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MASTER'S THESIS

OPTIMIZING AUTOMATED MEDICAL DISPENSING CASES THROUGH VOICE OF CUSTOMER

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DECLARATION

I hereby declare that this master's Thesis titled as "**Optimizing Automated Medical Dispensing Cases Through Voice of Customer**" has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honor.

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ABSTRACT

Master's Thesis

Optimizing Automated Medical Dispensing Cases Through Voice of Customer

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The importance of using resources in health institutions effectively is increasing day by day. Materials are one of the most important resources. For this reason, there have been many studies conducted in terms of using these materials more effectively and appropriately.

This paper aims at developing a computer-controlled automated medical dispensing cabinet in order to provide the material management through automation in health institutions. So that users' needs are prioritized by using QFD method in developing the design.

Another expectation of this study is to fill the gap in the sector with a user-centered design which focuses on the voice of customers.

While designing the computer-controlled automatic medical dispensing cabinets, a typical middle-sized material in random shape sampling has been created to cover 90% of hospital's material portfolio. Its size and dimension have been calculated to design a cabinet and a box as a visual prototype in a

minimum range for the protection of the materials. 3D form modeling software program has been used for preparing the visual prototype.

The study has aimed at guiding the manufacturers and designers interested in this subject and developing designs with technical specifications for the users' needs in the hospitals.

Because of the fact that designs should be assessed as prototypes, they can be modified in different shapes according to the intended purposes.

Keywords: Computer-controlled Automated Medical Dispensing Cabinet, Quality Function Deployment, Voice of Customer

ÖZET

Yüksek Lisans Tezi

Otomatik Medikal Saklama Depolarının Müşterinin Sesi Yoluyla Optimizasyonu

Jülide NALLIOĞLU

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Sağlık işletmelerinde kaynakların etkin kullanımının önemi her geçen gün daha da artmaktadır. Bu kaynaklar arasında malzeme önemli bir yer tutar. Bu nedenle malzemelerin daha kontrollü ve amacına uygun olarak kullanılmasına yönelik birçok araştırma yapılmaktadır.

Bu tez çalışması ile sağlık işletmelerinde malzemelerin otomasyon ile yönetiminin sağlanması için bilgisayar kontrollü bir malzeme dolabı geliştirilmesi amaçlanmış olup kullanıcı isteklerini ön planda tutacak şekilde kalite fonksiyon göçerimi yöntemi kullanılarak bir tasarım geliştirilmeye çalışılmıştır.

Bu tezin bir diğer amacı da bu araştırmaları farklı bir yöne taşıyarak müşterinin sesini dinleyen, kullanıcı odaklı bir tasarım ile bu alandaki bir eksikliği kapatmaya çalışmaktır.

Bilgisayar kontrollü malzeme dolapları tasarlanırken aynı zamanda tipik orta büyüklükteki bir hastanenin malzeme portföyünün %90'ını kapsayacak şekilde rassal biçimde malzeme örneklemesi yapılarak ebatları incelenmiş ve bu kapsamdaki malzemeleri muhafaza edecek en az çeşitlilikte dolap ve kutu tasarımı, görsel prototip olarak da canlandırılmaya çalışılmıştır. Görsel prototip için 3 Boyutlu katı modelleme yazılımlarından faydalanılmıştır.

Yapılan bu çalışma ile bu konuyla ilgili imalatçılar ve tasarımcılara yol gösterilmesi, hastane malzeme kullanıcılarının ihtiyaçlarına tam olarak cevap verebilecek teknik spesifikasyonlara sahip tasarımlar geliştirmesi hedeflenmektedir.

Tasarımlar prototip olarak değerlendirilmesi gerektiğinden kullanım amaçlarına göre farklı biçimlerde de modifiye edilip özelleştirilebilecektir.

Anahtar Kelimeler: Bilgisayar Kontrollü Malzeme Dolabı, Kalite Fonksiyon Göçerimi, Müşterinin Sesi

OPTIMIZING AUTOMATED MEDICAL DISPENSING CASES THROUGH VOICE OF CUSTOMER

TABLE OF CONTENTS

CHAPTER TWO

USER CENTERED DESIGN, RAPID PROTOTYPING AND AUTOMATED MEDICAL DISPENSING CABINETS

CHAPTER 3

THREE APPLICATION

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

In today's condition, stock management has become one of the most important factors affecting the profitability of all the organizations in the industry and service sector. In order to have a successful stock management, first of all, the loss of material, scrap, etc. situations should be effectively followed and such situations should be eliminated.

Day by day, in the changing world order, the health sector in Turkey has also undergone many changes. In the past years, the health service was provided by the state and there were no financial concerns. However, today with the increasing number of the conscious population, there has been an increase in the hospital densities as well as the costs due to the purpose of providing health services at higher levels. Therefore, the cost analysis for the hospital management has become an important issue.

Managing drugs that constitute the majority of hospital expenses properly is equally important for both hospital and patients. Drug management should follow the process of drug stocking and administration (from the stock area to the patient). Drug management should also record this process not only to control hospital expenses but also to improve the quality of patient safety and care.

It is nearly impossible to manage drugs manually because of digital needs and work load in hospitals. Charged staff has excessive work load while managing and administering drugs in manual systems which prevents their clinical duties. Moreover, problems in terms of both patient safety and hospital expenses occur due to wrong drug managing.

According to the study conducted in hospitals in the USA on patients' safety;

- The error rate changes between 33% and %38. (Bates et al. , 1995: 202).
- The most frequent error is "dose error" with the range of %7.9-58.3 while administering drugs (Bates et al., 1995: 201).
- In one of the studies in 2002, the rate of dose error was 48% and in another study conducted in Turkey on the assessment of administering 641 antibiotics showed the dose error as 40% (Alparslan and Erdemir, 1997: 46).
- In case of drug request, the rate of writing error is between 6% and 12% (Hicks et al., 2004: 25).
- In case of drug consumption, the rate of error is between 5% and 14%. (Bates et al., 1995: 202).

The resulting table due to these errors is;

- 98K people get harm per annum (Kinnaman, 2007: 8).
- Drug errors seen in children triple (potentially more harmful) compared to adults (although both have same rate) (Fortescue et al., 2003: 54).
- 7000 people died because of wrong drug administration per annum (Tansüyer, 2010: 42).
- The range of loss is between 1.6 and 5.6 billion dollars (Kohn et al., 2000: 103).

With the application of Automated Medical Dispensing Cabinets;

- Nurses can reach the drugs only with doctors' request in a controlled way to provide patients' safety.
- The data on the amount of the drug used is entered automatically into patients' bill.
- The amount of drug administered to the patient is automatically delisted from the stock which fosters stock safety and the availability of instant stock control.
- Ordering and administering the drugs that are immobile (not dynamic) provide using drugs before their expiration dates.

According to the data taken from the automated medical dispensing cabinet samples applied in the world, 20% of drug savings are seen per annum.

Dokuz Eylül Research and Application Hospital is one of the leading hospitals in Turkey's health industry. In order to provide an effective control of materials and eliminate the situations like expired and loss materials, they started using Automated Medical Dispensing Cabinets since March 2011 in the emergency aid department; a pilot area where the material losses are frequently seen. Unfortunately, these medical dispensing cabinets couldn’t meet the expectations as they were used actively by warehouse clerks in emergency service. This led to some problems and complaints due to the lack of functionality of the cabinets. As a result, the redesign of the Automated Medical Dispensing Cabinets came to the forefront again.

In this study, our goal is to provide redesigning the cabinets in the modular system in a more controlled and systematic manner in terms of the data gained by observations and customers’ needs. In our study, the area is Dokuz Eylül Research and Application Hospital and customers are dear valued patients, doctors, nurses and warehouse clerks.

CHAPTER ONE
QUALITY FUNCTION DEPLOYMENT

1.1 NEED FOR QFD

The perfection dream has been an issue since the history of humanity. Everybody wants to be perfect whatever he does. He also wishes to get each product with high quality and low cost. However customer needs are variable and it is impossible to provide it via a simple quality control system. For this reason, quality function deployment methodology has a great deal of advantages in this respect. QFD is a system that aims at providing product development, customer satisfaction and basic quality of products and services (Bolt and Mazur, 2002: 47).

QFD transforms customer needs into the best technical characteristics via house of quality matrix. This method divides customer needs into categories and also makes a detailed analysis like production planning from the general to the specific. Such a system is quite different from other quality methods since QFD maximizes customer satisfaction while minimizing their dissatisfaction. The aim of this method is zero defect (Bolt and Mazur, 2002: 46).

QFD is a customer-oriented product development method and the main aim towards product design is what the customer expectation is. The most important point of QFD is specifying the functions of products according to the customer needs and wishes (Yenginol, 2002: 35).

The companies that use QFD has lower cost of design, production and service except the cost loss because of the quality problems.

Companies using QFD should have a harmony among design, raw material suppliers and marketing departments. QFD helps organizations work together in

order to fulfill customer needs and therefore provides a great deal of contribution to the total quality management.

1.2 MEANING, DEFINITION AND PURPOSE OF QFD

QFD is a process called house of quality that has product development and improvement through matrices system. QFD has various definitions by different authors and different scientists. These definitions are as follows:

QFD is defined by Akao one of its creators, as follows: "It is a method that aims to develop design quality in order to satisfy the customers and to meet the customers' demands during the production and transfer them into the main quality assurance points. QFD is a great way of getting design quality under control during the production stage (Akao, 1990: 3).

QFD is the only comprehensive quality system aimed specifically at satisfying the customer. It concentrates on maximizing customer satisfaction (positive quality) by seeking out both spoken and unspoken needs, translating these into actions and designs, and communicating these throughout the organization end-to-end. Further, QFD allows customers to prioritize their requirements, benchmark us against our competitors, and then direct us to optimize those aspects of our product, process, and organization that will bring the greatest competitive advantage (Talbot et al. , 2011: 97).

"QFD is a structured production planning and development method that provides the customers' needs and requests, evaluates the offered service or products systematically by a developer team (Cohen, 1995: 11).

According to Shillito; (1994: 68)

- QFD focuses on customer needs
- QFD uses market potential to specify design targets

- QFD uses team work among functions
- QFD uses flexible and easy to understand documents
- QFD makes customer needs measurable targets therefore it provides true product and service for the market much easily and early. It is an interdisciplinary team process that helps new products and services to plan and design

QFD is a way of listening to the voice of customer and determining the best methods to fulfill customer's needs (Guinta and Praizler, 1993: 116).

QFD is a product and service development process followed by an interfunctional team using a series of matrix that looks like a house concerning its design, production and service (Hauser and Clausing, 1988: 64).

All of these definitions show that QFD;

- Transforms the needs and requests of customers to the characteristics of a product or a service of a complete functional components in an organization.
- Such a process is carried out by interfunctional team work.
- is a structured and detailed study.
- flexible and easy to understand.

In this respect, QFD can be defined as "a structured, detailed, flexible and understandable development method that is carried out by interfunctional team work transforming the needs and requests of customers into the characteristics of a product or a service of a complete functional components in an organization" (Yenginol, 2000: 25-26).

1.3 HISTORICAL DEVELOPMENT OF QFD

QFD was developed by Prof. Shigeru Mizuno and Yoji Akao after 1960s (Iskander, 2008: 264). QFD was known in Japan as a quality system that aimed customer satisfaction regarding product and service (Bolt and Mazur, 2002: 47). During second world war, QFD emerged as a method or a concept towards product development via total quality control systems. QFD was formularized for the first time in Mitsubishi Kobe Shipyards in the mids of 70s (Akao, 1997: 1).

QFD concept was published in 1972 in a magazine named "Standardization and Quality Control" by Akao and it was explained by Akao in one of his articles called "New Product Development and Quality Assurance-Quality Deployment System" (Abasov, 2002: 24). However there were still some gaps in the system regarding quality design. This gap was filled by Mitsubishi Heavy Industries at Kobe dock in the same period (Akao, 1997: 2). First QFD matrix was created by Dr. Mizuno and Dr. Furukawa at Kobe deck in 1972 (Shillito, 1994: 1).

In 1975 Akao Japanese Society for Quality Control founded QFD research committee and presidency (Akao, 1997: 2). This committee had continued to study QFD methodology for 13 years.

In 1978 Akao and Mizuno were the editors of the book named “Quality Function Deployment-An Approach to Company- Wide Quality Control "published by JUSE (Revelle, 1998: 373).

Correlation matrix was used for the first time in quality charts and in 1979 Tsuneo Sawada used the term “house of quality” for the quality charts in JSQC conference. After that, Fukuhara introduced the quality charts using this term in USA (Akao, 1997: 4)

QFD became known in America and Europe just after the publication of Akao's study in the journal named Quality Progress' in American Society for Quality Control (Mazur, 2005: 2).

QFD was first used in service business by Ohfuji, Noda and Ogino companies in 1982 (Abasov, 2002: 25).

Today, QFD has been arousing interest all over the World via new usage, applications and studies each year. Today, the countries that hold national and international QFD seminars are Japan, Germany, Australia and Turkey (Mazur, 2005: 2).

Dr. Akao started being worried about quality and QFD application load in 1999 and organized some international conferences in the UN (Mazur, 2005:28). Some programs were developed by QFD institutions in 2000s for companies. This program is called as zone program and protected by South America, Europe and Asia as a registered mark of QFD institution (Mazur, 2005: 28).

Not only some successful companies such as Xerox, Ford, General Motors Digital Equipment, but also the companies like Hewlett Packard, AT&T and ITT started using QFD. The first white goods company Arçelik used QFD technique in 1994 in Turkey. This technique was applied by R&D for dish washer machines. In 1995, it was used for no-frost refrigerators, washing machines and vacuum cleaners (Abasov, 2002: 27). In Turkey, national QFD seminars are held each year in Izmir. With this technique QFD has been widely known in Turkey.

1.4 ADVANTAGES OF QFD

We can explain the advantages of QFD method in four main categories like identifying the customers' needs effectively, decreasing the run duration, fostering the development in team work and providing documentation.

A- It provides to determine the customer needs in a healthy way

QFD provides to determine the needs of customers and realizes the characteristics of product that meet those needs properly. These characteristics are also compared with the features of the product of competing organizations. The data is prioritized by using the Pareto diagram. By this way, the most profitable areas and products are specified.

B- It reduces the application time

If the draft of QFD is implemented truly, the design features that conflict with each other are determined in pre-production stages. This means less engineering change. Moreover QFD provides to determine the critical elements which would be problematic in the future and take these issues into a careful consideration during application stages.

For instance, while American car producers spent 5 years from the design to the production stage in the end of 1980s and the beginning of 1990s, Honda Company spent 2,5 and Toyota Company spent 3 years for the same process (Lowe and Ridgway, 2001: 3).

C- It helps the development of teamwork

QFD promotes the use of horizontal communication channels. The data that would be entered to the system is required by all levels of the organization and thus the customers' needs are met. Moreover, by this way each department knows what other departments do. The aim here is to prevent the possible mistakes and misunderstandings of different departments during application process. In other words, the right hand always knows what the left hand does. Speed and efficiency are always increased by a good teamwork.

D- It provides documentation

If the data used in former applications isn't recorded systematically, it might be lost. In QFD system, the data is kept for future use. These databases at the same time may be used for the training of the new personnel. Since the QFD matrices created by entering the data are flexible, changing matrices during the entrance of new data will be easier.

