ISO 16355: Modern QFD Generated From 50 Years of Practice

Dr. Catherine Y. P. Chan
President – Hong Kong Quality Function Deployment Association. Hong Kong
catherine@qfdhk.org

Glenn H. Mazur
Executive Director – QFD Institute. USA
glenn@mazur.net

ABSTRACT
The aim of the paper is to explain the key principles of Modern QFD. With reviewing the original development of QFD in Japan 50 years ago and introducing the recently published standard for QFD, the paper is focused on explaining the principles that are important to properly mastering the practice of Modern QFD. The principles are firmly grounded on the origin and accumulated from field experience and studies over the years. They are vital for best practices of QFD. To help clearly explain the principles, a case is used as illustrating example.

Keywords: Quality Function Deployment, QFD, Modern QFD, ISO 16355, New Product Development.

1. Introduction

Quality function deployment (QFD) was founded in Japan in the mid-1960s. It has been practiced by hundreds of thousands of companies of different industries in different countries for a variety of management purposes, in particular for making quality improvement, formulating strategies and policies as well as developing new products and services. The aim of satisfying the customers' true needs and the focus on improving the design, the build, the production and the delivery of a new product greatly help companies develop new products and services as well as generate new ideas and methods for production and operation for meeting the increasing competition of the market and keeping the vitality of the business. QFD firmly adheres to the central principles of total quality management and skilfully applies the concept and the technique of deployment. Besides it evolves with the new developments of various domains, the way of operation, the tools and the methods have been continuously improved. From the time of founding, QFD's aim of helping companies on achieving their goals and sustaining their business has not altered.

After 50 years of practice, QFD has come to the stage at which the ISO standard is published. In 2009, QFD Institute of the USA was asked to convene an ISO Working Group to write an international standard for QFD. As Mazur, Executive Director of QFD Institute as well as convenor of ISO TC69/SC8/WG2, stated, the biggest concern of standardizing the method is to provide an operational guidance that works best when custom-tailored to the new product development (NPD) process of an organization as well as for developing the specified products and services (Mazur, 2016). The International Council for QFD, on the one hand, liaised with its members, and, on the other hand, joined with the experts from Africa, the Americas, Asia, Europe, and India to write the ISO 16355 "Application of statistical and related methods to new technology and product development process". The standard consists of eight parts. Part 1 "General principles and perspectives of Quality Function Deployment (QFD)", the first and a very important part of the standard, was successfully published in December 2015. Parts 2, 4, 5 and 8 have just posted on the ISO website in February 2017.

In today's highly competitive business environment, NPD professionals have to fully master Modern QFD in order to be able to engage their organizations in creating products and services their customers truly demand. The aim of the paper is to explain the key principles of Modern QFD. With reviewing the original development of QFD in Japan 50 years ago and introducing the recently published standard for QFD, the paper is focused on explaining the principles that are important to properly mastering the practice of Modern QFD. The principles are firmly grounded on the origin and accumulated from field experience and studies over the years. They are vital for best practices of QFD. To help clearly explain the principles, a case is used as illustrating example.

2. Original Development of QFD in Japan

QFD was founded by late Prof. Shigeru Mizuno and late Prof. Yoji Akao, both received Deming Prize for Individuals in 1952 and 1978 respectively. Mizuno advocated that quality could hardly be achieved if each division or department of the company is only working on improving its own operations. He saw the tables and the diagrams used in QFD as ways of linking up the divisions and departments as well as tools and methods for communication. This advocate was built into QFD through his application of Value Engineering and Function Analysis, that is, by investigating all business functions and their respective contributions to quality assurance so as to improve the new product development process, for Katsuyoshi Ishihara of Matsushita Electronic Components. This concept and practice put forwarded by Mizuno is commonly termed as "Narrowly Defined QFD". Akao focused on seeking ways and formulating method for assuring quality in the development of new products. The ways of understanding the customers' needs and the method of deploying the customers' needs to various levels and aspects in forming a product is commonly termed as "Quality Deployment" (QD). The combination of Narrowly Defined QFD and QD is QFD (Figure 1). Bridgestone Tire made the first reported case of QFD in 1966.

