Keynote Paper:
ISO 16355: Modern QFD with AHP for Quantification

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ABSTRACT
For meeting the increasing application in business activities and satisfying the new needs demanded by the growingly complex projects, ISO 16355 for Modern QFD suggests using AHP for doing quantification. Cohesive and coherent flow of deployment as well as delivery of accurate priority data is of paramount importance to the development and sustainability of QFD. The aim of the paper is to introduce the practice of Modern QFD with the incorporation of AHP and explain why AHP is suggested for doing the involved quantifications. To help making the points clear, a reported case on applying QFD in a project for developing an information technology system was used for illustration.

Keywords: Quality Function Deployment, ISO 16355, Modern QFD, Comprehensive QFD, Blitz QFD®, AHP

1. Introduction

In the past 50 years, quality function development (QFD) has achieved successful growth and development. QFD was first suggested in the mid-1960s in Japan as an operation mechanism for doing product development and practicing *Hoshin Kanri*. By skilfully manipulated the quality management principles, QFD effectively teams up members from various departments and different levels to unify their efforts for achieving the goals of the organization. With satisfying the needs of the customers as the aim, QFD provides the team with the system and a toolbox with which members work together to specify functional requirements, devise plans and formulate strategies. With the development of industries and increasing competition faced by organizations, QFD is used for many other business purposes besides developing products. The goal achievement approach, the interpretation and translation concepts of deployment, the process of idea generation and the objective evaluation of alternatives are some of the remarkable features that make organizations apply QFD across the whole spectrum of business activities.

QFD has been considerably improved since it reached the USA in the early 1980s. Among the improvements, there are two which are particularly important. The first improvement was the introduction of Blitz QFD®. With the method of making deployment across multiple columns of a spreadsheet, the full range of compact tables suggested by Blitz QFD® considerably shortens the time required by the process. The second improvement was the incorporation of analytic hierarchy process (AHP) into the operation of QFD. With the growing applications in large-scale and complex projects, QFD is no more just doing the first house of quality (HOQ) and an unbroken continuity of prioritization is required for performing effective operation. AHP supplements the operation of QFD with a quantitative mechanism for generating and transferring accurate priority data throughout the whole process which, in many cases, involves a chain of deployments and multiple matrices. These two improvements provide great support to the sustainable development of QFD. In fact, after years of research and study, the integration of Blitz QFD® with AHP has already become a main stream of QFD application in nowadays field practice (Mazur, 2015).

AHP is a decision making model. It was formulated in such way that the derived priorities could give a proportionate ordering of the different possible outcomes to which one can allocate resources in an optimal

way (Saaty, 2007). The way of collecting inputs and the way of processing numbers of AHP greatly helps QFD on quantification and deployment. In order to let practitioners have a greater understanding with the operation, the aim of the paper is to introduce the practice of Modern QFD with the incorporation of AHP and explain why AHP is suggested for doing the involved quantifications. In the paper, the key features of AHP, including the use of ratio scale to collect inputs, pairwise comparison to capture judgments and ratio numbers to present outputs would be discussed. To help making the points clear, a reported case on applying QFD in a project for developing an information technology (IT) system, reported by Stansfield, Cole and Mazur in 2010, was used for illustration.

2. Modern QFD with AHP

In our paper last year, we had introduced the key principles of Modern QFD; and, "Watch the Mathematics" is one of the key principles (Chan & Mazur, 2017). "Watch the Mathematics" emphasizes not only the importance of accurate prioritization to the output quality of QFD but also valid quantification is absolutely essential for deploying items between matrices. In the following, let us take a look to a reported case of the development of an information technology system on how the principle of "Watch the Mathematics" was put into practice of Modern QFD as well as how AHP enables QFD to be practiced in a more holistic way.

