LAPPEENRANNAN UNIVERSITY OF TECHNOLOGY
Department of Industrial Engineering and Management

Design for Customer Needs

Utilization of Quality Function Deployment in Product Development

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Kansainvälisen kaupan kiristyessä yrityksien kyky täyttää asiakasketjunsa lailliset, sosiaaliset ja toiminnalliset asiakastarpeet tulee punnituksi. Globaalisuuden lisääntyessä asiakasketju voi sisältää toimintoja samanaikaisesti yli sadassa maassa. Jotta asiakasketjun tarpeet voidaan sisällyttää tuotteeseen tehokkaasti yhä useammat yritykset ovat siirtyneet käyttämään Quality Function Deployment nimistä projektijohto- ja laatutyökalua.

Quality Function Deployment työkalu auttaa yritystä muuntamaan sisäisten ja ulkoisten asiakkaittensa tarpeet, tuotefunktioiksi ja tuotespesifikaatioiksi. Näin tehdessä voidaan uuden tuotteen kehitysaikaa ja hintaa alentaa merkittävästi suunnittelmalla tuote alunalkaen paremmin.

QFD:tä on käytetty useissa yrityksissä Aasiassa, Pohjois-Amerikassa ja Euroopassa, sen kehittämisen jälkeen Japanissa 1960 luvulla. Tämä diplomityö antaa teoreettisen ja käytännön kuvauksen siitä miten QFD:tä kannatta käyttää ja mitä sen avulla voidaan saavuttaa vastaten kysymykseen "miten minä, ja yritykseni hyötyy jos käytän QFD:tä".

ABSTRACT

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As international trade has become more efficient the ability of corporations to meet the legal, social, and functional satisfaction requirements is highlighted. A product must meet the needs of it customer chain, legal chain and social chain in some cases in more than a hundred locations at one time. For this to be possible some are turning to Quality Function Deployment, a global project management/quality tool.

Quality Function Deployment (QFD) is an organizational framework tool focused on translating the needs of internal and external customers into product features and later product specifications. As a result, new product development time and cost can be decreased significantly.

The use of QFD has been applied by various companies in various industries in Asia, North America and Europe since its creation, in the mid-1960s in Japan. This thesis provides a theoretical and practical illustration of how to apply QFD, and what can be obtained by applying it. This thesis answers the question "I gain what from using Quality Function Deployment?" in a compelling manner.

Preface

My research has been made possible by a grant from Nokia Mobile Phones Salo. I would like to thank Mr. Metsävuori for providing me with such an interesting research topic and for his support in the research process. Where it not for the entire Nokia Mobile Phones team at Salo my research would have been both impossible and meaningless.

Mr. Tiusanen my advisor has worked diligently in supporting the my efforts to provide Nokia Mobile Phones with a worthy illustration of my capabilities, capabilities developed at the Lappeenranta University of Technology. Where it not for the aid of Mr. Tiusanen this research would not be of the quality it is now.

Thank you.

Place time 2000

Mika Valtasaari

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Glossary

AD	Advanced Development
AMS	After Market Services
BA	Business Analyst
CE	Concurrent Engineering
CPP	Conflict Product Parameter
CRM	Customer Research Manager
DFM	Design for Manufacturing
DFR	Design For Reliability
FFR	Field Failure Rate
FMEA	Failure Mode Effect Analysis
HOQ	House of Quality
LM	Launch Manager
MR	Marketing Research
NMP	Nokia Mobile Phones
PDM	Product Development Manager
PLM	Product Line Management
PM	Product Manager
PPM	Product Program Manager
QC	Quality Coordinator
QFD	Quality Function Deployment
QM	Quality Management
R&D	Research and Development
TA	Trend Analyst
TD	Tree Diagram
TQM	Total Quality Management
VOC	Voice of the Customer

1. THESIS INTRODUCTION

1.1 Introduction to International Business Theory

A company can be viewed as being at the center of two inter-linked environments one being external affairs and one been internal affairs. The major constituencies in the external affairs environment are the: general public, academia, stockholders, pressure groups, competitors, customers, suppliers, labor, church, financial community, conservationists, government agencies, public media, minority groups. (Cundiff, Hilger, 1984) Depending on the product a company produces and where the product is sold, all the constituencies presented multiplied a number of times may be present.

Appendix 1 has a Quality Function Deployment version of assessing the ability of a company's product to meet the needs of the above mentioned major constituencies. In this case, the company operates in two regions and has three products. The purpose of the matrix is to evaluate the ability of the product mix to meet and/or exceed a base rate of satisfaction among the constituencies, thereby guaranteeing unhindered access of the company to the chosen markets. How the base rate is calculated should be specific to a company. That the base rate is evaluated and that they are met is an important part of accessing the ability of a company to participate in international trade.

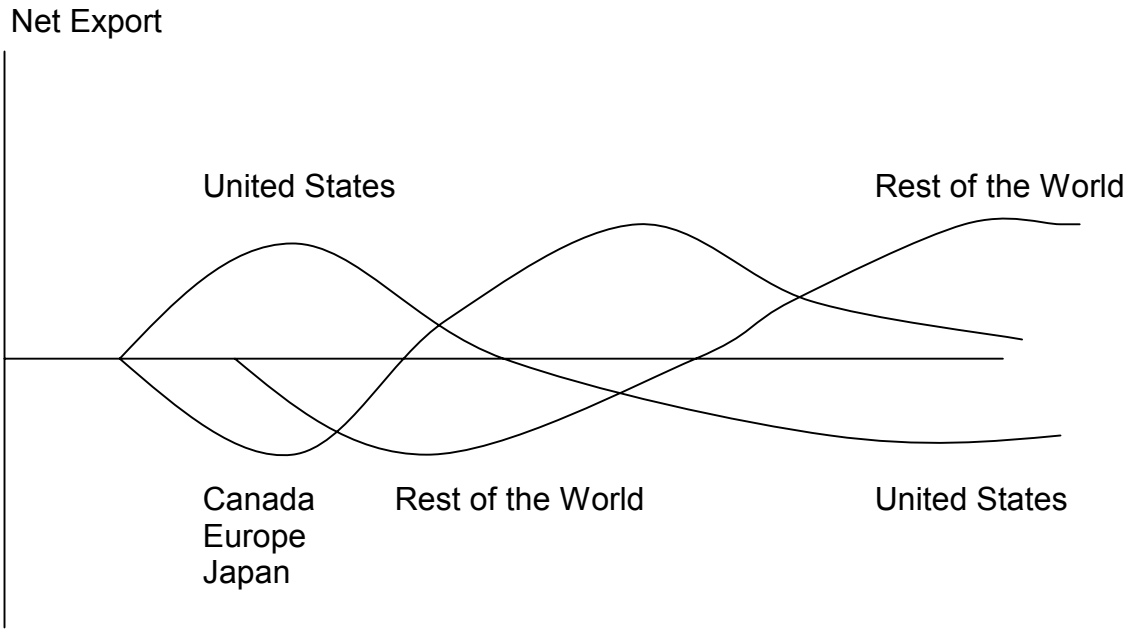

Figure 1 Trade Flows Over the Product Life Cycle (Rugman, Lecraw, Booth 1986)

Figure 1 illustrates a theory that had changed only in geography not in spirit. The product life cycle model provided an excellent explanation of world trade patterns in manufactured products in the early post World War II period. (Rugman, Lecraw, Booth, 1986). It would seem that despite the increasing globalization of the manufacturing environment the premise put forward in the product life cycle model is still very applicable, though taking into consideration the tendency of companies to apply manufacturing technologies and R&D resources on a more individual case by case basis. As manufacturing becomes more cost orientated and less technology orientated company's will tend to seek economies of scale in lower cost production areas close enough to consumers to decrease logistical risks.

For companies entering into international trade it is not uncommon to start with one or a limited amount of products only to segment their product mix later on

based on international and local customer needs. To be competitive in the international market it is important to produce a unique, high customer quality product that can be sold at competitive prices. Quality Function Deployment (QFD) is one way to assure a product is just what the end consumer wants when the product enters the market. QFD can also be used to design key aspects of a product in such a way as to meet the needs of different end consumer segments, making economies of scale easier to achieve. When buying a car for example customer group one is very interested in safety features such as size, ability to view traffic, antilock breaks, customer group two likes luxury features and luggage space while customer group three needs to stay in touch with business. A sports utility vehicle with the correct technological applications can meet the needs of all three customer groups if maximizing the customer satisfaction level of the three groups has been sought early on. If the customer satisfaction level of the three groups are not considered early on, the vehicle might not be built correctly decreasing demand and the ability to maximize production economies.

1.2. Product Quality

Product quality is an illustration of a customers experience with a product evaluated against their expectations during the buying process life cycle. The definition of customer, as seen earlier, includes a very large number of potential parties. If a number of individual products fail to meet a given threshold of expected quality, not only can it have an impact on the competitiveness of a product, it can impact the ability of a company to participate in international trade in a given market, assuming the concept portrayed by Cundiff and Hilger is correct. To define product quality only from a quality reliability standpoint, a perspective often taken, neglects to consider customer satisfaction strongly

enough. My intention is to add customer satisfaction as a guiding force to future quality discussions.

Product quality is established by balancing economically individual quality characteristics (Feugenbaum 1991). The greater the expectations of a client the higher the usability, reliability, and design level will have to be for satisfaction to occur. As satisfaction occurs in customers, the level required to obtain future satisfaction increases as does the risk of dissatisfaction. The better the image of a product, the higher the quality standard must be for dissatisfaction not to occur. The quality image of a product is dependent on the; (Kivelä 1999)

product sales chain,
mechanical and technological usability of a product,
field reliability of the product,
the after-market services quality of a product,
external design of a product ,
cost,
lifecycle,
image stability,
software and hardware features of the product.

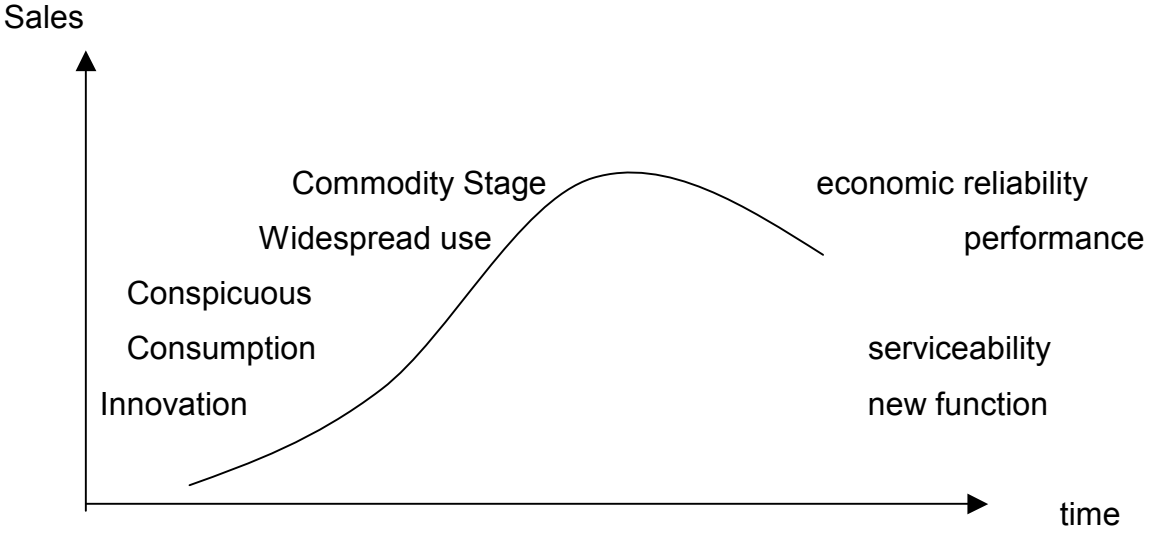

Figure 2. Product Quality Maturity Stages (Kivelä 1999)

As a product moves along its product quality maturity stage curve, illustrated in figure 2. from the innovation stage to the commodity stage the quality demands of customers increase. Where once a level of unreliability, lack of robustness, difficulty of use might even have increased the quality perception of a product, at the commodity stage a product must be easy to use, fault free and capable of taking the beating a commodity can be susceptible to. For a company to be able to produce a high quality product the R&D and product marketing departments must be able to work seamlessly together. In the past marketing, quality, and international trade where very separate concepts. When using QFD and a customer satisfaction perspective the three perspectives meld seamlessly into one format.

Quality management can be defined as " A systematic ways of guaranteeing that organized activities happen the way they are planned. It is a management discipline concerned with preventing problems from occurring by creating the attitudes and controls that prevent defects from happening in the company's performance cycle." (Crosby 1979) If international trade is viewed from a quality management perspective the needs of the major constituencies would have to be met when international trade is begun.