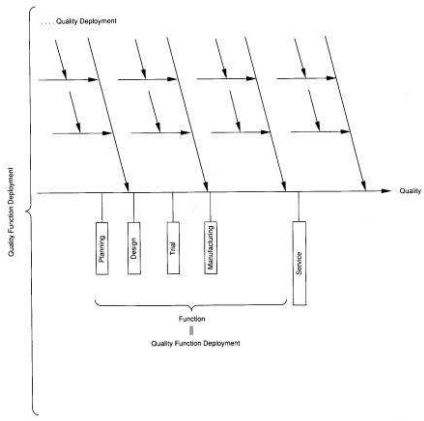

Figure 1: The Original QFD Model

Appendix 1 displays the QFD projects conducted by various companies and respective literature publication in Japan during the period of 1966 to 1977. From the table, we could notice that Akao started developing QD in the mid-1960s. His initial investigation was focused on deployment of quality objective and quality deployment system. The operation and flow suggested by Akao provides a logical system for transforming the users' demands into design quality, deploying the functions forming quality, deploying methods for achieving the design quality into subsystems and component parts and ultimately specifying the elements of the manufacturing process (Akao, 1994a, 1994b). QD promoted the spread and application of QFD in Japan. From the mid-1960s to early 1970s, Akao taught and instructed Komatsu, Isuzu, Fuji Motors, Brother and Matsushita doing quality deployment. After quality table was incorporated into the operation of QFD, he included it into his teaching and instruction. In the mid-1970s, Akao taught and instructed Hino Motor doing quality table and Dynic doing table of quality requirements. Toyota Group is one of the very first companies that put QFD into practice. In 1975, Takezawa of Toyota Auto Body initiated practicing QFD at his company. In 1979, he invited Akao to teach his company's engineers and managers QFD. Coupled with Akao's instruction and guidance, QFD was quickly introduced to Toyota Group (Akao, 1990).

The early version of QD was mainly focused on vertical deployment with the purpose of assuring production quality for products. For example, Toyoda Gosei employed the model to deploy quality characteristics into subsystems and parts, and, to prepare quality assurance charts for the manufacture of machine-assembled products (Aoki et al., 1990). With the increasing use of QD for product design, the model was elaborated and extended to include technology, cost and reliability deployments (Appendix 2). The addition of horizontal deployment could allow the extraction of bottleneck technologies, prevention of potential failures and planning for achieving target costs at the product design stage (Akao, 1994c).

The practice of leading companies not only quickly introduced QFD to respective industries but also promoted the dissemination of QFD to the whole industry of Japan. Stepped into the 1980s, the success

obtained by Toyota Group and some prominent companies from using QFD quickly stimulated applications in electric and electronics, mechanic, precision, transportation and construction industries. In an industrial survey conducted by Quality Deployment Study Group with 380 listed firms of First Division of Tokyo Stock Market and 38 winning companies of Deming Prize in the mid-1980s, over half of the respondents fed back that they were practicing QFD (Akao et al., 1987). QFD entered the high growth stage in the mid-1980s in its homeland. QFD was brought to the South East Asia as early as in the late 1970s and to the United States in the early 1980s (Chan et al., 2013). With more and more cases reported from the field together with the English version of Akao's and Mizuno's QFD books published in the early 1990s, QFD is getting known internationally (Akao & Mazur, 2003).

3. ISO 16355

The development of ISO 16355 was started by the International Standards Organization (ISO) Technical Committee TC69 (Applications of Statistical Methods) Subcommittee SC8 in 2009, with the purpose of standardizing global best practices for QFD and robust design. It consists of the following 8 parts:

Part 1: General Principles and Perspective of QFD Method
Part 2: Acquisition of Non-quantitative VOC or VOS
Part 3: Acquisition of Quantitative VOC or VOS
Part 4: Analysis of Non-Quantitative and Quantitative VOC/VOS
Part 5: Solution Strategy
Part 6: Optimization – Robust Parameter Design
Part 7: Optimization – Tolerance Design and Output to Manufacturing
Part 8: Guidelines for Commercialization and Life Cycle

ISO 16355 is dynamic and "descriptive" in nature. Since it was suggested in 1966, QFD has been continuously improving the methods and including relevant and effective tools for QFD users to respond to the changing business conditions. The methods and tools referenced in the Annexes of the standard represent decades of improvement to QFD. They are suggestions, not requirements, for guiding the users of the standard to do QFD. The suggested methods and tools are neither exhaustive nor exclusive. Those who have been using the old models will find these upgrades easier and faster for doing QFD.