2.1 AHP helps QFD start the project with voice of business

Organizations could hardly succeed if they could not map out how their projects would contribute to achieving the business goals. To Modern QFD, the first and also the most important step is to align the project with business needs. The start could be a discussion of the team members on the business benefits driving the project, as was the case of Thai beer (Vongpatanasin & Mazur, 2009 & 2012) that shared in our paper last year. However, a more comprehensive approach for aligning the project with management needs is to deploy the voice of the business (VOB) into project goals. It is not merely project goals but project goals attached with relative importance. The priority data of the project goals play a central role in the whole operation of QFD. They will be used to link up all the deployments of the project. They are going to be put into the subsequent matrices for making further prioritization and selection.

The IT case, reported by Stansfield, Cole and Mazur in 2010, was about the development of a customer relationship management (CRM) system for a global financial services company. The CRM system was going to be used to collate and analyse the sales and operation performance so as to inform managers on making decisions. It was a key IT component that enabled the delivery of business intelligence strategy of the company. Therefore, the project was not simply about coming up with a CRM system, but a project of the company for achieving the business goals.

The first thing the project team did was to establish explicit goals for the project. After determining the scope, the team members started to identify the goals of the project. The members gathered together to put forward their ideas about the project goals in regard to the business goals and processes. The consolidated ideas were processed into goal items. Upon grouping the items into project goals, the team members displayed their resultant work in the form of hierarchical structure for showing the constitution as well as the levels of the constituent items of each of the project goals. After that, the team continued with formulating and specifying the measuring details for assessing the attainment of the goals by the end of the project and did an AHP exercise on identifying the relative importance of the project goals.

The priority data obtained from the AHP exercise made the project goals further visible to the team members. More than this, they are mathematically valid. AHP produces outputs in ratio numbers; and, ratio numbers are subject to comparison. The weights of the project goals in Figure 1 not only display the magnitude of the importance of each goal but they also tell the distances the goals apart in terms of importance. Furthermore, ratio numbers are capable of addition, subtraction, multiplication and division. Therefore, the priority data produced by AHP enable the project goals to be deployed from high-level system design to detailed components and processes. To illustrate how this to be done, let us take a look on how the team made use of the mathematical property of ratio numbers for deploying the project goals to identifying the key customers of the CRM system.