1.2.1. Quality Cost

Quality costs are a means of qualifying the costs inherent to producing a low quality product relative to a high quality product (Kivelä 1999). Quality costs may amount to 20% of net sales (Lillrank 1990).

Production costs; sub-optimal base level production speeds, need for production breaks, need to replace failed products (Kivelä 1999).

Internal failure costs; due to failures detected prior to the products delivery to the customer. These costs include scrap, rework failure analysis and down grading, design upgrades, production scheduling (Kivelä 1999).

External failure costs; are associated with failures detected by the customer. These costs consist of warranty charges, complaint adjustments, returned material, images costs (Kivelä 1999).

Appraisal costs; resulting from quality assurances covering incoming inspection, final inspection, quality audit, maintenance of test equipment and evaluation of stocks (Kivelä 1999).

Quality Investments; are incurred to minimize/eliminate failure and appraisal costs, for instance quality planning, process planning and process control, internal and external quality audits and training. (Kivelä 1999)

International Trade Cost: incurred in correcting the negative impact of substandard quality upon international trade constituencies.

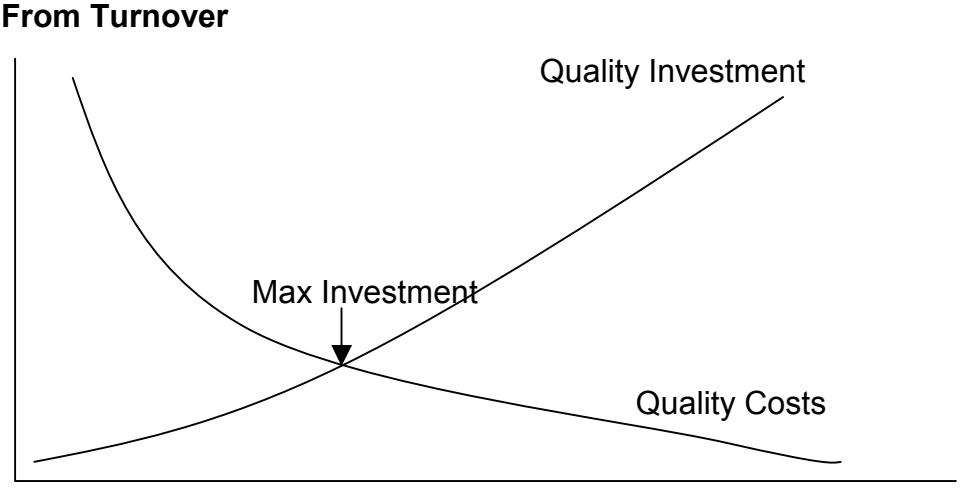

Figure 3. Company Quality Performance

The lower the level of company quality performance level is the better the Return of Investment (ROI) we get on quality investments. This is a possible metric to consider in quality implementation. As well, efficiency of the operation is optimized at a certain quality performance level. This needs to be counted in the costs and investment section of quality implementation. Rejected review or wrong product specifications are examples of quality costs and contract agreements.

When quality costs are minimized the cost of producing a product decreases and the competitiveness of products increases. On a corporation wide scale quality cost minimization can lead to very large savings in the short term and long term.

1.2.2. Quality Benefits

Producing quality products allows a company to concentrate on ensuring its competitiveness in providing customers satisfaction in markets where a company is active.

According to a survey of Total Quality Management organizations those company who has used TQM for more than three years had significantly better successes than those using TQM for two years or less with respect to customer satisfaction and retention, operational results and organizational climate.
(DDI 1994)

According to Taiichi Ohno Former Executive Vice President of Toyota. "Whatever an executive thinks the losses of poor quality are actually six times higher." (Taguchi and Clausing 1990)

1.2.3. Product Quality and QFD

In a product quality framework, QFD is;

a means of proactively detecting issues that may impact overall product quality,

a means of managing the usage of the wealth of alternative quality management tools,

a tool for ensuring other product quality tools have the desired impact on the product being developed.

QFD is essentially a communication tool that allows high quality products to be designed and produced effortlessly.

1.3. Conclusion

Product quality is an illustration of the products ability to meet the needs of the applicable international trade constituents "customers" from the customers perspective. Considering the major constituents does not mean the end consumer does not make the final customer satisfaction evaluation of the product they buy. It does mean that before they have a chance to make the final evaluation a number of international trade constituents have given the product their seal of approval.

The production of high quality products requires the seamless interaction of every aspect of product creation. By emphasizing product quality a company can increase productivity and increase profitability. By using QFD, managers can optimize product designs and minimize the difficulty associated with development changes within their projects.

2. RESEARCH METHODOLOGY

The goal of my research it is to explore the ability of Quality Function Deployment to improve the efficiency of product development at Nokia Mobile Phones (NMP) with a special emphasis given to locating and solving conflicting product parameter issues. In the highly competitive global marketplace the ability to meet the changing needs of customers quickly, accurately, and cost effectively is vital to a company. My ultimate goal is to support the continuous product improvement process at NMP.

Over the last decade mobile communication had moved from a luxury item to a necessity in a number of developed countries. With the shift in market paradigm the role of communication between R&D, product marketing and production has become increasing important and complex. Once a luxury item has evolved into a general-purpose means of connecting people. Once a technology based high end toy has entered the multi-segmented customer market.

Mobile technological development allows customers to illustrate their preferences beyond their need for voice communication in a mobile environment. That said, it has shifted the purpose of solving conflicting product parameters from building just smaller lighter phones, to a new emphasis on customer needs based product differentiation. The issue of conflicting product parameters has evolved into an issue of corporate wide importance from one based in individual departments.

It will be my task to research the ability of QFD to aid NMP in increasing product development efficiency and in productively solving conflict product parameters in the interface between the product marketing department, and R&D.

Structurally my research has two definitive if intertwined parts; a secondary study of QFD and an example format for applying QFD. The purpose of the secondary research is to qualify the ability of QFD to meet the requirements of NMP. The role of the case study is to test QFD in a practical setting and to create an example for further QFD usage.

3. RESEARCH BACKGROUND & NOKIA INTRODUCTION

Nokia is a global company specializing in the development and production of telecommunications hardware and software solutions. Nokia employs a substantial amount of people at various locations worldwide. Virtually all aspects of the market for mobile communication equipment are in a stage of very high growth.

Organizationally Nokia is comprised mainly of Nokia Networks and Nokia Mobile phones. Nokia Networks provides for 29% of total corporate sales and 43% of personnel. Nokia Mobile phones provides for 66% of total corporate sales and 43% of personnel. Other businesses contribute 5% of total corporate sales and 14 % of personal. (Nokia in Brief)

In 1999, the operating profit of Nokia was 3.9 billion Euro (57% increase),sales were 19.8 billion Euro (48% increase), the labor force grew to 55 260 from 44 543. And the market capitalization was 209.4 billion. The top ten markets for Nokia in terms of sales were, the United State of America, China, the United Kingdom, Germany, Italy, France, Brazil, Netherlands, Finland, Australia. Nokia had sales in 130 countries, R&D in 14 countries and production in 10. Obviously in company of this size and diversity organized communication is very important. The Nokia production and markets teams were supported by a talent group of well over 10,000 R&D personnel with a budget of over a billion Euros.
(Nokia 1999 Annual report)

In the case of Nokia, the number of people involved with the creation of mobile communication equipment is very high. The mobile phone division of Nokia produced 78.5 million mobile phones in numerous categories of mobile phones.

In 1999 the total global market for mobile phones was about 275 million. The total volume of mobile phones in use in 1999 was about 480 million. The production volume was double digit numbers higher than it was in 1998. For such production volume and volume growth to be possible the communication of current and future needs of the customer within the company are of the utmost importance. (Nokia 1999 Annual report)

The global mobile phone market is a classic example of a high growth, currently increasingly segmented consumer product market. In 1990, there were 11.2 million mobile phones world wide. In 1993, the annual growth of subscribers (11.2 million) equaled the total number of subscribers in 1990. In 1995 the number of new mobile phone users had grown to 87 million, a figure that would grow to 275 in 1999. In 1995 the annual growth rate increase in mobile phone useage was 32 million (EMC World Cellular Database May 1997). The market for mobile phone is growing at a remarkable rate.

Between 1994 and 2000 global telecom revenues from wireless communications rose from about 56 billion USD to a little over 172 billion USD. In that time, the wireless share of global telecom communications revenue rose from 10.4 percent to 17.8 percent, in Europe the share rose even more rising from 14.2 % to 24.1%. (Global Carrier Markets Database 1997) People would seem to like mobility. One obvious question is how much do they have to pay for that right?

In the early days of cellular communication the cost of a phone was in the thousands of dollars world wide. In the United States 1997, the cost of a digital phone was down to 162 USD. In 1991, the average cost of 250 prime time minute package in a major US city was 126 USD, a figure that would drop down to 46 USD by 1997 and to about 10 cents per minute in the year 2000 according to the internet site Verizon Wireless. (Herschel Shosteck Associates LTD 1999)

My digital dual band phone cost me about 300 USD in 1999, in Finland, a phone that can sometime be bought for about 150 USD. Mobile phone use has gone main stream as have the cost of using the phone. As one would expect with the market for mobile phones in a mass market situation, production economies play an important role in the business. The ability of companies to operate in the market successfully depends largely on their ability to maintain low unit prices in a segmented high growth environment. While the market has grown exponentially for some time it would seem that the trend is not likely to end soon. If every market in the western world (over 600 million people) had a market penetration rate of that of Finland's (70%+) and the use of the phone lasted for three years the annual product would have to exceed 140 million year to meet the demand for this segment alone. If the whole world would have a similar level of penetration the demand could hypothetically exceed 1.4 billion.

As the global market for mobile phone grows, meeting the needs of customers becomes more and more important. Many consumers are no longer content to

simply enjoy mobility, they require a phone that fits their technological and stylistic needs just as people require when purchasing their cars.

4. QUALITY FUNCTION DEPLOYMENT INTRODUCTION

"QFD is the comprehensive assurance of customer satisfaction throughout the development process -- end to end." (Dr. Yoji Akao) (Cohen 1995)

QFD is the visible memory of the corporation (Cohen 1995).

"QFD is a system for translating consumer requirements into appropriate company requirements at each stage from research and product development to engineering and manufacturing to marketing/sales and distribution." (Slabey 1990)

"QFD is a practice for designing your processes in response to customer needs". (Goetsch and Davis 1994)

"QFD analysis will tell you where you have problems." (Domb 1997)

"QFD is now the seventh most frequently used marketing research technique in the United States." (Vijay and Wind 1992)

QFD is the method to indicate product categories suitability to customer needs. (Nokia Team)

"QFD is the visualization of product current status and future target functions importance from a customer point of view" (Nokia Team)

With QFD for the first time, many development teams will learn why their products or services behave in a particular way. They will understand why customers prefer some aspects of their competitor's products. (Hales 1995)

Under QFD, time is spent up front by the design team carefully defining product requirements from the customers' point of view. These requirements typically are of three types: (1) customer needs, (2) customer expectations or wants, and (3) exciting features. While product definition time increases with QFD, the total design cycle time is reduced by eliminating design changes in subsequent stages. The design-to-market cycle time often can be reduced from 20 to 90 percent because technical targets planned in the early stages help designers avoid problems in later stages (Juliard 1991).

In some organizations, while maintaining and enhancing design quality, QFD has helped reduce design time by 40% and design cost by 60 % (Hauser 1993).

Toyota and NGK reported the following benefits from using QFD: engineering changes where cut by 30% - 50%, design cycled were shortened by 30-50%, start-up costs were trimmed by 20-60% and warranty claims were reduced by 20-50% (Kathawala and Motwani 1994).

In 1990, Puritan-Bennett, a medical equipment company, successfully used QFD to help redesign its spirometry business in order to regain their market share (Hauser 1993).

The point here is not to indicate what Quality Function Deployment is or the standing of QFD in the theoretical quality world, it is to point out that the many definitions illustrate QFD's versatility as a general purpose project management/ quality tool. That QFD has been applied to the extent it has been gives an indication of it potential usefulness. The actual usefulness of the tool will depend on applicability of the tool to a given project and the skill level of those applying it.

4.1. Purpose

Quality Function Deployment (QFD) is an organizational tool that concentrates the efforts of internal and external product development stakeholders on the needs of customers. If successfully implemented, its use leads to error free higher quality product designs and a quicker more accurate product development process. Increasing the usability of products and decreasing product field failure rates are important aspects of product development directly influencing the ability of a companies sales people to sell products. One aspect of both factors is finding and then optimizing solutions to conflicting product parameters.

Traditionally the purpose of Quality Function Deployment was the translation of customer needs into product features throughout the manufacturing process as well at to assure that organizational functions properly understand and execute their jobs in accordance with established standards (Akao and Mazur 1998). The tradition has not changed with time except in the level of consumer orientation of applications, massive scale products have become smaller and production run sizes have grown.

