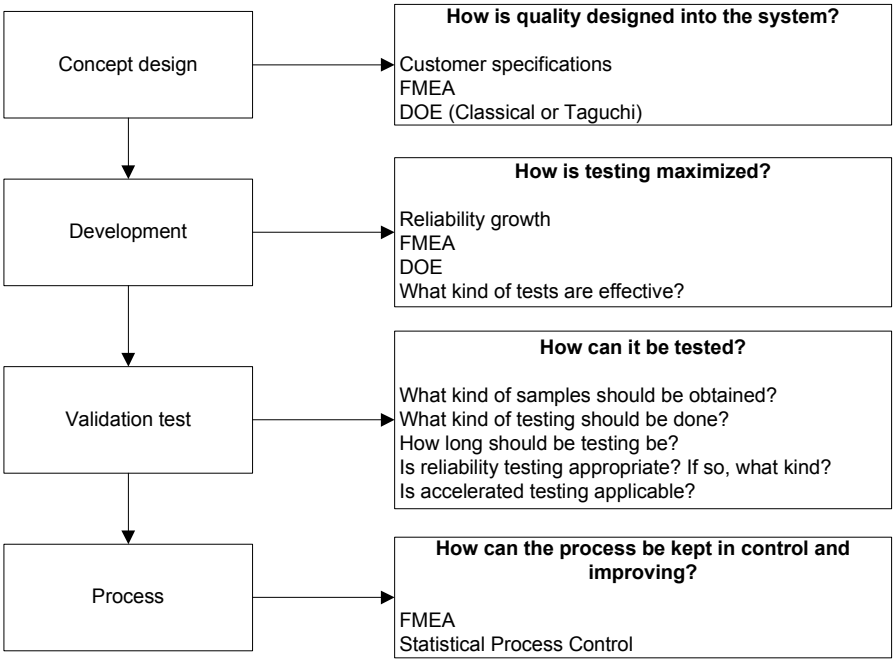


Figure 4.5 The road of FMEA (Stamatis,2003).

4.3.1.2 Set of FMEA Team

FMEA is a teamwork and can't be applicated alone. Although the application of the method by a person instead of a group can provide the information by finishing the analysis, this isn't wanted because of that biasness of evaluation can occur (Kaiser,2002).

The size of FMEA team is generally formed by from five to eight educated that know the process well and can produce ideas. At the head of the team must be a leader that coordinate the team and is an expert at FMEA subject. The presence of the people that are top management in the team, is significant for the results that are obtained from the study to be better.

4.3.1.3 Examination of the System, Design, Process or Service

For the success of FMEA studies, detail information about the examined system, design, process or service must be reached. For the reason, the subject that FMEA study will applicate to must be examined detailed.

Firstly, the functions of the product or the system, the form at working and production are determined. Usefulness and purposes of the functions, products or systems are defined. At this stages, work flow schemas can be helpful (Stamatis,2003).

4.3.2 *The Studies About the Errors in the System*

At the result of the initial studies, enough information about the subject, purpose, scope that FMEA will be applicated and the team that will applicate FMEA. The next stage is the examination of the potential errors at the subject that will be examined. Generally this stage and the initial stage are actually one within the other. This stage must be examined fussily, because it directly affects the later stages (Stamatis,2003).

4.3.2.1 Determination of the Probable Error Modes

Error mode is the situation that doesn't overlap the needs, desires and the expectations of internal and external customers and desired functions of a product or process can't be performed exactly. Error made is defined as physical property. While the probable error mode is being defined, the assumption of that error can occur but don't need to occur is accepted (Stamatis,2003).

While the probable error modes are being determined, some of the questions that is needed to answer are as below (Yılmaz, 1997):

- What are the probable problems related to the system, design, process or service?
- What are the situations of the product/service that don't provide the determined conditions?
- What is the unacceptable according to the customer?

Another approach that can be used to used to determine the probable error modes by FMEA team is the thing that must be in the product or the service or the determination of what the product or service consists. Each property that is wanted but not realized is an error.

Relationship diagrams and fishbone diagrams can be useful to determine the probable error modes. Also; customer complaints, similar product/service informations, previous FMEA studies will be helpful to determine the error modes.

4.3.2.2 Determination of the Probable Error Effects

Error effect; is the situation that can be experienced by the customer and form displeasure and danger. The probable error effect is the reaction of the customer when error becomes real.

The probable error effect, is determined by searching an answer to the question “If this error becomes, what modes of results will realize?” (Stamatis,2003).

While the probable error effects are being determined, the customer complaints, warranty datas, the studies in the similar situations and the previous FMEA studies are used.

4.3.2.3 Determination of the Probable Error Reasons

Error reason, is the factor that cause error to occur. The reason of the error its first event that cause error to occur.

The probable error reason is determined by searching an answer the question “What are the reasons that can cause the probable error mode?”. while the probable error reasons are being determined, probabilities below must be paid attention (Stamatis,2003):

- An error reason can cause to one or more error modes.
- More than one error reason can cause to one error mode.
- An error reason can consist of one or more factor.

Fishbone diagram and FTA are often used to determine the probable error reasons.

4.3.2.4 Determinations of Present Controls

The present controls, are controls that are at the beginning of FMEA study and are used to prevent the related error mode to occur and to go to the customer. The controls that are done to prevent an error to occur and to decrease help to find the detectability value (Stamatis,2003).

The weight, size controls, precautions as consultations that are performed in the companies can be presented as examples of controls.

4.3.3 *Evaluation of Error Modes*

After the probable error modes, effects, reasons and present controls were determined, next process error modes are evaluated according to their criticalities.

The essence of the FMEA is to identify and prevent known and potential problems from reaching the customer. To do that one has made some assumptions, one of which is that problems have different priorities. Thus, finding that priority is important and the thrust of the methodology. (Stamatis, 2003).

There are three components that help define the priority of failures:

- Occurrence (O)
- Severity (S)
- Detection (D)

Occurrence is the frequency of the failure. Severity is the seriousness (effects) of the failure. Detection is ability to detect the failure before it reaches the customer.

There are many ways to define the value of these components. The useful way is to use numerical scales (called critical guidelines). These guidelines can be qualitative and/or quantitative.

If the guideline is qualitative, it must follow theoretical (expected) behavior of the component. For example, in the case of the occurrence the expected behavior is normality. This behavior is expected because frequencies over time behave in normal fashion. Thus, the quideline should follow the normal distribution. In the case of severity, the expected bahavior is lognormal. This behavior is expected bacause the failures that occured should be of the nuisance category as opposed to critical or

catastrophic. Thus, the quideline should follow a distribution that skews to the right. In the case of detection, the expected behavior is that of a discrete distribution. This is expected because there is more concern if the failure is found by the customer as opposed to finding to failure within the organization. Therefore, there is a discrete outcome (internal organization versus customer) in the detection. Thus, the guideline should follow a distribution with a gap between the values (Stamatis,2003).

If the guideline is quantitative, it must be specific. It must follow actual data, statistical process control data, historical data and/or similar or surrogate data for evaluation. The guideline does not have to follow the theoretical behavior. If ıt does, it is strictly coincidence. Table 4.1, displays some of guidelines for the selection guideline (Stamatis,2003).

Table 4.1 Criteria for selecting ratings. (Stamatis,2003)

If	Then Use	Select
The system is similar to others or historical data exist.	Statistical data from either historical or surrogate systems: Reliability data, actual distribution, mathematical modelling, simulation.	Actual data and/or C_{pk}
Failure history is available with the system itself or similar, or surrogate parts	Historical data based on reliability, system, actual distributions, mathematical modelling, simulation, cumulative data, and/or fraction defectives.	Actual data and/or cumulative number of failures.
The system is new and/or no quantification for any data is available	Team judgment	Subjective criteria. Use team consensus and be conservative
The design is similar to others or historical data exist.	Statistical data from either historical or surrogate systems: Reliability data, actual distribution, mathematical modelling, simulation.	Actual data and/or C_{pk}
Failure history is available with the design itself or similar, or surrogate parts	Historical data based on reliability, system, actual distributions, mathematical modelling, simulation, cumulative data, and/or fraction defectives.	Actual data and/or cumulative number of failures.

The design is new and/or no quantification for any data is available	Team judgment	Subjective criteria. Use team consensus and be conservative
If	Then Use	Select
The process is under statistical process control (SPC)	Statistical data: reliability data, process capability, actual distribution, mathematical modelling, simulation.	Actual data and/or C_{pk}
The process is similar to others or historical data exist	Statistical data from either historical or surrogate systems: Reliability data, process capability, actual distribution, mathematical modelling, simulation.	Actual data and/or C_{pk}
Failure history is available with the design itself or similar, or surrogate parts	Historical data based on reliability, process, actual distributions, mathematical modelling, simulation, cumulative data, and/or fraction defectives.	Actual data and/or cumulative number of failures.
The process is new and/or no quantification for any data is available	Team judgment	Subjective criteria. Use team consensus and be conservative

The service is under statistical process control (SPC)	Statistical data: simulation	Actual data and/or C_{pk}
The service is similar to others or historical data exist	Statistical data from either historical or surrogate systems: Reliability data (queue modelling), process capability, actual distribution, mathematical modelling, simulation.	Actual data and/or C_{pk}
Failure history is available with the design itself or similar, or surrogate parts	Historical data based on reliability, process, actual distributions, mathematical modelling, simulation, cumulative data, and/or fraction defectives.	Actual data and/or cumulative number of failures.
The service is new and/or no quantification for any data is available	Team judgment	Subjective criteria. Use team consensus and be conservative

The ranking for the criteria can have any value. There is no standard for such value; hovewer, there are two way common ranking used in all industries today. One is ranking based on 1 to 5 scale and the second, 1 to 10 scale.

The ranking of 1 to5 is limited in nature, but offers expediency and ease of interpretation. It does not provide for sensitivity (accuracy) of specific quantification, because it reflects a uniform distribution. The ranking of 1 to 10 is used widely and, in fact, is highly recommended because it provides ease of interpretation, accuracy and precision in the quantification of the ranking. Rankings of higher than 1 to 10 scales are not recommended (even though they can be very precise and accurate) because they are difficult to interpret and lose their effectiveness (Stamatis, 2003).

The priority of the problems is articulated via the RPN. This number is a product of the occurrence, severity and detection. The value by itself should be used only to rank order and concerns of the system, design, product, process and service. All RPNs have no other value or meaning (Ford,2000).

4.3.3.1 Determination of Occurrence Values

Occurrence is the occurrence freguency of failure mode that a potential cause of failure will be occured.

Occurrence number does not refer to occurrence frequency of any failure, but it expresses meaning in accordance with occurrence number. Occurrence number is obtained by the rating which related to definitions expressing frequency of occurring failure. To obtain occurrence frequency, it is needed some initial informations related to the same or similar products. It can be seen the occurrence numbers in Table 4.2.

Table 4.2 Occurrence number of design FMEA (Ford Motors,& General Motors,1995)

Probability	Likely Failure Rates	Ranking
Very High: Persistent failures	≥100 per thousand pieces	10
	50 per thousand pieces	9
High: Frequent failures	20 per thousand pieces	8
	10 per thousand pieces	7
Moderate: Occasional failures	5 per thousand pieces	6
	2 per thousand pieces	5
	1 per thousand pieces	4
Low: Relatively few failures	0.5 per thousand pieces	3
	0.1 per thousand pieces	2
Remote: Failure unlikely	≤0.01 per thousand pieces	1

4.3.3.2 Determination of Severity Values

Severity is effect degreee of a potential failure mode on the customers. Severity number is used for rating severity of potential failure mode on the customers. Severity number for FMEA is indicated in Table 4.3.

Table 4.3 Severity number of design FMEA (Ford Motors,& General Motors,1995)

Effect	Criteria: Severity of Effect	Ranking
Hazardous without warning	Very high severity ranking when a potential failure mode effects safe vehicle operation and/or involves noncompliance with government regulation without warning.	10
Hazardous with warning	Very high severity ranking when a potential failure mode effects safe vehicle operation and/or involves noncompliance with government regulation with warning.	9
Very high	Vehicle/item inoperable, with loss of primary function.	8
High	Vehicle/item operable, but at rduced level of performance. Customer dissatisfied.	7
Moderate	Vehicle/item operable, but comfort/convenience item(s) inoperable. Customer experiences discomfort.	6
Low	Vehicle/item operable, but comfort/convenience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.	5
Very Low	Fit & Finish/squeak & Rattle item does nort confirm. Defect noticed by most customer.	4
Minor	Fit & Finish/squeak & Rattle item does nort confirm. Defect noticed by average customer.	3
Very Minor	Fit & Finish/squeak & Rattle item does nort confirm. Defect noticed by discriminating customer.	2
None	No effect.	1

4.3.3.3 Determination of Detection Values

Detection is probability that potential design or process failures is detected before the products reach to the customers.

Detection number is related to detection probability of failure mode in design or process FMEA before the products reach to the customer. It can be seen the detection numbers in Table 4.4.

Table 4.4 Detection number of design FMEA (Ford Motors,& General Motors,1995)

Probability of Detection	Ranking
Absolute Uncertainty: Design control will not and/or can not detect a potential cause and subsequent failure mode; or there is no design control.	10
Very Remote: Very remote chance the design control will detect a potential cause and subsequent failure mode	9
Remote: Remote chance the design control will detect a potential cause and subsequent failure mode	8
Very Low: Very low chance the design control will detect a potential cause and subsequent failure mode	7
Low: Low chance the design control will detect a potential cause and subsequent failure mode	6
Moderate: Moderate chance the design control will detect a potential cause and subsequent failure mode	5
Moderately High: Moderately chance the design control will detect a potential cause and subsequent failure mode	4
High: HİIgh chance the design control will detect a potential cause and subsequent failure mode	3
Very High: Very high chance the design control will detect a potential cause and subsequent failure mode	2
Almost Certain: Design control will almost certainly detect a potential cause and subsequent failure mode	1

4.3.3.4 Computation of RPN

Risk Priority Number (RPN) is a risk measure acquired with multiplying by occurrence, severity and detection numbers.

The threshold of pursuing failures/problems is an RPN equal to or greater than 50 based on a 95 percent confidence and 1 to 10 guideline scale. By no means is this a standard or a universal number. It can and does change with the scale chosen and the statistical confidence the engineer wants. Of course, there is no limit to pursuing all failures, if that is the goal. At that point the order is determined by the magnitude of the RPN for each failures (the high RPN failures are addressed first, then the lower and so on until all failures have been resolved). To undertake an analysis of all problems at the same time is not recommended and is contrary to the philosophy of the FMEA (Stamatis,2003).