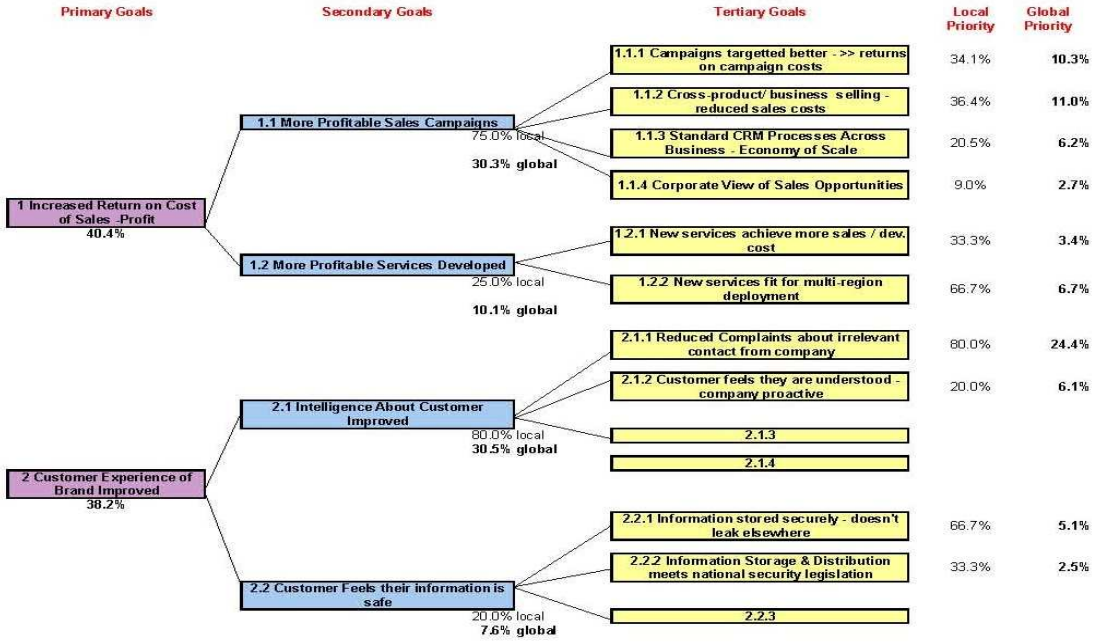

Figure 1: Hierarchy Diagram of Project Goals of CRM System Project

2.2 AHP helps QFD identify the key customers

The CRM system involved several groups of customers. After an exercise on understanding the potential benefits each of the customer groups would obtain from the CRM system, the team continued to find out which is the major group of which the needs of the customers had to be properly addressed. By listing the project goals vertically on the left and the customer groups horizontally on the top side of a QFD matrix as exhibited in Figure 2, the team members worked together on assessing the impact of the customer groups on the delivery of the project goals pair by pair with a normalized scale. By multiplying the aggregated scores with the respective importance of the project goals, the team was able to identify the key customers of the CRM system.

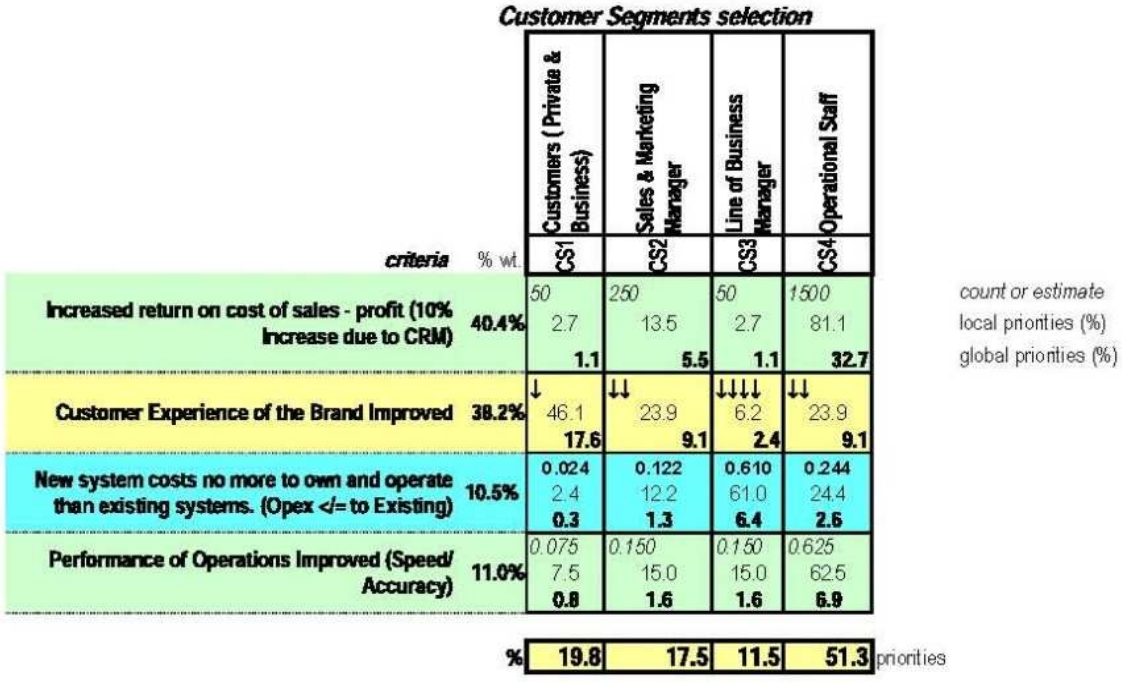

Figure 2: Relative Impact of Customer Groups on Delivery of Project Goals of CRM System Project

Noticed that the ways of using the system and the kinds of information retrieved from the system were different among the customer groups, the team members thus drew up a tailor-made plan for collecting the voice of the key customers. With the technique of Customer Process Model (CPM) together with the method of "Supplier, Input, Process, Output, Customer (SIPOC)", they outlined a plan with details for preparing themselves to pay *gemba* visits to the key customers. After completed the visits, they used Customer Voice Table (CVT) to assist them on making two deployments with the collected information. The first deployment was to interpret the collected voice piece by piece to extract the embedded meanings and compile them into a list of need items. The second deployment was processed in the extension of the CVT, or more exactly, the Maximum Value Table (MVT). The work was to translate the need items into the requirements of the CRM system.