In the past, it was the task of product marketing to listen to consumers and then adapt the sales, distribution and new product mixes based on what they heard. Once the information was gathered, it was the task of R&D to develop the technologies needed in the product, the task of engineering to design the product, the task of production to build it based on instructions from engineering and the raw material or subassemblies provided by purchasing. In a linear organizational system the customers of R&D are; the end customer, the retailer, the wholesaler, the product marketing department/logistics system of a company, the production department, the purchasing department, the subcontractors, the engineering department. Functionally linear processes tend

to take a number of iterations and time before a new product can be successfully created or an old product upgraded.

In a QFD organization the customer thinking concept of different functions remains the same, but the transitional phases of the traditional system are transformed from stoppage points into a smooth process orientation with the aid of cross-functional teams. What QFD does is create a framework that concentrates the focus of product development team members simultaneously on the ends customers and the other customers of an organization allowing managers to support the smooth flow of a project through its development. Typically QFD enables product managers to have a greater level of organized information, a wider skills matrix at their disposal making it easier for manager to plan and control the development process. The end result of QFD utilization is better product design, fewer quality problems, lower customer acceptance risk, a shorter development cycle time, lower production costs, and higher profits. (American Supplier Institute 03.2000.)

Traditional QFD deployment in a western cultures is inhibited by greater natural individualism, secrecy issues, and time management factors. The issue of secrecy can be bypassed by concentrating on solving technical problems and their interaction without using project names or entire production specifications. To optimize a widget problem, one requires more than a specification but less than an entire engine design.

The issue of individualism should be supported in brainstorming sessions of various compositions. Individualism, according to our experience, leads to innovation when managed correctly.

The volume of time needed by QFD depends on the number of brainstorming sessions, the number of people at the sessions, the need for mid-stage

consensus, the volume of unfiltered data utilized, and the reusability of previous studies. If time is limited careful selection of participants, the careful selection of issues discussed, the filtering of data and the minimization of brainstorming sessions lowers the time required by the QFD to manageable parameters while not necessarily having a negative impact on the final outcome of the development process.

4.2. What is QFD?

Quality Function Deployment is a means of;

solving complex conflicting product parameters by concentrating on what customers desire in a product,

fact based management

standardized communication,

avoiding miscommunication,

maximizing the quality and volume of skills simultaneously allocated to solving a problem,

organizing the product development process,

increasing the speed and decreasing the risk associated with product development,

translating active and passive customer needs into product solutions.

QFD focuses the entire product development system of a company on the customer (Hauser and Clausing 1988). By so doing, a company can maximize its product orientation, eliminate misunderstandings associated with linear functional systems, minimize the time to market of a product. The customer and team focus of QFD allows problems to be solved proactively by those most knowledgeable in the area and those most likely to be affected by the problem. By solving problems before they arise, the entire development process can be sharpened and turbo charged.

4.3. Quality Function Deployment History

QFD evolved in Japan within the framework of corporate quality control in the mid to late 1960s. The "father" of QFD is Yoji Akao who introduced the concept. The concept was published in 1972. QFD was first implemented at Mitsubishi's Kobe shipyard in the mid 1970s (Hauser 1993, Akao & Mazur 1998)

In the United States, the use of QFD was pioneered by Ford and by Xerox in the mid-1980s (Hauser 1993). Since its creation, QFD has been applied with varying degrees of success by the auto, chemical, educational, medical, metal, and consumer electronics industries.

At first QFD, was used in large-scale consumer and industrial product development projects common to shipbuilding and the automotive industry. With time, it has been successfully applied in a variety of short and mid-term projects in virtually every field. For a listing of some of the companies that have utilized QFD see appendix 2.

It is important to notice that QFD was created in a cultural environment where consensus, life long employment, and extreme de-facto vertical integration was the norm. In a Japanese company, in the 1970s, the need for internal secrecy was minimal, and individual innovativeness in the western definition of the concept was less common. At a typical western high technology company internal and external secrecy is very important, individual innovativeness is supported, and employees do change jobs and can be hired by competitors. One western benefit of QFD is the ability to retain information that might otherwise to lost to company when an employee leaves.

QFD is most commonly used on a project management scale in new product or concept development. We have not found a reason why QFD could not be efficiently used in strategic, tactical and operational planning, project or process analysis or as a purely educational tool.

4.4. QFD Structure

At the core of Quality Function Deployment is the House of Quality, figure 4 appendix 3 (Hauser & Clausing 1988, Bossert 1991). The House of Quality is the tool that translates the needs of customers into product features, compares ability of a company to meet the needs of customers against competitors, prices solutions and evaluates technical features and compares the technical relationships. The House of Quality is the final result of six stage building process.

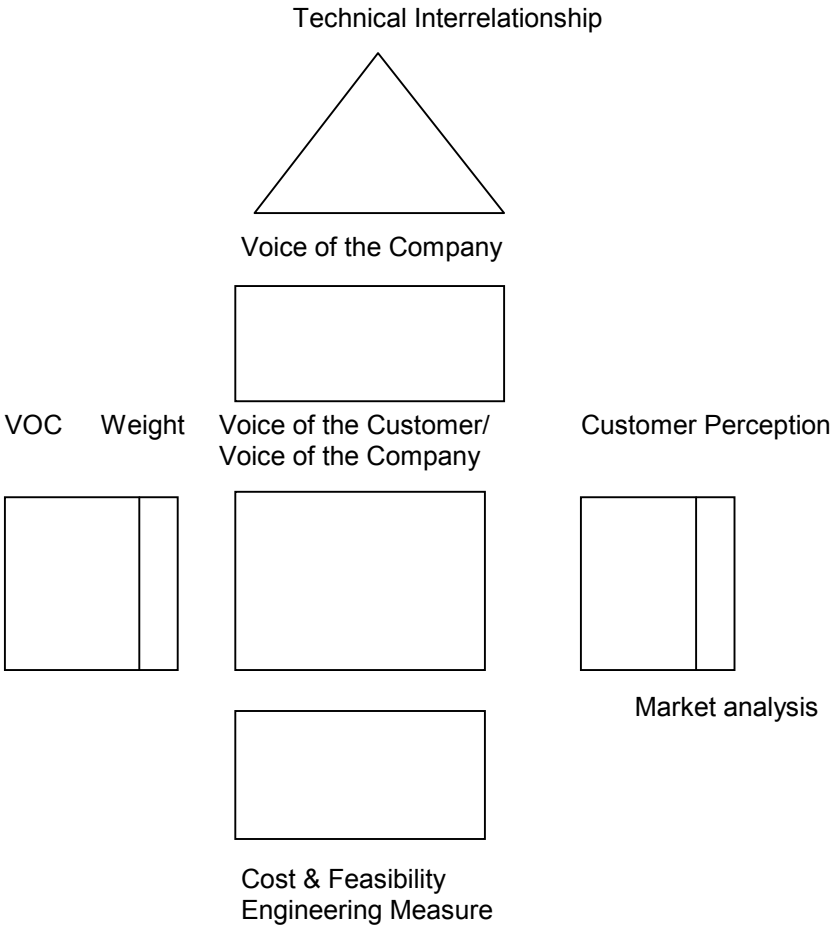

Figure 4. House of Quality

The most commonly used parts of the House of Quality are the Voice of the Customer, first vertical axes. Voice of the Company, the first horizontal axes. By shifting the Voice of the Company to the Voice of the Consumer even the most complex projects can be broken down into manageable components without loosing touch of the end customers needs. An illustration of breaking down process is available in appendix 4.

QFD matrixes typically use importance weights for illustrating the relative importance of customer needs and the importance of technical functions available for meeting the needs. Importance weights also provide a format for cross-functional brainstorming and project development analysis. Once the main

matrix is compiled, the different customer needs/technical requirement boxes can be broken into new matrixes if necessary.

4.4.1. Voice of the Customer

The Voice of the customer asks the question what does a customer/customer chain really need?

The VOC focuses product development team members on meeting the real needs of consumers at a given reliability level. Organizationally the act of seeking the needs of customers motivates and empowers development team members which inadvertently increases the information level available to managers. A typical team focusing on new product development will be composed of people with expertise in sales, product marketing, trend analysis, R&D, quality control, purchasing, production and various levels of management.

When creating the Voice of the Customer it is important to segment the needs of customers into general categories such as customer chain, R&D, product marketing, production, legal, political, user environment. The purpose of separation is to ensure mandated requirements do not overwhelm the importance assessment process, leading to legally correctly built technically high quality but low quality products from an end consumer perspective. Through segmentation, it is possible to focus on the needs of different customers in the customer chain in a flexible innovative way utilizing leeway areas in the base parameters of even mandated specifications.

4.4.2 Voice of the Company

The Voice of the Company ask the question how does a company meet the needs of customers?

The Voice of the Company translates the needs of customers into technical functions. The Voice of the Company will typically consider such parameters as phone size, weight, software, memory capacity, design, reliability, durability, battery time and user interface, relative to the needs of customer at a given level of reliability. The interaction between the Voice of the Company and the Voice of the Customer determines the usability of the end product to the customer.

The Voice of the Company section begins with a very technically vague description of how the company will meet customer needs. Once that is done the section can broken out into ever more specific categories by shifting the Voice of the Company parameters into a new matrix where it goes into the Voice of the Customer horizontal section and a more specific breakdown of the product parameters is placed in the vertical section. This process can be continued a number of times until a complex issue is sufficiently broken out for it be manageable. In theory the number of iterations can go on for ever. I would suggest for the sake of clarity that no more than 4 iterations are used and that a roadmap of the iterations is kept. The final iteration should have the product part specifications and their level of accuracy.

Non-linear iterations can be made into the Voice of the Customer Voice of the Company matrix where required for example when inputs into the linear system are required. I would suggest that when external inputs are required a funneling matrix be used, followed by a totally new QFD. In a product planning QFD

system, subcontracted modules, purchasing, advertising are areas where the inclusion of non-linear iterations may be necessary.

The interrelationships between different segments of the Voice of the Company (phone size, weight, software, memory capacity, design, reliability, durability, battery time and user interface) should be studied at different phase levels. The studies allow developers to optimized the product in relation to both the consumer and company. Studying the interrelationships also helps developers find areas where the overemphasis of factors in a given group may have a negative affect on the overall quality of the end product.

4.4.3. QFD Body

The QFD body translates the needs of customers and the needs solutions of a company into a numerical format answering the questions, how are the needs of customers met by different product features? and how do different product features meet the needs of different customers?

The QFD body is the section where the importance of different technical features are weighted in relation to customer needs. It is in this section that lays the basis for the mathematical analysis of information through the needs and company importance weights. Vertical analysis of data informs developers of the impact level a product feature has in meeting different customer needs. Horizontal analysis of data illustrates how the different product features together meet the needs of consumers and set the stage for future benchmarking.

4.4.4. Technical Relationships

How do the specified technical features interact with each other? Located on top of the Voice of the Company, the technical descriptor relationships section, is used to evaluate the level and direction of technical relationship factors, find conflict areas, evaluate where failure risks are likely to exist, evaluate the interaction of reliability factors of different parts and modules and to find areas where further development would increase customer satisfaction. The number of interrelationships and or conflicts at even a very basic level can be over a hundred, at a specifications level the number can easily be in the thousands. Example. When product weight is found to be a critical factor in customer satisfaction concentrating on all the factors in the technical relationships section that correlate with weight can be used to improve product quality as perceived by the customer. Though the previous case exercise may seem obvious, when there are 1000 factors it is anything but. The weighting system of QFD not only allows for the illustration of interrelationships, it can be used to build a timetable for solving issues and a timetable tracking system for evaluating progress in the solution process.

4.4.5. Market Analysis

The marketing analysis section answers the question of, how does a company succeed in meeting market satisfaction or technical requirements relative to its competitors?

The market analysis section is located on right of the House of Quality matrix allows a project to be benchmarked against competitors current and future products. This allows managers to evaluate the ability of different products to meet client needs. Based on the benchmark a new product might be introduced

or an old product upgraded to compete with a competitor. The addition of an extra feature or new attribute into a relatively ready future product can be made possible by the high level of organization inherent to QFD use in a project.

Benchmarking gives a perspective to QFD team members of how other companies meet customer needs, how a company might learn from its competitors, what areas a company is inadvertently under-performing / over-performing in. The benchmarking section supports the use of QFD as more than just an internal product development tool.

4.4.6. Technical and Cost Feasibility Sections

The technical and cost sections illustrate the feasibility of a given project. Technical and cost feasibility are the final extremely important perspectives of any QFD project. Tracking the technical economic feasibility of a project supports the optimization of a customer satisfaction simultaneously on a technical and economic basis, decreasing the risk of project cost overruns or end product cost based dissatisfaction. Example Three years ago customers may have been satisfied by WAP technology that has only recently been technically and economically feasible.