1.5 QUALITY FUNCTION DEPLOYMENT PROCESS

Generally, QFD process includes four steps in an organization, these steps are

A- Planning

B- Meeting of "the voice of customer" / the determination of customers' needs

C- Creating the house of quality

D- The analysis and interpretation of the results (Cohen, 1995: 210).

1.5.1 Planning

QFD application is a project and it must be planned before its application. This plan includes all arguments such as project goals, time and budget constraints, timelines, use of the material and the working team. Before the application of QFD, the team members should come to an agreement on the following considerations (Govers, 1996: 577).

- Which product or characteristics of the product should we work on?
- How can we think just like our customers?
- Which competing products will we use to develop our products?

- What kind of a QFD approach would help us to plan the product and process?

After considering these issues, the main planning stage includes the organizational support for the provision, determination of goals, customer group decision, determination of time horizon, decision of the concept of a product/service, the establishment of QFD team, QFD process design, ensuring the necessary ingredients of the plant (Cohen, 1995: 213).

1.5.2 The Identification of Customer Needs

The customer needs are the requests and needs in terms of the characteristics of a product or a service. The identification of customer needs is the first step of design and development studies and the most critical period in QFD applications. This stage is the longest and most important part of QFD process.

While starting a QFD study, the basic data is the customer needs and expectations. To collect the data, a systematically communication study is needed. The data at the end of the study is called as “the voice of customers”. After the firm defines its identification of customers, it should plan how to get into touch with customers, more generally how to hear the voice of customers (Kageme, 2002: 2).

A true identification of customer segment is required in order to have successful and accurate results in the study. For example, questions such as "what is the customer profile that will lead to the best? Are all of our clients equally important to, or more valuable than the others?" etc. should clearly be given.

In addition, the removal of the customer segments in Table 1 makes the design, usability and functionality of the product easier to be understood by researchers. A sample related to “Customer Segments Table" can be seen in Table 1.

Table 1: Customer Segments Table

Who	What	When	Where	Why	How
Patient	Recover their health, to die in peace	24/7, 365	Near home, ER, hospital room, hospice	Specialty care, religious affiliation, doctor has privileges	ER, referral
Patient's family	Comfort patient, advocate for patient, pray	During admission, after patient is admitted	Waiting room, hospital room, chapel, cafeteria	Make decisions, assure patient's needs are met, moral support	Discuss with medical staff, on-line research
Patient's employer	Recover health, rehabilitate injury, preventive care	During disability, after injury, annual physical, healthy living programs	In-patient, physical therapy, satellite clinic, in-company, in-home	Get patient back to work safely, reduce cost of temporary replacement workers, reduce workman's compensation costs	Contract, insurance (HMO, PPO), Plant medical person
Third party payer	Reimburse hospital, physicians	After bills are submitted, Before treatment authorized	Office	Assure procedures are aligned with insurance contract, assure proper billing by hospital, MD	Electronic, web, fax, mail, telephone
Referring physician	Specialty care for their patients, tests	Scheduled, emergency, walk-in clinic	Hospital, ambulatory care clinic	Beyond their clinic's capabilities, exotic illness	Telephone, outcomes report, notification of death

Source: http://www.mazur.net/works/qfd_to_define_value.pdf, accessed at 2014-01-10

The router force of QFD is the product specifications which customers attribute. Customer satisfaction can only be provided by meeting their expectation.

The sources used are focus groups, reviews, complaints, consultants, standards and regulatory requirements and customer's expectations. Customer expectations are generally the concepts expressed more general and implicit. The task of QFD team is to make these concepts more specific. During this process, the customer needs should be understood truly and transformed to the managers' expectations.

QFD starts by doing a market research on customer expectations. While collecting the data, QFD team must answer at least the following questions during the study;

- What do the customers really want?
- What are the customers' expectations?
- Can customers' expectations be directed towards the application?
- What can design team do to meet the customers' satisfaction?

The indetermination of customer expectation prevents the creation of a high-quality product. For instance, in the market research of Ford firm for their new model Taurus in the beginning of 1980s, they thought that the customers want to have a fuel-efficient car. In fact, the results of QFD application showed that the customers' main wish was a powerful car (Griffin, 1992: 175).

Voice of the customer is obtained by various ways such as face-to-face interviews, questionnaires, observations, field reports, and the data after guarantee application, the views of customers related to the product or service.

Data related to the product design cannot be obtained only from the customer. There are two ways to collect the data. Firstly, it can be obtained directly from the customer (direct dial telephone lines, field research, consumer testing, commercial tests, customer reviews, buying the product research, etc.). Secondly, it can be obtained indirectly (sales people, training programs, meetings, trade magazines, trade shows, suppliers, academic environment, the company employees, etc.) In both ways, collected data may be quantitative, qualitative, systematic or random (Öter and Tütüncü, 2001: 99-100).

Most of the companies have free call services known as "customer services hotline". Some of them call their customers and get some information within 90 days after the sale in order to check the customer satisfaction. Some other companies organize regular face to face meetings with their key customers. The representatives that sell product and service to the companies and key customers participate the product design and development meetings held within the organization (Halis, 2000: 131).

The most widespread research technique while getting "the voice of customers" is a survey. Survey can be defined as a method that provides some information by reaching the customers through a questionnaire (Boyacıoğlu, 2001: 1).

In order to understand the customers better, QFD uses gemba as well as these traditional methods and also other methods such as Kano model and classification of product quality.

QFD aims not only meeting the customer needs but also increasing the level of the expectations. Each QFD team works to make the designed product better, more attractive and appealing than the current product and competing products. For this reason, the customer faces unexpected features that motivate the product development. For instance, the glass holders in cars are extra functions for the customers. They didn't wish to have a glass holder in the car but when they encountered the holders, they liked it and added this function into their wish-lists.

1.5.2.1 Gemba Analysis

Gemba is the real environment where the product is used. In other words, the product or the service is a value for the customer. By this method, unknown needs become obvious by observing the product use. The real clues related to the customers are only available in gemba. The main advantages of gemba are as follows (Ronney, Olfe and Mazur, 2000: 72).

- As the customers don't express everything, gemba provides the unspoken needs of customers.
- The product or the service is not a value by its own. The product or a service is a tool that helps to make customers satisfied. Gemba provides to understand the real value of the product/service.

- It optimizes the product development process.

As it has been stated in the introduction part of this study, the analysis of the observed item by gemba makes the unspoken opportunities for the new products and services available. After introducing yourself, you should make your customer stay with you during the business process in the study. The customer's reactions and statements with respect to the product-related problems also make the problems more obvious due to the fact that when people face problems; their stress, depression and such kind of feelings help them to express themselves more clearly and easily. Furthermore, transferring the possible solutions for the problems might be helpful for the study. Sometimes some customers may not be able to see the problems during the process. In this respect, the customer should be persuaded to speak. To make him speak more, the statements like "it is clear that you are good at this subject" or "I can see that you do not get on well with it".

The main purpose of gemba is to hear the customer's untouched (innocent) "naive" voice.

For instance, when the workers in Toyota face a problem, they immediately call an engineer to the work area and the engineer sees the problem by his own eyes hears it by his own ears and touches the problem by his own hands, etc. In order to understand and figure out the situation they trust not on the reported data but on their own experience (Liker, 2003: 65).

Gemba is the customer value of the services and products in QFD. In other words, where the product is really used and where the real value of the product is sent to the customers are the issues for gemba. By gemba, we can see who the real customer is, what his problem is, how he should use the product. Gemba is used to reveal and see the problems and opportunities of customers. Contrary to the data that collected by the techniques such as focus groups and surveys, the questions related to the problems cannot be asked to the customers. The customers cannot be gathered in

an artificial area like customer meeting room (unless the product is a table or chair). Gemba is not only related to the reports on the problems of customers. Instead, it focuses on the data like direct statements of the customers, video records, and customers' observation on the product. Thus more comprehensive understanding occurs. Researcher masters the problem and the solution ways. Moreover, s/he can feel empathy with customers more easily. In short, the best solution for a problem is truly about the place where the problem arises (Imai, 1997: 17).

A sample on "Customer process table" by gemba can be seen in Table 2 below.

Table 2: Customer Process Table

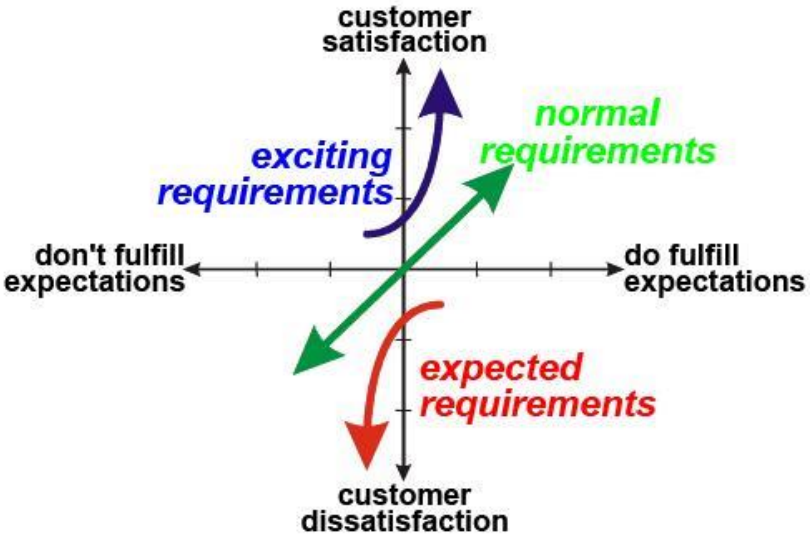
Customer Process	Customer Scenario (observations and verbatims)	Problems and opportunities	Failure Modes
Nurse enters patient room.	39 year old male, admitted through ER for pancreatitus. Presence of gall stones required 4 week stay prior to cholecystectomy. NPO.	I feel fine. I have a busy life to get on with. I am afraid of catching some infectious disease while in the hospital.	Nurse does not ask permission to enter. Privacy not respected.
Nurse carries central catheter tubing.	Nurse brings sealed tubing, wears surgical mask and surgical gloves, asks visitors to leave room, puts mask on pt.	Pt environment kept as sterile as possible during procedure. I am afraid of catching some infectious disease while in the hospital.	Tubing not sealed until at bedside. Non surgical mask or no mask, non-surgical gloves or no gloves. Nurse has cold.
Nurse opens tubing package.	Sealed connectors of tubing must remain sterile.		Tubing uncoils and drops on floor.

Source: http://www.mazur.net/works/qfd_to_define_value.pdf, accessed at 2014-01-10

1.5.2.2 The Customer Needs Management

In order to be a successful company, the determination of consumer requirements is not enough. It is important to know how and to what extent these requirements affect customer satisfaction. For this reason, organizations have started using Kano model that provides the analysis the customer needs truly. This model developed by Noritoki Kano is a model that underlines the relationship between the customer satisfaction and the degree of meeting the customer expectations. The graphical representation of the Kano model can be seen in Figure 1. The horizontal axis of the chart shows how the product and service is successful at meeting the customer needs. In short, the success level is the degree of meeting the customer expectations. Vertical axis shows the customer satisfaction degree related to the product and service (Matzler and Hinterhuber, 1998: 26).

Figure 1: Kano Model



Source: Talbot, Hepler and Mazur, 2011, p.110

A- Expected Quality: The characteristics of a product which customers already know. It has the components of a product or a service. These contribute to the satisfaction more or less. However, if they are not available, dissatisfaction is felt immediately. If the product has a basic functional loss, that shows a stable problem in the product. Customers rarely speak about the basic needs. A clean car or a fresh product from a supermarket is an expected thing. These are the function of a product or a service. These basic elements aren't considered as a quality by customers (Sauerwein and the others 1996: 316-317).

B- Normal quality: When you ask the customer what s/he expect from the product, the answer is quality. This is the basic performance of a product.

C- Exciting quality: this is the quality that is unexpected by the customers. It motivates the customer and it is defined as exciting quality. Exciting quality is a surprising function and makes the customer happy.

If explain these three dimensions of quality;

For instance, a customer who stays in an average hotel which is not luxurious expects a clean hotel. This is a basic quality. The check in process takes a lot of time. Accelerating this process makes the customer happy and satisfied. This is an expected quality. When the customer comes into the hotel room and receives a bottle of wine, s/he gets surprised. This is an exciting quality.

The advantages of classifying customer requirements by means of the Kano method are very clear:

- Priorities for product development: It is, for example, not very useful to invest in improving must-be requirements which are already at a satisfactory level but better to improve one-dimensional or attractive

requirements as they have a greater influence on perceived product quality and consequently on the customer's level of satisfaction (Sauerwein and the others, 1996: 322).

- Product requirements are better understood. The product criteria which have the greatest influence on the customer's satisfaction can be identified. Classifying product requirements into must-be, one-dimensional and attractive dimensions can be used to focus on.
- Kano's model of customer satisfaction can be optimally combined with QFD. A prerequisite is identifying customer needs, their hierarchy and priorities. Kano's model is used to establish the importance of individual product features for the customer's satisfaction and thus it creates the optimal prerequisite for process-oriented product development activities (Griffin and Hauser, 1993: 8).
- Kano's method provides valuable help in trade-off situations in the product development stage. If two product requirements cannot be met simultaneously due to technical or financial reasons, the criterion can be identified which has the greatest influence on customer satisfaction.
- Must-be, one-dimensional and attractive requirements differ, as a rule, in the utility expectations of different customer segments. From this starting point, customer-tailored solutions for special problems can be elaborated which guarantee an optimal level of satisfaction in the different customer segments. (Sauerwein and the others, 1996: 323).
- Discovering and fulfilling attractive requirements creates a wide range of possibilities for differentiation. A product which merely satisfies the must-be and one-dimensional requirements is perceived as average and therefore interchangeable (Hinterhuber and the others, 1994: 42).

1.5.3 House of Quality

One of the basic planning means is the house of quality in QFD. The house of quality transforms the voice of customer into the design characteristics that meet the special goals and determines how the organization can fulfill these goals. Moreover, according to many managers and engineers, the most appropriate matrix method in quality planning is the house of quality.

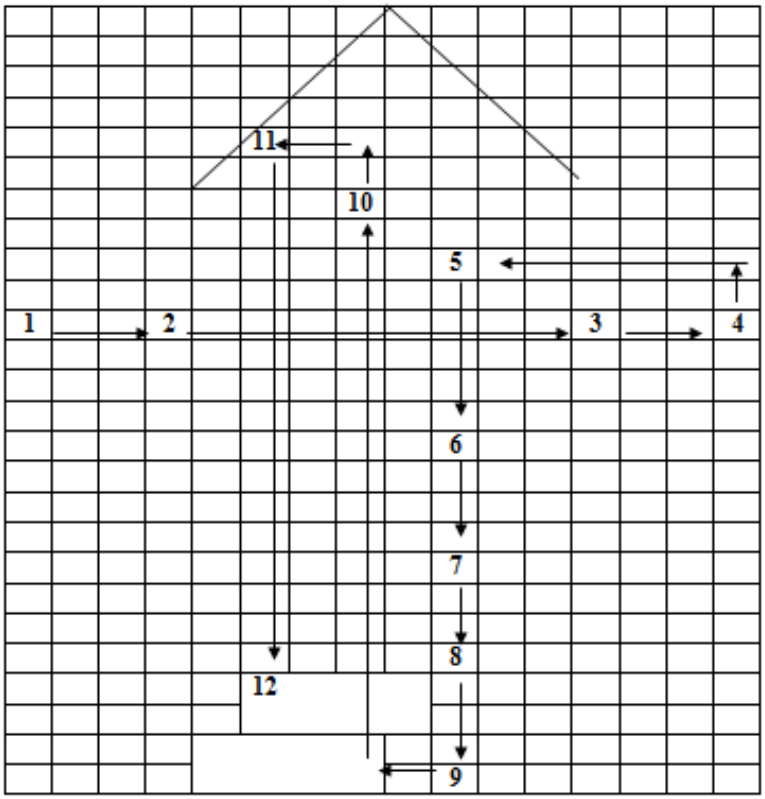
In other words, the house of quality is a scheme in a matrix style dealing with the issues like, "WHAT" the customers' needs are, "HOW" the engineering specifications correspond to these needs (Hauser and Clausing, 1988: 63).