The threshold can be changed for any given statistical confidence and/or scale. For example, say 99 percent of all failures must be addressed for a very critical system, design, product, process and/or service on a guideline scale of 1 to 10. What is threshold? The maximum number possible for RPN is 1000 (10 x 10 x 10 from occurrence, severity and detection). Ninety-nine percent of 1000 is 990. Now subtract 1000–990=10. Therefore, the threshold of examining the failures would be anything equal or greater than a 10 RPN. If the statistical confidence is 90 percent with a scale of 1 to 10, then the threshold becomes 100, and so on (Stamatis,2003).

If the scale is 1 to 5, then the threshold changes accordingly. The method is same, however the total number is 125 instead of 1000. Thus in a 90 percent, 95 percent and 99 percent confidence the RPN of concern is 13, 7 and 2, respectively.

4.3.3.5 FMEA Form

FMEA forms are used to record regularly informations that are obtained by FMEA study, to make FMEA process easy and to create a certain standard. In these forms, there are generally information about FMEA type, error mode, the cause, effects and results of the error, present controls, RPN values, FMEA responsible and the precautions that will table. An example FMEA form is represented below.

Table 4.5 FMEA Form (SMMT,1989)

FAILURE MODES &EFFECTS ANALYSIS																	
Item	Part No Name Issue	Function or Process	Failure Mode	Effects of Failure	Cause of Failure	Current Mode	Current Status				Recommended Corrective Action	Action By	Action Taken	Revised Status			
							O	S	D	RPN				O	S	D	RPN

4.3.4 *Evaluation of RPN*

After RPN are computed, the errors are ordered from big values to small values according to this value. After this stage, the error modes that will be took precautions and the precautions for these error modes are determined.

4.3.4.1 Determination of the Error Modes that will be Took Precautions

After the RPN has been determined, the evaluation begins based on the definition of the risk. Usually this risk is defined by the team as minor, moderate, high and critical. It may be changed to reflect different situations (Stamatis,2003):

- Under minor risk, no action is taken.
- Under moderate risk, some action may take place.
- Under high risk, definite action will take place (Selective validation and evaluation may be required.).
- Under critical risk, definite actions will take place and extensive changes are required in the system, design, product, process and/or service.

In Ford Engine Company FMEA Applications, the decisions of taking corrective according to RPN values are made in respect of this metric:

- If RPN <40, there is no need to take precaution.
- If $40 \leq RPN \leq 100$, taking precaution is profitable.
- If RPN>100, taking precaution is a must.

FMEA applications that are made in Renault, the errors that are RPN>100 are stated as errors that corrective precaution must be took. The error that has maximum value above 100, is a error mode that must be examining first, because of that it will have the maximum risk.

If there are more than two failures with same RPN, then first address the failure with high severity, and then detection. Severity is approached first because it deals with the effects of the failure. Detection is used over the occurrence because it is customer dependent, which is more important than just the frequencies of the failure (Stamatis,2003).

4.3.4.2 Determination of the Precautions that will be Took

The objective of the precautions that will be took as an result of FMEA studies is to decrease the RPN values. To decrease the RPN values, the values of occurrence, severity and detection must be decreased.

The precautions that will be took to decrease the occurrence values are stated as below:

- Plans
- Production methods, work flow schemas
- Organization
- Designs
- The changes that will be done at enviroment and protection conditions.

To decrease the severity values, the changes must be done at product or system design. The degreee of severity may not be changed in some situations.

To decrease the detection values are stated as below (Stamatis,2003):

- To increase the freguency of controls.
- To increase the reliability of the control method.

To decrease the RPN values, the factor value that is decreased, is determined by taking account the profit that will obtain and cost.

4.3.4.3 Applications of Difficulties

Applications of the precautions consitutes the dynamic stage of FMEA. At first, the people that will take the precautions and the length of time that these precautions will have been applicated, are determined. Then it is determined whether the forecasted precautions were applicated efficiently or not. At this stage the results are examined and evaluated till the critical RPN values are lost. When the RPN values reach the desired level, a new FMEA application is started to determine the new RPN values and new error modes that may become real in some situations.

4.3.5 *The Advantages and Difficulties of FMEA*

4.3.5.1 The Advantages of FMEA

Provided by FMEA are examined, everybody can see that quality and reliability of companies are increased by this technique, and qualified products are produced with less cost and less error. Also, the studies in order to preventing faulty products before they reached the customers, increase the customer satisfaction and the power of competition.

If the provides of FMEA are examined (Bolat,2000):

- It inspects systematically the error modes to prevent even the minimum loss that are derived from the error in system, product, process or service.
- It defines each error mode that may be effect the system, product, process or service and the effect and the cause of these errors.
- It determines the criticalities of these defined errors and it defines the probable maximum damage and the effects of this damage.
- It determines the probability of occurrence of any error.
- It determines the weak, lacking and inadequate point of the system, product, process or service.

4.3.5.2 The Difficulties of FMEA

The biggest difficulty at the application of FMEA technique is caused by lack of data. The lack of all information about FMEA, the lack of a reliable database make FMEA applications difficult and may cause the unhealthy results.

Also, the lack of an common standard and unwillingness of people who are at top management decrease the productivity that will be obtained.

Ordering the error modes that have same RPN values and the accepting the severity of risk factors same form the the most of reviews about FMEA technique. Furthermore, it becomes inadequate at digitizing technique, risk factors in the conditions that the data is inadequate (Pillay, Wang, 2003). Fuzzy logic approach is recently used across these reviews about FMEA technique (Price, Taylor, 2002).

CHAPTER FIVE

APPLICATION

5.1 Introduction and Brief History of the Company

ESHOT General Directorate was founded in 1943 to give a wide range of services as electricity, water, gas and urban public transport to Izmir. It is an experienced, knowledgeable and deep-rooted company that is independent budgeted, but affiliated with Metropolitan Municipality of Izmir. It constituted Turkish Electricity Administration and Izmir Water and Sewerage Administration from its structure.

Today, ESHOT General Directorate continues its studies to do its efficient role and mission in the urban public transport network of Izmir as targeted modern measures. Therefore, it endeavors to make it fleet conservationist, new, rejuvenate and large by means of its present fleet and buying new buses.

ESHOT General Directorate today transports passengers in an area of 50000 hectares and consolidate its fleet by buying new buses in parallel with population growth rate. It gave service in general directorate buildings that were in Karataş, Gümrük, Basmane, Yeşilyurt and Konak. It lastly moved to the service building in Gediz Heavy Maintenance Workshop on March, 1997.

ESHOT is a company that continously gives service and transports averagely 850000 passengers daily by a bus fleet that has 1258 buses. It realizes nearly 62% of the urban public transport in Izmir. Today, it has 320 lines and gives services successfully in a wide area of from the west to the east, from the south to the north of Izmir and to the municipal corporations that are around Izmir. ESHOT General Directorate is a company that adopts continous improvement as a principle to give more qualified service to the citizens of Izmir.

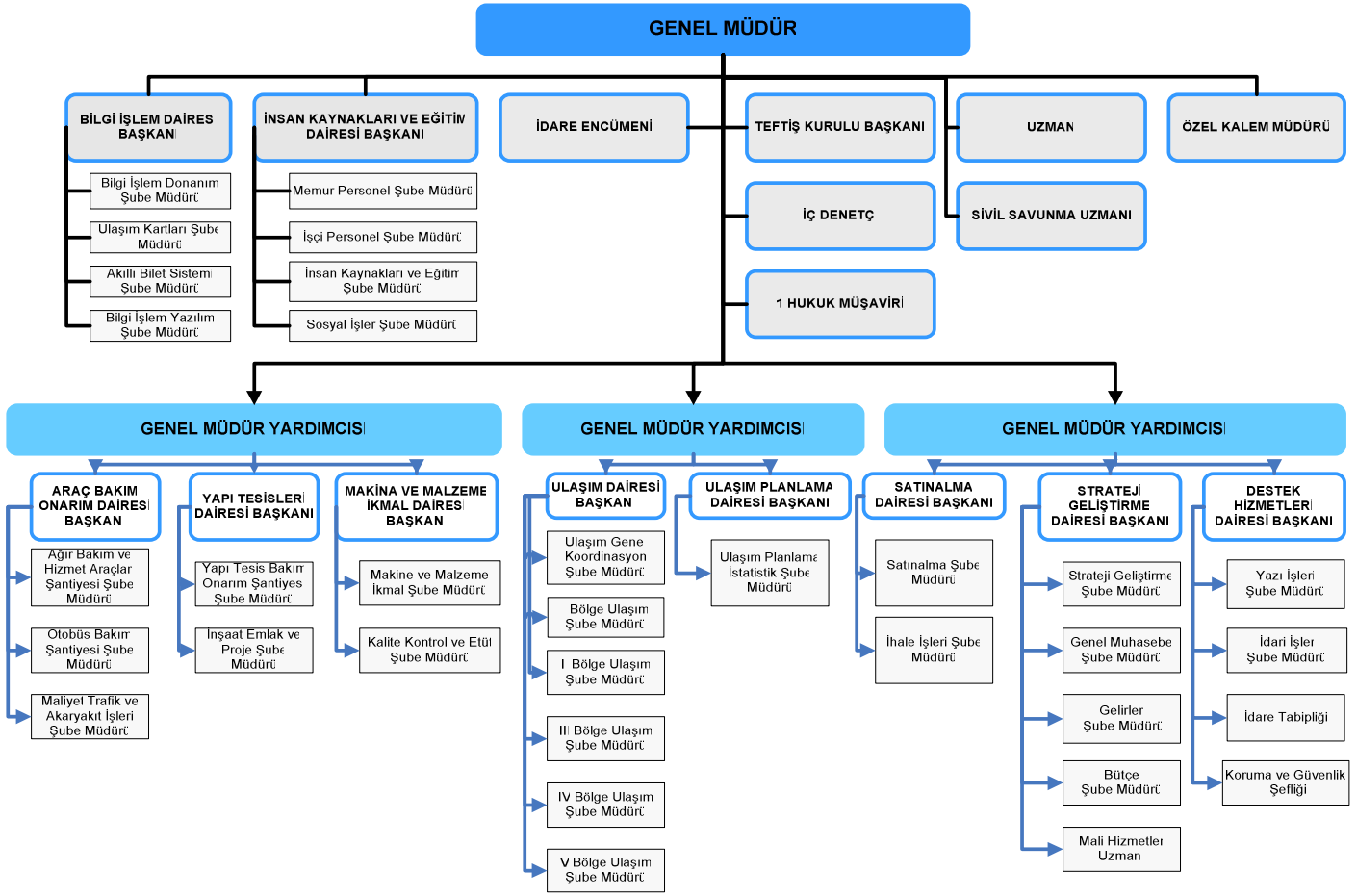


Figure 5.1 Organizational Structure.

Table 5.1 ESHOT General Directorate Regions and Number of Lines

Region	Region Name	Number of Lines
Region I	Konak	81
Region II	Karşıyaka	82
Region III	Buca	61
Region IV	Bornova	48
Region V	İnciraltı	48

5.2 Measurement of ESHOT Service Quality by Servqual Method

Whether the citizens that live in İzmir are satisfied with services of ESHOT is an important subject for both government of the Metropolitan Municipality of İzmir and ESHOT. Although the service quality and complacency seem cognitively different, they are very related from the point of their basic structures. If the performance of service drops down below the expectations, the customer will not be satisfied with this service.

The service quality of ESHOT is studied to measure by using servqual technique. Servqual technique is a technique that is developed by Parasuraman, Zeithaml and Berry and can be applied to all service organizations to measure the perceived service quality of the firms that present service by customer perception.

5.2.1 The Goal of the Research

The detection of the expectations of the passengers for the service quality criterias and how these criterias are perceived by ESHOT to measure the quality of the public transport service that is given by ESHOT in İzmir-Karşıyaka region and the complacence of the passengers that take this service is the goal of this study.

5.2.2 The Model of the Research

In this research, the servqual technique will be used as stated before. This technique can be applied to three different groups. First of these, the customers (passengers) who are really the decision makers of the quality, the second; the managers of the company that gives the service and the last group is the personel who give the service. In the section that is applied to the customers, the goal is to measure the service quality, as for the section that is applied to the managers and personel, to determine the reasons of low service quality.

The servqual technique identifies the service quality as the measure of the difference between the expectations of the customers and the perceptions of the services that are given by the company.

Service Quality = Perceived Service – Expected Service

According to this, the difference between the service that is expected and that is perceived by passengers is accepted as the service quality and this model is presented in summary in Figure 5.2.

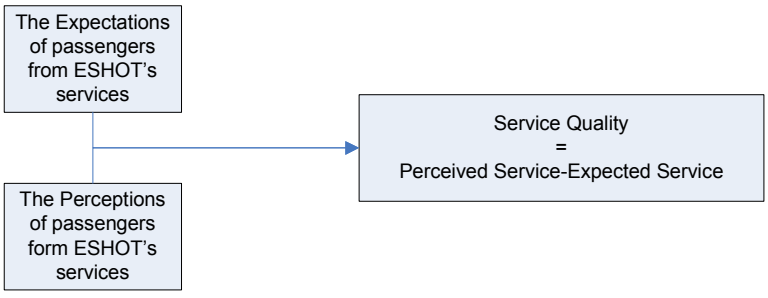


Figure 5. 2 The Model of Research.

5.2.3 The Sampling Method of the Research and Obtainment of Data

This research contains passengers in İzmir-Karşıyaka region that use ESHOT buses as public transport vehicles.

The data that are necessary for the research were obtained by simple random sampling. Sample size was computed by

$$n = \frac{Npq}{(N-1)D + pq}$$ (Taro Yamane,1967)

In this formula;

N : the size of population

p : the ratio of people that are satisfied with the service quality

q : the ratio of people that aren't satisfied with the service quality ($q = 1 - p$)

B : Bound on the error of estimation;

D is computed as, $D = \frac{B^2}{4}$ (Yamane,T.,1967)

In this research, p and q values were accepted as 0.5. The reason is that a similiar study hasn't been applied before in ESHOT, moreover the size of the sample becomes the largest because of that the value max $p \cdot q$ is obtained when $p = 0.5$.

In the research, all of 150000 (daily mean-ESHOT Statistics Branch Office) passengers that ESHOT given service in one day in Karşıyaka region are expected as the population. Bound on the error of estimation part is determined as %10 ($B = 0.10$) and as a result, the size of the necessary sample for this research is found as 100.

In five days that are ramdomly selected from the fifteen days between 28.04.2008 and 12.05.2008, everyday in two lines were selected randomly from 82 Karşıyaka

region lines that are given in Appendix 1. The questionnaire that in Appendix 3 as an example is applied to the passengers who sit at randomly selected seat numbers by 2 pollster by face to face method. The sampling plan of this research was given in Appendice 2.