4. Modern QFD

ISO 16355 describes how Modern QFD to be practiced. There are several principles of Modern QFD. In order to clearly explain and make users easily apply these principles, a case on using QFD to understand the image needs of a Thai beer is used for illustration. The beer case was done by Mazur, an author of this paper, together with Vongpatanasin, QFD Black Belt®, some years ago. Besides presented at *German QFD Symposium 2009* under the paper of "Why we drink beer: Using QFD, Kansei, and AHP to understand how consumers identify with brands", it was also published under the paper of "Thai Brewery deploys QFD tools to tap into consumer motivation" in *ASQ Knowledge Center* in December 2012.

1. Start with Voice of Business, not Voice of Customer

It would not be long if only customers' needs are satisfied but without addressing those of the company. For healthy development, both the needs of the customers as well as the initiatives and the strategies of the business have to be satisfied.

For the beer case, the initiative drove the project was the business potential created by the "Thailand Wave". With Thai food becoming more and more popular worldwide, the company found that there would be a great opportunity for expanding the global distribution of the beer. To boost the sales in foreign markets, better understanding of the non-Thai customers' interests, motivations, self-images and some other characteristics with beer was important to formulating winning marketing collateral. To satisfy this business need of the company, a project on understanding the needs in regard to the image needs of the customers was set up, choosing the United Kingdom market as the place of study. The

company aimed to use the findings of the project to formulate how to fit the beer into the love of life of the customers in building the brand and designing commercials.

2. Custom-Tailored QFD Process

A common mistake of doing QFD is to fit the case and/or the company to a standardized QFD model. As the product development process, customers, technology and some other factors of no two companies are the same, there is no single way that could well suit all QFD projects. It is necessary to tailor the QFD process to each case and to each company. The QFD process should be efficient as well as effective for meeting the defined goal of the project. An important aim of the ISO 16355 standard is to liberate practitioners from the "one-size-fits-all" concept with QFD.

The traditional 4-Phase Model works well in the automotive component industry and some product development projects. However, it is not appropriate for the beer project. In order to be able to acquire a deeper insight into the customers' unspoken needs, Blitz QFD®, with some adaptations, was adopted as the method for executing the project (Figure 2).

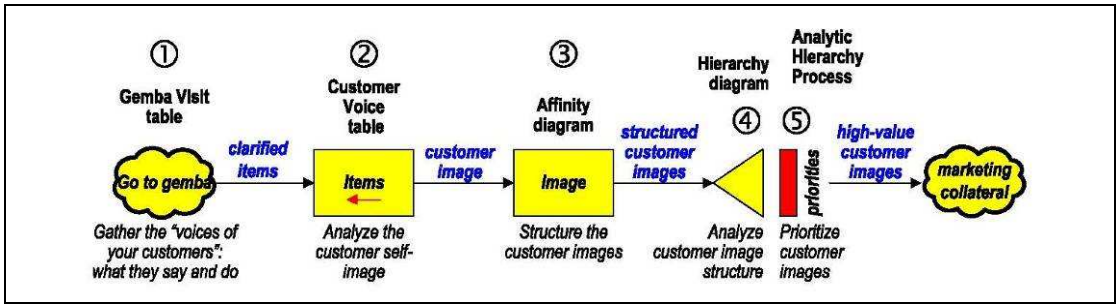

Figure 2: The Custom-Tailored QFD Process for the Beer Project

3. Go to Gemba

Gemba is a Japanese term meaning the place where the truth could be learnt. It is a technique commonly used to find the true causes of deficiency or variation for making quality improvement. True customer satisfaction comes from solving their problems for and adding values to them in regard to their business, activities or some other issues. It is necessary for the project team members to go to observe how the customers work, how the customers perform the activity or how the customers live their lives. It is necessary for the project team members to go to interact with them, listen their stories, note their verbal and non-verbal expressions and ask them questions so as to acquire a better understanding of their situations. Collection of information in both tangible and non-tangible forms is important and necessary to understand and discover the true needs of the customers. In order to assist practitioners on performing this important step of Modern QFD, the ISO 16355 standard adequately describes and provides numerous examples on how to plan, conduct and analyse gemba visits to uncover the explicit as well as the implicit needs of the customers.