The house of quality consists of 6 main blocks. The sub-blocks of the house of quality also consist of 12 parts. These sub-blocks are listed below: (Yaralıoğlu, 2010: 48)

1. The Customer Needs and Expectations
2. The Meaning of the Customer Needs and Expectations
3. Competitive Comparisons
4. The Other Criteria Regarding Customer Needs and Expectations
5. Features of the Product or the Project
6. The Relationship Between the Customer Needs and Expectations, and the Features of the Product or the Project
7. The Meaning of the Features of the Product or the Project
8. The Competitive Comparison of the Features of the Product or the Project
9. The Other Criteria about the Features of the Product or Project
10. The Optimization Aspect of the Properties of the Product or the Project
11. The Interaction of the Product or the Project Features
12. The Target Values of the Product or Project Features

The relationship between the above-listed sub-blocks is also shown in Figure 2.

Figure 2: The Relationship Between the Blocks of the House of Quality



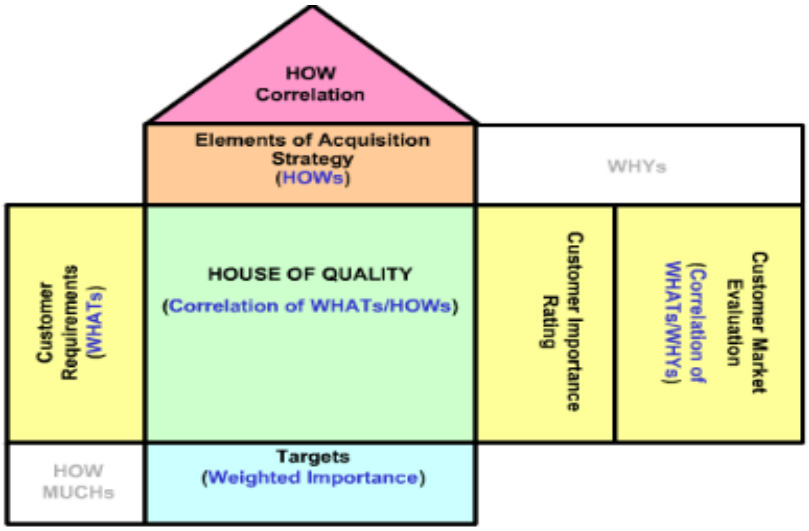
Source: Yaralıoğlu, 2010, p.50

If we want to examine the house of quality portions in general; (Hauser and Clausing, 1988: 64)

- The outer walls of the house are designed as the customer needs. On the left wall, there is a list of customer expectations. On the right wall, there are customer expectations or a planning matrix.

- The attic or the second floor of the house includes technical definitions. The consistency of the product is obtained by the characteristics of engineering, limitations in design and parameters.
- The inner walls of the house show the relations between the customer expectations, technical definitions. The function of this part is that it explains the customer expectations in technical definitions and parameters.
- The roof includes the technical definitions. Similar or opposite technical definitions are studied in this section.
- In the entrance, technical definitions are available. This section has some concepts such as benchmarking, the degree of technical difficulty and target value.

Figure 3: Blocks of Quality House



Source: http://quanterion.com/Training/REPERTOIRE/index.asp, accessed at 2013-06-20

1.5.3.1 The Creation of the House of Quality

House of Quality have been defined in 7 steps. These steps are listed below:

- The list of customer expectations
- Technical definitions list
- The matrix that shows the relationship between the expectations of the customers and the technical definitions
- The correlation matrix between technical indicators
- Business purpose and objectives
- The competition matrices
- Priority of customer requests and the technical characteristics

Step 1: List of Customer Expectation

The first step in the house of quality is the list creation of the customer expectations. The List is prepared by the specialists marketing and according to the needs of the customer and about the features of the products.

It is important to determine the customer expectations correctly. Future studies will be directed according to these determined elements. All of the determined customer expectations may not be equally important. For this reason, the second transaction at this stage is to determine the order of importance of the customer expectations. For this purpose, the level of customers' importance is determined by using either question forms or asking directly customers. The customer expectations and wishes are rated from 1 to 5 regarding their level of importance (Hauser and Clausing, 1988: 66).

Step 2: List of Technical Descriptions

The purpose of the house of quality is to design the product for the customer expectations or to develop the existing designs. For this purpose, the most important point is to convert the customer expectations to the technical definitions during the engineering phase. Technical definitions form the second floor and the ceiling of the house of quality. In other words, the marketing group first determines "WHAT" to do and then R&D group determines "HOW" to do these. At this stage, the group members determine a few measurable design elements that will meet each customer expectation and prepare house of quality matrix. In house of quality matrix, while the lines show customer needs and their importance level, the columns show engineering features to meet these needs (Park and Kim, 1998: 570).

Step 3: The Matrix that Shows the Relationship between the Expectations of the Customers and the Technical Definitions

In the preparation of the Quality House, the 3rd step is the creation of the body of quality house. In other words, it points out the extent of technical features regarding the customer expectations.

For this purpose, the quality house matrix can be studied in 2 stages regarding the relationship between WHAT's and HOW s;

a) Do the technical definitions have any effect on customer expectations?

b) If so, what is the degree of this effect?

At this point the relationship between the customer expectations and the technical features is generally shown by the symbols. These symbols used are shown in Figure 4.

Figure 4: Symbols and Their Meanings

Symbol	*Relationships*	*Rate*
◉	Strong positive	9
O	Medium positive	3
△	Medium negative	1
-	*Strong negetive*	0

Source: Maddux, Amas and Wyskida, 1991, p.35

The transaction after the creation of relationship matrix is to study the gap lines and columns. A gap line reveals that a customer expectation cannot be related to any technical definition. In such situations, a new technical definition should be found and related it to customer needs. Gap columns in the matrix show that the related definition cannot affect any customer expectation. These technical definitions should be omitted from the matrix after a careful analysis.

For each technical requirement has a development aspect with the most positive nature for the customer satisfaction. The development aspect is determined by the blank term "it should be more ... to have". To determine the direction of this development, the following symbols are used:

⬇ : Goal value is the best goal. If there is any difficulty in the meeting of this target, it should be at the bottom of the target.

⬆ : Goal value is the best goal. If there is any difficulty in the meeting of this target, it should be at the upper side of the target.

- : ın order to meet a particular target, the customer satisfaction is the best.

Step 4: The Correlation Matrix between the Technical Indicators

While creating the structure of the quality of the house, the correlation matrix in the form of a triangle is used in order to demonstrate the internal relations between the technical definitions. Just like in the former step, it would be the right thing to use symbols and letters in this matrix to show the strenght of the internal relationship between the terms (Hauser and Clausing, 1988: 70-71).

+1: positive

0: neutral

-1: negative

Step 5: Business Goals and Objectives

In this step, the question of HOW MUCH" is answered regarding each engineering feature. Target values have to be determined according to the customer satisfaction. At this stage, when a new product is launched, it is important to determine the benchmark values have to be calculated. However, as it is hard to find the right value at once, it is possible to start studying with an estimated value and analyze these values to determine the target values. For the determination of the target values, it is a must for the design engineers to work with the team closely and in harmony.

On the other hand, at this stage, the difficulty level of each engineering feature process is determined by the study team and expressed in the "organizational difficulty" line.

Step 6: Competition Matrices

Competition matrices shows the comparison between the existing product and the competitive products. For this purpose, the competing products in the market need to be assessed a general analysis from both engineering and customer perspective. Accordingly, the competition matrices are examined in two categories.

a) **Customer Reviews:** It is created according to the customer needs and on the right of the Correlation matrix. 1 The worst is determined by 5 and the best is determined by 1. Others are rated from 5 to 1. Comparing customer evaluations are the best ways to determine the customer expectations' results and the focus areas of the new design (Hauser and Clausing, 1988: 71-72).
b) **Comparative Technical Assessments:** The comparative technical assessments are created as a block under the quality of the house. After each department has placed, the products are evaluated by their technical features. Just like in the analysis of customer needs, it is rated from 5 to 1 (Hauser and Clausing, 1988: 71-72).

Step 7: The determination of the Priority of Customer Requests and the Technical Characteristics

At this stage, each of engineering feature, the relative and absolute importance degrees of the customer requests are calculated by the formula given below:

$$\textit{The Absolute Importance} = \sum \textit{(the matrix weight} \times \textit{customer importance degree)}$$

After that, the absolute importance of the engineering features is added and the total importance is gained. Each feature's absolute importance degree is divided to this value and the relative importance value calculation is shown (Park and Kim, 1998: 573).

The relative importance = the absolute importance / the total importance $\times$ *100*

CHAPTER TWO
USER CENTERED DESIGN, RAPID PROTOTYPING AND AUTOMATED MEDICAL DISPENSING CABINETS

2.1 USER CENTERED DESIGN

The term ‘user-centered design’ originated in Donald Norman’s research laboratory at the University of California San Diego in the 1980s and became widely used after the publication of a co-authored book entitled: User-Centered System Design: New Perspectives on Human-Computer Interaction. Norman built further on the user-centered design concept in his seminal book The Psychology of Everyday Things (POET). In POET he recognizes the needs and the interests of the user and focuses on the usability of the design. He offers four basic suggestions on how a design should be:

- Make it easy to determine what actions are possible at any moment.
- Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions.
- Make it easy to evaluate the current state of the system.
- Follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state (Norman, 1988: 188).

These recommendations place the user at the center of the design. The role of the designer is to facilitate the task for the user and to make sure that the user is able to make use of the product as intended and with a minimum effort to learn how to use it. Norman noted that the long cumbersome, unintelligible manuals that accompany products are not user-centered. He suggests that the products should be

accompanied by a small pamphlet that can be read very quickly and draws on the user's knowledge of the world (Abras and the others, 2004: 764).

Telling designers that products should be intuitive is not enough; some design principles are needed to guide the design. Norman suggested that the following seven principles of design are essential for facilitating the designer's task:

- Use both knowledge in the world and knowledge in the head. By building conceptual models, write manuals that are easily understood and that are written before the design is implemented.
- Simplify the structure of tasks. Make sure not to overload the short-term memory, or the long term memory of the user. On average the user is able to remember five things at a time. Make sure the task in consistent and provide mental aids for easy retrieval of information from long-term memory. Make sure the user has control over the task.
- Make things visible: bridge the gulfs of Execution and Evaluation. The user should be able to figure out the use of an object by seeing the right buttons or devices for executing an operation.
- Get the mappings right. One way to make things understandable is to use graphics.
- Exploit the power of constraints, both natural and artificial, in order to give the user the feel that there is one thing to do.
- Design for error. Plan for any possible error that can be made, this way the user will be allowed the option of recovery from any possible error made.
- When all else fails, standardize. Create an international standard if something cannot be designed without arbitrary mappings (Norman, 1988: 189-201).

Norman's work stressed the need to fully explore the needs and desires of the users and the intended uses of the product. The need to involve actual users, often in the environment in which they would use the product being designed, was a natural evolution in the field of user-centered design. Users became a central part of the development process. Their involvement lead to more effective, efficient and safer products and contributed to the acceptance and success of products (Preece and the others, 2002: 81).

In participatory design the users are involved in development of the products, in essence they are co-designers. The participatory design approach emerged in Scandinavia. It was born out of the labor unions push for workers to have more democratic control in their work environment. Because cultural differences can often arise between users and designers, sometimes the users are unable to understand the language of the designers, it is recommended that the team uses prototypes, such as mockups (three dimensional paper-based representation), or a paper-based outline of the screen of a webpage, or a product. Other types of prototyping techniques are PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) and CARD (Collaborative Analysis of Requirements and Design). The PICTIVE prototyping method uses low-fidelity office products, such as pens, papers, and sticky notes. The actions of the users are videotaped. CARD uses playing cards with pictures of specific items on them. PICTIVE concentrates on the detailed aspects of the system while CARD looks at the flow of the task, just as storyboarding (Abras and the others 2004: 771-772).

In recent years the participatory design approach has gained momentum for designing novel systems. For example, Druin and her team have developed their own version of participatory design in which children are design partners for developing software for children (Abras and the others 2004: 772).

2.1.1 How to Involve Users in Design?

It is necessary to think carefully about who is a user and how to involve users in the design process. Obviously users are the people who will use the final product or artifact to accomplish a task or goal. But there are other users as well. The people who manage the users have needs and expectations too. What about those persons who are affected in some way by the use of the artifact or use the products and/or services of the artifact? Shouldn't their needs and expectations be taken into consideration in the design process? Eason identified three types of users: primary, secondary, and tertiary. Primary users are those persons who actually use the artifact; secondary users are those who will occasionally use the artifact or those who use it through an intermediary; and tertiary users are persons who will be affected by the use of the artifact or make decisions about its purchase. The successful design of a product must take into account the wide range of stakeholders of the artifact. Not everyone who is a stakeholder needs to be represented on a design team, but the effect of the artifact on them must be considered (Preece and the others, 2002: 92-93).

Once the stakeholders have been identified and a thorough investigation of their needs has been conducted by performing tasks and needs analyses, designers can develop alternative design solutions to be evaluated by the users. These design solutions can be simple paper and pencil drawings in the beginning phase of the process. Listening to users discuss the alternative designs can amplify designers understanding of the intended purpose(s) of the artifact and may provide information that does not come out of initial interviews, observations, and needs analysis. As the design cycle progresses, prototypes (limited versions of the product/artifact) can be produced and user tested. At this point, designers should pay close attention to the evaluations by the users as they will help identify measurable usability criteria.

Measurable usability criteria address issues related to the effectiveness, efficiency, safety, utility, learnability and memorability (how long it takes to remember to perform the most common tasks) of the product/artifact and users' subjective satisfaction with it. You can see how difficult it would be for designers to know or imagine all the usability criteria that are important to the users. It is only through feedback collected in an interactive iterative process involving users that products can be refined (Abras and the others, 2004: 767-768).