The questionnaire form that is developed to measure the service quality and consists of two stages is given in Appendix 3. At the first stage of the questionnaire, there are 22 guestions that have questions related to the expectations of passengers about ESHOT and how they find the performance of ESHOT. In the answering of questions, expectation and perceive levels defined by numbers between 1 and 7 by using Likert scale. The statement “I certainly don’t agree with” is 1 point, as for the statement “I certainly agree with” is 7 point. At the second stage, in the assesment of the service quality of ESHOT, the goal is to build the signifance order of the service quality criterias. Accordingly, total 100 point, is wanted to be portioned out by the passengers.

5.2.4 Analysis of the Data

In the analysis of the data, SPSS and Minitab statistical package programmes were used. The reliability analysis was done to test the reliability of the scale that was used in the research. Bacause of that the service quality had multi criteria, Cronbach α that presented the coefficient of reliability was computed individually for each criteria for t-test was used for the significance of the difference between expectation and perception means, as for the variance analysis for the analysis of grouped variables.

5.2.5 Reliability of the Model

The reliability which is are of the properties that the scale need to have, is an indicator of consistency of measurement values that are obtained by measurements that is replicated in same conditions by a measurement instrument (Carey, 1988).

The coefficient of alfa method that was developed by Cronbach (1951), is an internal consistency prediction method that is suitable in the conditions that have a scoring system as 1-3, 1-5, 1-7, not true-false. The coefficient of Cronbach alfa that is found by dividing the sum of the variance of k item that is in the scale by general variance, is a weighted standard variation mean. The coefficient of alfa can have values between 0 and 1. If this coefficient that is found;

$0 \le \alpha < .40$ the scale is not reliable,
$0.40 \le \alpha < .60$ the scale has a low reliability,
$0.60 \le \alpha < .80$ the scale is reliable,
$0.80 \le \alpha \le 1$ the scale is too reliable is accepted.

The coefficient of Cronbach alfa was computed as in the reliability analysis that is done for the items related to the expectations of servqual scale that is used in the research, the coefficent of Cronbach alfa was computed as 0.844, in the reliability analysis that is done for items related to the perceptions of the customers for the given services, the coefficient of Cronbach alfa was computed as 0.921. These coefficients that were computed demonstrate that the reliability of the scale applied was high.

5.2.6 Measurement of the Service Quality

Servqual score were computed by using the datas that were obtained from the survey study that was applied to the passengers. While the servqual scores were being computed, the algorithms that were given in Chapter 2 were considered, two different service quality values as weighted quality and unweighted quality values

were computed. In Table 5.2, expected and perceived service quality means for each question and unweighted servqual scores that were computed by using these means were given. In Table 5.3, weighted and unweighted servqual scores were briefly presented together.

Table 5.2 Perception and Expectation Scores of Paseengers from ESHOT and Servqual Scores

Dimensions	Question No	Perceived Service				Expected Service				Servqual Score		
		Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Difference	Dimension	Mean
Tangibles	1	1	7	4.69	1.48	2	7	6.12	1.01	-1.43	-1.15	-1.425
	2	1	7	4.43	1.46	1	7	5.59	1.32	-1.16		
	3	1	7	5.31	1.42	1	7	6.53	0.87	-1.22		
	4	1	7	4.26	1.64	1	7	5.03	1.76	-0.77		
Reliability	5	1	7	4.71	1.68	4	7	6.50	0.85	-1.79	-1.77	
	6	1	7	4.19	1.69	2	7	6.40	0.94	-2.21		
	7	1	7	4.28	1.70	1	7	5.49	1.60	-1.21		
	8	1	7	4.65	1.72	3	7	6.53	0.74	-1.88		
	9	1	7	4.50	1.70	3	7	6.26	0.99	-1.76		
Responsiveness	10	1	7	4.52	1.63	1	7	6.23	1.05	-1.71	-1.75	
	11	1	7	4.28	1.76	3	7	6.29	0.95	-2.01		
	12	1	7	4.43	1.76	3	7	6.42	0.90	-1.99		
	13	1	7	4.54	1.61	1	7	5.81	1.33	-1.27		
Assurance	14	1	7	4.70	1.70	1	7	6.51	0.89	-1.81	-1.66	
	15	1	7	4.90	1.52	2	7	6.46	0.90	-1.56		
	16	1	7	4.50	1.71	1	7	6.17	1.17	-1.67		
	17	1	7	4.36	1.74	1	7	5.94	1.38	-1.58		
Empathy	18	1	7	3.38	1.87	1	7	3.82	2.23	-0.44	-0.86	
	19	1	7	3.18	1.97	1	7	3.92	2.33	-0.74		
	20	1	7	3.31	1.97	1	7	4.31	2.22	-1.00		
	21	1	7	3.84	1.76	1	7	4.98	1.98	-1.14		
	22	1	7	3.35	1.98	1	7	4.35	2.17	-1.00		

Table 5.3 Score of Service Quality

Dimensions	**Unweighted Servqual Scores**	**Weighted**	**Weighted Servqual Scores**
Tangibles	-1.145	%24.30	-0.278
Reliability	-1.770	%28.10	-0.497
Responsiveness	-1.745	%18.20	-0.318
Assurance	-1.655	%18.95	-0.314
Empathy	-0.864	%10.45	-0.090
Unweighted Servqual Score		-1.425	
Weighted Servqual Score		-1.497	

Negative values being present in Table 5.3 show that Gap 5 exists. When the unweighted and weighted servqual scores are taken into consideration, it is seen that the highest value is on dimension of reliability. Responsiveness and Assurance dimensions in both unweighted and weighted servqual score are seen to be higher than the others.

Gap 5 forms by collecting the other four gaps together. These four gaps' directions and degrees make a positive or negative effect on the expected-perceived service gap. In other words, in the case of absence of these gaps, there won't be Gap 5, therefore expected and perceived service qualities will be equal. Consequently, the other four gaps and their roots were strived to measure. At first, the questionnaire that includes the questions that are related with their perceptions of the customer expectations and is given in Appendix 4 was applied to the managers of ESHOT General Directorate. Gap 1 values that were computed by taking differences between the answers of the passengers and the answers of the managers to the questionnaire in Appendice 3 and the weighted gap 1 values are given in Table 5.4.

Table 5.4 Scores of Gap 1

Dimensions	**Unweighted Servqual Scores**	**Weighted Servqual Scores**
Tangibles	-0.599	-0.146
Reliability	0.011	0.003
Responsiveness	0.490	0.089
Assurance	-0.313	-0.059
Empathy	-0.424	-0.044
Unweighted Servqual Score	-0.171	
Weighted Servqual Score	-0.157	

When the scores of Gap 1 are examined, the case that the values for tangibles, assurance and empathy dimensions are negative is seen. This is a demonstration of the right perceptions of these dimensions' expectations by top management. For reliability and responsiveness dimensions, Gap 1 values are positive. The management's wrong perception of the customer expectations is seen as the reason of this. Especially for responsiveness dimension, one can conclude that service quality being effected adversely by the passengers' expectations not being answered.

The questionnaires that are given in Appendice 5 were applied to the managers and personel to measure Gap 2, Gap 3 and Gap 4. Gap 2, Gap 3 and Gap 4 were computed as 4.553, 4.730 and 5.261 respectively and a high value is defined as a small gap. These values show that the expectations of the passengers can not be met because of lack of some standards, not being able to meet present standards from time to time and having some problems while the commited services are tried to actualize.

At the next stage, by applying the questionnaire including 20 questions in Appendice 6 to the managers, Gap 1 and Gap 2 roots, by applying the questionnaire including 30 questions in Appendice 6 to the personnel, Gap 3 and Gap 4 roots were measured. These results were given in Table 5.5 and 5.6.

Tablo 5.5 Scores of Gap 1 and Gap 2 Roots

Gap 1 Roots	**Scores**
Lack of Marketing Research Orientation	3.740
Inadequate Upward Communication	3.948
Too Many Levels of Management	5.083
Gap 2 Roots	**Scores**
Inadequate Management Communication to Service Quality	3.063
Absence of Goal Setting	4.833
Inadequate Task Standardization	5.208
Perception of Infeasibility	4.139

Tablo 5.6 Scores of Gap 3 and Gap 4 Roots

Gap 3 Roots	**Scores**
Role Ambiguity	4.493
Role Conflict	4.375
Poor Employee-Job Fit	5.429
Poor Technology-Job Fit	5.857
Inappropriate Control Systems	4.917
Lack of Perceived Control	4.054
Lack of Teamwork	5.971
Gap 4 Roots	**Scores**
Inadequate Horizontal Communication	4.321
Propensity to Overpromise	4.411

The smallest score for the antecedents of a gap, given that gap exists, is assessed as the most possible cause of the gap to which it belongs. When the scores of the gaps' antecedents in the tables are observed, the smallest scores for antecedents of gaps is obtained in antecedents of, for Gap 1, lack of marketing research orientation and inadequate upward communication; for Gap 2, inadequate management communication to service quality; for Gap 3, lack of percieved control, role conflict and role ambiguity; and for Gap 4, inadequate horizontal communication.

5.2.7 Conclusions and Statistical Analyses on Passenger's Expectations and Perceptions

The levels of the passenger's expectations and perceptions from the service and descriptive statistics are given on Table 5.2. To determine whether or not there is a significant difference in between the means of expectation and perception scores, t test is applied for 0.05 significance level.

H_0 : $x_i'th$ statement's expectation and perception means do not have a significant difference.

H_1 : $x_i'th$ statement's expectation and perception means have a significant difference.

(for all i; i: 1,2,3,…,22)

In all the questions except the eighteenth question, H_0 hypotheses are rejected. Though the property that is measured in the eighteenth question is not an expected or a perceived property in public transport services, one can say that there are significant differences between the expectations and perceptions of the passengers for all the questions.

The mean values of the passenger's expectations for each dimension and other descriptive statistics are given on Table 5.7.

To determine whether or not there is a significant difference in between the means of expectation and perception for each servqual dimension, t test is applied for 0.05 significance level.

Table 5.7 Descriptive statistics concerning passenger's expectation and perception scores for each dimension

		Expectation				Perception			
Dimensions	**N**	**Min**	**Max**	**Mean**	**Standard Deviation**	**Min**	**Max**	**Mean**	**Standard Deviation**
Tangibles	100	1	7	5.818	0.800	1	7	4.673	1.080
Reliability	100	1	7	6.236	0.617	1	7	4.466	1.279
Responsiveness	100	1	7	6.188	0.754	1	7	4.443	1.301
Assurance	100	1	7	6.270	0.769	1	7	4.615	1.316
Empathy	100	1	7	4.276	1.742	1	7	3.412	1.543

To determine whether or not there is a significant difference in between the means of expectation and perception for each servqual dimension, t test is applied for 0.05 significance level.

H_0 : The means of expectation and perception for the i' th dimension do not have a significant difference.

H_1 : The means of expectation and perception for the i' th dimension have a significant difference.

(for all i; i: 1,2,3,4,5)

Table 5.8 Results of the test for each dimension

Dimensions	Difference	%95 CI for difference	T-value	P-value
Tangibles	-1.145	(-1.41036; -0.87964)	-8.51	0.000
Reliability	-1.770	(-2.05083; -1.48917)	-12.46	0.000
Responsiveness	-1.745	(-2.04211; -1.44789)	-11.60	0.000
Assurance	-1.655	(-1.95612; -1.35388)	-10.85	0.000
Empathy	-0.864	(-1.323159; -0.404841)	-3.71	0.000

According to the results of the test, H_0 is rejected for all dimensions and the significant difference between means of expectation and perception is noted.

5.2.8 Variance Analysis (ANOVA)

In the questionnaire that was applied to the passengers, the statements were wanted to define by the passengers by means of a scale that had values between 1 and 7. In this case, because of that the result of the service quality is simply obtained by substracting the perceived value from the expected value, the result for each statement will change between -6 and +6.

Accordingly, the service quality of passengers is classified to 3 groups according to the evaluation values; if the value is between -6 and 0 bad quality, if it is 0 good quality, if it is between 0 and +6 perfect quality conclusion is made. (Parasuraman, Zaitham&Berry, 1988).

Based on the dimensions the measurement on the unweighted and weighted servqual scores, according to the values for mentioned three groups are:

H_0 : There is no significant difference between group mean values for the dimension.

H_1 : At least one of the dimensions has a different mean than others.

Hypotheses are tested with one-way variance analysis method for 0.05 significance level.

At the result of the analysis, in the unweighted test scores, H_0 hypothesis was rejected and a significant difference between the dimensions was found. Accordingly, a significant difference between reliability and assurance dimensions was not found and these dimensions took place in the bad quality group. Moreover, although they were better than these three dimensions, there wasn't any significant difference between tangibles and empathy dimensions, these dimensions took place in the bad quality group, too.

In the weighted test scores, H_0 was rejected, a significant difference between the dimensions was found. Accordingly, because of that a significant difference between

tangibles, responsiveness and assurance dimensions wasn't found, these three dimensions took place in the bad quality group. Although reliability dimension was worse than these three dimensions and empathy dimension was better than these three dimensions, these dimensions took place in the bad quality group.

5.3 The FMEA Analysis of ESHOT

FMEA analysis was applied by a team that had 7 people and was constituted within the body of ESHOT. Occurrence, severity and detection scores and corrective activities that were suggested in consequence of the analysis were obtained by brain storming method by this team.

The analysis of any process by FMEA method is carried out by the process FMEA, determination of the flowprocess schema of the process is necessary to apply the process FMEA.

ESHOT is a company that is in service in many different areas as public transport to the maintenance of buses, a variaty of social- cultural works to the education. In this study, the public transport proceses that are accepted as the primary mission of ESHOT will be examined. The other proceses are accepted as supporter processes to this primary process.

There are a beginning, an ending point and a constant route for each line, but also the process that start at the beginning point at certain times, continues by following the bus stops in the roule, amd finishes at the ending point.

The determination of the potential errror mode is needed to analyse the process by FMEA. The effects and the reasons of the error mode be defined depending upon the potential error mode. In this study, the conceptional factors that build up the gaps in the service quality were taken as the error mode and each gap process was analyzed by using FMEA form. The analysis was done is given in Table 5.12.

