Advanced QFD Applications

M. Xie • K.C. Tan • T.N. Goh

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Preface

Quality is probably the most important selling point today. Higher quality eventually leads to a larger market share, a higher selling price, or both, thus higher profit. Quality engineering aims at analyzing products and processes to reduce production cost and improve customer satisfaction. It is important to study the tools that can be used for these purposes.

Quality function deployment (QFD) is a widely–used tool in both quality management and quality engineering. QFD helps to translate customer needs and requirements into product and process design characteristics so that they can be best designed to improve customer satisfaction. However, most of the existing literature on QFD deals mainly with the basic QFD applications and their general benefits. An integral part of QFD, the house of quality (HOQ), for example, is generally not analyzed beyond its basic formulation.

The aim of this book is to take some steps beyond the basic QFD analysis to maximize its potential in practical applications. The emphasis is on both quantitative and qualitative analyses. A number of techniques for further analysis of the HOQ are described and illustrated with simple examples. Although we hope that the readers will have some basic idea of QFD in order to read and use this book, no in-depth knowledge or experience with QFD is required.

A general discussion is presented in Chapter 1 to provide some historical background of QFD. Chapter 2 contains a basic introduction to QFD that is suitable for beginners. An application example is presented. In this chapter, a summary of some current studies of advanced QFD analysis is also provided.

Chapters 3 through 5 deal with several important issues that are usually not found in standard QFD texts. Chapter 3 focuses on the prediction of the voice of the customer, especially their future voices. Some methods for this type of analysis and use of the voice of the customer are discussed. Chapter 4 deals with some quantitative analysis on handling variability in gathering customers' voices. Sensitivity analysis of the QFD processes is also discussed. Some detailed optimization models that make use of HOQ are discussed in Chapter 5. The aim in this chapter is to provide some techniques for detailed analysis and optimization for better resource allocation and decision making.

Chapters 6 through 8 present some detailed analysis on the use of benchmarking data and information, Kano's model for better customer satisfaction, and QFD for service-related applications. The discussion here provides more insights into QFD applications with a focus on the spoken and unspoken customer needs. Finally, in Chapter 9, we summarize some other advanced QFD applications for cases where there are segmented customer groups and linguistic data. We also present a study on the reduction of the HOQ for better presentation and decision making.

Many illustrative examples from service, the Internet, product design, and so on are shown in this book together with advanced and further analyses in QFD. This self-contained book can be used as a reference text for basic quality or management courses, or as a main text for senior or graduate-level courses on QFD. It can also be used for training or self-study.

This is a unique and useful book, much different from many existing QFD books on the market. We hope that this book will serve as a valuable addition to the quality literature. Furthermore, it is the aim of this book to bring together QFD practitioners and researchers to make the QFD even more useful for quality professionals and decision makers.

We would like to thank a number of individuals who have helped in the process of preparing this book. First of all, the contribution of many of our students, especially Dr. H. Wang, Dr. X. X. Shen, Mr. K. L. Sim, Ms. R. Vijayalakshmi, and Ms. T. Pawitra are acknowledged. Their interest and hard work have motivated us to finally complete this book. The support and interest of many of our colleagues are also acknowledged.

The help of Mr. Michael O'Donoghue of the American Society for Quality in getting this project started is very much appreciated. The book was initiated after his visit to Singapore Quality Institute, with which we are associated. We also appreciate the help of Ms. Annemieke Koudstaal and Mr. Paul O'Mara of the ASQ Quality Press, as well as several reviewers who have provided many useful comments to earlier versions of the manuscript.

Finally, we would like to thank our families for their support and understanding through the course of research and preparation for this book.

Min Xie
Kay-Chuan Tan
Thong Ngee Goh

Singapore, 1 February 2003

Chapter 1
Introduction

Product quality is probably the most vital selling point in today's global market. For improvement of quality and productivity, many companies have adopted total quality management (TQM) as a key initiative with the use of methods, such as quality function deployment (QFD), design for manufacturability, and statistical process control. Among these approaches, QFD has been used to translate customer needs into engineering design characteristics through the integration of marketing, design, engineering, manufacturing, and other relevant functions of an organization (Akao, 1990; Cohen, 1995).