4.4.7. QFD Tertiary Structures

QFD is a full service project management quality control tool flexibly supported by such management tools as Kano Models, Fishbone Diagrams, Tree Diagrams, Affinity Charts, and Concurrent Engineering.

The Kano Model allows five aspects of customer satisfaction to be considered in a visual illustration as shown in the written example below and in appendix 5.

Expected quality	The mobile phone is light and easy to use
One dimensional quality	Automatic full service warranty Makes customers happy when they have it and unhappy when they don't
Exciting quality	Mobile phone works globally. Phone works after a swim Surprises a customer.
Indifferent Quality	Mobile internet access to some customers
Reverse Quality	Mobile personal tracking. They are unsatisfied if it does happen.

The purpose of the Kano model is to provide a means of evaluating which aspects of a product are of importance to a customer, and how they affect the customer perception of product quality. The model focuses designers efforts on customer needs satisfaction prioritization, improving the efficiency of resource use. As not all needs are critical to the market performance of a product, the Kano model allows developers to concentrate on the most critical factors.

Fishbone Diagrams can be used to study the cause and effect factors of customer needs with each-other, with the environment, and with different solutions. (Ishikawa 1985)

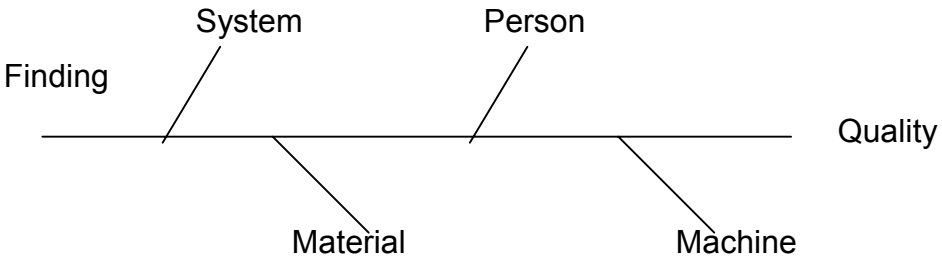

Figure 5. Fishbone Diagram (Turunen 1991)

Affinity Charts are a means of grouping unsorted information for example customer responses or brainstorming data into categories. Once the categories have been created they can be placed into a QFD matrix directly or into a Tree Diagram for further consideration.

When documenting brainstorming and other data it is very important to keep the number of response classes to a minimum. By decreasing the number of response classes the time required by documentation and future analysis is kept at reasonable proportions. Affinity diagrams are a very useful tool for this purpose.

Tree Diagrams are a simple means of organizing data or breaking down information into weighted or non-weighted sub-categories. The diagram can be a precursory step used before data is placed into QFD matrix. According to some authors the matrix format of QFD potentially scares people away from Quality Function Deployment. By using a tree diagram a barrier of QFD utilization can be circumvented.

Concurrent Engineering is the process of people in two or three functional areas working on different aspects of the same problem at the same time. CE allows sub-categories of a project move through the development process as development on a sub-category proceeds instead of at the rate of the whole project. Concurrent Engineering effectively speeds up the product development process by decreasing the external time of a project. Concurrent Engineering is more an outcome of QFD usage than a tool of it. Since the benefits or Concurrent Engineering are made possible and can be attributed to QFD Concurrent Engineering in this paper it is considered a retroactive QFD tool. A very basic illustration of concurrent engineering is similar to a relay racer getting into position and up to speed before the baton is handed to them. Taken a step further, people in the next development stage can organize their time and obtain the resources necessary to complete their part of the product development and production process.

4.5. QFD SWOT Analysis

Project management and product development are a quintessential part of being a competitive consumer products company. The analysis of a new project management tool is a quintessential aspect of evaluating its value. For the purpose of this paper the SWOT analysis technique has been chosen for use in analyzing QFD due to its ability to evaluate QFD simultaneously both internally and externally.

Strengths	Weaknesses
Problem Solution Strength	Work Overload
Customer Focus	Front End Time
Teamwork	Communication
Communication	Organization
Organization	Team Time
Speed	
Opportunities	**Threat**
Multiple Product Development	Change
New Ideas & Upgrades	Lack of Time
Old Products	Misapplication
Market Segmentation	

4.5.1. Strength

Problem Solution Strength

The structured multidisciplinary application of QFD promotes the creation of a standard means of problem solving and communication, effectively eliminating miscommunication based fake conflicting product parameters. By eliminating fake conflicts, prioritizing existing conflicts and choosing people with the right skills to solve the real problems, the resources required by conflict management can be correctly utilized.

In a test done at the Total Quality Forum VI Speakers Focus on Change in 1994, 12 volunteers were taken from the audience and divided into three groups. In four 90-second segments, the groups were given plastic building blocks with which they were supposed to construct four different parts (arms, legs, body,

and head) of what was supposed to become a model of a student. As the groups worked through the four sections, they were shown what each individual part was supposed to look like but volunteers were not shown how the final model was supposed to look. Therefore, none of the groups constructed anything that was even close to what the final model looked like (Rubach 1995). Now imagine if they had had to consider the production and material issues as well on a project with 100 not 4 parts.

Customer Focus

The customer focus, organizational transparency, cross-functionality inherent to QFD allows a product to be designed, tested, and produced in a virtual environment. The product and its production actually “exists” at the end of the design stage. Since it "exists", problems associated with the movement of a product from stage to stage can be anticipated, circumvented, and solved by those involved in the conceptualization and creation of the product. Designing the products in a multifunctional team format makes it possible for the team members to be rewarded based on their individual and team performance as well as their contribution to customer needs fulfillment. Emphasizing customer needs eliminates user-unfriendly technology solutions, unnecessary components, and promotes innovative solutions to existing product issues.

By concentrating on the needs of customers a management team has a reference perspective to guide them in evaluating conflicting product problem solutions. When R&D people, product marketers, and production people work together from a client viewpoint the needs of the customer are less likely to be overlooked at any point of the product development process. In a functional system the needs of the customer can relatively easily be overlooked.

Teamwork

Team work increases the level of knowledge interacting on a given aspect of a project. The purpose of the team is to decrease problem creation, improve solution quality, eliminate miscommunication, and speed up the solution process. For the team approach to work, employees and the corporate decision making structure needs to understand, support, reward and be rewarded by open communication even when failures therein occur. QFD provides procedures to enhance communication and structure decision-making between marketing and R&D (Griffin 1992). Quality Function Deployment reduces the marketing/R&D barriers of different thought-worlds languages and organizational responsibilities and provides mechanisms to increase information utilization across the functions as well as resolving conflicts between them (Griffin and Hauser 1996).

From a time management perspective QFD related teamwork requires more time during the initial phase of a project. Later in the project the time allocation will be earned back many times over. The reward for the time allocation is having to correct fewer mistakes later in the development state and the need to solve fewer product conflicts during the development process.

Communication

Equality based communication is the cornerstone of the competitiveness of any and every company. Without it customer needs cannot be satisfied and product and processes cannot be managed effectively. Yet it is still common to build corporate structures that hinder communication (functional systems) or bury it in a matrix format where confusion and the dogging of problem responsibility, can rule supreme? Organizationally QFD can easily evolve into a multidimensional matrix mass of paperwork and unresponsibility and yet QFD, when applied correctly, facilitates communication on a grand scale. The challenge is to maintain responsiveness, mobilize group dynamics and understand diversity

and mistakes. In a QFD group, cross-cultural, cross-functional and cross-organizational communication is the key to problem minimization, problem solution, and development speed. When we stop to consider a mobile phone is the end result of numerous part groups with a number of subcategories the importance of effective communication becomes highlighted.

Organization

The matrix format of QFD organizes, and tracks the product development process. Organization decreases the amount of effort required in project evaluation by management, improves the ability of managers to forecast and track progress, provides more time for removing problems and bottlenecks in the early stages of the development process, and defuses the challenges associated with loosing project members. Placing all the information of a project into one framework simplifies the obtaining and analysis of information. If used wrong, the matrix system can lead to information overload.

Speed

One aspect of QFD is the promotion of concurrent engineering in a project. (Hirotaka and Nonaka 1986) Concurrent engineering is used to change the two dimensional environment of functional systems into a three dimensional environment. In a three dimensional environment, work is overlapped as far as possible, effectively decreasing the external time it takes to complete a project. (Hirotaka and Nonaka 1986) Instead of six segments of 2 person months taking a year to complete, a systematic over lap of one months halves the external time of the project. The outcome, a greater short-term cost, a lower miscommunication based quality problem level, a clearly shorter product development cycle, a similar or slight shorter product life cycle and significantly higher returns. See figures 6 and 7.

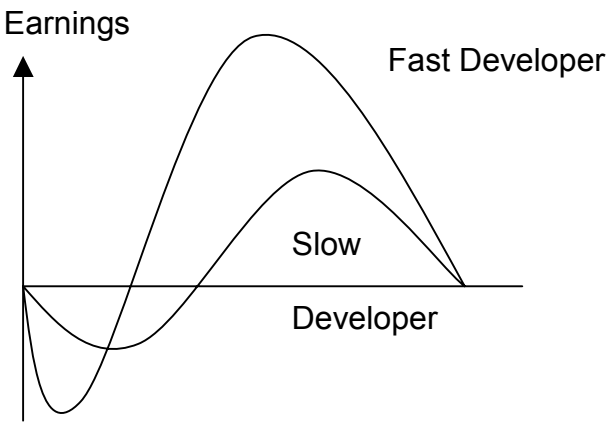

Figure 6. Rapid Developers Benefit Financially (Turunen 1991)

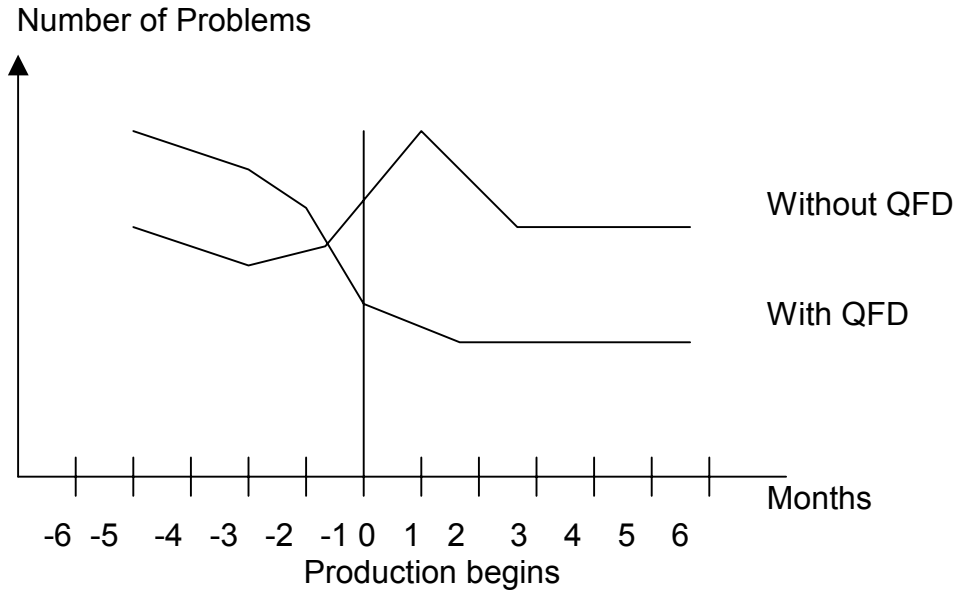

Figure 7. Economic Benefits of Investment in Product Design (Turunen 1991)

That QFD use prioritizes the needs of the customers and solutions to customers needs, enables developers to predict the customer satisfaction development of a product. Having a greater understanding of a products ability to meet customer needs makes it possible for developers to fine tone the release date of a product.

By concentrating on customer needs, working in teams, communicating better, the costs of correcting internal failures decrease, the speed of development increases, and the risks associated with new product failures can be virtually eliminated. A company can also force a less flexible competitor to reconsider their participation in a given market.

4.5.2. Weaknesses

QFD potentially requires a radical reorganization of project management, project communication, and the project rewards systems of a company. Change, means friction to change, selling the concept to possible team members, and the need for patience. According to available research the benefits of QFD are clear but they may take 2-3 years to materialize and requires a strong consistent level of commitment. (Griffin 1992, Griffin and Hauser 1993) Historically most major competitive high technology companies have shown an ability to adapt when adaptation was supported by sound logic.

Front End Time

The largest cost associated with QFD is the need for front end time. It is this cost that makes advanced problem solving, decreases in project time and expense possible. The need for more time in an organization where everybody is busy is an important challenge that must be overcome for QFD application to be possible.