2.1.2 Usability Testing

Usability testing, according to Dumas & Redish, aims to achieve the following five goals, to:

- improve the product's usability
- involve real users in the testing
- give the users real tasks to accomplish
- enable testers to observe and record the actions of the participants
- enable testers analyze the data obtained and make changes accordingly (Rosenbaum, 2000: 1)

Usability testing focuses on user needs, uses empirical measurement, and iterative design. Dumas & Reddish (1993) stress that interactive-systems designers are now aware that many pilot tests should be conducted before releasing any product to the public. An interactive system is like a play, where extensive rehearsals are expected especially close to opening night. Historically usability tests are conducted in usability laboratories that are staffed by people who are experts in user-interface design and testing and this is still the practice in large companies such as Microsoft and IBM. These laboratories are equipped with an area that allows the designers to observe the testers unnoticed. However, due to the cost of running such

laboratories and the distributed nature of many systems it is increasingly common to use mobile usability testing kits that are a fraction of the cost (Abras and the others, 2004: 768-769).

Before product implementation, paper mock-ups of screen displays can be tested in order to assess the wording and layout. Many techniques are employed in usability testing, including:

- Think aloud techniques in which the user is asked to articulate all the steps of his / her actions.
- Videotaping is valuable to review what the participants did, and to show designers where the problems are in their designs (Shneiderman, 1998: 131).
- Interviews and user satisfaction questionnaires enable designers to evaluate the users likes and dislikes about the design and to gain a deeper understanding of any problems.

Typically the tests require typical users to perform typical standardized tasks in a typical task environment so that the following data can be collected:

- Time for users to learn a specific function
- Speed of task performance
- Type and rate of errors by users
- User retention of commands over time
- Subjective user satisfaction (Shneiderman, 1998: 135).

After the product is released, it is also recommended that evaluation be continued. The most frequent method of evaluation is interviews and focus groups. Both provide valuable information about user satisfaction and any problems with the functionality that might need rethinking. Data logging may also be performed (Abras and the others, 2004: 769).

2.1.2.1 Variations on Usability Testing

Usability testing has limitations; it does not cover all the interface features; it lasts for a few hours in the laboratory and therefore it is hard to ascertain how the product is going to perform over a few weeks or months in the real environment. Furthermore, the small number of participants rarely represents the whole population (Abras and the others, 2004: 770).

Mayhew suggests that the usability engineering lifecycle provides a complete approach for developing the interface that includes three phases of iterative testing. The first level evaluation is an iterative conceptual model evaluation, designed to get feedback before any code has been developed. Formal usability testing is often used at this stage. For each iteration, there should be between three to ten users, the testing should be done in the workplace, and a minimum of instructions should be provided in order to test ease of learning. The next testing stage should be done after the prototype has been coded to get early feedback about its usability. The same evaluation principles used in the first level evaluations are employed here, except, that at this second level the prototype is complete, while in the first level a paper mockup was used. The third testing phase occurs after the interface is ready, and its purpose is to evaluate the final product against the usability goals set at the beginning of development (Abras and the others, 2004: 770).

2.2 THE DEVELOPMENT OF 3D MODELS THROUGH RAPID PROTOTYPING CONCEPTS

Mechanical parts represent an important fraction of various products widely used in our society. Fierce competition demands a permanent increase in productivity and faster response to changing technical and commercial demands on such parts.

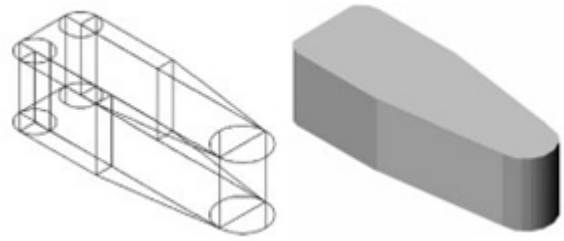
This has led to widespread use of automatic design procedures, based on either traditional mechanics or on numerical methods such as finite element analysis, in order to evaluate stress and strain levels. Such analyses demand an initial 3D modeling of the part under consideration. (Santos at al. , 2005: 1)

An increased interest in 3D models of mechanical parts is also observed. These serve as prototypes, allowing the analysis of the interference with other parts, of the kinematic behavior of the product and of the manufacturing processes to be employed in the production of the part. (Gardner, 1993: 21)

The conceptualization and preparation of such models is of special importance in the education and research in mechanical engineering. It allows a far better 3D visualization of parts, leading to enhanced geometric interpretation and spatial analysis of mechanical parts. This is of particular importance in the areas of mechanical design and manufacturing processes. (Gardner, 1993: 22)

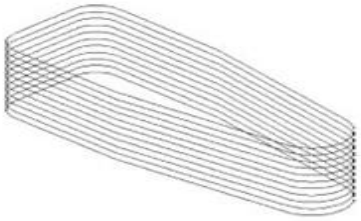
These models can be developed using various methods, such as mass modeling, surface planification, and rapid prototyping with removal or addition of material based on a CAD/CAM platform. This latter approach was employed in the present paper. Complex solids are formed through the Boolean association (involving addition, subtraction and intersection) of elementary solids such as spheres, prisms, cylinders, torus, etc., and then rapid prototyping is applied involving a slicing process. A virtual model based on a CAD platform allows the determination of paths for each sliced level. These are translated into numerical control codes, and fed to a milling process of a blank, allowing the manufacturing of a 3D model. Figures 5 and 6 illustrate the above procedure. (Santos at al. , 2005: 1)

Figure 5: The Association of Elementary Solids in Order to Obtain a 3D Model



Source: Santos, Pertence, Campos and Cetlin, 2005, p.2

Figure 6: Slicing Process Leading to Milling Paths



Source: Santos, Pertence, Campos and Cetlin, 2005, p.2

2.2.1 The 3D Form Program

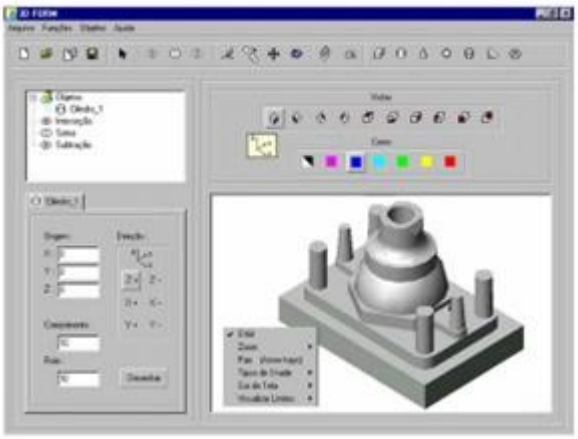
The "3DForm" is a computer program for the generation of 3D models, originally developed at the Federal University of Minas Gerais, in Brazil. It uses the association of elementary solids in order to obtain complex shapes. The "3DForm" works as a "Client" program, controlling the generation of the elementary solids, and manages "Slave" programs such as a CAD platform offering a programming interface for external use of its commands (Foley, 1990: 8).

The "3DForm" employed the Visual Basic® six language in order to control an AutoCAD® 2000 platform. Its main features are the following:

- Control of the generation of elementary solids (spheres, prisms, cones, cylinders, etc.) in a CAD platform, at desired positions and with the required dimensions.
- Application of Boolean operations of addition, subtraction and intersection of the above-mentioned solids, allowing the construction of 3D mechanical parts.
- Allows the permanent edition visualization and printing, from various observation viewpoints, of the 3D mechanical parts under analysis.
- Slicing of the parts modeled in the CAD platform, at any desired position and slicing interval, leading to rapid prototyping procedures.
- Capturing, treating and storing of the geometric data generated in the slicing process, for each cutting plane in the mechanical part.
- Development of CNC code files for a pre-defined equipment, allowing the creation of an automatic sequence for the machining of the contours of each cutting plane and the physical manufacturing of the mechanical part (Omura, 1999: 34-36).

The graphical interface of the "3DForm" program presented in Figure 7 covers the creation of complex solids based on the association of elementary solids. A visualization tree allows the permanent tracking of the creation history of the object. This tree can be saved in a file, either for a completed or partially constructed part. The interface is user friendly and the commands are easily accessible (Santos at al. , 2005: 2).

Figure 7: Main Screen of the 3D Form Program



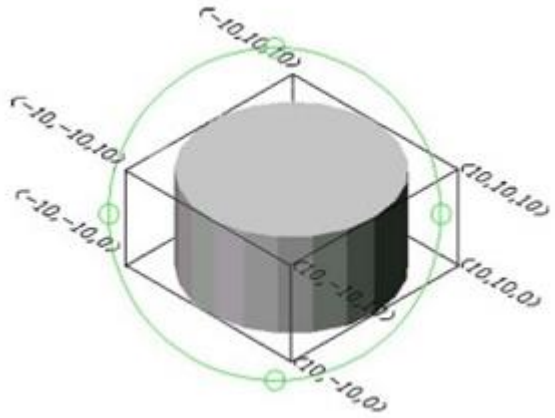
Source: Santos, Pertence, Campos and Cetlin, 2005, p.2

The main screen of the 3DForm program is shown in Figure 7, and can be divided into five areas with pre-defined functions:

- The region of the main commands is in the upper part of the screen. It contains the commands for object creation, for Boolean operations, for the generation of G codes, etc.
- The region in the upper left region of the screen displays the instantaneous creation sequence of the part, allowing a clear tracking of all the steps followed by the user.
- The region in the upper right region of the screen displays the visualization commands, involving the definition of preferential views and of the colors of the created solids.
- The region in the lower left of the screen allows the introduction of the data for the creation of the elementary solids. This data is permanently saved and can be accessed at any moment.
- The 3D drawing can be viewed the right lower region of the screen. The following options can be used: orbital positioning, zoom, shading,

pan and background colors (black or white). It is also possible to display the limits of the selected object, as shown in Figure 8 (Santos and the others, 2005: 2).

Figure 8: Visualization of the Limits of an Object



Source: Santos, Pertence, Campos and Cetlin, 2005, p.2

A special system for the opening, saving and recovery of the drawing was created, in order to facilitate stopping and re-starting of the project at any time. Saving involves two types of files: one covers all operation steps up to the saving moment, whereas the other includes the last drawing version.

Before final manufacturing of the prototype, it is necessary to make some simulations and tests, in order to verify possible problems in the codes, eventual incompatibilities between these codes and those for the equipment, or some other errors (Santos and the others, 2005: 3).

2.3 AUTOMATED MEDICAL DISPENSING CABINETS

Implementing automated dispensing cabinets as part of a decentralized or hybrid medication distribution system can improve patient safety and the accountability of your inventory, streamline certain billing processes, and, ultimately, lead to increased nursing and patient satisfaction.

Because automated dispensing cabinets track user access and dispensed medications, their use can improve your control over your drug inventory. Computer-controlled automatic medical dispensing cabinets can only be used by the program defined users and provide drug and materials stored in a secure environment. It respectively answers the medical supplies requests of the user defined and entered to the program. While a cell is working, you cannot turn the other one on. You have to wait the closure of the former cell. Thus, the formation of drug and material defects is blocked. The person who uses the system, the time when the system is used and drug and inventory records are reported by the program. Thus the losses are eliminated, the total drug and material costs are reduced, stock control is provided effectively.

The real-time inventory reports generated by many cabinets can simplify the fill process and help pharmacy track expired drugs. Furthermore, by restricting individual drugs - such as high-risk medications and controlled substances - to unique drawers within the cabinet, you can improve your overall inventory management, patient safety, and medication security. Of further benefit to your patient safety bottom line, automated dispensing cabinets allow the pharmacy department to profile physician orders before they are dispensed (McCormick, 2006: 2).

Automated cabinets can also enable providers to capture medication charges upon dispensing, reducing the billing paperwork pharmacy is responsible for. In

addition, nurses can note returned medications using the cabinets' computers, enabling direct credits to patients' accounts. In theory, because automated dispensing cabinets make drugs available on the nursing unit floor, nursing will have speedier access to a patient's medications. Decreased wait time can lead to less frustration on the part of your nursing staff and to improved patient comfort and care (McCormick, 2006: 2).

Following are descriptions of a majority of the automated dispensing cabinets currently available in the market.

- **AmerisourceBergen Technology Group**

Customizable and modular, MedSelect medication cabinets can store active data and transactions for five years, enabling health systems to search for medication usage trends and outliers. In addition, customizable alerts help the pharmacy control medication usage. The available DrugPoints database from Thomson Micromedex puts medication information at the nurse's fingertips at the MedSelect display terminal, and a biometric scanner can increase security and save time during login. A bar code scanner helps expand tracking and accurately confirm inventories. MedSelect also offers single-dose dispensing for increased inventory control. (McCormick, 2006: 2).

- **CareFusion**

The Pyxis Medstation, Medstation Rx, and Medstation Rx 1000 are automated dispensing devices kept on the nursing unit.These machines are often compared to automatic teller machines (ATMs). The Medstation interfaces with the pharmacy computer. Physicians' orders are entered into the pharmacy computer and then transferred to the Medstation where patient profiles are displayed to the nurse who accesses the medications for verified orders. Each nurse is provided with a password that must be used to access the Medstation. Pharmacists or technicians keep these units loaded with medication. Charges are made automatically for drugs

dispensed by the unit. Earlier models had sufficient memory to contain data for about one week, and newer models can store data for longer periods (Shirley, 1999: 1543).

The cost of automated dispensing mainly involves the capital investment of renting or purchasing equipment for dispensing, labeling, and tracking (which often is done by computer). A 1995 study revealed that the cost of Medstation Rx to cover 10 acute care units (330 total beds) and 4 critical care units (48 total beds) in a large referral hospital would be $1.28 million over 5 years. Taking into account costs saved from reduced personnel and decreased drug waste, the units had the potential to save $1 million over 5 years. (Murray, 2001: 114)

- **Omnicell**

OmniRx medication dispensing cabinets come in a variety of sizes, with a range of drawer types. The cabinets also feature biometric ID security systems and single-dose dispensing capabilities for increased security and inventory control. Bar code scanning features verify the identity and location of a medication, and "guiding light" technology directs the user to the correct medication during dispensing and restocking. The cabinets are integrated with a Web browser for clinical reference information and patient medication profiling. (McCormick, 2006: 4)

2.3.1 General Expectation Properties

Drug management system should have the mechanisms that make the physicians identify the errors and minimize these errors throughout patient-drug application. The system should also have a stock tracking system in the centralized pharmacies and drug application services of the hospital.

Medical stuff management system is to have automated dispensing cabinets which are known as the material usage sections and a main control system where the

control of the activities and services with the management of the filling processes occur.

As to the expected physical features of automated dispensing cabinets, firstly they must be transparent or matt in specific size with locked boxes or drawers. Plus, because of the fact that sections and drawers are modular, cabinets can be organized and modified according to the difference in size, content or material in time.

In order to prevent the errors during the usage of the drawers with unlocked section, there should be lightened drawers where lights direct you to the right types of medicines. Drug dispensing drawers with locked pockets automatically work after drug selection. That is, when you close the locked section, the other locked one automatically comes into service. Moreover, when any of the drawers break down, others must not be affected by such disfunction.

Cabinets which keep drugs under a certain room temperature are to have units with heat and moisture meter. These cabinets must alarm the main control system when the cabinets' inner heat and moisture level go out of the expected ranges.

In case of power cut, the security system should provide manual control of drawers and uninterruptible power supply till the generator runs (in 5 min) to let the floor station work.

In the main control systems of the automated dispensing cabinets, there should be data based management systems and security updates through a server. Drugs can be recorded, changed or deleted along with the information on brand and generic name, dose, size, dose form and patient discharge unit data.

Defining the bio-equivalent drugs, matching the drugs with different potentials, combining doses (doses with more than one drug or serum mixture) and dynamic doses which can be changed due to patients' condition are possible to implement into the system.