QFD could enable a company to improve its products and processes to levels exceeding the expectation of the customer. It works best within a company when there are organizational commitment and a disciplined approach to implementation. The QFD discipline provides both a framework and a structured process to enhance an organization's ability to communicate, document, analyze, and prioritize. The documentation and analysis steps lead to breakthroughs that enhance competitiveness.

DEFINITION AND USES OF QFD

The term *quality function deployment* originated from a Japanese phrase consisting of three characters with the following meaning:

Hin shitsu, which can mean "quality," "features," "attributes," or "qualities"

Kin, which can mean "functions" or "mechanisms"

Ten kai, which can mean "deployment," "evolution," "diffusion," or "development"

According to the translation of these Japanese phrases, QFD means deploying the attributes of a product or service desired by the customer throughout all the appropriate functional components of an organization (ReVelle et al., 1998). QFD also provides a mechanism for its achievement, that is, the set of matrices that serves as both a structure and a graphic of the deployment process. However, there are several different definitions that have been proposed in the literature.

According to Akao (1990), QFD is defined as "a method for developing a design quality aimed at satisfying the consumer and translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase." Sullivan (1986) conceptualized QFD as "a method that helps a manufacturing company to bring new products to the market sooner than competition with lower cost and improved quality."

Quality function deployment, according to the American Supplier Institute (ASI), is defined as "A system for translating customer or user requirements into appropriate company requirements at every stage from research, through product design and development, to manufacture, distribution, installation and marketing, sales, and service."

According to Growth Opportunity Alliance of Lawrence, Massachusetts/Quality Productivity Center (GOAL/QPC), QFD is a system for designing products and services based on customer demand and involving all members of the producer or supplier organizations. It is sometimes referred to as the most advanced form of total quality control, Japanese style.

QFD is a way of making the voice of the customer heard throughout an organization. It is a systematic process for capturing customer requirements and translating them into requirements that must be met throughout the supply chain (Hutton, 2001). The result is a set of target values for designers, production people, and even suppliers to aim at, in order to produce the output desired by the customer.

QFD is particularly valuable when design trade-offs are necessary in order to achieve the best overall solution, for example, when some requirements conflict with others. QFD also enables a great deal of information to be summarized in the form of one or more charts.

QFD is sometimes referred to by other names, such as *the voice of the customer* (VOC) (from its use as a way of communicating customer needs) or *the house of quality* (HOQ) (from the characteristic house shape of a QFD chart, see Figure 1.1).

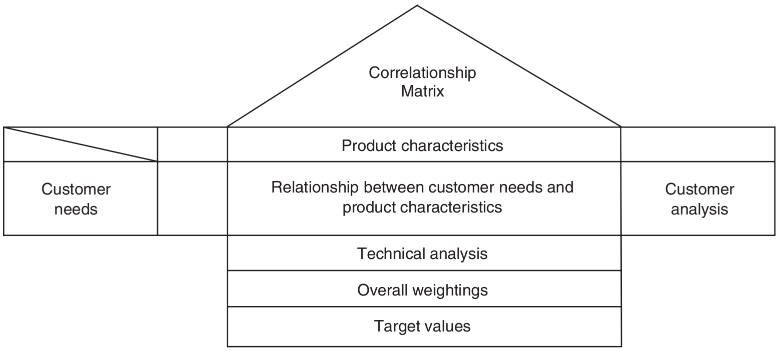

Figure 1.1 The house of quality is the basic matrix structure used to define the voice of the customer.

Benefits of QFD

QFD is not simply a tool. It can be seen as an entire quality system (Govers, 2001); it can also be seen as a planning process (Day, 1993), a mechanism (Sullivan, 1986), and a methodology. Since its first use, QFD has been accepted by a large number of organizations worldwide, for example, Du Pont, General Motors, IBM, AT&T, Digital, Motorola, Philips International, and Texas Instruments (Burn, 1990; Kathawala and Motwani, 1994; Chan and Wu, 2002).