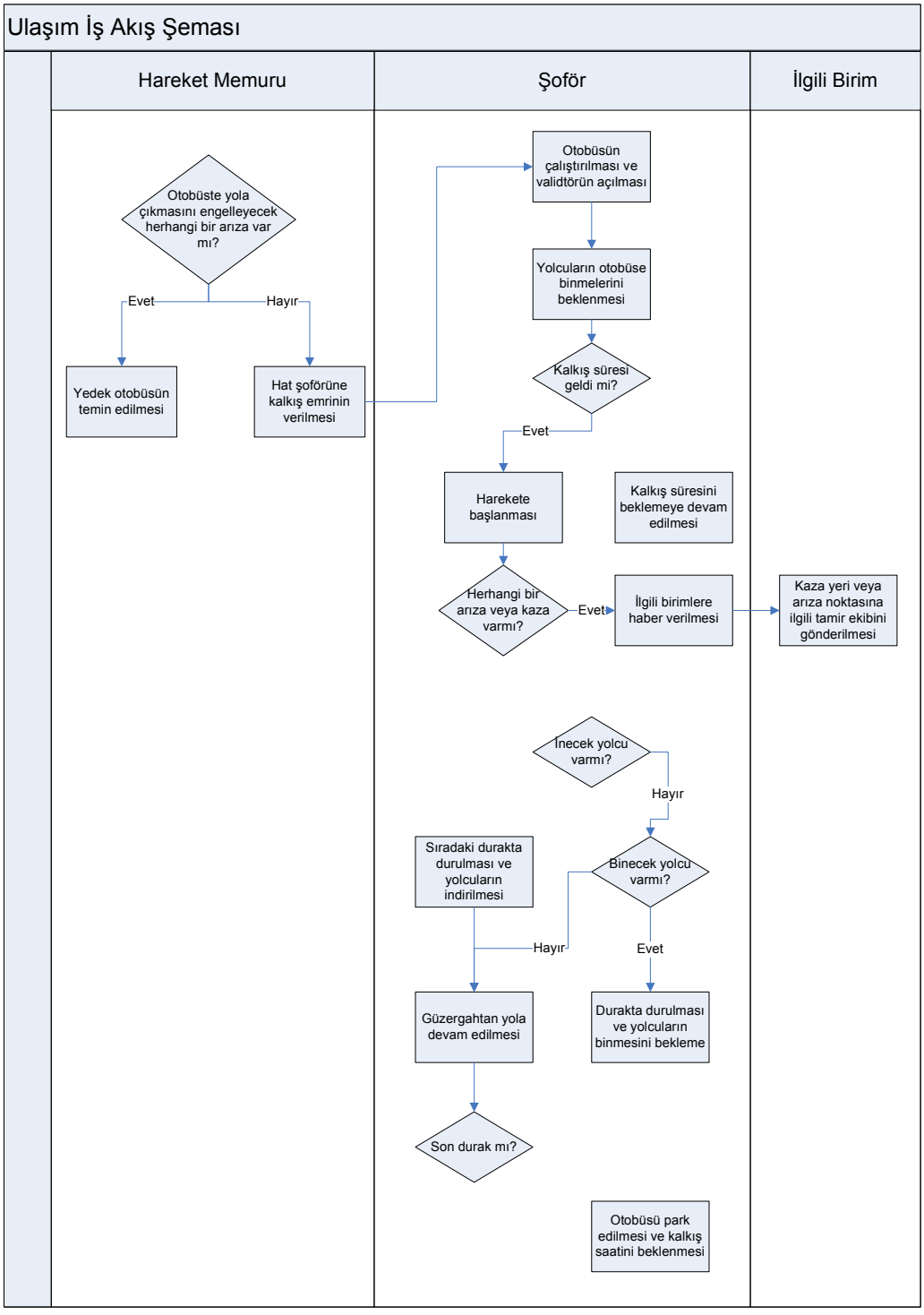


Figure 5.3 Transport Flowchart.

Table 5.9 Occurrence number of FMEA

The Probabiliy of the Error	Scores
Very High: Occurrence of the error is certain.	10
	9
High: The error occurs very often.	8
	7
Medium: The error occurs in some cases.	6
	5
	4
Low: The probability of the error is low.	3
Very Low: The probability of the error is rotably low.	2
Very Little: The error doesn't eminently occur.	1

Table 5.10 Severity number of FMEA

The Signifance of the Effect	Scores
Very High: The effect that make inroads on the corporation	10
	9
High: The effect that cause to the discontent of the passengers and the low performance in the service processes	8
	7
Medium: The effect that may cause to the discontent of the passengers	6
	5
	4
Low: The effect that can be awaked by the passengers but cause to the low discontent	3
	2
Very Low: The effect of the error is absent or the error can' t be became aware of.	1

Table 5.11 Detection number of FMEA

The Probability of Determination	Scores
İmpossible: There isn't any control mechanism and the determination of the control mechanism is impossible.	10
Very Low: The probability of the determination of the error by the present control mechanism is too low.	9
Low: The probability of the determination of the error by the present control mechanism is low.	8
	7
Medium: The present control mechanism can define the error.	6
	5
High: The probability of the determination of the error by the present control mechanism is high.	4
	3
Very High: The probability of the determination of the error by the present control mechanism is very high.	2
Certain: The present control mechanism certainly define the error.	1

RPN numbers were obtained by multiplying the occurrence reasons and the effects the potential error modes and the control mechanisms by the detection, severity and occurrence numbers. The corrective activies are started by analyzing the reason of the potential error that has the maximum RPN value among the reasons that satisfy the RPN≥100 case. In Table 5.13, the correctiveactivities that are made suggestion for the potential error modes that RPN values greater than 100 are given. The corrective activities aren't made suggestion for the potential error reasons that don't satisfy RPN≥100 case.

Table 5.12 Process FMEA Form for ESHOT

POTENTIAL ERROR MODE	REASON OF POTENTIAL ERROR MODE	EFFECT OF POTENTIAL ERROR MODE	CONTROL MECHANISM	Severity	Occurrence	Detection	RPN
LACK OF MARKETİNG RESEARCH ORIENTATION	Not doing research continously	Not be able to define and meet the expectations of the passengers in time	Top management assamblages	8	5	8	320
	Research results that include technical terms	The result of the research can't be understood, misdirection	Top management assamblages	3	3	2	18
	Research method which is not fit for purpose	Misdirection, time and fund spending	There isn't any control mechanism	5	4	4	80
	Not paying attention to complaints and advices that are done while service is taken or before service	The problem continues, the complaints continue and complacence of the passengers decrease	Townsman communication center	8	4	3	96
	Not researching special desires and advices for the regions and the lines	Decrease of complacence of the passengers, lost of credibility, low service quality	Transport head of department	6	3	5	90

INADEQUATE UPWARD COMMUNICATION	The advices that are came by the personnel that are in contact with the passengers aren't considered by the managers	Discontent of the passengers and the personnel	There isn't any control mechanism	5	4	4	80
	Not being able to provide right communication because of density of bureaucracy	Lag of service and the other works, waste of time	There isn't any control mechanism	8	6	8	384
	The personnel and the passengers aren't considered adequately by the managers	Discontent of the passengers and the personnel	There isn't any control mechanism	3	3	8	72
	There isn't any advice and complaint box in the buses	The management is not aware of the passengers' expectations, complaints and advices	There isn't any control mechanism	5	6	5	150
	There isn't any advice and complaint box in ESHOT General Directorate building	The management is not aware of the passengers' expectations, complaints and advices	There isn't any control mechanism	3	6	4	72
TOO MANY LEVELS OF MANAGEMENT	Bureaucratic reasons, being a public enterprise, numerousness of the management stages	Loss of motivation, not being able to use human resource efficiently	There isn't any control mechanism	4	6	5	120
	Problems aren't reached to the management in time	Waste of time, extension of time for evaluation and improvement studies	Top management assamblages	4	3	4	48

	All of complaints and advices that come from the personnel or passengers aren't transmitted to the management	Continuance of complaints, low passenger content	There isn't any control mechanism	5	2	2	20
INADEQUATE MANAGEMENT COMMUNICATION TO SERVICE QUALITY	Disruption of works and not being to finalize them because of bureaucratic balks	Decrease of passengers' content	There isn't any control mechanism	4	6	5	120
	Lack of vehicle and personnel that are needed for service	Not being able to meet the given commitments, decrease of passengers' content,problems while service is being accomplished	Top management assamblages	8	5	3	120
	The existed resource can't be used efficiently	Not being able to meet given commitments, decrease of passenger content, problems while service is being accomplished	Top management assamblages	8	5	5	200
PERCEPTION OF INFEASIBILITY	The goals are comprised by not examining their practicability	Not being able to realize the goals completely	Top management assamblages	10	3	3	90
	The goals can't be overhaulled in accordance with changes	Discontent of the passengers	Ttop management assamblages	8	3	4	96
INADEQUATE TASK STANDARDIZATION	Personnel source can't be used efficiently	Decrease of performance, loss of motivation	Human resources and training head of department	2	7	7	98

	The systems that are used aren't fit for purpose	Decrease of performance	There isn't any control mechanism	10	2	2	40
ABSENCE OF GOAL SETTING	The performance about whether service quality goals are met can't be measured	Discontent of the passengers	Top management assamblages	8	3	4	96
ROLE AMBIGUITY	Mission definitions aren't clear, written and accurate	Chaos, absence of standards, decrease of performance	The related head of department	10	2	1	20
	The lines that the drivers work change frequently	Decrease of performance	Transport head of department	5	3	5	75
	Education programs that will provide the personnel to learn new developments aren't arranged	Decrease of the service quality	Human resources and training head of department	3	5	3	45
	The managers don't consult with the personnel about their expectations from the personnel	Loss of motivation, not being able to use human resource efficiently, decrease of service quality	Transport head of department	8	3	4	96
ROLE CONFLICT	The personnel works intensively in the hours of labor	Increase of complaints, decrease of performance	There isn't any control mechanism	8	6	3	144

	There is a difference between the personnel and the management's perceptions about same work	Disagreement of corporation-personnel, lack of standard	There isn't any control mechanism	8	3	5	120
	Numerousness of the personnel	Controlling and setting standard get difficult	There isn't any control mechanism	3	5	4	60
POOR EMPLOYEE - JOB FIT	The personnel hasn't got information, skill and experience that are fit for the job	Increase of error ratio, decrease of passengers' content and service quality	Human resources and training head of department	8	3	4	96
	Not allocating adequate time and fund for stage of recruitment	Decrease of quality of the doing and the given service	Human resources and training head of department	8	5	3	120
	The personnel's ability of perceiving present changes and application is low	Decrease of performance, decrease of service quality	There isn't any control mechanism	8	3	4	96
	The existed personnel isn't worked in the area of expertise	Decrease of performance	Human resources and training head of department	8	5	4	160
POOR TECHNOLOGY – JOB FIT	Vehicle and equipment that are needed can't be given to the personnel	Delay of the operations, decrease of performance, decrease of service quality	There isn't any control mechanism	9	2	4	72
	Breaking down of equipment	Waste of time	There isn't any control mechanism	2	6	2	24

	Breaking down of buses	Delay of the service, increase of complaints and decrease of passengers' content	Vehicle maintenance and repair head of department	8	6	2	96
INAPPROPRIATE CONTROL SYSTEMS	The people who audit the personnel don't give information to the personnel about evaluation criterias	Replication of the errors, decrease of service quality	Transport head of department	3	5	4	60
	Communication of the personnel with passengers isn't considered by people who audit	Decrease of performance, loss of motivation	Transport head of department	4	5	4	80
	Lack of awarding system	Not being able to do improvement about performance evaluation	Transport head of department	4	5	4	80
	Awarding system isn't applied justly	Disagreement between the corporation and the personnel and among personnel, motivation lowness, decrease of service quality	There isn't any control mechanism	4	4	4	64
	The personnel especially the drivers aren't appreciated according to their contributions to development of service quality	Loss of motivation, not being able to use human resource efficiently	Transport head of department and human resources and training head of department	3	5	5	75

LACK OF PERCEIVED CONTROL	The personnel is dependent on the other units and personnel to solve the problems	Waste of time, decrease of passengers' content	There isn't any control mechanism	4	5	2	40
LACK OF TEAMWORK	The personnel and the managers don't participate to team work	Motivation lowness	There isn't any control mechanism	3	7	4	84
	The personnel doesn't perceive themselves as a part of the corporation	Individualization, motivation lowness	There isn't any control mechanism	1	6	8	48
INADEQUATE HORIZONTAL COMMUNICATION	The personnel doesn't exchange opinions between each other about the service	Not being able to provide standardization	There isn't any control mechanism	1	3	7	21
	Lack of communication among the related units	Decrease of performance	There isn't any control mechanism	4	4	6	96
PROPERSITY TO OVERPROMISE	There is a difference between the service that is made commitment to the passengers and the actual service	Impairment of corporate image, discontent of passengers	Top management assamblages	10	3	3	90
	The corporation makes a lot of commitments to the passengers	Disbelief of passengers to the corporation, discontent of passengers	Top management assamblages	8	2	2	32

Table 5.13 Prioritized RPN values higher than 100 and corrective actions

POTENTIAL ERROR MODE	REASON OF POTENTIAL ERROR MODE	EFFECT OF POTENTIAL ERROR MODE	CONTROL MECHANISM	Severity	Occurrence	Detection	RPN	PREVENTIVE ACTIVITIES
INADEQUATE UPWARD COMMUNICATION	Not being able to provide right communication because of density of bureaucracy	Lag of service and the other works, waste of time	There isn't any control mechanism	8	6	8	384	Increasing communications that are in-house and between the corporation and citizens
LACK OF MARKETING RESEARCH ORIENTATION	Not doing research continously	Not be able to define and meet the expectations of the passengers in time	Top management assamblages	8	5	8	320	Increasing frequency and extention of researches
INADEQUATE MANAGEMENT COMMUNICATION TO SERVICE QUALITY	The existed resource can't be used efficiently	Not being able to meet given commitments, decrease of passenger content, problems while service is being accomplished	Top management assamblages	8	5	5	200	Checking the existed resources,researching how these resources can be used more efficiently
POOR EMPLOYEE – JOB FIT	The existed personnel isn't worked in the area of expertise	Decrease of performance	Human resources and training head of department	8	5	4	160	Canalizing the existed personnel to work in their area of expertise

INADEQUATE UPWARD COMMUNICATION	There isn't any advice and complaint box in the buses	The management is not aware of the passengers' expectations, complaints and advices	There isn't any control mechanism	5	6	5	150	Locating advice and complaint boxes to the buses
ROLE CONFLICT	The personnel works intensively in the hours of labor	Increase of complaints, decrease of performance	There isn't any control mechanism	8	6	3	144	Providing participations of the drivers to social activities
ROLE CONFLICT	There is a difference between the personnel and the management's perceptions about same work	Disagreement of corporation-personnel, lack of standard	There isn't any control mechanism	8	3	5	120	Presenting questionnaires and feedbacks that provide information about expectations and perceptions of the personnel as a report to the management
INADEQUATE MANAGEMENT COMMUNICATION TO SERVICE QUALITY	Lack of vehicle and personnel that are needed for service	Not being able to meet the given commitments, decrease of passengers' content, problems while service is being accomplished	Top management assamblages	8	5	3	120	Supply of needed vehicle and personnel
POOR EMPLOYEE – JOB FIT	Not allocating adequate time and fund for stage of recruitment	Decrease of quality of the doing and the given service	Human resources and training head of department	8	5	3	120	Accomplishing needed stages in recruitment of personnel, allocating time and fund

TOO MANY LEVELS OF MANAGEMENT	Bureaucratic reasons, being a public enterprise, numerousness of the management stages	Loss of motivation, not being able to use human resource efficiently	There isn't any control mechanism	4	6	5	120	Improvements to decrease effect of bureaucracy
INADEQUATE MANAGEMENT COMMUNICATION TO SERVICE QUALITY	Disruption of works and not being to finalize them because of bureaucratic balks	Decrease of passengers' content	There isn't any control mechanism	4	6	5	120	Improvements to decrease effect of bureaucracy

CHAPTER SIX

CONCLUSIONS AND SUGGESTIONS

In this study, the service quality of Eshot General Directorate was tried to measure and suggestions about corrective activities were made by using servqual scale and FMEA.