Communication

The essence of Quality Function Deployment and one of its key difficulties, a make or break parameter. As a make or break parameter, communication is both a weakness and strength. The selling and facilitation of communication is at first the responsibility of the project initiator and later of the entire team staff.

Increasing communication requires the promotion of understanding between very functionally different people in different parts of the company and not becoming bogged down in meaningless ineffective discussion. The importance of communication between just marketing and R&D in product development success has been shown by research (Griffin & Hauser 1994). In any given development project there can be as many as 9 functions actively or passively involved, figure 12. Information from the 9 functions is ultimately funneled into the Marketing/ R&D interface shown in see figure 9 page 54.

Work Overload

Concentrating all the information of a project into one format can lead to information paralysis. Information paralysis is an indication the use of QFD has not been well thought out. If too much information is being processed, a filtering mechanism should be initiated or more people should to used to handle the information in an efficient manner.

Teams

The greater the size of the QFD team, the more theoretically correctly QFD can be applied. In practice time, geographical, and information sensitivity limit the size of the QFD team. The practice of applying QFD in an interlinked functional format seems to work rather effectively as long as communication opportunities exist between different functions. The semi-cross-functional format allows a company to retain local sensitivity without unduly hindering cross-functional communication. The system minimizes the extra time requirements of QFD, decreasing corporate inertia against the system.

4.5.3. Opportunities

Multiple Product Development

If consumer needs are well researched conflicting product parameters can be used to build product families or value adding accessory modules. The customer focus of the QFD system supports development processes that bring fourth alternative options for product development. The alternatives can than be used by development teams in support of one or more products. From this perspective QFD effectively transforms a potential problem into an advantage. In this format QFD not only provides a problem solution tool but a means of increasing market potential, increasing production volumes, and productivity.

Swatch made the wrist watch into a fashion trend with design segmentation. QFD can help NMP further transform phones into a technology and design based multiunit item effectively doubling, tripling, or quadrupling market potential. The stylish phone for going out, the unbreakable phone for the youth market with text and game services, the work phone with virtually unlimited call time, the minicomputer with extended functions this list could elongated substantially.

New Ideas & Upgrades

Can existing platforms be upgraded with new technical solutions to meet consumer needs more effectively. If the answer is yes, development costs can be decreased along with purchasing and assembly costs. This system of platform and product reuse is common among some car manufacturers who have been using QFD for decades. By pinpointing where conflict product parameters are, product development team members can seek areas where existing products can be upgraded with minimal effort. An upgrade can be something as apparently mundane as decreasing the length of code 10%, increasing the reliability of a system 2%, or decreasing battery power

expenditure 5%. This process approach to systems improvement has been in place for years in a number of companies.

4.5.4. Threat

Change and Time

Corporate product management and the employees that work for them have limited time allocations and typically plenty of work to fill the allocation. Change is thereby an aberration not to be considered except when necessary or when overwhelming benefits are possible. Unfortunately, QFD requires change, which must thereby be cloaked into a non-change format for it to be more acceptable.

Lack of Management Support

The success of new systems is dependent on overcoming the initial time considerations of the learning process. If time is not made available and management does not support the concept through possible trials and tribulations, the quality system is at risk of going unimplemented, not because it did not have potential but because the company did not have patience. One means of obtaining management support is by implementing QFD at first in a limited manner. A gradual learning process allows employees to gather experience in applying the quality system before a corporate implementation is considered.

Misapplication

QFD can be very handy in many situations. If it is applied to situations in which it is not effective or those applying it are not sufficiently comfortable in the application, the value of the entire concept may be discounted. An example of a misapplication is old project that does not require any innovative new solutions of any kind and already work well as is.

4.6. Conclusion

QFD is a straight forward revolving matrix based system for structuring, standardizing and promoting communication in the product development process. By focusing on customer needs and increasing the skills base available to project managers the speed and accuracy of product development can be increased, increasing product quality, sales volume, and corporate profits.

5. CONFLICTING PRODUCT PARAMETERS

"Over 90 % of the problems engineers face have been previously solved in some analogous form." (Braham 1995)

A typical mobile phone product development process must deal with a number of potentially conflicting product parameter groups. When these groups are broken out and their parameter interaction is researched the number of potential conflicts grows exponentially. In addition to internal conflicts, conflicts can arise with external factors in the physical and software environment.

Example

When Nokia signed a 500 million USD network and mobile phone handset deal with VoiceStream Wireless Corporation announced on April 3.2000, the ability of NMP to optimize seven potentially conflicting product parameters where mentioned as being critical requirements to reaching a contract. The parameters were; viewing of information, easy text input, fast access to information, smart access to information, weight, size, and performance. (VoiceStream Pressrelease 2000) An example of the potential conflicts inherent to the needs of VoiceStream is shown in figure 8.

	Viewing	Text Input	Fast Access	Access	Weight	Size	Performance
Viewing of information							
Easy text input		X					
Fast access to information	X	X					
Smart access to information		X	X	X			
Weight	X	X	X	X	X		
Size	X	X	X	X	X		
Performance		x	x	x	x	x	

Figure 8. Potential VoiceStream Conflicts

In the VoiceStream example, there are 21 potentially conflict parameters. The actual figure would depend on the engineering solutions applied.

5.1. What?

Conflict product parameters are an aspect of products that can never be eliminated. Who would not enjoy using a light weight, high performance moderately priced mobile phone? The challenge of a company is to use the actual unavoidable conflicts productively.

The VoiceStream provides a ball park illustration of how many individual potentially conflicting factors play an important role in product development. Managing these basic parameters optimally is one aspect of the daily routine of product managers and the corporate decision making hierarchy. Streamlining and organizing the process is in the interest of managers responsible for corporate long and short term wellbeing.

The mobile phones started as a very cumbersome means of communication that made it possible to communicate with people in a mobile format. As the technology developed the size of the phone got smaller, use time increased, and what the phone could communicate increased. With the solution of basic technological problems, consumer oriented conflicting product parameters became more prevalent. As the number of mobile phone users and feature alternatives grew the number and types of people involved in developing the phone grew to include designers, salespeople, product marketing people, production engineers, purchasers subcontractors opening new markets and creating new challenges for developers. The evolution has lead to a greater need for organizational communication and a greater need to optimize the development process.

Central to understanding conflict product parameter problems is the knowledgement that consumers know the conflicts exist and vote on the success of solutions by their consumer behavior. Success in optimizing conflict product parameters is evident in the quality, usability of the product and acceptance of the product among consumers. NMP has been very successful in improving both usability and consumer acceptance as is illustrated by our marketshare.

5.2. Where?

Conflicts tend to arise within functional segments and in the reaction phase between functions. More efficient smaller, lighter, more reliable battery technology challenges product marketing, design, and sales people to create new markets for the new technology. Similarly, product marketing having found a large potential market for smaller phones can challenge researcher's to create the technology that will make it possible to enter the market. In both cases, the production engineers and purchasers will be challenged to incorporate the new technology into a manufacturable format. In both the previous cases, the solution of a technical problem made it possible to decrease the weight of the existing product providing entry to a previously unaccessible market.

Conflicts can also arise from internal or external miscommunication regarding customer needs and parameter flexibility. People may not really want a lighter battery, they may be interested in more use time or a more robust battery assembly.

Conflict parameter management is affected by the competitive environment of the company and the companies image. If sales are soaring production capacity is sold months in advance, a new concept for a product or even a market penetration avenue may be ignored regardless of the potential of the idea, while a new concept that increases product output or tweeks product quality a little bit is more likely to be accepted. A concept that in one market situation would be acted upon immediately in another is ignored and visa versa.

In a high demand, low supply market companies tend to concentrate on solving conflicts that affect the ability of a company to meet demand. In a low demand high supply market, companies will tend to concentrate on innovations that will

shift customers to their company. By balancing these two scenarios a company can secure short and long term stability in demand.

Conflicts may also arise based on social aspects of product development. The current consumer market is very sensitive to environmental and social issues. This sensitivity has pushed companies to put into place environmental standards, eliminate the use of certain chemicals both internally and among subcontractors. The increase in environmental and social standards increases costs in direct conflict with policies to provide competitively priced products to as large a potential market as possible challenging purchasers to decrease costs. The establishment of a corporate social policy thereby increases the number of potential conflicts in a product by a level of magnitude.

Examples of Company Conflict Environments
Mass customization vs production cost
Error freeness vs development speed + production cost
Social quality vs the right to free speech made possible by low cost production

5.3. How?

For potential conflicting product parameters to be valuable starting points of new product development instead of roadblocks, people within an organization must be capable of communicating with each other openly. The better the communication within and between functions the greater the knowledge base will be that can be used to eliminate ghost conflicts and create value from real existing conflicts. Ghost conflicts are conflicts caused by miscommunication. A quintessential aspect of solving CPP issues is maximizing the skills base available to problem solvers and having a standardized organized method for solving problems in a customer focused fashion.

Conflicting product parameters are an indication that a given product or product category is moving forward along its lifecycle toward a more commodity type phase. Consumers know technology is moving forward, the number of potential subcontractors is skyrocketing as is the number of technologies that could be included in a product. The basic solution to meeting the challenges inherent to this stage is having a standardized cross functional multi-skill communications system that is focused on the customer, QFD.

6. ACCESSABILITY

6.1. Introduction

Accessability is the ability of a maximum volume of consumers to use a product easily and effectively. The term is definitionally, a developed customer service based version of product development in that an important basic aspect of product development is making a product or product family usable to the maximum volume of consumers either directly or with the aid of accessories.

Mobile communication has over that last decade brought connecting people to a large volume of people who in the past did not have access to landline based communication. If people did have landlines near them, societies could control access to lines thereby controlling the ability of people to access information and exchange ideas by limiting who could talk on a given phone at a given time with a given level of real privacy. Mobile communications has brought the communication infrastructure to once geographically and economically isolated areas.

Once a mobile infrastructure has been brought to an area the ability of people to connect to it, is a matter of obtaining a phone not both a phone and a phone line. The ease of purchasing a phone, relative to line and phone combination, supported possibly by increasing common prepaid systems has had a very positive affect on the right to free speech of individual people and a negative affect on the right to control speech by political or economic entities. Mobile phone networks have increased the accessability of people to free communication on a global scale.

Running phone lines is expensive. It is almost unheard of that numerous lines would be run into an individual house, while it has become common in many developed countries to have numerous competing mobile phone networks available to an individual phone. Mobile communication in and of itself has radically increased the level of access to communication of people, communication is freer, less controlled and more competitive then it has ever been.

One aspect of communication is having a communication infrastructure, the mobile network. The second aspect of communication is the availability of a means of accessing the infrastructure, the mobile phone. The third aspect of communication is the price of sending and receiving information or the ability of consumers to gain economic access to freer communication. At Nokia Mobile Phones there is a great deal of interested in maximize the level accessibility of consumers. The interest has lead to the development of various standard mobile phone categories. The different categories allow NMP to target the needs of specific consumer segments with phones that specifically meet their needs. This increases the accessibility of people to mobile communication. Such features as large/small keys, sound volume, and voice control are good examples how it is possible to increase the ability of people to access the mobile phone communication.

6.2. Mobile Phone Accessability

As consumers we all enjoy having a phone that is not too large and not too small, physically easy for us to use and easy for us to use the software that we want there to be. Consumers want the phone to be visually appealing, appropriately shaped and usable whenever where-ever they are. They want the software in the phone to communicate effectively with the external environment,

enabling them to use operator supported software and of course their should obtain all of this at a reasonable prices as defined by their vision of reasonable.

Increasing mobile phone accessability at even a very basic level requires the optimization of a very large number of product features, parts, and subassemblies parameters. If accessability issues are addressed correctly the experience mobile phone users have with their phone will improve, the number of users will increase, and the cost of providing the experience will decrease.

6.3. Market

All phone buyers want to buy a phone that meets their needs. That the mobile phone market in 1988 grew a great deal and that the market for Nokia products grew with respect to market-share is an illustration of Nokia's success in meeting customer needs (Nokia 1999). Some company's might concentrate on more efficient production systems, concentrating on benefiting from the current endemic growth in the market. At NMP in addition to seeking production cost benefits, we continue to seek ways that allow more people to enjoy their phones more. To make this possible it is import to focus on the needs of internal and external customers needs throughout product development and production.

One aspect of the NMP experience is selling high quality phones in all market segments. Lower priced models increase the number of people who have access to phones. High quality, moderately priced products are made possible by large volume long term economies of scale. As the production time and production volumes grow the cost of producing the phone decreases with fixed cost depreciation at NMP and at NMP subcontractors, with lower marketing and sales costs and because the production system optimizes itself with time as people learn how to make the product more efficiently. Since subcontractors

know a product line will be in production a long time the initial cost of components decreases.