To a large extent, the widespread acceptance of QFD is due to many of its benefits. The power of QFD lies in its exposing an organization's processes and showing how these processes interact to create customer satisfaction and profit (Raynor, 1994). QFD users claim and often report benefits, such as the following:

- Reduced design cycle time and engineering changes
- Minimized start-up costs
- Tremendous efficiency, including shorter lead times
- Reduction in prelaunch time and after-launch tinkering
- Increased customer satisfaction and market share
- Reduced warranty claims
- More stable quality assurance planning
- Fewer product returns

In addition to the above arguments, other benefits of QFD include superior product design, the potential for breakthrough innovation, and low project and product costs. QFD also helps companies discover that innovation, manufacturing, and quality can fit together comfortably. Kenny (1988) argued that QFD is a new paradigm for quality assurance. QFD can be viewed as one of the main pillars for successful *total quality management* and *product development* (Zairi and Youssef, 1995). More discussion can be found in Burke et al. (2003) in which some misuses are also discussed.

The uses of QFD are not limited to improving an existing product. QFD is also useful in new product design, as the focus on QFD analysis is to address the needs of customers. Furthermore, QFD is useful in both product design and process design. In addition, since QFD requires an organizational effort, teamwork is promoted; this is very important for complex products and processes.

In investigating the impact of QFD on product development, numerous field studies and surveys have been conducted. One of the assumptions when working with QFD is that a *cross-functional team* carries out the project. This is in order to use the experience of people with different backgrounds and to cut through the functional barriers. Based on a field comparison of QFD and the phase-review product development process, Griffin and Hauser (1993) concluded that this new pattern of communication appears to increase team communication on all nonadministrative aspects of new product development. An empirical study of QFD's impact on product development was carried out recently. Vonderembse et al. (1997) and Vonderembse and Raghunathan (1997) investigated the technical, organizational, and personal dimensions of QFD that lead to its successful application. Based on a survey of 80 QFD projects from 40 companies, they concluded that product design, documentation efforts, and customer satisfaction improved significantly. Product costs and time-to-market showed only modest improvement but may be bettered with enhanced training and more experience.

DEVELOPMENT OF QFD

Quality function deployment was originally developed in Japan as an effort to get engineers to consider quality early in the design process, and the idea was introduced in the 1960s (Akao and Mazur 2003). Similar ideas were used in the Kobe shipyards of Mitsubishi Heavy Industries around 1972 (Shillito, 1994) as a way to expand and implement the views of quality as taught by Deming and others. The quality chart introduced later became known as the quality function deployment methodology.

Since then, it was developed further by the Japanese automotive industry. Toyota, in particular, used it to significantly reduce development time and to deal with more complex situations, as evidenced by their solutions to the serious problem of car body rust confronting Toyota cars. Car body rust was a common problem with Japanese cars in the 1960s and 1970s. Toyota made many attempts at improvement, but a real breakthrough eluded them. The seriousness of the problem was such that warranty charges exceeded company profit by a factor of four.

Body rust was a complex problem with many contributing factors (Burn, 1994). Toyota adopted the QFD process to identify and target the more important contributing factors, thus resulting in the elimination of body rust during the warranty period. The application of QFD has been one of the keys to Toyota's success.

QFD was formally introduced to the United States in 1983 by Furukawa, Kogure, and Akao during a four-day seminar for about 80 quality assurance managers from prominent U.S. companies. Also instrumental in the introduction of QFD in the United States was an article by Kogure and Akao in the October 1983 issue of *Quality Progress*: "Quality Function Deployment and CWQC in Japan" (ReVelle et al., 1997).

Because of the success of their Japanese competitors (especially Toyota), American companies started to investigate how the Japanese companies operated, thereby learning about QFD. In 1984, Donald Clausing introduced QFD to Ford. Eventually, enough was learned by some of the automotive-related training organizations that QFD started to be taught widely within the United States. Use of QFD has since spread into many nonautomotive industries.

Various QFD-related activities are currently carried out for its advancement. For example, an annual North American Symposium on QFD has been held in Novi, Michigan, starting in 1989. With the international trend in QFD development, the International Symposium on Quality Function Deployment (ISQFD) has also been held annually since 1995. Further, to provide a unified body to coordinate QFD organizations, efforts, and events around the world and to promote QFD-related research, the International Council for QFD (ICQFD) was established in 1997.

QFD APPLICATIONS

Since its introduction, QFD has been applied considerably in Japan. A survey of the Japanese Union of Scientists and Engineers member companies in 1986, for example, reported that 54 percent utilize QFD, with a majority in the high technology and transportation industries (Sullivan, 1986).