Karşıyaka region was chosen as an example region to measure given service quality by servqual scale. Accordingly, obtained results and the conclusions that were made about the given service is only valid for Karşıyaka region.

While the sampling method was being chosen, ten lines were randomly chosen among all lines of Karşıyaka region and the datas were collected by applying the sample plan in Appendice 2. When the passengers that sat at seat numbers that were described in Appendice 2 didn't want to participate to the survey or when that seat was empty, the survey was tried to apply to the passengers that sat in the next seat. The coefficients of Cronbach alfa were found 0.844, 0.921 for expectations and perceptions respectively. This demonstrates that the scale is reliable.

The service that ESHOT General Directorate was measured on the basis of criterias by using servqual scale, service quality and weighted service quality were computed. Obtained values are negative, this demonstrates that the perceptions of the passengers from the service that ESHOT gave is lower than their expectations. In other words, in this region ESHOT can't meet the expectations of the passengers. The highest value was obtained in the reliability criteria and the lowest value was obtained in the empathy criteria according the results of service quality and weighted service quality.

The highest expectation value and the lowest standard deviation were obtained at question 3 (employees of firms that give urban public transport service must be natty and clean) among the questions in the questionnaire. Question 8 (when firms that

give urban public transport service give commitment about their services, they must accomplish this commitment) and question 16 (the personnel of the firms that give urban public transport service must continously behave kindly to the passenger) followed question 3.

After Gap 5 was computed, the reasons of this gap were analyzed and some questionnaires were applied to the managers and personnel to do this. At the result of the analysis, Gap 1 was found as -0.171. This demonstrates that there isn't a significant difference between ideas of the management and ideas of the passengers about urban public transport. About this subject, one can conclude that the performance of work is affected by the problems of work and this is seen at the perception level of the customers. Gap 2, Gap 3 and Gap 4 were also obtained as 4.553, 4.730 and 5.261 respectively. For these gaps one can say that large numbers describe small gaps and so Gap 2 (determination of whether specific standards are exist or not) has the biggest problem.

Root reasons for each gap were analyzed, the highest values for Gap 1, Gap 2, Gap 3 and Gap 4 were found as lack of marketing research orientation, inadequate management commitment, lack of perceived control and inadequate horizontal communication criterias respectively.

After quality of the service that ESHOT gave was measured by servqual technique, FMEA method was applied. In this study, service quality gaps and roots of gaps were accepted as potential error modes. For each potential error mode, severity, occurrence and detection numbers were determined by a team that was chosen among ESHOT employees by brainstorming method and RPN values were computed by producting these values. Corrective activities were offered for the potential error modes that had RPN values that were 100 or greater than 100.

FMEA is a method that doesn't prefer planning to do improvements for hundreds of error modes, prioritise the error modes that provide the biggest contribution to the

system. Because of that recent quality concept bases on continous improvement, if the continuity of the studies provided, gainings that will be obtained will be big.

To do a study like this is assuredly very important in a corporation that has 3000 employees, is leader of urban public transport in Izmir and transports nearly 850000 passengers daily. Additionally to begin to do studies like this study in public sector will contribute to both development of public sector and improvement of our country.

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APPENDICES

Appendix–1 Lines of Karşıyaka Region

Hat No	Başlangıç Noktası	Bitiş Noktası	Güzergah
77	NAFİZ GÜRMAN	GÜMRÜK	GÜMÜŞPALA - BAYRAKLI - MONTRÖ
78	YAMANLAR	GÜMRÜK	SOĞUKKUYU - BAYRAKLI - MONTRÖ
120	MAVİŞEHİR	KONAK	KARŞIYAKA - BAYRAKLI - MONTRÖ
121	MAVİŞEHİR	KONAK	KARŞIYAKA - ALTINYOL - TALATPAŞA
122	ŞEMİKLER	GÜMRÜK	SERİNKUYU - ALTINYOL - MONTRÖ
123	ŞİRİNEVLER	GÜMRÜK	SOĞUKKUYU - ALTINYOL - MONTRÖ
125	ESİN SİTESİ	GÜMRÜK	SERİNKUYU - ALTINYOL - MONTRÖ
126	CUMHURİYET MAH.	KARŞIYAKA	SERİNKUYU - GİRNE
128	EGEKENT-2	GÜMRÜK	B.ÇİĞLİ - ALTINYOL - MONTRÖ
129	GÜZELTEPE	GÜMRÜK	B.ÇİĞLİ - BAYRAKLI - MONTRÖ
130	BOSTANLI İSKELE	BORNOVA METRO	KARŞIYAKA - BAYRAKLI - AĞAÇLI YOL
131	CUMHURİYET MAH.	GÜMRÜK	BAYRAKLI - ALSANCAK - MONTRÖ
132	HAVA ÜSSÜ LOJ.	GÜMRÜK	B.ÇİĞLİ - BAYRAKLI - MONTRÖ
135	DOĞANÇAY	KARŞIYAKA	GÜMÜŞPALA - SOĞUKKUYU - GİRNE
136	ÖRNEKKÖY	KARŞIYAKA	DEDEBAŞI - GİRNE
137	YAMANLAR	KARŞIYAKA	SOĞUKKUYU - GİRNE
140	ÖRNEKKÖY	GÜMRÜK	DEDEBAŞI - ALTINYOL - MONTRÖ
141	GÜZELTEPE	KARŞIYAKA	SERİNKUYU - GİRNE
142	EGEKENT	GÜMRÜK	B.ÇİĞLİ - BAYRAKLI - MONTRÖ
143	EGEKENT	KARŞIYAKA	SERİNKUYU - GİRNE
144	EVKA-2	GÜMRÜK	SOĞUKKUYU - BAYRAKLI - MONTRÖ
145	EVKA-2	KARŞIYAKA	SERİNKUYU - GİRNE
146	EVKA-5	KARŞIYAKA	B.ÇİĞLİ - SERİNKUYU - GİRNE
147	POSTACI	GÜMRÜK	ÖRNEKKÖY - ALTINYOL - MONTRÖ
148	ONUR	GÜMRÜK	SOĞUKKUYU - BAYRAKLI - MONTRÖ
149	KAKLIÇ	KARŞIYAKA	B.ÇİĞLİ - SERİNKUYU - GİRNE
155	HARMANDALI	KARŞIYAKA	ANADOLU CAD.GİRNE
195	BALATCIK	GÜMRÜK	B.ÇİĞLİ - ALTINYOL - MONTRÖ
197	NAFİZ GÜRMAN	KARŞIYAKA	GÜMÜŞPALA - GİRNE
198	DOĞANÇAY	GÜMRÜK	SOĞUKKUYU - BAYRAKLI - MONTRÖ
200	ÇİĞLİGRJ	HAVAALANI	M.ŞEHİR-EFES OTELİ-Y.DERE
222	ŞEMİKLER	KARŞIYAKA	SERİNKUYU - GİRNE
227	ORGANİZE SAN.	BOSTANLI İSKELE	ATAKENT M.ŞEHİR İST. ALTI UĞUR SİTESİ
228	EGEKENT-2	KARŞIYAKA	B.ÇİĞLİ - SERİNKUYU - GİRNE
242	EGEKENT	BOR.KAMPÜS	ANADOLU CAD. - BAYRAKLI - MANAVKUYU
243	EVKA 5	BOR.KAMPÜS	ANADOLU CAD. - BAYRAKLI - MANAVKUYU
244	EVKA-2	BOR.KAMPÜS	ANADOLU CAD. - BAYRAKLI - MANAVKUYU
246	EVKA-5	GÜMRÜK	ANADOLU CD. - BAYRAKLI- MONTRÖ
247	EVKA-6	GÜMRÜK	ANADOLU CD. - BAYRAKLI - MONTRÖ
258	ONUR	KARŞIYAKA	DEDEBAŞI - GİRNE

295	**HARMANDALI**	**GÜMRÜK**	UĞUR MUMCU - ALTINYOL - MONTRÖ
300	**KARŞIYAKA**	**F. ALTAY**	ALTINYOL - MÜRSELPAŞA - MİTHATPAŞA
322	**ESİN SİTESİ**	**BOSTANLI İSKELE**	TRT BLOKLAR - ŞEMİKLER
326	**EVKA 6 ESİN SİTESİ**	**KARŞIYAKA**	SERİNKUYU - GİRNE
329	**ÇİĞLİ KOOP**	**GÜMRÜK**	ANADOLU CAD.-ALTINYOL-MONTRÖ
330	**BOSTANLI İSKELE**	**BOR.KAMPÜS**	BAYRAKLI - MANAVKUYU - BORNOVA
342	**EGEKENT**	**GÜMRÜK**	B.ÇİĞLİ - ALTINYOL - MONTRÖ
343	**ŞİRİNEVLER**	**KARŞIYAKA**	SERİNKUYU - GİRNE
344	**EVKA-2**	**GÜMRÜK**	SOĞUKKUYU - ALTINYOL - MONTRÖ
346	**EVKA-5**	**GÜMRÜK**	ANADOLU CD. - ALTINYOL- MONTRÖ
360	**BOSTANLI İSKELE**	**BUCA**	GİRNE - ALTINYOL - YEŞİLDERE
361	**BAHRİYE ÜÇOK**	**KONAK**	GİRNE - KARŞIYAKA - ALTINYOL - MONTRÖ
395	**BALATCIK**	**KEMER**	ANADOLU CAD. - BAYRAKLI
400	**MENEMEN**	**KARŞIYAKA**	B.ÇİĞLİ - ANADOLU CD. - GİRNE
427	**UĞUR SİTESİ**	**KARŞIYAKA**	DUDAYEV - BOSTANLI
428	**EGEKENT-2**	**BOSTANLI İSKELE**	B.ÇİĞLİ - DUDAYEV - ATAKENT
429	**GÜZELTEPE**	**BOSTANLI İSKELE**	B.ÇİĞLİ - DUDAYEV - ATAKENT
436	**ÖRNEKKÖY**	**BOSTANLI İSKELE**	GİRNE
440	**ÖRNEKKÖY**	**BOR.KAMPÜS**	*POSTACI-YAMANLAR--MANAVKUYU*
443	**EGEKENT**	**BOSTANLI İSKELE**	B.ÇİĞLİ - DUDAYEV - ATAKENT
445	**EVKA-2**	**BOSTANLI İSKELE**	DUDAYEV - ATAKENT
446	**EVKA-5**	**BOSTANLI İSKELE**	B.ÇİĞLİ - DUDAYEV - ATAKENT
447	**EVKA-6**	**BOSTANLI İSKELE**	SERİNKUYU - ŞEMİKLER
461	**BAHRİYE ÜÇOK**	**BOSTANLI İSKELE**	GİRNE BLV.
477	**NAFİZ GÜRMAN**	**GÜMRÜK**	KÖY YOLU - ALTINYOL - MONTRÖ
487	**DEMİRKÖPRÜ**	**KARŞIYAKA**	BOSTANLI - YALI CD.
495	**HARMANDALI**	**BOSTANLI İSKELE**	UĞUR MUMCU – DUDAYEV - ATAKENT
527	**UĞUR SİTESİ**	**KARŞIYAKA**	ATASAN-UĞUR SİT-KARŞIYAKA
540	**BOSTANLI İSKELE**	**KEMER**	KARŞIYAKA - TURAN - BAYRAKLI
542	**ÇİĞLİ MERKEZ**	**KARŞIYAKA**	GİRNE - SERİNKUYU - ANADOLU CAD.
577	**GÜMÜŞPALA**	**GÜMRÜK**	SOĞUKKUYU NALDÖKEN ALTINYOL MONTRÖ
578	**YAMANLAR**	**GÜMRÜK**	SOĞUKKUYU NALDÖKEN ALTINYOL MONTRÖ
595	**HAVA ÜSSÜ LOJ.**	**BOSTANLI İSKELE**	B.ÇİĞLİ - DUDAYEV
600	**KARŞIYAKA**	**F. ALTAY**	ALTINYOL - YEŞİLDERE - İNÖNÜ CD.
612	**BOSTANLI İSKELE**	**OTOGAR**	BAYRAKLI - MERSİNLİ - ALTINDAĞ
740	**ALİAĞA**	**MENEMEN**	ALİAĞA-HELVACI-MENEMEN
744	**FOÇA**	**MENEMEN**	FOÇA-BAĞARASI-MENEMEN
745	**YENİFOÇA**	**MENEMEN**	Y.FOÇA-BAĞARASI-GERENKÖY
747	**EMİRALEM**	**MENEMEN**	MANİSA YOLU-ÇANAKKALE YOLU
749	**KOYUNDERE**	**MENEMEN**	K.DERE-ASARLIK-
750	**MALTEPE**	**MENEMEN**	VİLLAKENT-SEYREK-MENEMEN
751	**SASALI**	**ÇİĞLİ**	ESKİHAVAALANICAD

Appendix–2 Sampling Plan

Date	**30.04.2008**			
Line Munber	197		121	
Line Name	Onur Mah. - Karşıyaka		Mavişehir - Konak	
Travel Time	13:40		20:30	
Direction	Departure	Return	Departure	Return
Seat Number	3	18	17	8
	25	35	13	17
	16	21	7	21
	30	5	31	36
	23	9	23	12

Date	**03.05.2008**			
Line Munber	446		137	
Line Name	Evka 5 -Bostanlı Iskele		Yamanlar - Karşıyaka	
Travel Time	08:40		10:45	
Direction	Departure	Return	Departure	Return
Seat Number	10	7	34	8
	27	13	6	14
	6	5	17	21
	35	19	23	22
	13	27	14	33

Date	**05.05.2008**			
Line Munber	400		141	
Line Name	Menemen - Karşıyaka		Güzeltepe - Karşıyaka	
Travel Time	12:45		19:45	
Direction	Departure	Return	Departure	Return
Seat Number	4	2	7	11
	15	5	15	19
	32	11	28	8
	3	18	32	4
	9	25	4	26

Date	**08.05.2008**			
Line Munber	126		242	
Line Name	Cumhuriyet Mah. - Karşıyaka		Egekent - Bor.Kampüs	
Travel Time	15:00		11:10	
Direction	Departure	Return	Departure	Return
Seat Number	32	4	15	18
	23	9	6	25
	20	14	34	8
	16	19	10	26
	2	23	23	33

Date	**11.05.2008**			
Line Munber	436		487	
Line Name	Örnekköy - Bostanlı İskele		Demirköprü - Karşıyaka	
Travel Time	17:20		21:30	
Direction	Departure	Return	Departure	Return
Seat Number	9	33	32	12
	13	31	24	15
	18	27	7	28
	6	15	21	36
	28	23	3	33

NOTE: If the seats are empty or the passengers that sit at the seat numbers that are determined at the sample plan don't accept to participate to the survey, questionnaire is applied to the passenger that sits at next seat.