A second aspect optimizing standardized conflict product parameters for particular market segments. Examples of standardization are the battery recharging mechanism and number keys. Examples of individualization are the software characteristics and the mechanical design. The production of a number of product categories is an illustration of the prevalence of customer needs over production cost and R&D. It is also an illustration of why for accessability to be maximized R&D, product marketing, and production has to work seamlessly together.

6.4. R&D

The purpose of R&D is to make it possible for more people to have a greater level of access to new and more reliable solutions to their current and future needs. This means R&D must have a very good practical understanding of the needs of customers and the customer chain, how the needs are met by competitors, the needs of production and the needs illustrated by applicable standards and legal requirements. Understanding the needs of existing potential and advanced new market customers and production is stage one to producing future solutions. Another stage is knowing what is technologically possible in the near and long term. Another stage brings the future technologies into interaction with customer needs and production needs. Another stage is optimizing the new conflict product parameters brought about by the new technology. Another stage five is packaging the old and new solutions into one or a variety of high quality packages in association with production people.

R&D success can be evaluated by its ability to;

give existing mobile phone users a flow of new exciting features,
Existing customer satisfaction

make the mobile phone easier to use from the perspective of the user,
Existing & future customer satisfaction

bundle more features more flexibly,
Future customer satisfaction

persuade more people to begin using a mobile phone for the first time,
New customer penetration

make it possible for more people to actually use a phone.
Advanced new market penetration

Example

There are thousands of people who like to drink coffee in their car. For these people the ability to drink coffee on the run, increases their quality of life. Having the right to do so, required agreement among cup producers and cup manufacturers as to the importance of meeting the need.

In the future, the development of cups and smooth driving systems should increase satisfaction among old and new consumers alike. It is important to note that the same development process that allows people

to access their coffee in their car may provide a greater level access to a pleasurable coffee moment to coffee drinkers in very different situations, may provide mothers with news ways of providing the children food or improve driving comfort.

When QFD is used appropriately new applications designed by R&D and product marketing will be used in the appropriate old and new models. When this takes place the cost of developing the application can be spread out across the appropriate product lines. By spreading the budgeted cost across the appropriate product lines, the true desirability of an application can be assessed before a significant development effort is begun.

Organized communication, understanding the interaction between different technological solutions, and prioritized customer need recognition make it possible for the R&D to successfully support the product marketing and production departments in maximizing the accessibility of high quality products. Figure 9 provides a limited illustration of information should flow during the product development process.

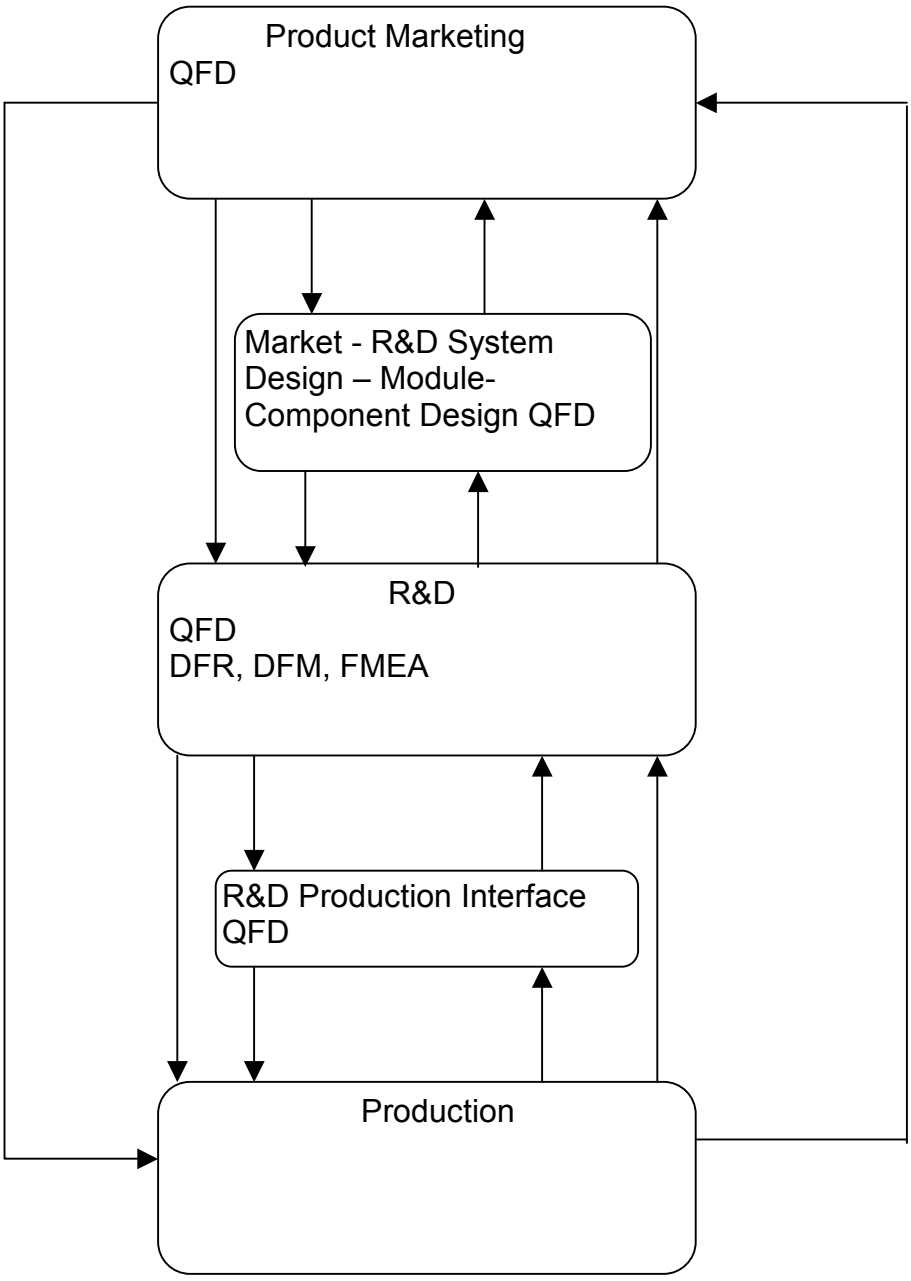

Figure 9. Product marketing, R&D, Production Communication Flow Chart.

7. ECONOMIC & QUALITY FUNCTION DEPLOYMENT

Accuracy, and speed are important factors in the economics of product development. In an ideal world, a company would bring to market an infinite amount of products at the maximum speed of consumer new product interest without the costs of having to employ people and build products. The ability to solve conflicting product parameters inherent to the product and the product development/production process are a central factor in decreasing the time it takes to develop a new successful product. The shorter the time and the better the accuracy of product the greater the returns will be as illustrated by figure 6 on page 36.

7.1. Accuracy

New product development and old product upgrades are a continuing processes companies use to respond to the changing needs of old customers and to meet the needs of new customers through conflicting product parameter solutions. Product usability improvements allow a company to provide for the needs customer groups whose specific needs may not be currently met. The accuracy of these improvements decides the payoff for the work done to make the improvements.

Accuracy has two dimensions, the ability to provide the intended group of consumers a product to their liking and the ability to build the products cost effectively error freely. Success in the first dimension illustrates the customer understanding of a product development team. Success in the second dimension illustrates the ability of the same team to work together.

High technology companies typically use a relatively large proportion of their available funds to develop new products. In the mobile phone business development costs range from very little to quite a lot. The accuracy of the investment has a very very strong correlation with the financial success of a given company. In an environment where sales have to grow at strong two figure levels the ability of a company to effectively maximize the usability of products by solving conflicting product parameters is decisive to economic success. That QFD increases the organizational level of the product development process and increases the level of communication improves the ability of team members to make potentially necessary changes. The cost of making a correction to a product at different phases of production development is illustrated below. (Bossert 1991)

At Design	35$
Before Procurement	177$
Before Production	368$
Before Shipment	17000$
Recall	590,000$ (16500 * At Design)

In the high and higher stakes development, the increasing level of difficulty of the development process is pushing developers toward systematically designing possible problems out of products. The old system of product development process comprised of a functionally linear process of R&D, engineering, production, quality, and marketing simply has a difficult time competing in a modern environment.

The price of inaccuracy is the summation of customer service time, sales time, marketing time as a whole, product replacement, warranty costs, new product development time and losses to competitors and losses in brand value.

The more accurate the development process is, the fewer resources need be expended in correcting the problems of the past, effectively freeing resources for use in increasing market-share or for repatriation to shareholders. The accuracy of product development can be improved by QFD as illustrated by figures 7, 10,11. The figures show the differences in technical quality between Japan and other countries and the affect of QFD on quality problems. Obvious the generalization is rough, if worth considering our knowledge of the mode of operation of QFD. In essence, by concentrating on removing problems in early stages of development eliminates the need for further in the development process, allowing a company to concentrate on getting the product to market effectively.

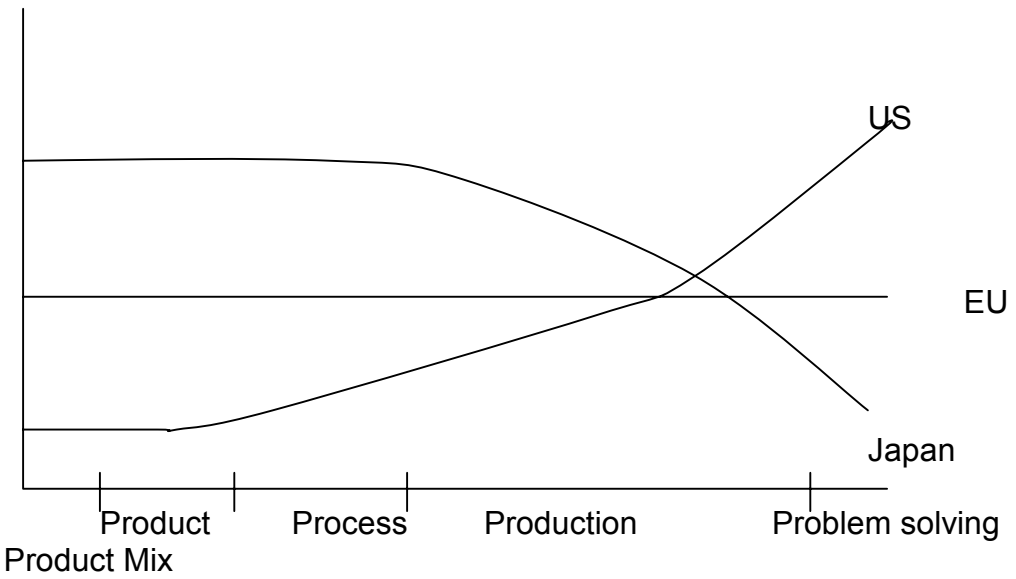

Figure 10. Benefits of Investing in Product and Production Planning (Turunen 1991)

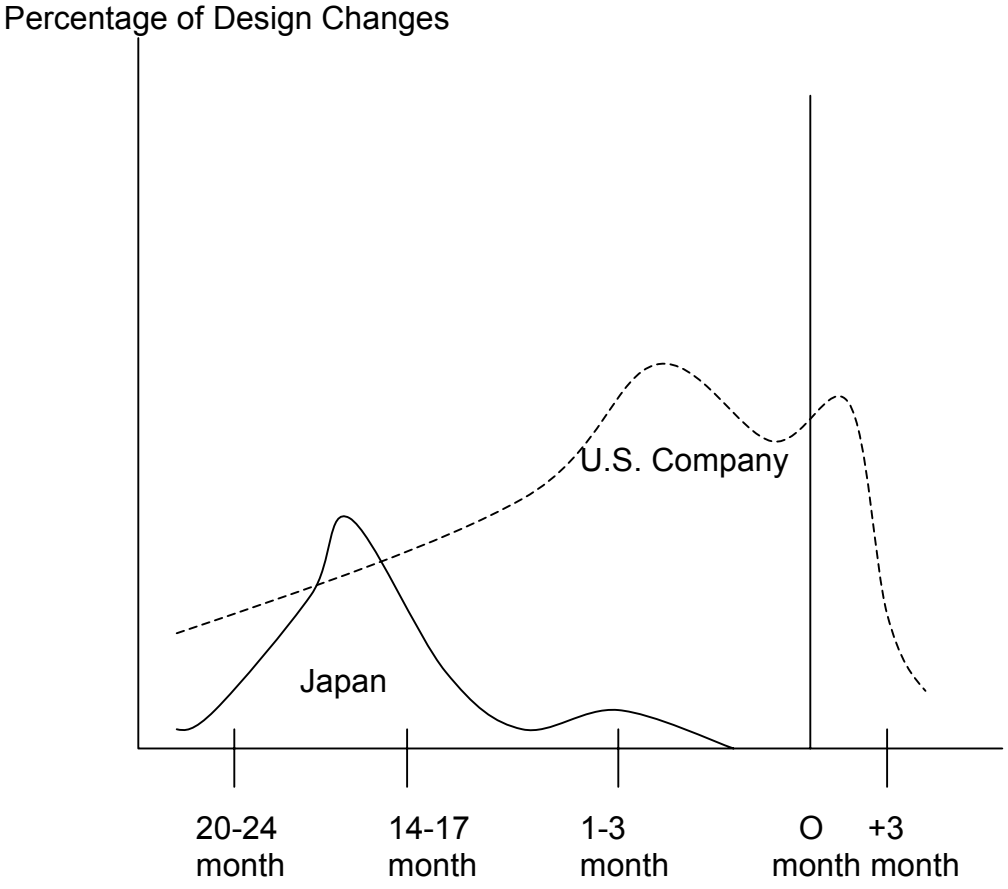

Figure 11. Design Change Cultural Difference Between the US and Japan (Hauser and Clausing 1986)

To ensure the accuracy of product development the entire product development team must communicate effectively together. In practice this means specialist quality management, testing & type approval, marketing & sales, after market services, new technology development, industry standards, industry design, technology & platforms and product design must work well together. Where QFD fits into this picture is illustrated in figure 12.