The QFD concept did not, however, appear in the English-language literature until 1983. With the widespread applications of QFD in Japan and the United States, it was also brought to the attention of companies in many other countries. This has led to a wide-spread application in terms of application areas and also in terms of functional stages of QFD process.

The traditional QFD model is based on the paradigm of designing and manufacturing physical objects, that is, hardware. However, QFD has been extended beyond its initial concept. It was reported that QFD has been applied to many other fields for various purposes. Some of the application areas include the following:

- Automotive (De Vera et al., 1988; Dika, 1995; Tsuda, 1997)
- Construction (Mallon and Mulligan, 1993; Armacost et al., 1994; Abdul-Rahman et al., 1999)
- Education (Chen and Bullington, 1993; Ermer, 1995, Pitman et al., 1995; Lam and Zhao, 1998; Franceschini and Terzago, 1998; Hwarng and Teo, 2001; Bier and Cornesky, 2001)
- Electronics (Burrows, 1991; Liner et al., 1997; Tan and Neo, 2002; Herzwurm and Schockert, 2003)
- Food industry (Charteris, 1993; Bech et al., 1997; Viaene and Januszewska, 1999; Costa et al., 2000)
- Healthcare (Hauser, 1993; Radharamanan and Godoy, 1996; Jeong and Oh, 1998; Foster, 2001)
- Marketing (Lu et al., 1994; Lu and Kuei, 1995; Mohr-Hackson, 1996; Vairaktarakis, 1999)
- Research and Development (Griffin, 1992; Tottie and Lager, 1995; Price, 1995; Matzler and Hinterhuber, 1998; Cristiano et al., 2000; Delano et al., 2000; Yamashina et al., 2002; Masui et al., 2003)
- Service (Denton, 1990; Graessel and Zeidler, 1993; Ghobadian and Terry, 1995; Ermer and Kniper, 1998; Dube et al., 1999; Pun et al., 2000; Selen and Schepers, 2001)
- Software (Zultner, 1990; Yoshizawa et al., 1993; Erikkson and McFadden, 1993; Barnett and Raja, 1995; Haag et al., 1996; Trappey et al., 1996; Elboushi and Sherif, 1997; Karlsson, 1997; Pai, 2002)

The above is only a list of selected papers. An extensive survey of the literature of quality function deployment is presented in Chan and Wu (2002). Over 600 publications can be found in that paper. The classification is based on the functional fields of quality function deployment, as well as the applied industries.

SCOPE AND OBJECTIVES

The scope of this book includes a brief introduction to QFD, starting with its definition and a brief history. A review of QFD is presented next, which includes the various approaches to QFD, examples of its applications, some updates and observations, and the limitations of QFD. This book focuses on the voice of the customer, that is, the task of analyzing the importance ranking of customer needs, weighting scale of the relationship matrix, and the prioritization techniques. Examples are used and presented to help the reader to better understand the techniques and applications of QFD.

Chapter 2
QFD Basics

As ReVelle et al. (1997) explained, the need for QFD was driven by objectives that start with the customers of a product and end with its producers. Producers convert the customers' needs for product benefits into substitute quality characteristics at the design stage. They then deploy the substitute quality characteristics in the production activities, thereby establishing the necessary control points prior to production start-up.

This chapter presents the basic steps of QFD and the structure of the HOQ. Readers familiar with quality function deployment may skip this chapter and move on to Chapter 3. For more details on basic QFD and the implementation issues, Day (1993), Cohen (1995), Revelle et al. (1997), and Chan and Wu (2003) are some useful references.

HOUSE OF QUALITY

The HOQ, sometimes also called the A-1 matrix, is the most commonly used matrix in the QFD methodology. The foundation of an HOQ is the belief that products should be designed to reflect customers' desires and tastes. Thus, marketing people, design engineers, and the manufacturing staff must work closely together from the time of product conceptualization. The HOQ is a kind of conceptual map that provides a means for interfunctional planning and communication (Hauser and Clausing, 1988).

The focus in HOQ is the correlation between the identified customer needs, called the *WHATs*, and the engineering characteristics, called *HOWs*. Ideally, an HOQ should be developed by a cross-functional team made up of members from various departments. It should consist of several submatrices