Who uses product?	What is product used for?	Where is product used?	When is product used?	Why is product used?	How is product used?
business people at lunch	go with meal	restaurant	lunch	lunch beverage, take edge off bad day or end of week	glass
business people relaxing after work at pub	quench thirst	pub, indoors or outdoors	after work	relax after work, socialize with friends, while waiting for friends to arrive	pint or bottle
business people having dinner with friends and family	go with meal	restaurant	night	dinner beverage, relax in evening	glass
shoppers at market	drink later	home, BBQ	?	always buy beer	?

Figure 3: The Customer Segment Table of the Beer Project

Gemba in the beer case referred to the place where customers interacted with beer, including the occasions they bought beer and they drank beer. The project team members planned the gemba visits using a Customer Segment Table (Figure 3). Under the guidance of "5W1H", not only they had identified the key customers, the places and the best time to conduct the visits, they had also noted down the unknowns which they needed to explore.

4. Deploy Voice of the Customer into Clarified Items

The voice of the customers (VOC) collected from the gemba visits has to be processed before the customers' needs could be uncovered. VOC is raw data and it has to be deployed, that is, through step-by-step of clarification, before a more comprehensive list of possible needs of the customers could be obtained. The project team members are required to interpret the expressions, extract the embedded meanings, put aside the irrelevant and add in the missing items. Clarification requires the team to explore beyond the obvious to discover the unknown unknowns.

Figure 4 is an excerpt of the Gemba Visit Table of the beer project. The clarified items such as "mild" and "authentic" were extracted from some of statements expressed by the customers. Some other clarified items were derived upon making a deeper analysis, such as the item of "work team" was added after studying the voice of preferring less gassy Corona (a Mexican beer) at lunch because the customers need to get back to office to work after lunch. The purpose of Gemba Visit Table not just helps doing clarification but also notes down the trace of the deployments.

Observations	Verbatims	Documents	Notes	Clarified Items
8 men, 1 woman having buffet. 4 Coronas, 2 Singhas, 3 soft drinks.	Like Thai food because less salty than Chinese or Indian food, so it is milder and easier to eat at lunch. Usually have a beer at lunch = prefers Corona because it is less "gassy." Like authenitc flavors and fragrance. Cooks Thai style at home by adding coconut milk and green curry which are easily available, for a special meal that is unusual and romantic (and it works!).		Need to go back to work and be in appropriate mood for work (not drunk)	Fast (I have one hour for lunch, and I walk 10 min from office) Easily available Good deal Fragrant Mild With work team Break from the usual Light Authentic Special moments Romantic

Figure 4: An Excerpt of Gemba Visit Table of the Beer Project

5. Deploy Demanded/Clarified Items into Product Requirements

Not brainstorming nor searching suggestions, the requirement items of the product should be deployed from, that is, to be deduced or derived from the source of information given by the customers. One of the tools that introduced for practicing Modern QFD in the ISO 16355 standard is Blitz QFD®. It would easily help the project team members apply the important "customer first" and "needs driven" principles.