Maximum, minimum and the critical level of the drug (for filling in the automated dispensing cabinet) should be specified. The expiration dates of the drugs that are to fill in the station should be recorded in the main control system.

The users of the system should be defined as groups in terms of their authority and duty in order to distribute tasks easily and unerringly.

Drug management system must instantly provide every kind of data in automated drawers. For example, when the feature of taking drugs in the drawers is cancelled, you can still record the drug without any buying or returning. Each drug buying activity in the name of patients can be related to the inventory so that routine out-of-stock situation is to be prevented. At the same time, when drugs taken from the system are not used for any reason, they should be back to the system.

Station Inventory data, expiration date, oncoming drug list and the reports about all system activities can be managed via main control system. Besides, drug management system should send a notification mail to the staff who deal with the problems on specific situations such as out-of-stock, critical level, and inconsistencies.

In case of urgency or exceptions, it is a must to have discharging the authority right and administering medication by nurses without a written medical statement (oral order).

CHAPTER THREE
APPLICATION

3.1 DESCRIPTION OF APPLICATION AREA

Dokuz Eylül University Faculty of Medicine was founded in 1978 under the name of Ege University İzmir Medical School. It provided health care first at İzmir Karşıyaka State Hospital and then at Municipality of İzmir Esrefpaşa Hospital until 1982. With the Decree Law No. 41 in 1982, the faculty was incorporated in Dokuz Eylül University. Old buildings of Faculty of Pharmacy in Ege University were restored and temporarily put into service under the name of Dokuz Eylül University Hospital in 1985 with 325 inpatient bed availability.

The Central Laboratory, the place for routine Biochemistry, Microbiology, Hematology, Parasitology, Pharmacology examinations, was founded in the fourth block in February 1998 so that patients became able to get service in a single station. After that, Muzaffer Kayhan Oncology Hospital started to provide service in May 1998. This department is one of the basic aims of our hospital in terms of an important reference center for Oncology patients.

In December 1998, Hemodialysis unit was renewed but it started to provide service in its new location with ideal conditions in January 2001. At the same time, Coronary Angiography Unit was put into service in the fifth block with new possibilities. In the same year, Pharmacy was opened in this building under ideal conditions.

Today the building of new clinics with 925 inpatient bed availability, Children's ER, IVF Center, Organ Transplant Center, Radiology with advanced technology, Emergency Service with the first Emergency Medical specialty in Turkey, Day Hospital where surgical applications were carried out with small and

short monitoring, Karşıyaka Clinic serving patients in Karşıyaka, 34 clinics, private places and cafeterias were carefully set up in the hospital area.

To support the work of this versatile contemporary structuring of patient units with infrastructure works is an important component of health care services. This issue may not be considered as the focal point at first but it is at the foreground in our institution for service quality and enough fund flow. In this respect, some positive steps that increase the productivity have been taken for 10 years. For instance, Form and Printing House founded in February 1996 which helped to decrease related costs.

Laundry, tailoring and central sterilization units with modern equipments started to work in 1998. Cafeteria and kitchen were renewed and put into service. Moreover, patient records and billing information were electronically stored and used in this way.

Another unique development was seen in September 1998 in which total quality management studies were carried out in a state hospital for the first time in Turkey. The system is adopted to the hospital needs and connected to the management motto "constant renewal project" which fosters the improvement in different areas. The most important advantage of this system is that process and management are seen together at the forefront. Besides, the first strategic planning was carried out with the observations at specific periods. That is, our institution has a mission, vision, and plan in order to reach its aims.

The educational unit of Dokuz Eylül Research and Application Hospital was founded in the Faculty of Medicine in 1997. Active education is based on the system in which students reach the information in accordance with their needs and improve themselves. In this respect, in the very first three years they normally have a lot of lesson hours. However here at this university students learn by doing on problem and application basis along with professional skills, area studies, private study modules with different resources and free study hours.

The active education system has humanistic approach to Medical students and specialists (assistants). That means students are to observe the application and do that experiment on a model then be competent and as a result apply it to the patient. For this reason, professional skills laboratory has been founded in our hospital. This system is ideally carried out and such attempts are used for educational purpose with modern methods so that the quality of education increases while the possibility of misapplications decreases.

3.2 DOKUZ EYLÜL RESEARCH AND APPLICATION HOSPITAL AND AUTOMATED MEDICAL DISPENSING CABINETS

Dokuz Eylül Research and Application Hospital which is one of the leading hospitals in Turkey in health sector wanted to implement the use of medical dispensing cabinets in order to control the materials more effectively and deal with some problems like loss of medical materials and illegal or expired products. However, just before the action, two automated medical dispensing cabinets came into service in the emergency department as a pilot area to foresee the possible problems during the implementation. Those cabinets which were used by the storage officers (managers) actively did not meet the expectations. As a result, some complaints about the non-functionality of the cabinets were received by the managers.

First of all, observations of the application area which had automated medical dispensing cabinets were carried out together with four personnel responsible for storage section of the emergency department of Dokuz Eylül Research and Application Hospital. Especially between 18:00 and 00:90 which is the most crowded time in the emergency department. According to the data based on the

observations and interviews with storage managers; the problems about automated medical dispensing cabinets are;

A- Inadequate cabinets with undersized cells/parts:

Due to the fact that the size of cabinet parts are 10 cm x 12 cm x 8,5 cm, few materials can be used in cells. For this reason, the parts of cabinets are to be filled during the day.

B- Undersized cabinet cells for different kinds of materials and medicals:

Because of their capacity, undersized parts of the cabinets are only available for the medicines, capsules and small consumables that are 7cm and 9 cm high and max 2,5 cm in diameter. In order to popularize this new application and achieve its goal, cabinets should have various and suitable cells available for all medicines and medical consumables.

C- The risk seen when medicines fall down while opening cabinet doors:

Because of the fact that cabinet doors can rotate 180 degrees, capsules and medicines may fall into the floor.

D- The difficulty in opening the cabinet doors:

When doors are opened suddenly, they hit the electronic opening system each time. As a result, the system breaks down and doors do not work appropriately.

E- The height of cabinets:

Due to the fact that automated medical dispensing cabinets are too high, the personnel experiences difficulty in reaching the upper side of the cabinet parts.

F- Insufficient cabinets in terms of their capacity for all materials

3.2.1 The Features of the Materials

Medicines and other consumables that are supposed to be kept in automated medical dispensing cabinets used in Dokuz Eylül Research and Application Hospital are examined in terms of their width, height and depth along with their frequency of use. Medicines that are consumed as tablets can be supplied in packs for single dose by suppliers. For this reason, medicines consumed as tablets are not examined in terms of their height, depth and width. On the other hand, ampoule medicines - vials are produced in specific standards in terms of their sizes all around the world. The related data can be viewed in table 3 below;

Table 3: Standard Sizes of Ampoule Medicines – Vials

AMPOULE MEDICINE	HEIGHT	DIAMETER
Type 1	5 cm	1 cm
Type 2	6 cm	1 cm
Type 3	7 cm	1cm
Type 4	9 cm	2 cm

We can generalize the size of single use prefilled dose mixture & gel & ointment & cream as 5cm- 15 -17cm and 4 cm. (This information is gathered from the material storage of the emergency department of Dokuz Eylül Research and Application Hospital after the materials measurement. Such data can only be used during the design of automated medical dispensing cabinets of material storage in the emergency department of Dokuz Eylül Research and Application Hospital. It can not be related to other medicines produced and used all over the world).

According to 2011-2012 material movements and consumption gathered from Dokuz Eylül Research and Application Hospital, the information on the width, length and height of consumables listed as favorite materials can be seen in appendix 1.

3.2.2 House of Quality

According to the gemba study conducted in the material store of the emergency department at Dokuz Eylül Research and Application Hospital, customer needs in terms of the problems with the medical dispensing cabinets have been defined as cabinet cells with appropriate size, storing different kinds of medicines and materials, safe cabinet cells to minimize the risk to fall, cabinet doors easy to open, accessible cabinets in height and majority of medicine and material types.

In order to fulfill the needs of customers, engineering techniques, modular design, cabinet cells design with different dimensions, standardization, cabinet cells designs with stoppers and channel design and changing the lock mechanism have been determined as a 'must do list'.

Customer demands have been identified in terms of their level of importance in gemba study conducted by storage keepers at the emergency department of Dokuz Eylül Research and Application Hospital thanks to AHP (Analytical Hierarchy Process), a quantitative method in choosing and ranking the decision alternatives according to multi-criteria. AHP matrix, specifically designed for this purpose, was graded by the materials manager in Dokuz Eylül Research and Application Hospital in reference to the AHP evaluation scale of customer demands seen below.

Table 4: AHP Evaluation Scale

Numerical Value	Definition
1	Elements are equally important or their level of importance cannot be decided
3	1st element is a bit more important or in demand than 2nd element.
5	1st element is more important or in demand than 2nd element.
7	1st element is a lot more important or in demand than 2nd element.
9	1st element is extremely more important or in demand than 2nd element.

Source: Saaty, 1994, p.55

AHP Matrix factors were used through the analysis and the data obtained from the analysis was sorted descending. As a result customer demands were defined in terms of their level of importance. As it can be seen in the AHP matrix below, top two concerns among customer demands have been specified as cabinet cells with appropriate size and majority of medicine/material types.

Table 5: AHP Matrix a

	CABINET CELLS WITH APPROPRIATE SIZE	STORING DIFFERENT KINDS OF MEDICINES AND MATERIAL	FALL SAFE CABINET CELLS	CABINET DOORS EASY TO OPEN	ACCESSIBLE CABINETS IN HEIGHT	MAJORITY OF MEDICINE AND MATERIAL TYPES
CABINET CELLS WITH APPROPRIATE SIZE	1	5	7	7	7	3
STORING DIFFERENT KINDS OF MEDICINES AND	0,2	1	5	5	7	1
FALL SAFE CABINET CELLS	0,142857143	0,2	1	5	7	0,2
CABINET DOORS EASY TO OPEN	0,142857143	0,2	0,2	1	1	0,142857143
ACCESSIBLE CABINETS IN HEIGHT	0,142857143	0,142857143	0,142857143	1	1	0,142857143
MAJORITY OF MEDICINE AND MATERIAL TYPES	0,333333333	1	5	7	7	1
TOTAL VALUE	1,961904762	7,542857143	18,34285714	26	30	5,485714286

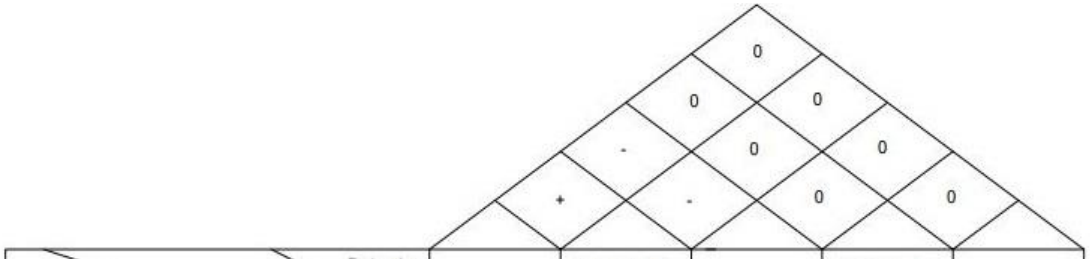
Table 6: AHP Matrix b

	CABINET CELLS WITH APPROPRIATE SIZE	STORING DIFFERENT KINDS OF MEDICINES AND	FALL SAFE CABINET CELLS	CABINET DOORS EASY TO OPEN	ACCESSIBLE CABINETS IN HEIGHT	MAJORITY OF MEDICINE AND MATERIAL TYPES	AVERAGE VALUE	IMPORTANCE TO CUSTOMER
CABINET CELLS WITH APPROPRIATE SIZE	0,509708738	0,662878788	0,381619938	0,269230769	0,233333333	0,546875	0,43394109	6
STORING DIFFERENT KINDS OF MEDICINES AND	0,101941748	0,132575758	0,27258567	0,192307692	0,233333333	0,182291667	0,18583931	4
FALL SAFE CABINET CELLS	0,072815534	0,026515152	0,054517134	0,192307692	0,233333333	0,036458333	0,10265786	3
CABINET DOORS EASY TO OPEN	0,072815534	0,026515152	0,010903427	0,038461538	0,033333333	0,026041667	0,03467844	2
ACCESSIBLE CABINETS IN HEIGHT	0,072815534	0,018939394	0,007788162	0,038461538	0,033333333	0,026041667	0,0328966	1
MAJORITY OF MEDICINE AND MATERIAL TYPES	0,169902913	0,132575758	0,27258567	0,269230769	0,233333333	0,182291667	0,20998668	5

At the house of quality seen in Figure 9 and created by the data of studies conducted in the material store of emergency department, at Dokuz Eylül Research and Application Hospital, the most significant steps which are to be taken according to the levels of importance among specialized engineering techniques are determined

as modular design, designs of cabinet cells with different dimensions and standardization.

Figure 9: House of Quality



Customer Requirements / Importance to customer / Engineering characteristic		Modular Design	Cabinet cells design with different dimensions	Standardization	Cabinet cells designs with stoppers and channel design	Changing the lock mechanism
Cabinet cells with appropriate size	6	3	3	3	1	1
Storing different kinds of medicines and materials	4	3	3	3	1	1
Fall safe cabinet cells	3	1	1	1	3	1
Cabinet doors easy to open	2	1	1	1	3	3
Accessible cabinets in height	1	3	1	1	1	1
Majority of medicine and material types	5	3	3	3	1	1
Importance weighting		53	51	51	31	25

Moreover, when contradiction matrix is analyzed, it can be seen that there is a contradiction between standardization and cabinet cells designs with different dimensions. In order to figure this problem out, it would be better to have materials and medicines in limited numbers and sizes instead of designing cabinet cells for each material.

3.2.3 Experimental Study

Experimental works and the house of quality data gathered from gemba studies conducted in the materials store in the Emergency Department of Dokuz Eylül Research and Application Hospital can be altered only for visualization and demo during the manufacturing scale production.

Because of the different kinds of medicines and consumables used in hospital departments in terms of their types and amount of use, the need for automated medical dispensing cabinets may not be the same. For this reason, each department should have its own automated medical dispensing cabinet regarding their own specific needs. In this respect, modular system is used for the new design of such cabinets. Therefore, customers will be able to have their own automated medical dispensing cabinets by matching modules with the right size and number. The system works when modules come together which can be organized easily considering the customer needs.

According to the data on medicine sizes in the material storage of Dokuz Eylül University Emergency Department, 3 different cabin/cell modules in 10 cm x 18 cm x 12 cm, 10 cm x18 cm x 18 cm and 10 cm x 18 cm x 24 cm have been designed in order to store tablet medicines, size of single use prefilled dose mixture, ampoule medicines-vials, gel, ointment and also cream.

Visual works on automated medical dispensing cabinets created by linking the modules along with modular components (module carcass, module right-left side boards, module top-bottom boards) can be seen in Figure 10, 11, 12 and 13 below.