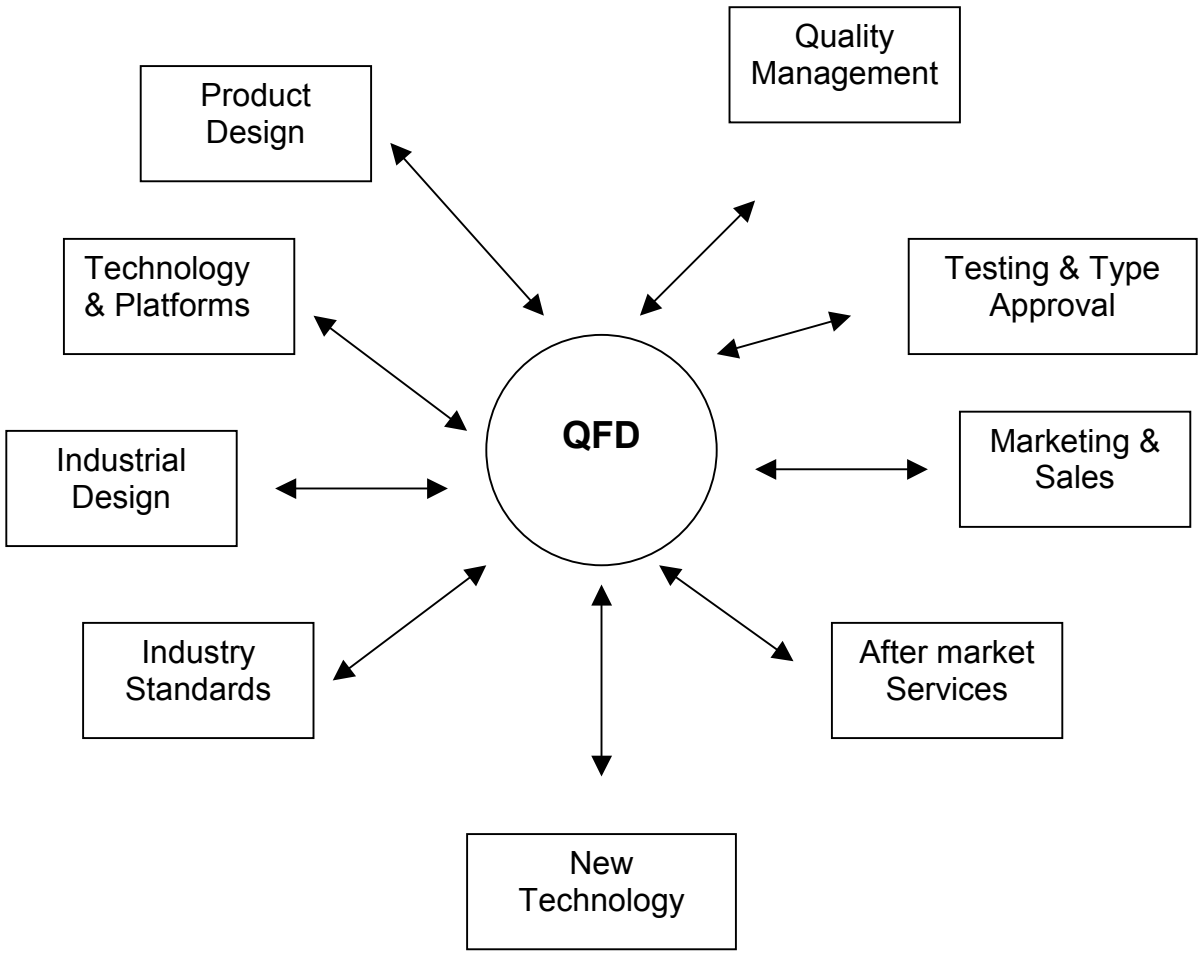

Figure 12. Corporate QFD Teams Skill Requirements (Nokia Inc)

7.2. Speed

The quicker a new product life cycle can be begun, the greater the profits will be from it due to less competition from competitors products, the ability to provide unique value addition to distributors and the ability to become established among the distribution systems first. How quickly a company can bring a product to market depends on the organization within it.

With the aid of a needs establishment and prioritization process, a program manager can concentrate on optimizing the most important or easiest product parameters first, the second most important second and so fourth. The prioritization process eliminates inefficient work and improves the time management ability of managers leading to quicker product development.

The structural attributes of QFD and the ability of QFD to promote cross-functional communication has a positive affect on the speed and accuracy of product development. QFD can in theory at least both improve the return of investment of a product due to shorter development times and improved final quality parameters.

7.2.1 Concurrent Engineering

Once a company has begun emphasizing product development speed, error free production, and development accuracy, it becomes possible for a company to begin further developing different aspects of product at the same time. By meshing the development, engineering and production processes, a company can further improve and increase the speed of product development by decreasing lead times and through-put times.

7.3. Economies of Conflicting Product Parameter Solving

Conflict product parameters are the heart and soul of product development economics. When conflicts areas are located their existence can be reformed into customer based value addition via new products, product upgrades and reliability improvements increasing customer satisfaction and lowering warranty

costs. The potential increase of development accuracy and decrease in customer dissatisfaction, opens the door to increasing obtainable market-share increasing production economics while lowering the affect of production efficiencies associated with reliability problems.

Traditionally market segmentation was used improve product satisfaction among different customer groups thereby making the product useful to more possible clients. It can be said that to a degree the entire process of product development and market segmentation is a continuum of solving internal and external conflicting product parameters. Different process solutions are used to find optimum production economies. Different product solutions are used to meet the needs of different client groups. Different mixes of process and product solutions are used to simultaneously maximize market potential and production economies. By changing the solution a company can move toward or away from mass-customization. With the aid of organized and documented solutions to conflict product parameters, the production system, and a product mix can be optimized from segmentation, development speed and accuracy perspectives. For example by rating the needs of chain of customers a company can concentrate on meeting the most important needs of customer instead of wasting time on unimportant improvements. By clearly documenting the needs of customers and how they are met now, new customer segments can be sought and the needs of old customers can be met better.

With QFD conflict product parameter solutions will lead to quality weaknesses being cost effectively designed out of products. The closer a product gets to a customer the more design changes cost, in wasted material, production time, negative product and corporate image and possibly in changes to the entire production system. I believe car companies in the United States were among the first groups to consistently apply QFD because the massive negative cost

economies of changing products midstream, and the cost of fixing products after they have been sold to customers.

7.4. Conclusion

Customers needs satisfaction, market potential maximization, speed of product development, quality, communication, risk minimization (accuracy) are all simple concepts, the understanding and optimization of which have provided research funding and book titles to thousands of researchers in the field of economics. Does Quality Function Deployment offer something unique to these concepts? Yes it does. QFD utilization allows a project to be designed, managed, and comparatively analyzed in a single clearly organized transparent format with a strong emphasis on meeting the needs of customer effectively improving the cost efficiency of the project, increasing production economies and eliminating warranty costs. QFD helps a company increase market penetration because more people are happy with the company's better more competitively priced products.

8. THESIS CONCLUSION

Product quality as perceived by individual customers and by the market is critical to the economic success of a company. The easiest way I have found to improve quality is to determine the needs a product fills with customers, determine the product parameters that satisfy the needs of customers and their level of satisfaction creation, determine the conflicting product parameters that need to be optimized by customer group for maximum satisfaction to occur and ensure a sufficiently level of communication between R&D, marketing, production, and legal/standardization departments that a high quality product can be made. Quality Function Deployment is a multifunctional organizational tool that can effectively be used to inspire, organize, and then communicate information within a company, effectively melding the different skills and mindsets with a company together. QFD has been tested for use in improving the level innovation organization in R&D, product marketing, and production and their respective subsections. Based on secondary research of QFD use in other company's and on theoretical research of QFD it can used successfully in decreasing product development times, decreasing the needs for product design changes, increase the returns of investment in product development and of course in improving the potential for improving customer satisfaction.

In the projects I have been involved in, QFD has a provided a wonderful format for working with a number of very talented people with a wide range of information available to the development team. My experience though preliminary in nature does indicate that the QFD format increases development speeds, improves skills utilization and saves money through the better allocation of resources.

To the question Can QFD be used in solving multidimensional product parameters in a manner that lowers development cost, time and the acceptance risk inherent to product development? As QFD is a system which locates area of potential difficulty, breaks down projects into manageable components, promotions lasting communication, improves design quality and increases development speed the answer is YES.

That QFD can be used effectively does not mean people will show interest in it or that the tool can not be used ineffectively. I leave it quality managers it sell the QFD system to projects where they are confident benefits arise from its use. My personal expertise includes positive experiences from applications to time management, recruiting, financial services and project management.

In the future it is my goal to support the creation of a national QFD information based as well as to support the development of more consumer friendly QFD software applications.

9. EXAMPLE SYSTEM

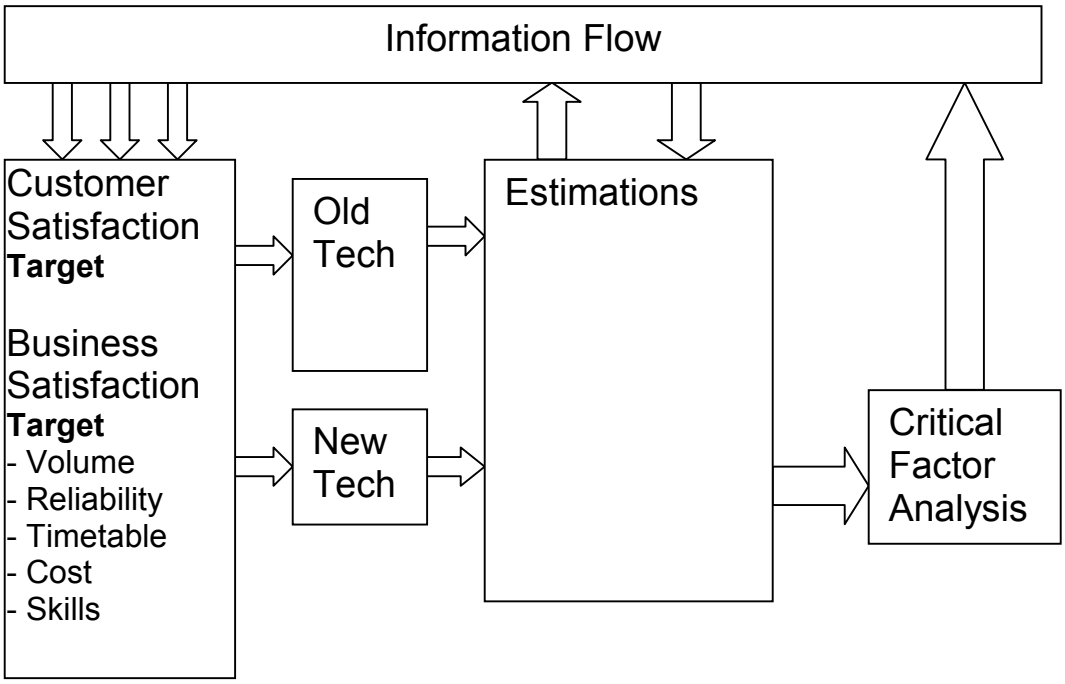

Figure 13. QFD Work and Information Flow Chart

A decision to apply QFD should made as soon as possible by those potentially involved in a project. When a decision is made to apply QFD, the appropriate time, skills and financial resources should be allocated, a skilled QFD coordinator should be chosen and clear targets for the QFD process should be applied. The process of creating a House of Quality can be a 7 stage process. How many stages are actually used depends on the application and the applicator.