Gemba Visit Table is the former part and Customer Voice Table is the latter part of Blitz QFD®. Upon completed the Gemba Visit Table, the team members of the beer project continued the QFD process with Customer Voice Table (Figure 5). The Customer Voice Table facilitates the deployment and the translation of the clarified items into need/image items. Same as Gemba Visit Table, Customer Voice Table notes down the trace of the deployments.

clarified items	#	customer scene	benefit		product
			need/image	problem	
Fast (I have one hour for lunch, and I walk 10 min from office) Easily available Good deal Fragrant Mild With work team Break from the usunal Light Authentic Special moments Romantic	1	Lunch time in London's central business district on a warm, sunny Monday. Mostly office workers in business or casual clothes, younger ones are single. Warm sunny day, in upstairs a la carte menu dining. Those in a hurry enjoying downstairs Buffet (8GBP), those with more time (business lunch, colleague birthday party) in upstairs a la carte menu dining. Most having soft drinks as it is too early in week for alcohol at lunch - Monday (first day of week).	I want to have fun with my friends. I want something convenient. I enjoy the fragrance. I want to feel refreshed afterwards. I like to be adventurous. I want to spend my time the way I want. I'm in control. Authentic. Romantic. Special moments. A break from the ordinary. I'm a leader. I know what I like.		Good deal. Fragrant food. Mild spices. Light meal.

Figure 5: An Excerpt of Customer Voice Table of the Beer Project

6. Focus on the Vital Few

In today's business environment, organizations do not have enough resources to address every need of their customers. They only could focus their efforts on those that matter most to the customers. The ISO 16355 standard explains how to use the Maximum Value Table to combine the key elements of all QFD matrices into one chart. In this way, the project team members could easily realize the top three to five important needs.

For the beer project, the team members used analytic hierarchy process (AHP) to find out the important image needs. By sensibly stratifying the abstraction levels, the image items were grouped into image needs by first using the technique of affinity diagramming and then put into a hierarchy (Figure 6). After aggregating the pairwise comparisons responded by the customers, the important image needs were identified.

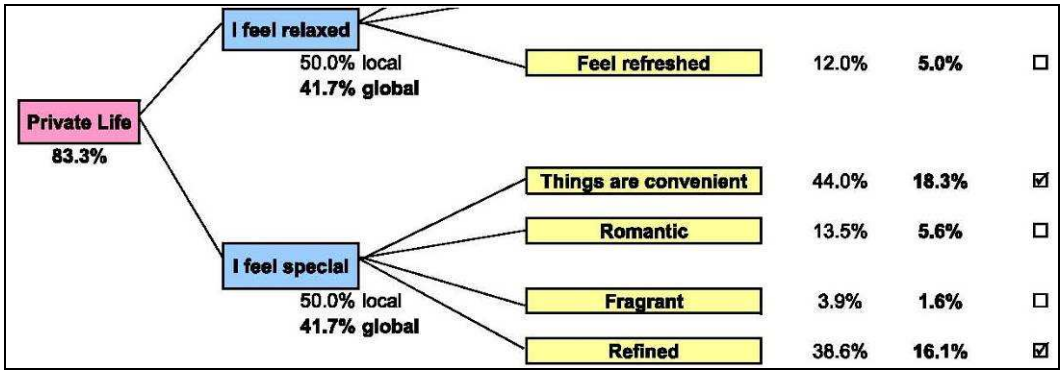

Figure 6: An Excerpt of the Image Needs Hierarchy of the Beer Project

7. Watch the Mathematics

Early QFD used ordinal scale of 1-5 for calculation. However, mathematical operation is not feasible for ordinal scale. AHP is in ratio scale; therefore, addition, subtraction, multiplication and division could be mathematically operated. AHP is a recommended approach for doing selection, prioritization and comparison that commonly involved in QFD. The ISO 16355 standard has a detailed description on the rationales of and gives numerous examples on using AHP for doing QFD.

5. Conclusion

Modern QFD is essential for today's NPD professionals to engage their organizations in innovating and creating the products and services their customers demand. In the paper, the important principles of Modern QFD have been discussed. These principles and other upgrades that stated in the ISO 16355 standard are very important to practitioners on properly mastering Modern QFD – an effective and versatile method that not only greatly helps new product development but also business operation.