Figure 10: Module 10 cm x 18 cm x 12 cm

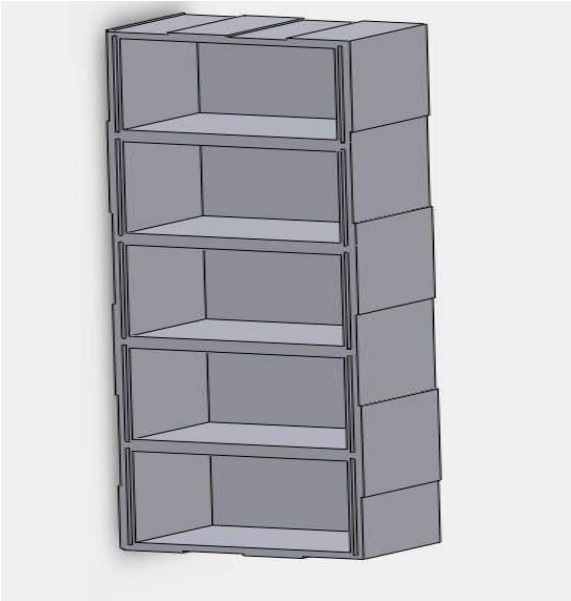


Figure 11: Left and Right Side of Module

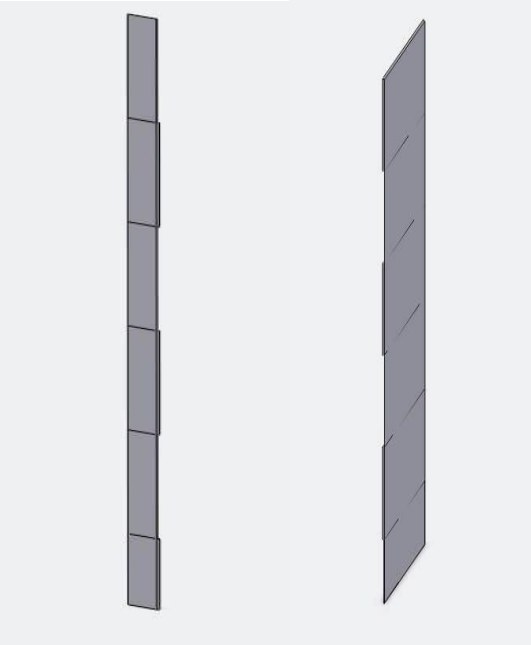


Figure 12: Top and Bottom of Module

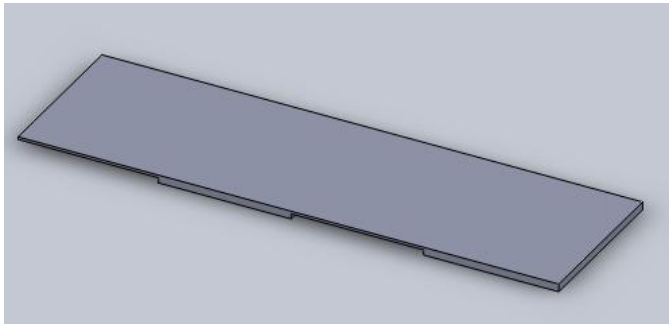
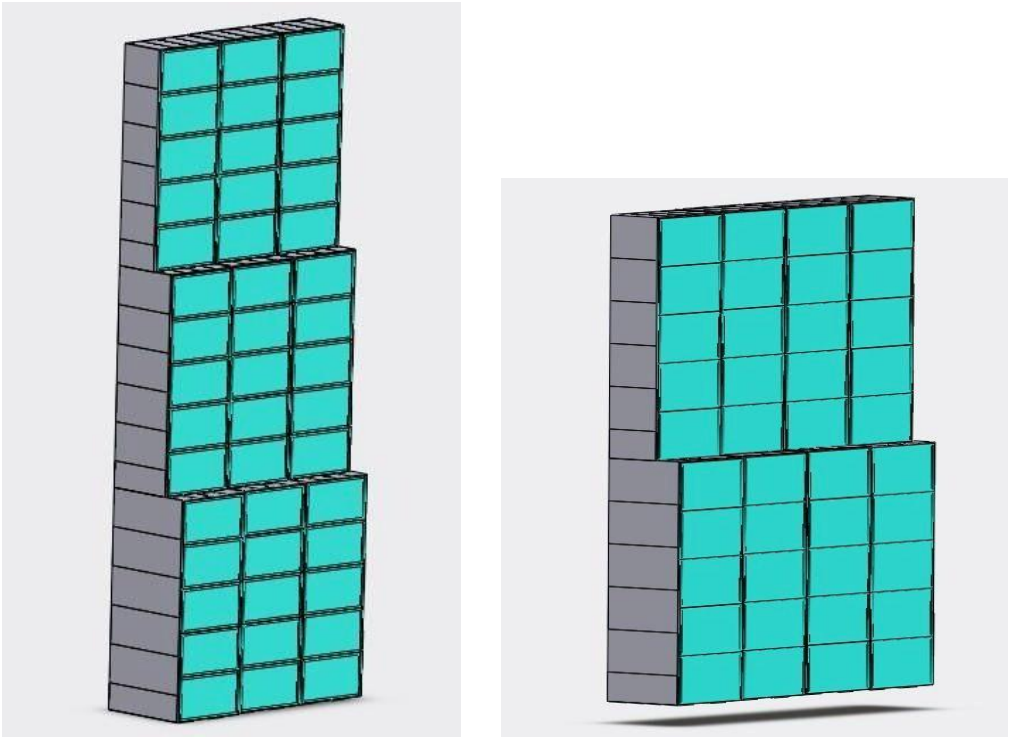


Figure 13: Examples of Group Module

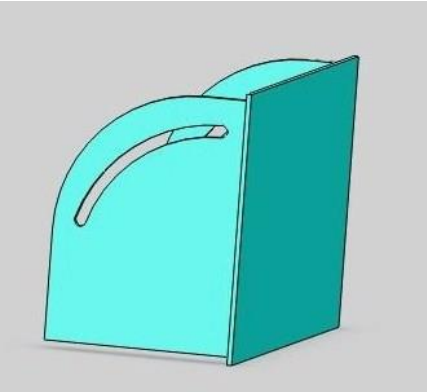


Moreover, cabinet doors open suddenly (quick action doors) and hit the electronic system. This problem which causes system error leads to the fact that the doors would be hard to open and/or unserviceable. The issue has been resolved

thanks to the stopper designs of cell canals into which the doors' side panels penetrate.

As it can be seen from the photo below; side panels of doors' penetrate into the cell canals. The doors have a limited opening capacity (a man's hand can reach it out very easily) due to stoppers. As a result, there would be no mechanic impact of the electronic system on the lower cap. Additionally, the limited opening capacity of cell doors led to no falling risk of the materials (especially tablet and ampoule medicines).

Figure 14: Cabinet's Cover



According to the data on the material movements in Dokuz Eylül Research and Application Hospital between 2011-2012, medical consumables listed as favorite materials used frequently have been divided into 5 categories considering their material sizes. It has been seen that there is no need for an extra cabinet design to store the medical consumables with their common material size in category 1. Instead, the cell designed in 10 cmx18 cmx 24 cm can be used to store tablet medicines, size of single use prefilled dose mixture, ampoule medicines-vials, gel, ointment and also cream.

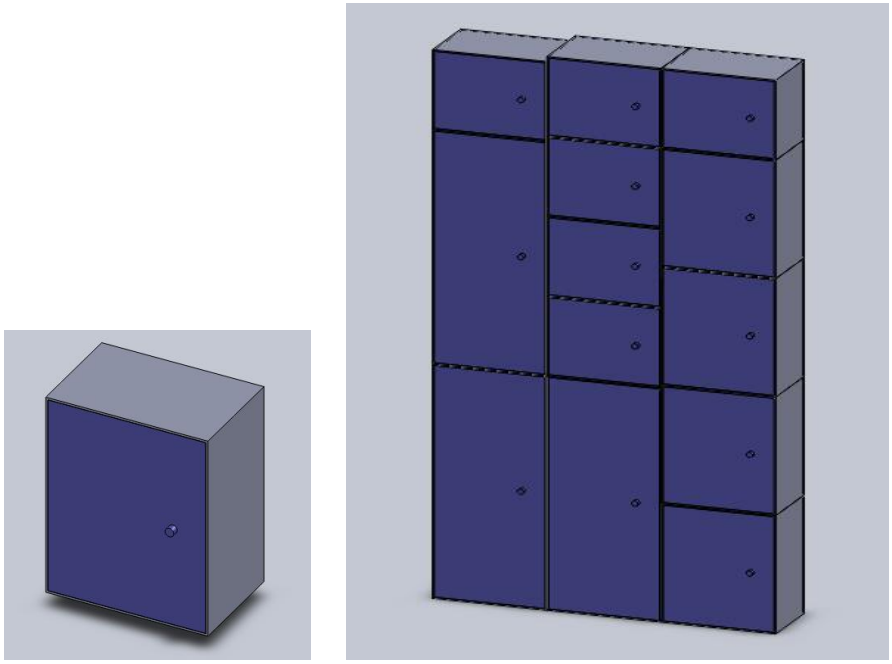
Table 7: Regards to Dimensions Favorite Medical Consumable Materials Categories of Dokuz Eylül Research and Application Hospital

CATEGORY	WIDTH (cm)		LENGHT (cm)		HEIGHT (cm)	
	minimu	**maximu**	**minimu**	**maximu**	**minimu**	**maximu**
1 **2**	2 3,8	20,8	0,1	20	0,4	21,5
2	3,8	29	0,1	34,5	0,1	33,5
3	6	35,5	0,1	57	0,3	57
4	5	31	0,6	81,5	1	87
5	9,5	24	1,5	290	0,5	204

In order to store medical consumables of different categories, 36 cm x 24 cm x 30 cm automated medical dispensing cabinets for the 2nd category, 36 cm x 24 cm x 60 cm automated medical dispensing cabinets for the 3rd category and 36 cm x 24 cm x 90 cm automated medical dispensing cabinets for the 4th category are to be designed because of materials' size.

Due to the fact that the size of materials of 5th Category is too wide and deep, the usage of medical dispensing cabinets becomes problematic. Also as the number of materials in the 5th category is 2,7 percent of total materials, the materials of Category 5 is excluded from the automated medical dispensing cabinet applications.

Figure 15: Examples of Group Cabinet for Medical Consumables



As a result, 90 percent of all medicine and medical consumable materials used in Dokuz Eylül Research and Application Hospital can be controlled actively and periodically through automated medical dispensing cabinets.

CONCLUSION

In recent conditions, inventory management has become one of the most important factors that affect the profitability of all institutions in service/industry sectors. For a successful inventory management, it is necessary to monitor lost materials, junks and wastes primarily and effectively. Afterwards, such problems should be eliminated. In health sector, medicine and medical consumables are considerable cost items in terms of their material values. On the other hand, problems such as loss of material, leakage, shrinkage and expired medicines frequently occur in hospital stocks. When these conditions are taken into accounts, computer based automated medical storage cabinets become at utmost importance as they are designed to monitor the consumption and control of medicine and medical consumables used in health organizations in a more restricted and systematic way.

Dokuz Eylül Research and Application Hospital is Turkey's one of the leading hospitals in health sector. This study has been conducted when the automated medical storage cabinets that are used to monitor materials more effectively and eliminate some problems like lost, contraband, waste and expired medicine and medical consumables have not met the expectations functionally. Soon after, the design of automated medical storage cabinets has been carried out through the voice of customers.

QFD which is one of the most efficient methods on listening to the voice of customers and also User Centered Design method have been integrated to each other and used in this study. To make it clear; model design in QFD method has been conducted by the designer through the data collected from gemba study. However, QFD and User Centered Design methods have been combined including the customers and their observations into the study just as in the User Centered Design method in this application.

First of all, the problems, deficiencies and user needs obtained right after the examination of the present system have been taken into consideration and then a new automated medical storage cabinet design has been carried out in this perspective. 3D prototypes of automated medical storage cabinets have been prepared and demo studies have been finalized through user feedbacks through the process of designing.

In the study, designs have been carried out by considering the size of the medicines and consumables used in Dokuz Eylül Research and Application Hospital and wished to be stored in automated medical storage cabinets and examining their amount and frequency of use from 2011 to 2012. Nonetheless, different designs can be applied according to the size of the material used in other institutions that plan to have the system.

It is possible to develop automated medical storage cabinets with similar designs and applications toward the needs in the other sectors like office equipment, gold-jewelry, automotive, electronics, pharmacy as well as health sector via minor modifications. The main approach is that the value of the materials should be relatively higher than the cost of keeping materials.

Such kind of applications can be preferred due to the fact that automated storage cabinets are electronically controlled and regular stock control is a must for stock-out avoidance. The best example for this issue can be butorphanols (i.e. analgesic medicine group).

It shouldn’t be so difficult to popularize the application of automated medical storage cabinets. Besides, according to the data gathered from the medical storage cabinet examples applied in health sector, it has been seen that 20% of medicine saving has been provided in a year. Additionally, the investment amortized itself over 5 years on the average. Moreover, the cost of automated medical storage cabinets can be decreased with the help of alternative materials in designing

automated medical storage cabinets as long as they meet user needs and expectations.

Automated medical storage cabinets have been in use since 1980 in the world while they have been gaining a popularity in Turkey only for the last 5 years. The cabinets provide an efficient inventory management and increase the safety of medicine. Moreover automated medical storage cabinets make the inventory management efficient through simplifying the tasks of warehouse personnel and accounting department along with the process of net invoicing.

The most of problem with the automated medical storage cabinets in use in Dokuz Eylül Research and Application Hospital is related with design issue. On the other hand, due to the fact that any user expectation about the enhanced software applications of automated medical storage cabinets used in worldwide has not been encountered so far, thus this study has not included any information on software and electronic design. However, fresh studies can be carried out on the point in question if users wish new software and hardware applications, the process to improve or get better in the future with increasing expectations on reporting and budget.

A better follow-up process on patient and medicine becomes more efficient and more observable through installable hardware and interfaces in the view of user needs on automated medical storage cabinets. In addition, new applications can be implemented and the contribution provided to managers by various detailed reports on management can be increased.

In the forthcoming years, the rate of automated medical storage cabinets' use and importance is going to increase in the sector in Turkey when the ministry of health gets centralized management started in all departments of health sector since the application of these cabinets provides them instant traceability of patient and medicine.

Automated medical storage cabinets can be recommended to be in use in intensive care units, cardiology and psycho-neurosurgery departments which all need instant follow of medicine doses for patients. Also they can be implemented in emergency departments in hospitals where patient and medicine records may pose problems because of the fact that the utmost importance is human life and therefore stress is inevitable in such cases. Finally, the automated cabinets can highly be helpful in the hospitals which have diverse medicine types and in some units which have problems with inventory management.

The approach adopted in this study develops simpler, easier and cost-efficient systems with the comfort of use for users instead of technologically equipped premium machines which requires broad area of utilization in institutions. QFD is a commonly used method to develop such systems. The implementation of QFD method into the design of automated medical storage cabinets is a new idea for such studies. Different systems and designs can be developed easily by listening to the voice of customers and thanks to this approach for other purposes.

This study is restricted to the observations and data on materials in Dokuz Eylül Research and Application Hospital. Related designs can differ in the course of time because of both population and periodical needs. In such cases, it would be necessary to listen to the voice of customers again. It is possible to carry out a field survey of prototype studies on the developed 3D designs. Thus, necessary design modifications along with the most appropriate practices can be implemented in the light of customer feedbacks. Besides, optimization suggestions obtained through focus group actions and gemba studies which will be conducted with users and observations of available applications on automated medical storage cabinets at other hospitals can be taken into consideration throughout the design process of the future study.