The first stage of applying QFD is choosing the members involved in projects management and educating them as to what can be expected. The second stage is deciding on, and defining the consumer of the product a good means of doing is with an organized brainstorming session. Appendix 6 has one chart for organizing this type of information. I leave it to you to decide who should be

present at the brainstorming meeting. At the brainstorming I would suggest defining three times more potential consumers than will be ultimately chosen for further development and analysis. This eliminates risks associated with too early elimination of potentially lucrative markets. The extra groups can be eliminated as further information becomes available and the appropriate market research is done.

The third stage is deciding upon the needs of consumers. I leave it to you to decide who should be present at the brainstorming meeting, I do suggest the maximum amount of experience in different functions be present without the group growing beyond 10-20. If more people are needed the sessions should be divided into two or more separate occasions. This step should bring fourth 100-400 needs that can later be whittled down and grouped together. Once the number has dropped to between 50 and 100 the list of needs should be sent to those present at the brainstormings for prioritization. An example tool for grouping prioritizing needs is shown in appendix 7 Depending on the focus of the project the ultimate number of needs should be less the 25 and grouped under no more than 5 five major groups. The purpose of the limitation is to keep the number of needs being considered manageable while forcing project members to keep focused. The needs once established should be prioritized. I like using a logarithmic scale 9 (very important), 3 (important), 1 (less important) 0 (not important) . Where important, customers other than the end consumer (the end product producer, the wholesaler, the retailer, legislators, politicians, cultural experts, standardization organizations, marketing, R&D, production, subcontractors, different levels management hierarchy) should be considered.

The fourth stage is to decide on the technological solutions that will be used to meet the needs of the consumers and benchmarking the solutions against those of competitors. The final solutions package should be as short as possible and grouped into categories. I would suggest the use of no more than 5 main

categories with a total of 30 solutions. An example of a chart of needs and solutions is available in appendix 8.

At this stage it will be possible to evaluate which solutions have the greatest affect on meeting consumer needs and the solutions that have the greatest affect on consumer satisfaction and how competitive the product is. Once at this stage the same format can be used to evaluate the potential FFR of a product, the market potential of product, the likely cost of the product and the ability of the product to meet a given timetable simply by changing the perspective of the exercise.

Stage five is deciding on the conflict product parameters of the solutions. The purpose of this is to find the factors that need to be solved for a product to be feasible. By so doing the feasibility of a project can be evaluated before the large scale use of resources.

Stage six is breaking out the project, to the degree necessary, by shifting the needs solutions into the needs section. This can be done until the project has been broken down to the point where technical specifications are used.

Stage seven is writing the appropriate reports required.

I have tested a few different QFD software packages non of which currently meet my unequivocal approval. In the future I intend to try to remedy this issue as I believe the usability of a quality system is dependent on the ability people to use supporting software products.

As further reading I suggest reading the thesis of Mr Kivelä Designing for Reliability Designing and Prototyping Reliability Breakthrough. I also ask you send me examples of how you are applying QFD.

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Major International Trade Constituencies QFD Format Example

Appendix 1

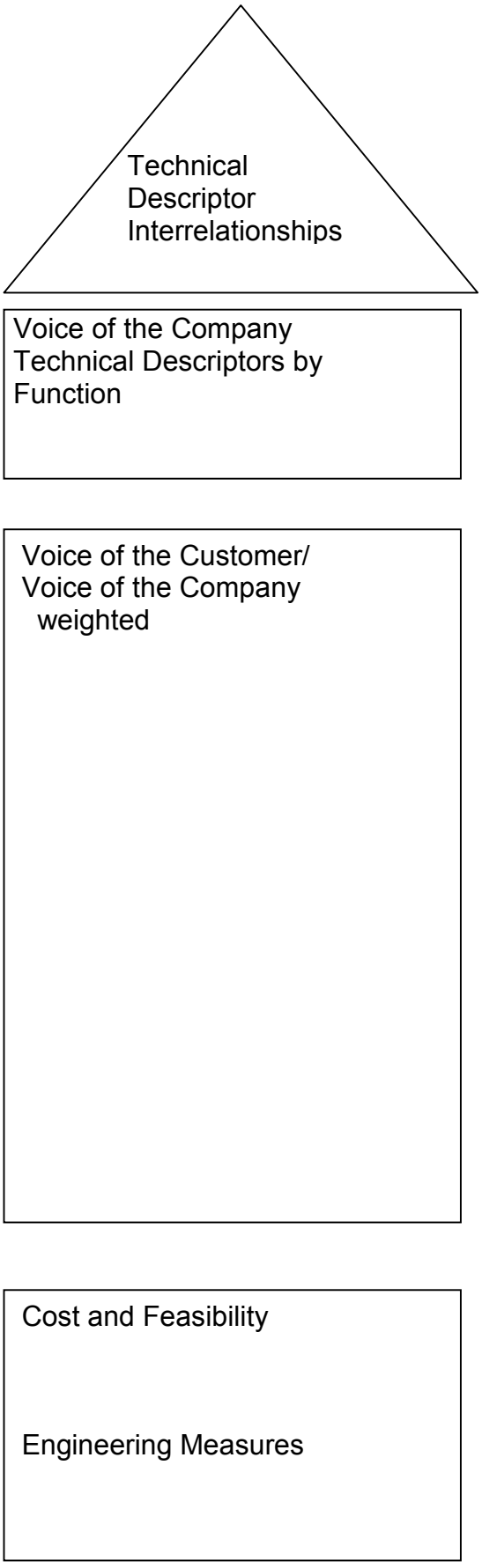
	How / **What**	**Importance Europe**	**Importance Asia**	Product 1	Product 2	Product 3
End Customer	Need 1					
	Need 2					
	Need 3					
	Corporate score					
	Base line					
Academia						
Stockholders						
Pressure Groups						
competitors						
General Public						
Suppliers						
Labor						
Church						
Financial Community						
Conservationists						
Government Agencies						
Public Media						
Minority Groups						

List of Companies that have used QFD

Anderson Consulting
3M
AT&T
Boeing Company
Chrysler Motors
Coopers & Lybrand Management Consultants
Digital Equipment Corporation
Ericsson
Ernst-Young
Ford
General Electric
General Motors
Hewlett-Packard
IBM Corporation
John Deere
Kodak
Lucent Technologies
Motorolla (8)
Pratt & Whitney
Procter & Gamble
Rockwell International
Saab
Texas Instruments
Toshiba Systems & Software Research Laboratories
Unisys Corporation
Xerox Corporation

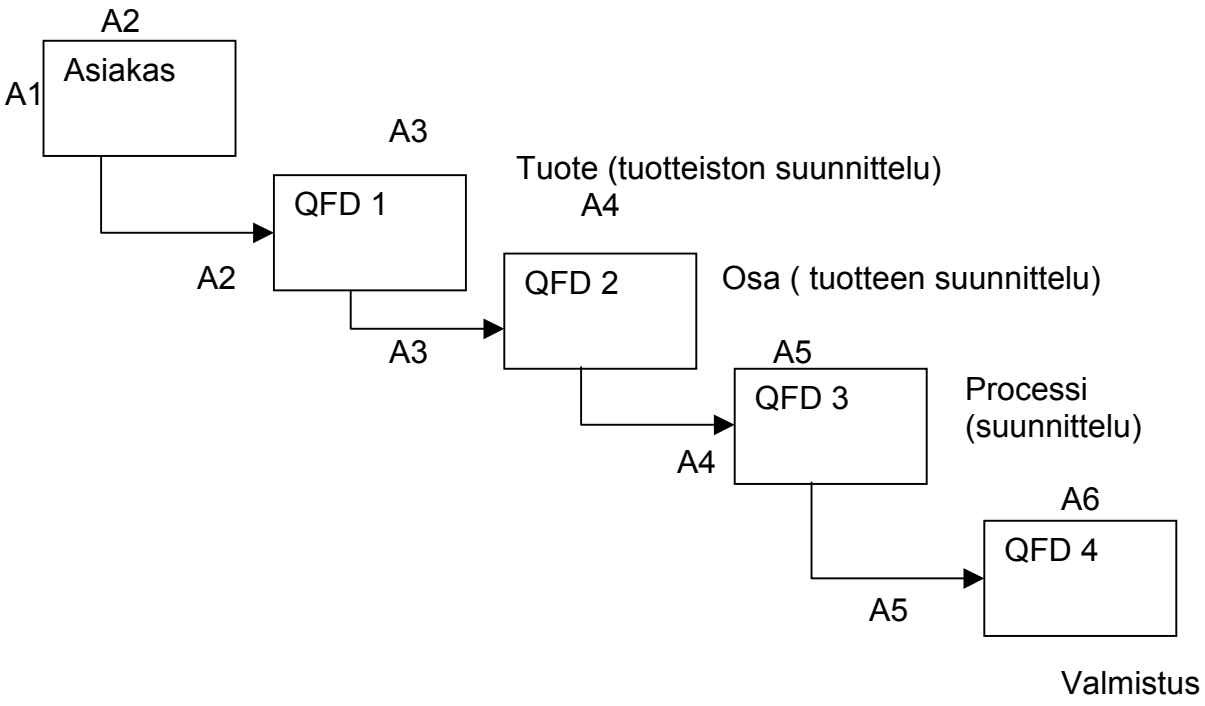
House of Quality

Appendix 3

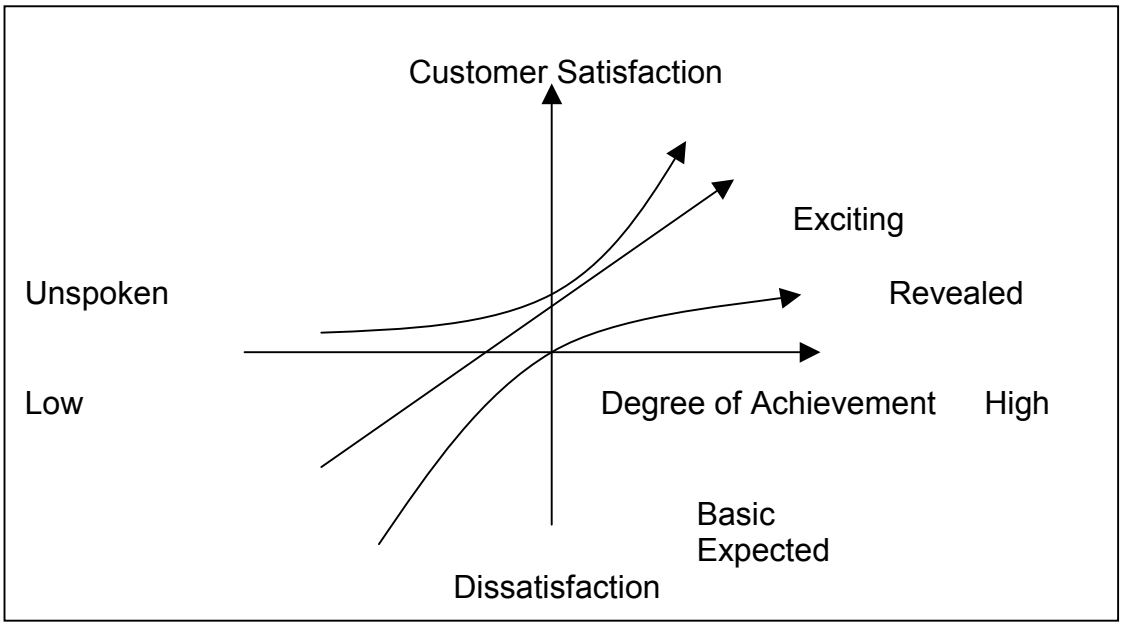


Adaptation from Hauser 1993

QFD Product Break Down Process



Kano Model Appendix 5



Adaptation published by Mazur, Rings, and Barton,1998

1	Who	What	When	Where	Why	How	Brand

Customer Needs Prioritization Chart Appendix 7

Project name			
SCALE:	**9-very important**		
	3-important		
	1-less important		**Priority**
Level 1 (Topic of Brainstorming)	**Level 2 ("grouped" needs)**	**Customer needs (WHAT's)**	
Concept	Concept		

Needs and Solutions Chart Appendix 8

Importance

9 Very important

3 important

1 Less Important

0 Not important

Relationship

9 Strong relationship

3 Medium relationship

1 Weak relationship

	Customer Requirement & Expectation														
	Product feature related	**IMPORTANCE**	**IMPORTANCE**	**IMPORTANCE**	**Importance / All (Average)**					SOLUTION	SOLUTION	SOLUTION	SOLUTION
1															
2															
3															
4															
5															
10															
11															
12															
13															
14															
15															
16															
	Absolute importance / All (Average)					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Absolute ranking / All (Average)														