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Authors' Backgrounds

<table>
<tr><td>  </td><td>Dr. Catherine Y. P. Chan is certified QFD Black Belt®. She is the President of Hong Kong QFD Association, Secretary General of Asia QFD Association and committee member of International Council for QFD. With the aim of sharing the knowledge and experience she has gained since the start of her research on QFD in the early 2000s, she focuses on and actively participates in promoting QFD in Hong Kong and South East Asia.</td></tr>
<tr><td>  </td><td>Mr. Glenn H. Mazur is the convenor of ISO TC69/SC8/WG2, the working group writing the ISO 16355 for QFD. He is also a member of TC176 responsible for ISO 9000:2015 and ISO 9001:2015 standards and TC279 Innovation Management. Glenn is the Executive Director of QFD Institute and International Council for QFD, a retired adjunct lecturer on TQM for College of Engineering of the University of Michigan. He is a senior member of both the American Society for Quality (ASQ) and Japanese Society for Quality Control (JSQC). Glenn is one of the two certified QFD Red Belt® (the highest level of QFD) in North America and certified QFD-Architekt #A21907 granted by QFD Institut Deutschland. He is the Honorary Presidents of Hong Kong QFD Association and Asia QFD Association, and, an Academician and the Secretary-Treasurer of the International Academy for Quality.</td></tr>
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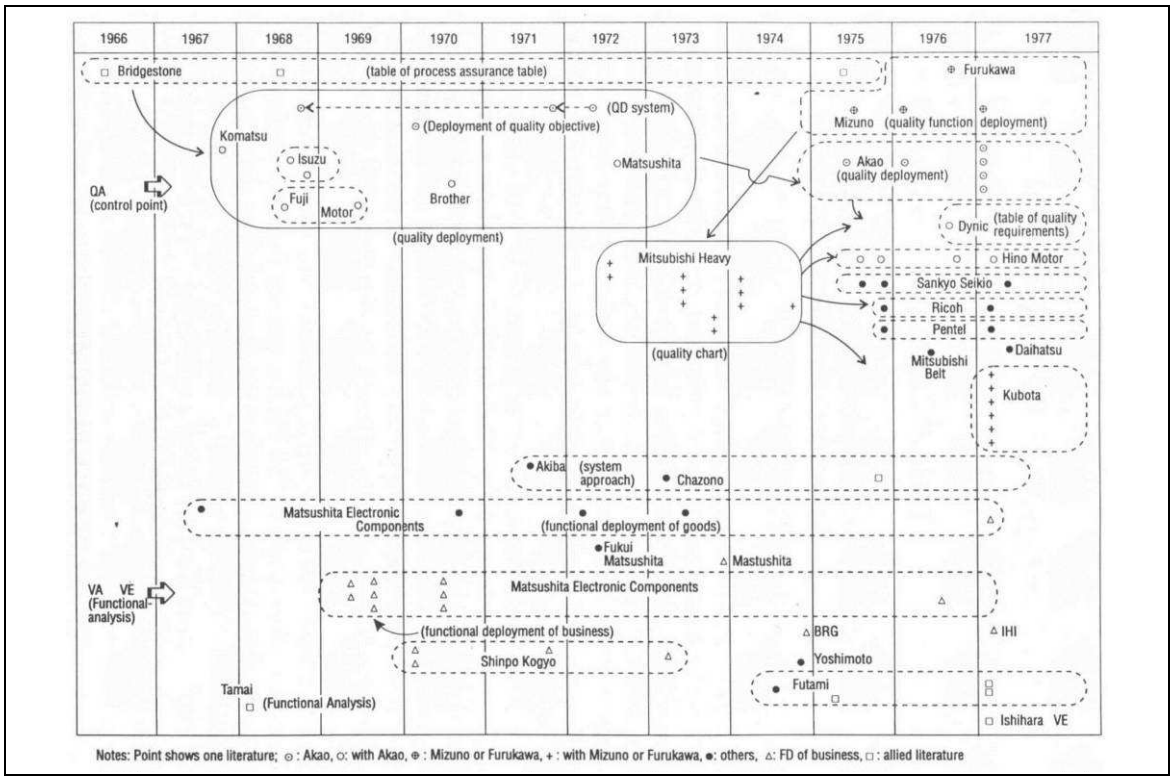
Appendix 1

Industrial Projects and Academic Publications of QFD in Japan: 1966 – 1977



Appendix 2

Akao's Comprehensive QFD Model