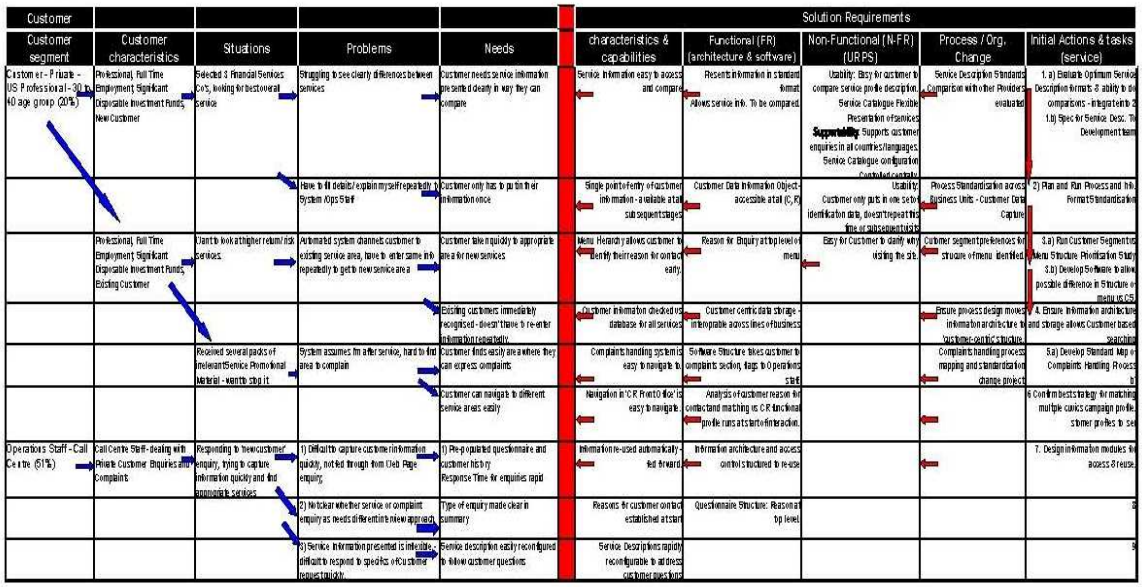

Figure 3: An Excerpt of Customer Voice Table with Maximum Value Table of CRM System Project

2.3 AHP helps QFD collect responses and capture judgments about customer needs

There were two common problems with the survey methods used in Classical QFD. The first problem was the provision of an ordinal scale for respondents to input their responses. In many cases, respondents were asked to make prioritization by ranking a set of given needs in numerical order and to use a set of ordinal numbers to indicate the strength of the relationship between two items. Such ways of collecting data were quite commonly found in identifying the importance of the demanded qualities and the effectiveness of the quality elements for meeting the demanded qualities in the first HOQs. However, the numbers put down by the respondents could not be added or divided to produce any value with mathematical meaning. The second problem was the use of only one single transaction was not rigid enough for receiving a judgment with accuracy. As we know, people could not always give precise judgments. Some even could not manage ranking a given set of items, not to say telling the magnitude of difference among the items. Therefore, the judgments received were often not actual and exact. To overcome these two problems, Modern QFD suggests using AHP for quantification.