This study has some limitations so do all scientific studies. First and foremost, a study on all materials can be done examining wide range of group of materials. However, a good long time is needed to complete such a study. Therefore, materials with high frequency of use and amount of consumption have been analyzed in this study because of time limitations. Functional applications could also have been carried into practice if the study had conducted with wider financial possibilities and in a longer time.

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APPENDICES

APPENDIX 1: Favorite Medical Consumable Materials List of Dokuz Eylül Research and Application Hospital Between 2011-2012

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
COCHLEAR IMPLANT-16 KANALLI-(BIONIK KUL	18	27,5	4
DIAG.QUADRIPOLAR EPS KATETERI CRD 5/6 F	27	40	3
GUIDING KATETER 6F XBLAD 3.5	11	190	2
KARDIYAK HARITALAMA VE GORUNTULEME PATC	20,5	27,5	1
MAMOREP MEME ISARETLEME IGNESI 21G 11CM	10	0,3	38,9
NEFROSTOMI RE-ENTRY KATETERI 16 FR	15	57	0,5
PDA COIL 3X4 MM	13,5	33	0,5
VITREKTOMI - FAKO SET	33	53	8
VITREKTOMI SETI (2500 KESI)	24,5	32,5	7
2 mm Tpakar Çocuk Cerrahisi	14	5	30
20 G ENDOLAZER PROBE	27	32,5	0,3
ABSORBENT STICK	10	14,5	7
AOR.KOK/ROOT KANUL COCUK(ROOT-14.16)	15	29	0,5
AORTA VEIN PUNCH NO 4.5	10	33	2
ARTER KANULU	5	13,5	1
ARTERIAL VENT KATETERI 20F(SILIKONLU,CO	15	57	2
ASD OCCLUDER DELIVERY SYSTEM	23	190	0,5
BASINC UZATMA HATTI	12	15	2
BASKET KATETER 3TELLI 3FR 10-12MM	32,5	47,5	2
BILIARY STENT SET 10F 7CM	25	29	2
BILIER DILATASYON BALONU	26	32	3,5
BLADE RAD 60	14	2,4	0,5
BRONKOSKOPI ICIN MUKUS EXTRACTOR	13,5	20	4,5
BY PASS ORTUSU (PEDIATRIK)	29	49	5
CAVAFIX 70 CM BASILICA	5	79	2
CRITICON KATETER%	29	49	1
DESTEKLEYICI PTCA KILAVUZ TELI	29	32	2,5
DOUBLE J STENT FLEXIMA 8X24	30	0,6	67,5
DOUBLE LUMEN SISTOMETRI KATETERI 6FR	20	52	0,5
ENDOSKOPIK MARKER	2	17	2

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
ENDOSKOPIK TRU-CUT ULTRASON KATETERI	27	54	1
ENJEKTOR 1 CC IVF ICIN	13	17,5	0,5
EPIDURAL MINI KIT 18G(KATETER)	12	2,9	21,5
EXCHANGE GUIDEWIRE 0.035' 2	24	29	0,5
FAKO BICAGI 2.2-2.8 MM	5,5	18,5	1
FLEXON 0 2597/63 YUV 26 MM 60 MM DÜZ İĞNE	6,5	13,5	6
GASTROSTOMI PEG SETI 20FR	29	52	4
GLUCOME VALVE	10	14	1
GN300040 - TROKAR 10MM UZUN	12	6	30
GN300042 - MANIPULATOR (UM201)%	18	4,5	28
GN300050-VERESS IGNESI 150 MM	15	1,5	30
GN300100 - ROTICULATOR 55-4.8 STP.(017614)	16,3	1,7	68
GN300101- KAPATICI 30 -4.8STAPLER	19,3	6	51
GN300122-KAPATICI KESICI STAPLER ATICI 75-80	12	4,5	33,2
GN300129-LAPAROSKOPIK STAPLER KARTUSU 45 - 3,5	16	2,5	68
GN300131 Premium Surgiclip II	14,1	1,7	47,2
GN300132 - KLIP ATICI (ML) 10 MM	18,4	4	54,5
GN300147 - THORACOPORT 11.5MM (179303)	9,5	3,5	12,5
GN300162 - VERSAPORT TROKAR SABITLEYICI 5-11MM-	8,8	4	12
GN300169 - LOCKING TROKAR 10 MM	11,2	6,8	51,2
GN300177 - ACILANDIRILABILIR MAKAS 5 MM	16	2,7	45
GN300181 - TROKAR SETI 5 MM	10,5	5	26,5
GN300186 - LAP.DMR KAP. VE KESME MONOP. KTR PRB 5MM	24,5	2,5	70
GN300189 - SPACEMAKER BALON	11,5	6,9	17,5
GN300191 - MULTIFIRE TA 45-4.8 STP	19,5	6	48,5
GN300205 - VERSAPORT TROKAR 15MM(179071P)	12,1	16,5	31
GN300215 - ACILANDIRILABILIR LAPAROSKOPIK STAPLER KARTUS 45-2.0	7,5	1,5	19,5
GN300216 - DAMAR KAPAMA ELEKTRODU (TIROID-PROBU)LS	13	3	28
GN300221 - TROKAR SETI 15 MM	10,5	5,5	26,5
GN300224 - PNOMOTIK KOMPRESYON	18	3	70

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
GUARDIAN OVERTUBE	28	50	3
GUIDE WIRE 0.038 J 150 CM	10	170	0,5
GUIDING KATETER 6F XBLAD 4.0	9,5	290	0,5
HEMOCRON(ACT) TUPU	11	28	8,5
IDRAR TORBASI KIZ COCUK	8,1	0,1	13
IGNESIZ VALFLI KONNEKTOR	3,5	8	1
INDEFLATOR (AC 3200)	12	34,5	6
INFERIOR TURBINATE BLADE 18-82040 2MM	19	25	1
INFINITY TUBING SET (GOZ)	22	24	5
INFUZYON PORTU 4 MM	15	20	0,4
INTRAVASKULER ULTRASOUND KATETERI(IVUS	34	39	2
IVT CUTTING BALON 2.25X10MM	25	25	2
İNPUT GF	10	29	10
KALICI DUAL LUMEN KATETER 8F 24CM	21	46	2
KALICI KATETER 14.5X32CM	30	45	3,5
KARE YARA ORTUSU 10 X 10(COMFEEL)	15,6	0,1	17,6
KILAVUZ TEL	24,5	27	0,1
KILITLI NEFROSTOMI SETI 12F	12,5	2	72,5
KILITLI NEFROSTOMI SETI 14F	12	0,8	70
KOLON TORBASI	19	25	2,5
KORONER STENT 3.0X18 MM	23	27	1,5
KORUMALI ONLUK	34	49	5
LEGACY TUBING SET	12,5	25	10
LIFE CATH CIFT LUMENLI PICC KATETER 4F	29	44	2
LIGACLIP 6 LI KARTUS (LT200)	11,5	14	6
MALLEABLE PENIL PROTEZ(90MM)	16	32	3,5
MANİFOD KİT	15	16	3,5
MICRO ENJEKSIYON KITI	15	26,5	2,5
MICRO PUNCTURE(MINI STICK 4F)	11	0,6	29,7
MICRO SPONGE	5,5	11	0,4
MONTGOMERY LARYNGEAL KEEL RADIOPAQ	9	12	4
NEFROSTOMI KATETERI (RE-ENTRY) 20F 17CM	10	43	3
NEFROSTOMI RE-ENTERY KATETERI 24FR 17CM	31	81,5	1
NON-CONTACT MAPPING MULTI ELEKTROD	24	275	2,5
OPU SETI	25	30	8

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
PEDIATRIK EPIDURAL SET (19G)	8,4	2,2	15
PEDIATRIK EPIDURAL SET 20G	12,4	2,6	27
PERITONEAL DIAL.PD TEMP CATHETER SET(2.	13,5	42	2
PERITONEAL DIALYSIS NEONATAL TENCHOFF C	15	48	0,5
PERKUTAN NEFROLITOTOMI AMPLATZ RENAL DIL	22	50,7	2
PVA 710-1000 MIKRON	8,3	3,8	13,5
RD302112 - SELDINGER NEDDLE (MADRENLI)	6	1,7	20,8
RD302112 - SELDINGER NEDDLE (MADRENLI)	20,8	1,5	6
RD302114 - INTRODUCER SET 6F	10,4	2,8	27,9
RD302118-HIDROFILIK GUIDEWIRE 0.035 J 180 CM	21,3	0,1	26,1
RD302119 - HIDROFILIK GUIDE WIRE 0.035 J 260 CM	28,5	2,8	28,3
RD302148 - INTRODUCER SHEATH SISTEM 7F	10,1	2,4	27,7
RD302149 - EXCELSIOR SL-10 MICRO KATETER	25,5	2	37
RD302189 - INTRODUCER SET 4F KISA PEDIATRI	11	2,5	26,5
RD302209 - 5F KOBRA KATETER 0.038' 65-	10	2,4	83
RD302224 - BILIER DRENAJ SETI 12-14 FR	12	1	68
RD302366 - SELFEXPENDABLE METALIK STENT 10X68MMX10	20	2,3	48,5
RD302441 - MIKRO GUDE WIRE 0.018 V-18 200 CM	28	1,3	28
RD302532-EMBOLI KORUMA SISTEMI FW EZ 190 MT	24,8	2	30,5
RD303068-PTA BALON KATETER (415-8060S) 80CM 80X6	6	1,5	87
RD303201 - SELFEXPENDABLE KAROTID STENT 7X40X135 C	29,2	2,2	56,2
RD303303-EMBOLI PRODECTION DEVICE 070	28	2	28
RD303472-DİZ ALTI PTA BALON 3,5X100X90	10	1,5	204
RESPIRATOR FLOW SENSOR(GALILEO UYUMLU	13,5	1,4	14
RESPIRATOR OKSIJEN SENSORU(DRAGER UYUMLU	7,7	33	12,3
RETROBULBAR IGNE (ATKINSON)	8	10	4
Roticulator 55	29	3	23,9
SELDINGER NEDDLE (MADRENSIZ)	7	16	0,5

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
SHAH VENTILASYON TUPU	19	8	1
SIL. PED.AKRIMAL ENTUBASYON (DSR) TUP	7,5	14,5	2
SILICONLU TORAKS DRENI(EGRI)32 F	25	49	2
SILIKON DOUBLE 3 MM NEONATAL NASAL VENTILASYON TUPU	14	26	1,5
SILIKON YAGI 1300 MPAS(10 ML'LIK CAM SIRINGADA)	12	17	3,5
SIRKULER FLEP BICAGI%	4	20	1
STEEL 4 2X45CM GS13(kutusuz)	8	52	0,5
T300145 - TWO DAY INFUSOR (2 GUNLUK)(PC1075K)	10	3	19,7
T300168 - KORUYUCU ONLUK	20,5	3,5	26
T300223 - KOLOSTOMI TORBA ADAPTORU	15	0,7	15
T300255-TRAKEOSTOMI KANUL KAFSIZ NO: 5	8	3	14,5
T300261-TRACHEOSTOMY KANULU KAFLI NO:7.5	9,5	5	14,5
T300270-TRAKEOSTOMI KANULU KAFSIZ NO 3.5	8	2	14,5
T300452 - ENT. TUPU (KAFSIZ) NO-3	10	0,2	27,5
T300605 FOLEY SONDA STERIL NO: 16	6,5	0,5	50
T300703 - CARMEN KANUL	15	0,1	45
T300704-CARMEN ENJEKTOR STERİL	15	3	48,5
T301012 - NELLCOR PULSE OKSIMETRE PROBU ERISKIN-NE	11	1	19,8
T301157 - AIR-WAY 50 MM	6	2	8
T301163 - AIR-WAY 90 MM	7,5	3,5	13
T301201 - THORAX KATETER NO-20(200/812)	6	0,8	57
T301295 - ENTUBASYON TUPU STILETI SMALL(PEDIATRIK)	3,8	0,2	33,5
T301351-BAKTERI FILTRESI	6	5,5	7,5
T301360 - THERMOVENT HEPA	10	4,3	12
T301361-THERMOVENT T	6,3	2	8
T301362-THERMOVENT O2	17	1,5	17
T301806 - GORE-TEX SEAMGUARD (PATCH)	7,5	2	20,5
T301811-TAPERED THINWALLED INTERING GRAFT 4X7 45CM	18,5	4	26,2
T301814-THIN BIFURCATION STR GRAFT 18X9 MM PTFE	16,5	4	31
T301815-THIN.BIFURCATION STR.GRAFT 20X10	24,5	4	25,5

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T301820 - TAPERED RINGLI GRAFT 4X7 48 CM	16,5	4	31
T301852 - URETERAL KATETER 3F	5,5	0,1	20
T301917-COMPOUNDER TRANSFER SET	25	1	27
T302038 - COM.TRANSFER SET(REF: 724)	20	3	51
T302752 - VAKUM YARDIMLI KUCUK KAPAMA SETI	24	3	30
T302753- VAKUM YARDIMLI BUYUK KAPAMA SET	24	3	29,5
T302754 - VAKUM YARDIMLI TOPLAMA SETI	14	5,5	29
T302795 DISPOSABLE RF KANULU E/MC100.05(STANDART	9,5	0,1	24
T302972-KAVISLI KAPATICI-KESICI STAPLER	24	3	52
T303004 - VAKUM YARDIMLI BEYAZ KAPAMA SETI(10X7.5C	16,5	1	25
T303006-KANAMA DURDURUCU (HEMOSTATIK MATRIKS	15,3	3	26,2
T303091-NUTRISYON 3000ML (KORUMALI)	25	2	29,5
T303235-FEP RİNGED STRETCH VASCULAR GRAFT 8MM 70CM SRRT08070070	16,3	4	31
T305344-WOVEN VASCULAR GRAFT 10MMX60CM(DACRON)	16,2	6	32
TEK ATIMLIK ENDOSKOPIK BAND LIGASYON SET	17	17	2
TEK LUMENLI LIFE CATH KATETER 3F	21	37	2
TORAKS DRENAJ KATETER SETI 8F	10	53	1
TR305076 - DESIGN M MALAR SHAPES RIGHT 64X19X7XMM	14,5	3	18
TR305536 - MEME PROTEZI(MENTOR CPG 323)	21,5	2,5	39,5
TRACHEOSTOMY SET NO: 7 FORSEP	17,9	5,8	26,2
TRAKEOSTOMI KANULU 8 LPC	8	5,5	5,5
TUR LOOP(REZEKTOSKOP)24-26 F(TEK GIRISLI	8	42,5	1
URETER DILATASYON BALON KITI 15 FR 4 CM	35,5	50,5	5
URETERAL KATETER ACCESS 6FR 70CM	8,5	81,5	0,5
UZATMA 1200PSİ - SABİT M-F 120CM	9	19	1
V.INTRAVASCULAR ULTRASOUND KATETER	35	40	3
VENOZ KANUL NO 22	10	63	2
VESSEL DILATOR (501-200/501-219A)	6	10	1
Y KONNEKTOR İĞNELİ	9	20	0,5
ZOR EMBRIYO TRANSFER KATETERI(BEYAZ)17.5	8	42	0,3