Appendix–3 Servqual Questionnaire to Measure Service Quality

BEKLENTİLER:

ESHOT' un verdiği hizmetleri kullanan bir kişi olarak tecrübelerinize ve düşüncelerinize dayanarak, ESHOT' un belirtilen özellikleri ne derecede taşıması gerektiğini ve ESHOT' un performansını belirtiniz. Eğer ifadede anlatılan özellikleri sağlanmasının zorunlu olduğunu düşünüyorsanız 7, zorunlu olmadığını düşünüyorsanız 1 rakamlarını işaretleyiniz. Eğer hisleriniz kuvvetli değilse 1 ve 7 rakamları arasında bir sayıyı hislerinizin kuvvet derecesini belirtecek şekilde işaretleyiniz. Bu ankette doğru ya da yanlış cevap söz konusu değildir, tamamen sizin toplu taşıma hizmetleri hakkındaki beklentilerinizi ve düşüncelerinizi doğru yansıtmanız için hazırlanmıştır (1: Hiç katılmıyorum, 7: tamamen katılıyorum).

		Sizin verdiğiniz önem	*Size göre bu özelliği ESHOT'un karşılama değeri*
1	Toplu taşıma hizmetlerini sunan firmaların sahip oldukları ekipmanların görünüşü modern olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
2	Toplu taşıma hizmetlerini sunan firmaların fiziksel yetenekleri, görsel olarak cazip olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
3	Toplu taşıma hizmetlerini sunan firmaların çalışanları iyi giyimli ve temiz görünmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
4	Hizmetlerle birleştirilen materyallerin (kitapçık, dekont vb.) görünüşleri dikkat çekici olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
5	Toplu taşıma hizmetlerini sunan firmalar, belirli bir zaman içinde yapmaya söz verdiklerini, gerçekleştirebilmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7

6	Toplu taşıma hizmetlerini sunan firmaların müşterileri bir problemle karşılaştıklarında firma problemin çözümlenmesi için ilgili davranmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
7	Toplu taşıma hizmetlerini sunan firmalar, hizmetleri ilk defada hatasız gerçekleştirmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
8	Toplu taşıma hizmetlerini sunan firmalar, hizmetleri ile ilgili söz verdiklerinde bu vaadi yerine getirebilmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
9	Toplu taşıma hizmetlerini sunan firmalar, hata kayıtları konusunda kararlı olmalıdırlar.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
10	Toplu taşıma hizmetlerini sunan firmaların çalışanları müşterilerine hizmetlerin tam olarak ne kadar zamanda sağlayabileceklerini söyleyebilmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
11	Toplu taşıma hizmetlerini sunan firmalar, müşterilerine hızlı hizmet vermelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
12	Toplu taşıma hizmetlerini sunan firmaların personeli müşterilere yardımcı olmaya istekli olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
13	Toplu taşıma hizmetlerini sunan firmalar, müşteri ricalarını yanıtlayamayacak kadar meşgul olmamalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
14	Toplu taşıma hizmetlerini sunan firmaların personeli davranışları ile müşterilerine güven aşılamalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7

15	Toplu taşıma hizmetlerini sunan firmaların müşterileri hizmet sırasında kendilerini güvende hissetmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
16	Toplu taşıma hizmetlerini sunan firmaların personeli, müşterilere karşı sürekli nazik davranmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
17	Toplu taşıma hizmetlerini sunan firmaların personeli, müşterilerinden gelecek sorulara cevap verebilmek için gerekli bilgiye sahip olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
18	Toplu taşıma hizmetlerini sunan firmalar, müşterilerine ayrı ayrı ilgi göstermelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
19	Toplu taşıma hizmetlerini sunan firmalar, tüm müşterileri için özel hareket saatleri oluşturmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
20	Toplu taşıma hizmetlerini sunan firmalar, müşterilere kişisel olarak ilgilenebilen personele sahip olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
21	Toplu taşıma hizmetlerini sunan firmalar, müşterilerinin ilgisini gönülden anlayabilmiş olmalıdır.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
22	Toplu taşıma hizmetlerini sunan firmaların personeli, kendi müşterilerinin özel ihtiyaçlarını anlayabilmelidir.	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Aşağıda verilen beş özellik toplu taşıma hizmetleri veren firmalar ile ilgilidir. Firmaların hizmet kalitesini değerlendirirken sizin bu özelliklerden hangisine önem verdiğinizi bilmek istiyoruz. Lütfen sizin için hangi özelliğin önemli olduğunu dikkate alarak puanlamayı 100 üzerinden yapınız. Lütfen beş ölçüt ile ilgili olan özelliklerin toplamının 100 olmasına dikkat ediniz.

	Özellikler	Puan
1	Toplu taşıma hizmetlerini sunan firmaların fiziksel özelliklerinin, ekipmanlarının, personelinin ve iletişim materyallerinin görünüşleri	
2	Toplu taşıma hizmetlerini sunan firmaların vaat ettiği hizmetleri gerçekleştirebilme gücü	
3	Toplu taşıma hizmetlerini sunan firmaların müşterilerine yardımcı olmaları ve acil hizmet sağlamaları	
4	Toplu taşıma hizmetleri sunan firmalar ve personelleri kendi güven ve itimatlarını ifade edebilecek yetenekte olmaları	
5	Toplu taşıma hizmetlerini sunan firmaların müşteriyle bireysel olarak ilgilenebilmeleri	
	Toplam Puan	100

- Yukarıdaki beş özellikten hangisi sizin için en önemlidir?
  Lütfen numarasını yazın.
- Yukarıdaki beş özellikten hangisi sizin için ikinci sıradadır?
  Lütfen numarasını yazın.
- Yukarıdaki beş özellikten hangisi sizin için en az öneme sahiptir?
  Lütfen numarasını yazın.

Appendix–4 Questionnaire to Measure Service Performance Gap

Anketin bu bölümü, müşterilerinizin toplu taşıma hizmetlerini, mükemmel bir hizmet kalitesi ile sağlayan firmalar hakkındaki düşüncelerini, ne kadar anladığınız ile ilgilidir. Lütfen müşterilerinizin, toplu taşıma hizmetlerini sağlayan bir firmada olması gerektiğini düşündüğü yada düşünebileceği özellikleri aşağıda ifadelere vereceğiniz cevaplar ile belirtiniz. Bu anket doğru yada yanlış şeklinde değerlendirilmeyecektir, tamamı ile müşterilerinizin toplu taşıma hizmetleri hakkındaki fikir/his veya düşüncelerini nasıl anladığınız ile ilgilenmektedir. Eğer müşterilerinizin ifadede anlatılan özelliğin toplu taşıma hizmetlerini sağlayan tüm firmalar için zorunlu olduğunu düşünüyorsanız 7 rakamını, düşünmüyorsanız 1 rakamını işaretleyiniz. Eğer hisleriniz kuvvetli değilse 1 ve 7 rakamları arasında bir sayıyı hislerinizin kuvvet derecesini belirtecek şekilde işaretleyiniz.

		Hiç Katılmıyorum						Tamamen Katılıyorum
1	Toplu taşıma hizmetlerini sunan firmaların sahip oldukları ekipmanların görünüşü modern olmalıdır.	1	2	3	4	5	6	7
2	Toplu taşıma hizmetlerini sunan firmaların fiziksel yetenekleri, görsel olarak cazip olmalıdır.	1	2	3	4	5	6	7
3	Toplu taşıma hizmetlerini sunan firmaların çalışanları iyi giyimli ve temiz görünmelidir.	1	2	3	4	5	6	7
4	Hizmetlerle birleştirilen materyallerin (kitapçık, dekont vb.) görünüşleri dikkat çekici mükemmellikte olmalıdır.	1	2	3	4	5	6	7
5	Toplu taşıma hizmetlerini sunan firmalar, belirli bir zaman içinde yapmaya söz verdiklerini, gerçekleştirebilmelidirler.	1	2	3	4	5	6	7
6	Toplu taşıma hizmetlerini sunan firmaların müşterileri bir problemle karşılaştıklarında firma problemin çözümlenmesi için ilgili davranmalıdır.	1	2	3	4	5	6	7
7	Toplu taşıma hizmetlerini sunan firmalar, hizmetleri ilk defada hatasız gerçekleştirmelidirler.	1	2	3	4	5	6	7

8	Toplu taşıma hizmetlerini sunan firmalar, hizmetleri ile ilgili söz verdiklerinde bu vaadi yerine getirebilmelidirler.	1 2 3 4 5 6 7
9	Toplu taşıma hizmetlerini sunan firmalar, hata kayıtları konusunda kararlı olmalıdırlar.	1 2 3 4 5 6 7
10	Toplu taşıma hizmetlerini sunan firmaların çalışanları müşterilerine tam olarak hizmetlerin ne kadar zamanda sağlayabileceklerini söyleyebilmelidirler.	1 2 3 4 5 6 7
11	Toplu taşıma hizmetlerini sunan firmalar, müşterilerine hızlı hizmet vermelidirler.	1 2 3 4 5 6 7
12	Toplu taşıma hizmetlerini sunan firmaların personeli müşterilere yardımcı olmaya istekli olmalıdırlar.	1 2 3 4 5 6 7
13	Toplu taşıma hizmetlerini sunan firmalar, müşteri ricalarını yanıtlamayacak kadar meşgul olmamalıdır.	1 2 3 4 5 6 7
14	Toplu taşıma hizmetlerini sunan firmaların personeli davranışları ile müşterilerine güven aşılamalıdırlar.	1 2 3 4 5 6 7
15	Toplu taşıma hizmetlerini sunan firmaların müşterileri hizmet sırasında kendilerini güvende hissetmelidirler.	1 2 3 4 5 6 7
16	Toplu taşıma hizmetlerini sunan firmaların personeli, müşterilere karşı sürekli nazik davranmalıdırlar.	1 2 3 4 5 6 7
17	Toplu taşıma hizmetlerini sunan firmaların personeli, müşterilerinden gelecek sorulara cevap verebilmek için gerekli bilgiye sahip olmalıdırlar.	1 2 3 4 5 6 7
18	Toplu taşıma hizmetlerini sunan firmalar, müşterilerine ayrı ayrı ilgi göstermelidir.	1 2 3 4 5 6 7
19	Toplu taşıma hizmetlerini sunan firmalar, tüm müşterileri için operasyon saatleri oluşturmalıdırlar.	1 2 3 4 5 6 7
20	Toplu taşıma hizmetlerini sunan firmalar, müşterilere kişisel olarak ilgilenebilen personele sahip olmalıdırlar.	1 2 3 4 5 6 7

21	Toplu taşıma hizmetlerini sunan firmalar, müşterilerinin ilgisini gönülden anlayabilmiş olmalıdır.	1 2 3 4 5 6 7
22	Toplu taşıma hizmetlerini sunan firmaların personeli, kendi müşterilerinin özel ihtiyaçlarını anlayabilmelidir.	1 2 3 4 5 6 7

Ölçütlerin Ağırlıklandırılması:

Aşağıdaki özelliklerin toplu taşıma hizmetleri veren bir firmanın hizmet kalitesi, sizin müşteriniz tarafından değerlendirildiğinde, aşağıda beş hizmet kalitesi ölçütünün müşteri bakış açısına göre ne kadar önemli olduğunu, sizden öğrenmek istiyoruz. Lütfen puanlamayı 100 üzerinden yapınız ve beş ölçüt ile ilgili özelliklerin puan toplamlarının 100 olmasına dikkat ediniz.

	Özellikler	Puan
1	Toplu taşıma hizmetlerini sunan firmaların fiziksel özelliklerinin, ekipmanlarının, personelinin ve iletişim materyallerinin görünüşleri	
2	Toplu taşıma hizmetlerini sunan firmaların vaat ettiği hizmetleri gerçekleştirebilme gücü	
3	Toplu taşıma hizmetlerini sunan firmaların müşterilerine yardımcı olmaları ve acil hizmet sağlamaları	
4	Toplu taşıma hizmetleri sunan firmalar ve personelleri kendi güven ve itimatlarını ifade edebilecek yetenekte olmaları	
5	Toplu taşıma hizmetlerini sunan firmaların müşteriyle bireysel olarak ilgilenebilmeleri	
	Toplam Puan	100

- Yukarıdaki beş özellikten hangisi sizin için en önemlidir?
  Lütfen numarasını yazın.
- Yukarıdaki beş özellikten hangisi sizin için ikinci sıradadır?
  Lütfen numarasını yazın.
- Yukarıdaki beş özellikten hangisi sizin için en az öneme sahiptir?
  Lütfen numarasını yazın.

Appendix–5 Questionnaire to Measure Gaps 2 through 4

Questionnaire to Measure Gap 2

Firmanızdaki performans standartları, resmi olarak onaylı, yazılı, açık, kesin, çalışanların anlayabileceği ve iletişim içinde olabileceği bir yapıda olmalıdır (Usule uygun) .Bunun aksi durumlar, onaylı olmayan, sözlü, karmaşık ve çalışanlar tarafından anlaşılması zor olabilir(Usule uygun olmayan). Firmanızın performans standartlarının bu iki durumdan hangisine uyduğu hakkında bilgi edinmek için, yedi noktadan oluşan skalayı kullanarak, aşağıdaki ifadelere görüşlerinizi aktarınız. Eğer firmanızda hiç standart yoksa uygun kutuyu işaretleyiniz.