APPENDIX 2: Material List of 1st Category

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
ENDOSKOPIK MARKER	2	17	2
IGNESIZ VALFLI KONNEKTOR	3,5	8	1
SIRKULER FLEP BICAGI%	4	20	1
ARTER KANULU	5	13,5	1
FAKO BICAGI 2.2-2.8 MM	5,5	18,5	1
T301852 - URETERAL KATETER 3F	5,5	0,1	20
MICRO SPONGE	5,5	11	0,4
RD302112 - SELDINGER NEDDLE (MADRENLI)	6	1,7	20,8
VESSEL DILATOR (501-200/501-219A)	6	10	1
T301157 - AIR-WAY 50 MM	6	2	8
T301351-BAKTERI FILTRESI	6	5,5	7,5
T301361-THERMOVENT T	6,3	2	8
FLEXON 0 2597/63 YUV 26 MM 60 MM DÜZ İĞNE	6,5	13,5	6
SELDINGER NEDDLE (MADRENSIZ)	7	16	0,5
GN300215 - ACILANDIRILABILIR LAPAROSKOPIK STAPLER KARTUS 45-2.0	7,5	1,5	19,5
T301806 - GORE-TEX SEAMGUARD (PATCH)	7,5	2	20,5
SIL. PED.AKRIMAL ENTUBASYON (DSR) TUP	7,5	14,5	2
T301163 - AIR-WAY 90 MM	7,5	3,5	13
T300255-TRAKEOSTOMI KANUL KAFSIZ NO: 5	8	3	14,5
T300270-TRAKEOSTOMI KANULU KAFSIZ NO 3.5	8	2	14,5
RETROBULBAR IGNE (ATKINSON)	8	10	4
TRAKEOSTOMI KANULU 8 LPC	8	5,5	5,5
IDRAR TORBASI KIZ COCUK	8,1	0,1	13
PVA 710-1000 MIKRON	8,3	3,8	13,5
PEDIATRIK EPIDURAL SET (19G)	8,4	2,2	15
GN300162 - VERSAPORT TROKAR SABITLEYICI 5-11MM-	8,8	4	12
Y KONNEKTOR İĞNELİ	9	20	0,5
UZATMA 1200PSİ - SABİT M-F 120CM	9	19	1
MONTGOMERY LARYNGEAL KEEL RADIOPAQ	9	12	4

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T302795 DISPOSABLE RF KANULU E/MC100.05(STANDART	9,5	0,1	24
T300261-TRACHEOSTOMY KANULU KAFLI NO: 7.5	9,5	5	14,5
GN300147 - THORACOPORT 11.5MM (179303)	9,5	3,5	12,5
T300145 - TWO DAY INFUSOR (2 GUNLUK)(PC1075K)	10	3	19,7
ABSORBENT STICK	10	14,5	7
GLUCOME VALVE	10	14	1
T301360 - THERMOVENT HEPA	10	4,3	12
T301012 - NELLCOR PULSE OKSIMETRE PROBU ERISKIN-NE	11	1	19,8
GN300189 - SPACEMAKER BALON	11,5	6,9	17,5
LIGACLIP 6 LI KARTUS (LT200)	11,5	14	6
EPIDURAL MINI KIT 18G(KATETER)	12	2,9	21,5
SILIKON YAGI 1300 MPAS(10 ML'LIK CAM SIRINGADA)	12	17	3,5
BASINC UZATMA HATTI	12	15	2
ENJEKTOR 1 CC IVF ICIN	13	17,5	0,5
BRONKOSKOPI ICIN MUKUS EXTRACTOR	13,5	20	4,5
RESPIRATOR FLOW SENSOR(GALILEO UYUMLU	13,5	1,4	14
BLADE RAD 60	14	2,4	0,5
TR305076 - DESIGN M MALAR SHAPES RIGHT 64X19X7XMM	14,5	3	18
INFUZYON PORTU 4 MM	15	20	0,4
MANİFOD KİT	15	16	3,5
T300223 - KOLOSTOMI TORBA ADAPTORU	15	0,7	15
KARE YARA ORTUSU 10 X 10(COMFEEL)	15,6	0,1	17,6
T301362-THERMOVENT O2	17	1,5	17
TEK ATIMLIK ENDOSKOPIK BAND LIGASYON SET	17	17	2
SHAH VENTILASYON TUPU	19	8	1
RD302112 - SELDINGER NEDDLE (MADRENLI)	20,8	1,5	6

app. p.2

APPENDIX 3: Material List of 2nd Category

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T301295 - ENTUBASYON TUPU STILETI SMALL(PEDIATRIK)	3,8	0,2	33,5
RESPIRATOR OKSIJEN SENSORU(DRAGER UYUMLU	7,7	33	12,3
AORTA VEIN PUNCH NO 4.5	10	33	2
İNPUT GF	10	29	10
T300452 - ENT. TUPU (KAFSIZ) NO-3	10	0,2	27,5
RD302148 - INTRODUCER SHEATH SISTEM 7F	10,1	2,4	27,7
RD302114 - INTRODUCER SET 6F	10,4	2,8	27,9
GN300181 - TROKAR SETI 5 MM	10,5	5	26,5
GN300221 - TROKAR SETI 15 MM	10,5	5,5	26,5
MICRO PUNCTURE(MINI STICK 4F)	11	0,6	29,7
HEMOCRON(ACT) TUPU	11	28	8,5
RD302189 - INTRODUCER SET 4F KISA PEDIATRI	11	2,5	26,5
INDEFLATOR (AC 3200)	12	34,5	6
GN300122-KAPATICI KESICI STAPLER ATICI 75-80	12	4,5	33,2
GN300040 - TROKAR 10MM UZUN	12	6	30
GN300205 - VERSAPORT TROKAR 15MM(179071P)	12,1	16,5	31
PEDIATRIK EPIDURAL SET 20G	12,4	2,6	27
LEGACY TUBING SET	12,5	25	10
GN300216 - DAMAR KAPAMA ELEKTRODU (TIROID-PROBU)LS	13	3	28
PDA COIL 3X4 MM	13,5	33	0,5
2 mm Tpakar Çocuk Cerrahisi	14	5	30
T302754 - VAKUM YARDIMLI TOPLAMA SETI	14	5,5	29
SILIKON DOUBLE 3 MM NEONATAL NASAL VENTILASYON TUPU	14	26	1,5
GN300050-VERESS IGNESI 150 MM	15	1,5	30
AOR.KOK/ROOT KANUL COCUK(ROOT-14.16)	15	29	0,5
MICRO ENJEKSIYON KITI	15	26,5	2,5

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T303006-KANAMA DURDURUCU (HEMOSTATIK MATRIKS	15,3	3	26,2
MALLEABLE PENIL PROTEZ(90MM)	16	32	3,5
T305344-WOVEN VASCULAR GRAFT 10MMX60CM(DACRON)	16,2	6	32
T303235-FEP RİNGED STRETCH VASCULAR GRAFT 8MM 70CM SRRT08070070	16,3	4	31
T301814-THIN BIFURCATION STR GRAFT 18X9 MM PTFE	16,5	4	31
T301820 - TAPERED RINGLI GRAFT 4X7 48 CM	16,5	4	31
T303004 - VAKUM YARDIMLI BEYAZ KAPAMA SETI(10X7.5C	16,5	1	25
TRACHEOSTOMY SET NO: 7 FORSEP	17,9	5,8	26,2
GN300042 - MANIPULATOR (UM201)%	18	4,5	28
COCHLEAR IMPLANT-16 KANALLI(BIONIK KUL	18	27,5	4
T301811-TAPERED THINWALLED INTERING GRAFT 4X7 45CM	18,5	4	26,2
KOLON TORBASI	19	25	2,5
INFERIOR TURBINATE BLADE 18-82040 2MM	19	25	1
KARDIYAK HARITALAMA VE GORUNTULEME PATC	20,5	27,5	1
T300168 - KORUYUCU ONLUK	20,5	3,5	26
RD302118-HIDROFILIK GUIDEWIRE 0.035 J 180 CM	21,3	0,1	26,1
INFINITY TUBING SET (GOZ)	22	24	5
KORONER STENT 3.0X18 MM	23	27	1,5
T302752 - VAKUM YARDIMLI KUCUK KAPAMA SETI	24	3	30
T302753 - VAKUM YARDIMLI BUYUK KAPAMA SETI	24	3	29,5
EXCHANGE GUIDEWIRE 0.035' 2	24	29	0,5
VITREKTOMI SETI (2500 KESI)	24,5	32,5	7
KILAVUZ TEL	24,5	27	0,1
T301815-THIN. BIFURCATION STR.GRAFT 20X10 MM PTFE	24,5	4	25,5

app. p.3

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T301815-THIN.BIFURCATION STR.GRAFT 20X10 MM PTFE	24,5	4	25,5
RD302532-EMBOLI KORUMA SISTEMI FW EZ 190 MT	24,8	2	30,5
OPU SETI	25	30	8
T303091-NUTRISYON 3000ML (KORUMALI)	25	2	29,5
BILIARY STENT SET 10F 7CM	25	29	2
T301917-COMPOUNDER TRANSFER SET (REF: 174)	25	1	27
IVT CUTTING BALON 2.25X10MM	25	25	2
BILIER DILATASYON BALONU	26	32	3,5
20 G ENDOLAZER PROBE	27	32,5	0,3
RD302441 - MIKRO GUDE WIRE 0.018 V-18 200 CM	28	1,3	28
RD303303-EMBOLI PRODECTION DEVICE 070	28	2	28
RD302119 - HIDROFILIK GUIDE WIRE 0.035 J 260 CM	28,5	2,8	28,3
DESTEKLEYICI PTCA KILAVUZ TELI	29	32	2,5
Roticulator 55	29	3	23,9

APPENDIX 4: Material List of 3rd Category

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
T301201 - THORAX KATETER NO-20(200/812)	6	0,8	57
T300605 FOLEY SONDA STERIL NO: 16	6,5	0,5	50
ZOR EMBRIYO TRANSFER KATETERI(BEYAZ)17.5	8	42	0,3
STEEL 4 2X45CM GS13(kutusuz)	8	52	0,5
TUR LOOP(REZEKTOSKOP)24-26 F(TEK GIRISLI	8	42,5	1
TORAKS DRENAJ KATETER SETI 8F	10	53	1
NEFROSTOMI KATETERI (RE-ENTRY) 20F 17CM	10	43	3
MAMOREP MEME ISARETLEME IGNESI 21G 11CM	10	0,3	38,9
GN300169 - LOCKING TROKAR 10 MM	11,2	6,8	51,2
PERITONEAL DIAL.PD TEMP CATHETER SET(2.	13,5	42	2
GN300131 Premium Surgiclip II	14,1	1,7	47,2
ARTERIAL VENT KATETERI 20F(SILIKONLU,CO	15	57	2
NEFROSTOMI RE-ENTRY KATETERI 16 FR	15	57	0,5
PERITONEAL DIALYSIS NEONATAL TENCHOFF C	15	48	0,5
T300703 - CARMEN KANUL	15	0,1	45
T300704-CARMEN ENJEKTOR STERİL	15	3	48,5
GN300177 - ACILANDIRILABILIR MAKAS 5 MM	16	2,7	45
GN300132 - KLIP ATICI (ML) 10 MM	18,4	4	54,5
GN300101- KAPATICI 30 -4.8STAPLER	19,3	6	51
GN300191 - MULTIFIRE TA 45-4.8 STP	19,5	6	48,5
DOUBLE LUMEN SISTOMETRI KATETERI 6FR	20	52	0,5
RD302366 - SELFEXPENDABLE METALIK STENT 10X68MMX10	20	2,3	48,5
T302038 - COM.TRANSFER SET(REF: 724)	20	3	51
TEK LUMENLI LIFE CATH KATETER 3F	21	37	2
KALICI DUAL LUMEN KATETER 8F 24CM	21	46	2

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
TR305536 - MEME PROTEZI(MENTOR CPG 323 495CC)	21,5	2,5	39,5
PERKUTAN NEFROLITOTOMI AMPLATZ RENAL DIL	22	50,7	2
T302972-KAVISLI KAPATICI-KESICI STAPLER	24	3	52
SILICONLU TORAKS DRENI(EGRI)32 F	25	49	2
RD302149 - EXCELSIOR SL-10 MICRO KATETER	25,5	2	37
DIAG.QUADRIPOLAR EPS KATETERI CRD 5/6 F	27	40	3
ENDOSKOPIK TRU-CUT ULTRASON KATETERI	27	54	1
GUARDIAN OVERTUBE	28	50	3
LIFE CATH CIFT LUMENLI PICC KATETER 4F	29	44	2
CRITICON KATETER%	29	49	1
GASTROSTOMI PEG SETI 20FR	29	52	4
BY PASS ORTUSU (PEDIATRIK)	29	49	5
RD303201 - SELFEXPENDABLE KAROTID STENT 7X40X135 C	29,2	2,2	56,2
KALICI KATETER 14.5X32CM	30	45	3,5
BASKET KATETER 3TELLI 3FR 10-12MM	32,5	47,5	2
VITREKTOMI - FAKO SET	33	53	8
INTRAVASKULER ULTRASOUND KATETERI(IVUS	34	39	2
KORUMALI ONLUK	34	49	5
V.INTRAVASCULAR ULTRASOUND KATETER	35	40	3
URETER DILATASYON BALON KITI 15 FR 4 CM	35,5	50,5	5

APPENDIX 5: Material List of 4th Category

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
CAVAFIX 70 CM BASILICA	5	79	2
RD303068-PTA BALON KATETER (415-8060S) 80CM 80X6	6	1,5	87
URETERAL KATETER ACCESS 6FR 70CM	8,5	81,5	0,5
RD302209 - 5F KOBRA KATETER 0.038' 65-	10	2,4	83
VENOZ KANUL NO 22	10	63	2
RD302224 - BILIER DRENAJ SETI 12-14 FR	12	1	68
KILITLI NEFROSTOMI SETI 14F	12	0,8	70
KILITLI NEFROSTOMI SETI 12F	12,5	2	72,5
GN300129-LAPAROSKOPIK STAPLER KARTUSU 45 - 3,5	16	2,5	68
GN300100 - ROTICULATOR 55-4.8 STP.(017614)	16,3	1,7	68
GN300224 - PNOMOTIK KOMPRESYON MANSONU (MEDIUM)	18	3	70
GN300186 - LAP.DMR KAP. VE KESME MONOP. KTR PRB 5MM	24,5	2,5	70
DOUBLE J STENT FLEXIMA 8X24	30	0,6	67,5
NEFROSTOMI RE-ENTERY KATETERI 24FR 17CM	31	81,5	1

APPENDIX 6: Material List of 5th Category

MATERIALS NAME	WIDTH (cm)	LENGHT (cm)	HEIGHT (cm)
GUIDING KATETER 6F XBLAD 4.0	9,5	290	0,5
GUIDE WIRE 0.038 J 150 CM	10	170	0,5
RD303472-DİZ ALTI PTA BALON 3,5X100X90	10	1,5	204
GUIDING KATETER 6F XBLAD 3.5	11	190	2
ASD OCCLUDER DELIVERY SYSTEM	23	190	0,5
NON-CONTACT MAPPING MULTI ELEKTROD	24	275	2,5