		Usule uygun olmayan standartlar				Usule uygun standartlar			Standart yok
1	Firmanın, fiziksel özellikleri, ekipmanları, personelin ve iletişim materyallerinin görünümü	1	2	3	4	5	6	7	( )
2	Firmanın vaat ettiği hizmeti güvenilir ve doğru sağlayabilme yeteneği	1	2	3	4	5	6	7	( )
3	Firmanın, müşteriye yardımcı olmaya ve acil öncelikli hizmet sağlamaya karşı olan istekliliği	1	2	3	4	5	6	7	( )
4	Firma personelinin bilgisi, nezaketi ve güven sağlamaya yönelik yetenekleri	1	2	3	4	5	6	7	( )
5	Firmanın müşterilerine ayrı ayrı ilgi göstermesi	1	2	3	4	5	6	7	( )

Questionnaire to Measure Gap 3

Hizmet kalitesine ait beş ölçüt aşağıda sıralanmıştır. Personel ve birimler bu beş ölçütü karşılayabilmek için hazırlanmış standartlara uymalıdırlar. Zaman zaman personel ve birimler hazırlanan standartları karşılamakta zorlanır. Her ölçüte karşı gelen skaladaki sayıların bir tanesini daire içine alarak, personelin ve birimlerin hazırlanan standartları karşılama yeteneklerini belirtiniz.

		Standartlar devamlı karşılanamıyor 1 2 3 4 5 6 7 Standartlar devamlı karşılanıyor Standart yok
1	Firmanın, fiziksel özellikleri, ekipmanları, personelin ve iletişim materyallerinin görünümü	1 2 3 4 5 6 7 ( )
2	Firmanın vaat ettiği hizmeti güvenilir ve doğru sağlayabilme yeteneği	1 2 3 4 5 6 7 ( )
3	Firmanın, müşteriye yardımcı olmaya ve acil öncelikli hizmet sağlamaya karşı olan istekliliği	1 2 3 4 5 6 7 ( )
4	Firma personelinin bilgisi, nezaketi ve güven sağlamaya yönelik yetenekleri	1 2 3 4 5 6 7 ( )
5	Firmanın müşterilerine ayrı ayrı ilgi göstermesi	1 2 3 4 5 6 7 ( )

Questionnaire to Measure Gap 4

Reklam, satış personelleri ve diğer firma iletişim araçları ile müşterilere bir hizmet kalitesi seviyesi vaat edilir. tüm vaatlerin, yerine getirilmesi her zaman olası değildir. Biz sizden aşağıdaki her hizmet kalitesi ölçütü için, firmanızın müşterilerine vaat ettiği hizmet kalitesi seviyesini derecelendirmenizi istiyoruz. bu konuda algınızı yansıtacak en iyi sayıyı lütfen daire içine alınız.

		Verilen sözler devamlı karşılanamıyor						Verilen sözler devamlı karşılanıyor
1	Firmanın, fiziksel özellikleri, ekipmanları, personelin ve iletişim materyallerinin görünümü	1	2	3	4	5	6	7
2	Firmanın vaat ettiği hizmeti güvenilir ve doğru sağlayabilme yeteneği	1	2	3	4	5	6	7
3	Firmanın, müşteriye yardımcı olmaya ve acil öncelikli hizmet sağlamaya karşı olan istekliliği	1	2	3	4	5	6	7
4	Firma personelinin bilgisi, nezaketi ve güven sağlamaya yönelik yetenekleri	1	2	3	4	5	6	7
5	Firmanın müşterilerine ayrı ayrı ilgi göstermesi	1	2	3	4	5	6	7

Appendix- 6 Questionnaire to Measure Roots of Gap 1 through 4

Questionnaire to Measure Roots of Gap 1 and Gap 2

Talimatlar

Aşağıda listelenen ifadeler firmanız ve firmaya ait operasyonlar hakkındaki algıladıklarınız ölçmek için hazırlanmıştır. Lütfen aşağıdaki her ifadeye 1-7 arasındaki skaladan bir sayıyı daire içine alarak, aynı fikirdeyim veya değilim şeklindeki cevabınızı değerlendiriniz. 1 rakamı, kesinlikle aynı fikirde olmadığınızı ifade ederken, 7 rakamı kesinlikle aynı fikirde olduğunuzu göstermektedir. Fakat düşünceleriniz bu kadar güçlü değilse aradaki sayılardan bir tanesini daire içine alarak cevaplandırınız.

		Kesinlikle aynı fikirde değilim						Kesinlikle aynı fikirdeyim
1	Biz düzenli olarak müşteri ihtiyaçları hakkında bilgi toplarız.	1	2	3	4	5	6	7
2	Müşterilerimiz hakkında toplanan pazar araştırması bilgilerini nadiren kullanırız. (-)	1	2	3	4	5	6	7
3	Müşterilerimizin hizmet kalitesi konusundaki beklentilerine ilişkin verileri düzenli olarak toplarız.	1	2	3	4	5	6	7
4	Firmalarımızın yöneticileri nadiren müşterilerle karşılıklı iletişim kurarlar. (-)	1	2	3	4	5	6	7
5	Müşteri ile sürekli karşı karşıya çalışan personel, yönetimle oldukça sık iletim kurarlar.	1	2	3	4	5	6	7
6	Firmanızdaki yöneticiler nadiren, müşteri hizmetleri hakkında müşteri ile karşı karşıya olan personelden öneri arayışı içine girerler. (-)	1	2	3	4	5	6	7
7	Firmadaki yöneticiler müşteri ile karşı karşıya çalışan personelle yüz yüze iletişim kurarlar.	1	2	3	4	5	6	7
8	Önceliğin anlamı, müşteri ile karşı karşıya olan personelle üst düzey yöneticiler arasındaki iletişimdir. Firmamızda bu iletişim müşteriye doğrudur.	1	2	3	4	5	6	7

9	Yönetim ve müşteri ile karşı karşıya gelen personel arasında firmamızda birçok yönetimsel kademe vardır.(-)	1 2 3 4 5 6 7
10	Firmamız, hizmet kalitesi için gerekli kaynakları teslim edemez. (-)	1 2 3 4 5 6 7
11	Firmamızda, hizmet kalitesinin arttırılması, geliştirilmesi için iç programlar uygulanır.	1 2 3 4 5 6 7
12	Firmamızda, hizmet kalitesinin gelişimine katkıda bulunan yöneticiler, diğer yöneticilerden daha çok ödüllendirilerek takdir görürler.	1 2 3 4 5 6 7
13	Firmamızda satış, müşteriye hizmetten daha çok vurgulanmaktadır.	1 2 3 4 5 6 7
14	Firmamızda, çalışanlar için hizmet kalitesi amaçlarının belirlenmesine yönelik resmi uygun prosesler vardır.	1 2 3 4 5 6 7
15	Firmamızda, özel hizmet kalitesi amaçlarını oluşturmaya çalışmaktayız.	1 2 3 4 5 6 7
16	Firmamız müşterilere verilen hizmetin devamlılığını sağlamak için otomasyon kullanmaktadır.	1 2 3 4 5 6 7
17	Firmamızda uygulanan programlar, hizmetin devamlılığını sağlayacak, operasyon prosedürlerinin geliştirilmesidir.	1 2 3 4 5 6 7
18	Firmamız hizmet açısından, müşteri gereksinimlerini karşılayacak yeteneklere sahiptir.	1 2 3 4 5 6 7
19	Eğer müşterilerimizin istedikleri seviyede hizmet veriyorsak, biz kayıplara uğruyoruz demektir.	1 2 3 4 5 6 7
20	Firmamız müşterilerimizin isteklerinin seviyelerini belirleyebilecek bir operasyon (iletişim) sistemine sahiptir.	1 2 3 4 5 6 7

Questionnaire to Measure Roots of Gap 3 and Gap 4

Talimatlar:

Aşağıda listelenen ifadeler firmanız ve firmaya ait operasyonlar hakkındaki algıladıklarınızı ölçmek için hazırlanmıştır. Lütfen aşağıdaki her ifadeye 1-7 arasındaki skaladan bir sayıyı daire içine alarak, aynı fikirdeyim veya değilim şekline cevabınızı değerlendiriniz. Skaladan 1'i daire içine alırsanız, kesinlikle aynı fikirde olmadığınızı, 7' yi daire içine alırsanız kesinlikle aynı fikirde olduğunuzu ifade edersiniz. Fakat düşünceleriniz bu kadar güçlü değilse aradaki sayılardan bir tanesini daire içine alarak cevaplandırınız.

		Kesinlikle aynı fikirde değilim						Kesinlikle aynı fikirdeyim
1	Kendimi kurumun bir parçası gibi hissediyorum.	1	2	3	4	5	6	7
2	Firmadaki herkes müşteriye hizmet vermek için bir takımda bireysel güçlerini ortaya koyuyor.	1	2	3	4	5	6	7
3	Yakın çalıştığım personelin kendi işlerini daha iyi yapmaları için kendimde onlara yardımcı olma zorunluluğu hissediyorum.	1	2	3	4	5	6	7
4	Yakın çalıştığım personel ve ben, birbirimizle rekabet etmekten daha çok dayanışma içinde çalışıyoruz.	1	2	3	4	5	6	7
5	Bu kurumun önemli üyelerinden biri olduğumu hissediyorum.	1	2	3	4	5	6	7
6	İşimde kendimi konforlu hissediyorum, bu anlamda işimi daha iyi yapabiliyorum.	1	2	3	4	5	6	7
7	Firmamız işinde uzmanlaşmış insanlardan yardım alır.	1	2	3	4	5	6	7
8	Firmamız işimi yapmamda gerekli olan araçları ve ekipmanları sağlamaktadır.	1	2	3	4	5	6	7
9	İşimde kontrolü kaybettiğim problemleri çözümleyebilmek için fazla zaman harcıyorum(-)	1	2	3	4	5	6	7
10	Kendi müşterilerimin ihtiyaçlarını tamamen karşılayabilmek, memnuniyetlerini sağlayabilmek için işimde özgürce davranabiliyorum.	1	2	3	4	5	6	7

11	Bazı zamanlarda kendi işimin üstünde kontrolümü kaybettiğim oluyor. Çünkü, birçok müşteri isteği hizmetlerim sırasında aynı anda geliyor. (-)	1 2 3 4 5 6 7
12	İşimdeki memnuniyetsizliklerimden bir tanesi de yolculara hizmet verirken başka personele bağımlı kalmamdır.	1 2 3 4 5 6 7
13	İşimdeki performansı ölçen denetçiler, yolcular ile iletişimi nasıl sağladığımı da dikkate almaktadırlar.	1 2 3 4 5 6 7
14	Firmamızda, müşteriye hizmet sağlarken özel bir çaba harcarsak, bu çabanın karşılığında bir ekonomik karşılık veya takdir göremeyiz. (-)	1 2 3 4 5 6 7
15	Kurumumuzda, müşteriye hizmet sağlarken daha çok çaba sağlayan ve işini daha iyi yapan personel, diğer personelden daha çok ödüllendirilir.	1 2 3 4 5 6 7
16	İşimde, yolculara etkili olarak hizmet eden kağıtların yoğunluğu beni oldukça zorluyor. (-)	1 2 3 4 5 6 7
17	Kurum tarafından müşteriye hizmetin oldukça çok vurgulanması, müşteriye hizmet etmemizi oldukça güçleştiriyor. (-)	1 2 3 4 5 6 7
18	Yolcularımızın benden yapmamı istedikleri ile yöneticilerimin benden yapmamı istedikleri genellikle aynı şeylerdir.	1 2 3 4 5 6 7
19	Kurum ile, işimin nasıl yapılacağı konusunda aynı fikirdeyiz.	1 2 3 4 5 6 7
20	İşimi nasıl yapacağım konusundaki gerekli bilgileri yönetimden edinebiliyorum.	1 2 3 4 5 6 7
21	Kurumumuz tarafından teklif edilen hizmetleri, sıklıkla anlamadığımı hissediyorum. (-)	1 2 3 4 5 6 7
22	Kurumda işimi de etkileyen değişimlerin, devamlılığını sağlayabiliyorum.	1 2 3 4 5 6 7
23	Yolcularla nasıl etkili iletişim kuracağımın eğitiminin kurum tarafından bana verilemediğini hissediyorum. (-)	1 2 3 4 5 6 7

24	Denetçinin performansımı değerlendirirken işimin gereklerinden hangisinin üstünde daha çok duracağı konusunda herhangi bir fikrim yok. (-)	1 2 3 4 5 6 7
25	Firmamız için reklam hazırlayan personel, gerçekçi reklamlar oluşturmaya önem gösterirler.	1 2 3 4 5 6 7
26	Firma reklamlarından her zaman ileriye dönük vaatlerin farkına varamıyorum. (-)	1 2 3 4 5 6 7
27	Benim gibi operasyonlarda çalışan personel, kendi aralarında müşteriye sağlanan hizmetin seviyesini tartışmaktadır.	1 2 3 4 5 6 7
28	Farklı bölümlerde müşteriye sunulan politikalarımız istikrarlıdır.	1 2 3 4 5 6 7
29	Firma içindeki güçlü rekabet yeni işlerin üstünde yüksek baskı yaratır. (-)	1 2 3 4 5 6 7
30	Firma rekabet içinde vaatler veriyor ama yeni müşteri kazanmak için belki de hiç çaba sarf etmiyor. (-)	1 2 3 4 5 6 7

Appendix- 7 Process FMEA Form for ESHOT (Turkish)

POTANSİYEL HATA TÜRÜ	POTANSİYEL HATA TÜRÜNÜN NEDENİ	POTANSİYEL HATA TÜRÜNÜN ETKİSİ	KONTROL MEKANİZMASI	Oluşum	Önemlilik	Belirlenme	RÖS
YOLCU MEMNUNİYETİ ARAŞTIRMALARININ YÖNLENDİRME YETERSİZLİĞİ	Araştırmanın sürekli yapılmaması	Yolcu beklentilerin zamanında belirlenememesi ve karşılanamaması	Üst Yönetim Toplantıları	5	8	8	320
	Araştırma sonuçlarının teknik terim içermesi	Araştırma sonucunun tam olarak anlaşılamaması, yanlış yönlendirme	Üst Yönetim Toplantıları	3	3	2	18
	Araştırmanın amaçlara uygun olarak yapılmaması	Yanlış yönlendirme, zaman ve kaynak harcaması	Mevcut Bir Kontrol Mekanizması Yok	4	5	4	80
	Hizmet sırasında veya hizmet öncesinde-sonrasında yapılan şikayet ve önerilerin yeteri kadar dikkate alınmaması	Sorunun devam etmesi, şikayetlerin devamlı hale gelmesi ve yolcu memnuniyetinde azalma	Hemşehri İletişim Merkezi	4	8	3	96
	Bölge ve hatlara özel istek ve önerilerin araştırılmaması	Yolcu memnuniyetinde azalma, güven kaybı, düşük hizmet kalitesi	Ulaşım Dairesi Başkanlığı	3	6	5	90
YUKARI DOĞRU İLETİŞİM EKSİKLİĞİ	Yöneticilerin, yolcu ile temas halinde olan personelden (şoför ve hareket memurları) gelen önerileri dikkate almaması	Yolcu ve personel memnuniyetsizliği	Mevcut Bir Kontrol Mekanizması Yok	4	5	4	80

	Bürokrasinin yoğunluğundan dolayı doğru iletişimin sağlanamaması	Hizmetin veya yapılacak diğer işlerin gecikmesi, zaman kaybı	Mevcut Bir Kontrol Mekanizması Yok	6	8	8	384
	Yöneticilerin, personel ve yolcuları yeterince dikkate almaması	Yolcu ve personel memnuniyetsizliği	Mevcut Bir Kontrol Mekanizması Yok	3	3	8	72
	Otobüslerde öneri ve şikayet kutusunun bulunmaması	Yönetimin yolcu beklentilerinden, şikayetlerinden ve önerilerinden haberdar olmaması	Mevcut Bir Kontrol Mekanizması Yok	6	5	5	150
	ESHOT Genel Müdürlüğü binasında öneri ve şikayet kutusunun bulunmaması	Yönetimin personel beklentilerinden, şikayetlerinden ve önerilerinden haberdar olmaması	Mevcut Bir Kontrol Mekanizması Yok	6	3	4	72
YÖNETİM KADEMELERİNİN FAZLA OLMASI	Bürokratik nedenler, kamu kuruluşu olması, yönetim kademe sayısının fazla olması	Motivasyon kaybı, insan kaynağının etkin kullanılamaması	Mevcut Bir Kontrol Mekanizması Yok	6	4	5	120
	Sorunların yönetime zamanında ulaşmaması	Zaman kaybı, değerlendirme ve iyileştirme çalışmaları için sürenin uzaması	Üst Yönetim Toplantıları	3	4	4	48
	Personelden veya yolculardan gelen şikayet ve önerilerin tamamının yönetime iletilmemesi	Şikayetlerin sürmesi, düşük yolcu memnuniyeti	Mevcut Bir Kontrol Mekanizması Yok	2	5	2	20

HİZMET KALİTESİ İÇİN VERİLEN VAADLERİN GERÇEKLEŞMESİNDEKİ YETERSİZLİK	Bürokratik engellerden dolayı işlerin aksaması, sonuçlandırılamaması	Yolcu memnuniyetinde azalma	Mevcut Bir Kontrol Mekanizması Yok	6	4	5	120
	Hizmet için gerekli olan araç ve personel eksikliği	Verilen sözlerin karşılanamaması, yolcu memnuniyetinde azalma, hizmeti yerine getirmede yaşanan sıkıntılar	Üst Yönetim Toplantıları	5	8	3	120
	Mevcut kaynağın etkin kullanılamaması	Verilen sözlerin karşılanamaması, yolcu memnuniyetinde azalma, hizmeti yerine getirmede yaşanan sıkıntılar	Üst Yönetim Toplantıları	5	8	5	200
YOLCU BEKLENTİLERİNİN UYGULANABİLİRLİĞİNİN YÖNETİCİLER TARAFINDAN ALGILANMAMASI	Hedeflerin yapılabilirliği sorgulanmadan oluşturulması	Hedeflerin tam olarak gerçekleştirilmemesi	Üst Yönetim Toplantıları	3	10	3	90
	Hedeflerin değişimlere uygun olarak revize edilememesi	Yolcu memnuniyetsizliği	Üst Yönetim Toplantıları	3	8	4	96
GÖREV STANDARTLAŞTIRMADA YETERSİZLİK	Personel kaynağının etkin kullanılamaması	Performans azlaması, motivasyon kaybı	İnsan Kaynakları ve Eğitim Daire Başkanlığı	7	2	7	98
	Kullanılan sistemlerin amaca uygun olmaması	Performans azalması	Mevcut Bir Kontrol Mekanizması Yok	2	10	2	40

HİZMET KALİTESİ HEDEFLERİNİN EKSİK BELİRLENMİŞ OLMASI	Hizmet kalitesi hedeflerinin karşılanıp karşılanamadığı konusunda performansın ölçülememesi	Yolcu memnuniyetsizliği	Üst Yönetim Toplantıları	3	8	4	96
BELİRSİZLİĞİN ROLÜ	Görev tanımlarının açık, yazılı ve kesin olmaması	Karmaşa yaşanması, standart olmaması, performans azalması	İlgili Daire Başkanlığı	2	10	1	20
	Sürücülerin çalışacağı hatların sık değişmesi	Performans azalması	Ulaşım Dairesi Başkanlığı	3	5	5	75
	Personelin yeni gelişmeleri öğrenmesini sağlayacak eğitim programlarının düzenlenmemesi	Hizmet kalitesinin düşmesi	İnsan Kaynakları ve Eğitim Daire Başkanlığı	5	3	3	45
	Yöneticilerin, personelden beklentileri konusunda personel ile görüşmemesi	Motivasyon kaybı, insan kaynağının etkin kullanılamaması, hizmet kalitesinde azalma	Ulaşım Dairesi Başkanlığı	3	8	4	96
ANLAŞMAZLIĞIN ROLÜ	Personelin çalışma saatlerinde yoğun bir tempoda çalışması	Şikayet artışı, performans azalması	Mevcut Bir Kontrol Mekanizması Yok	6	8	3	144
	Personel ile yönetimin aynı işe dair algıları arasında fark olması	Kurum-personel çatışması, bir standardın olmaması	Mevcut Bir Kontrol Mekanizması Yok	3	8	5	120

	Personel sayısının fazla olması	Kontrolün zorlaşması, standart oluşturulmaını zorlaştırması	Mevcut Bir Kontrol Mekanizması Yok	5	3	4	60
İŞE UYGUN PERSONELİN YETERSİZLİĞİ	Personelin işe uygun bilgi, beceri, tecrübeye sahip olmaması	Hata oranında artış, yolcu memnuniyeti ve hizmet kalitesinde azalma	İnsan Kaynakları ve Eğitim Daire Başkanlığı	3	8	4	96
	Personelin işe alınması ve seçilmesi aşamalarında yeterli zaman ve kaynağın ayrılamaması	Yapılan işin ve verilen hizmetin kalitesinde azalma	İnsan Kaynakları ve Eğitim Daire Başkanlığı	5	8	3	120
	Personelin mevcut değişimleri algılayıp, uygulama yeteneğinin az olması	Performans azalması, hizmet kalitesinin azalması	Mevcut Bir Kontrol Mekanizması Yok	3	8	4	96
	Mevcut personelin uzman olduğu alanda çalıştırılmaması	Performans azalması	İnsan Kaynakları ve Eğitim Daire Başkanlığı	5	8	4	160
İŞE UYGUN TEKNOLOJİNİN YETERSİZLİĞİ	Personele, ihtiyaç duyduğu araç ve ekipman verilememesi	İşlemlerin gecikmesi, performans azalması, hizmet kalitesinde azalma	Mevcut Bir Kontrol Mekanizması Yok	2	9	4	72
	Araç-gereçlerin arızalanması	Zaman kaybı	Mevcut Bir Kontrol Mekanizması Yok	6	2	2	24

	Otobüslerin arızalanması	Hizmetin gecikmesi, şikayetlerin artması ve yolcu memnuniyetinde azalma	Araç Bakım-Onarım Dairesi Başkanlığı	6	8	2	96
UYGUN OLMAYAN DENETİM VE KONTROL SİSTEMİ	Personelini denetleyen kişilerin, personele, değerlendirme ölçütleri hakkında bilgi vermemesi	Hataların tekrarlanması, hizmet kalitesinde azalma	Ulaşım Dairesi Başkanlığı	5	3	4	60
	Personelin yolcularla iletişimin denetleyen kişilerce dikkate alınmaması	Performans azalması, motivasyon kaybı	Ulaşım Dairesi Başkanlığı	5	4	4	80
	Ödüllendirme sisteminin eksikliği	Performans değerlendirme konusunda iyileştirmelerin yapılamaması	Ulaşım Dairesi Başkanlığı	5	4	4	80
	Ödüllendirme sisteminin adil bir şekilde uygulanmaması	Kurum ve personel ile personeller arası çatışma, motivasyon düşüklüğü, hizmet kalitesinde azalma	Mevcut Bir Kontrol Mekanizması Yok	4	4	4	64
	Personelin, özellikle sürücülerin hizmet kalitesi gelişimine katkıda bulunmalarına göre takdir görmemesi	Motivasyon kaybı, insan kaynağının etkin kullanılamaması	Ulaşım Dairesi Başkanlığı ve İnsan Kaynakları ve Eğitim Dairesi Başkanlığı	5	3	5	75
KONTROLÜN ANLAŞILMASINDA YETERSİZLİK	Personelin, problemleri çözümleyebilmek için başka birimlere ve personele bağımlı kalması	Zaman kaybı, yolcu memnuniyetinde azalma	Mevcut Bir Kontrol Mekanizması Yok	5	4	2	40

YETERSİZ TAKIM ÇALIŞMASI	Personel ve yöneticilerin takım çalışmasına katılmaması	Motivasyon düşüklüğü	Mevcut Bir Kontrol Mekanizması Yok	7	3	4	84
	Personelin kendilerini kurumun bir parçası olarak görmemesi	Bireyselleşme, motivasyon düşüklüğü	Mevcut Bir Kontrol Mekanizması Yok	6	1	8	48
YETERSİZ YATAY İLETİŞİM	Personelin kendi aralarında hizmete ilişkin fikir alışverişi yapmamaları	Standartlaştırmanın sağlanamaması	Mevcut Bir Kontrol Mekanizması Yok	3	1	7	21
	İlgili birimler arasında iletişim eksikliği	Performans azalması	Mevcut Bir Kontrol Mekanizması Yok	4	4	6	96
KARŞILANAMAYACAK KADAR FAZLA TAAHHÜTTE BULUNMAYA EĞİLİM	Yolculara taahhüt edilen hizmet ile gerçekleşen hizmet arasında farklılık olması	Kurum imajının zedelenmesi, yolcu memnuniyetsizliği	Üst Yönetim Toplantıları	3	10	3	90
	Kurumun yolculara çok fazla taahhütte bulunması	Yolcuların kuruma güvensizliği, memnuniyetsizliği	Üst Yönetim Toplantıları	2	8	2	32

Appendix- 8 Prioritized RPN values higher than 100 and corrective actions (Turkish)

POTANSİYEL HATA TÜRÜ	POTANSİYEL HATA TÜRÜNÜN NEDENİ	POTANSİYEL HATA TÜRÜNÜN ETKİSİ	KONTROL MEKANİZMASI	Oluşum	Önemlilik	Belirlenme	RÖS	DÜZELTİCİ FAALİYETLER
YUKARI DOĞRU İLETİŞİM EKSİKLİĞİ	Bürokrasinin yoğunluğundan dolayı doğru iletişimin sağlanamaması	Hizmetin veya yapılacak diğer işlerin gecikmesi, zaman kaybı	Mevcut Bir Kontrol Mekanizması Yok	6	8	8	384	Kurum içi ve kurum-vatandaş arasındaki iletişimin arttırılması
YOLCU MEMNUNİYETİ ARAŞTIRMALARININ YÖNLENDİRME YETERSİZLİĞİ	Araştırmanın sürekli yapılmaması	Yolcu beklentilerin zamanında belirlenememesi ve karşılanamaması	Üst Yönetim Toplantıları	5	8	8	320	Araştırmaların sıklığının ve kapsamının arttılması
HİZMET KALİTESİ İÇİN VERİLEN VAADLERİN GERÇEKLEŞMESİNDEKİ YETERSİZLİK	Mevcut kaynağın etkin kullanılamaması	Verilen sözlerin karşılanamaması, yolcu memnuniyetinde azalma, hizmeti yerine getirmede yaşanan sıkıntılar	Üst Yönetim Toplantıları	5	8	5	200	Mevcut kaynakların gözden geçirilmesi, bu kaynakları daha verimli bir şekilde nasıl kullanılabileceğinin araştırılması
İŞE UYGUN PERSONELİN YETERSİZLİĞİ	Mevcut personelin uzman olduğu alanda çalıştırılmaması	Performans azalması	İnsan Kaynakları ve Eğitim Daire Başkanlığı	5	8	4	160	Mevcut personeli uzman olduğu alanda çalıştırmaya yönledirme
YUKARI DOĞRU İLETİŞİM EKSİKLİĞİ	Otobüslerde öneri ve şikayet kutusunun bulunmaması	Yönetimin yolcu beklentilerinden, şikayetlerinden ve önerilerinden haberdar olmaması	Mevcut Bir Kontrol Mekanizması Yok	6	5	5	150	Otobüslere öneri ve şikayet kutusunun konulması

ANLAŞMAZLIĞIN ROLÜ	Personelin çalışma saatlerinde yoğun bir tempoda çalışması	Şikayet artışı, performans azalması	Mevcut Bir Kontrol Mekanizması Yok	6	8	3	144	Sürücülerin sosyal aktivitelere katılmasını sağlama
ANLAŞMAZLIĞIN ROLÜ	Personel ile yönetimin aynı işe dair algıları arasında fark olması	Kurum-personel çatışması, bir standardın olmaması	Mevcut Bir Kontrol Mekanizması Yok	3	8	5	120	Yönetime, personel beklenti ve algılarına ilişkin bilgi sağlayan anket ve geribildirimlerin rapor olarak sunulması
HİZMET KALİTESİ İÇİN VERİLEN VAADLERİN GERÇEKLEŞMESİNDEKİ YETERSİZLİK	Hizmet için gerekli olan araç ve personel eksikliği	Verilen sözlerin karşılanamaması, yolcu memnuniyetinde azalma, hizmeti yerine getirmede yaşanan sıkıntılar	Üst Yönetim Toplantıları	5	8	3	120	Gerekli olan araç ve personelin temini
İŞE UYGUN PERSONELİN YETERSİZLİĞİ	Personelin işe alınması ve seçilmesi aşamalarında yeterli zaman ve kaynağın ayrılamaması	Yapılan işin ve verilen hizmetin kalitesinde azalma	İnsan Kaynakları ve Eğitim Daire Başkanlığı	5	8	3	120	Personelin işe alınmasında gerekli aşamaların yerine getirilmesi, zaman ve kaynağın ayrılması
YÖNETİM KADEMELERİNİN FAZLA OLMASI	Bürokratik nedenler, kamu kuruluşu olması, yönetim kademe sayısının fazla olması	Motivasyon kaybı, insan kaynağının etkin kullanılamaması	Mevcut Bir Kontrol Mekanizması Yok	6	4	5	120	Bürokrasinin etkisini azaltmaya yönelik iyileştirmeler
HİZMET KALİTESİ İÇİN VERİLEN VAADLERİN GERÇEKLEŞMESİNDEKİ YETERSİZLİK	Bürokratik engellerden dolayı işlerin aksaması, sonuçlandırılamaması	Yolcu memnuniyetinde azalma	Mevcut Bir Kontrol Mekanizması Yok	6	4	5	120	Bürokrasinin etkisini azaltmaya yönelik iyileştirmeler