AHP uses ratio scale to collect responses and pairwise comparison to capture judgements. For the former, the equalized distance between the marks of ratio scale does not create any problem for putting the input numbers into addition, subtraction, multiplication and division. In this way, not only the judgments from a group of respondents could be combined but team decision would also be facilitated. For the latter, the way of asking a respondent to make comparison between any two of a given set of items until every pair of the items has been judged is so thorough that not only the rankings but also the magnitudes of the responses are revealed.

The way the team members processed with the customer needs was similar to what was processed with the project goals. They used the method of affinity diagramming to organize the need items into needs. After they represented the needs into a 3-level hierarchy and used AHP to find out first the local and global priorities of the primary needs and then those of the secondary needs (Figure 4)

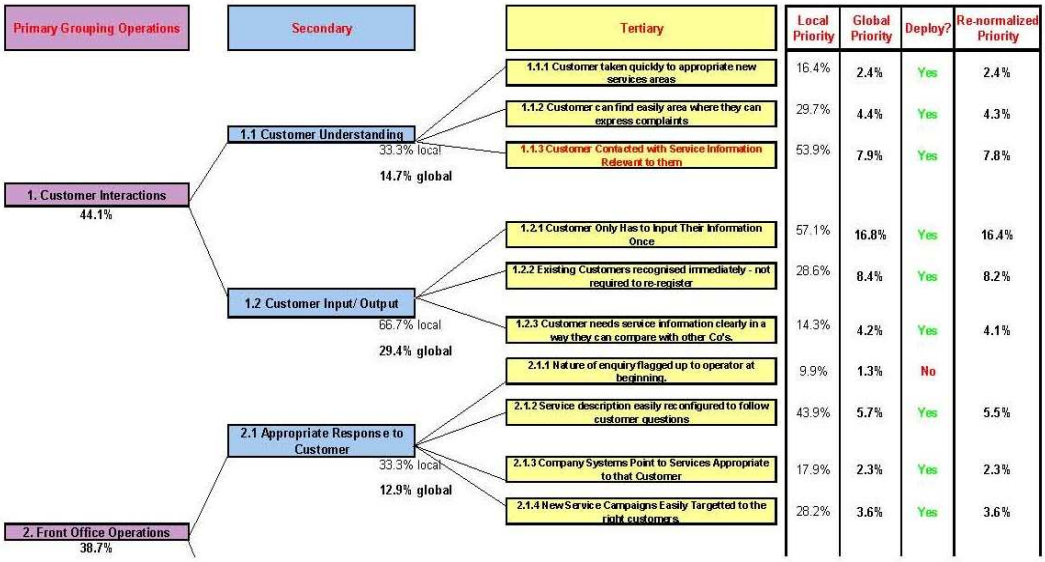

Figure 4: Hierarchy Diagram of Customer Needs of CRM System Project

2.4 AHP helps QFD focus on important branches

Classical QFD made deployment one time one matrix to one matrix only. Blitz QFD® speeds up the deployment process by using the Maximum Value Table for translating the need items into elements of the aspects that are related to the solution. With AHP, Blitz QFD® is further charged. Because priority data in ratio numbers could be apportioned and because hierarchy structure could display a matrix of matrices in the form of a tree with branches, the team could easily locate the high-value branches by working from the top of the hierarchy downwards. In this way, the most important items could be determined without evaluating all the items. This was a major benefit the project team of the CRM system had enjoyed. Using one QFD matrix for one solution aspect, the team first assessed the relationship between the elements of the aspect with the customer needs and then took in the relative importance of the customer needs. After completed assessing all solution aspects, the team was able to identify the requirements which were of high value to the customers.

2.5 AHP helps QFD on making rational selections

Although the case of the CRM system project had not mentioned the development of design options, Modern QFD does suggest continue the deployment further downward to evaluating the proposed options and incorporate AHP into Pugh Concept Selection to pick up the optimal design.

3. Conclusion

QFD puts organizations into a positive cycle. It would increase the chance of giving good performance and winning customer satisfaction of the final product or service. By focusing on meeting the needs of the customers instead of working within the capabilities of the company, new ideas could be generated and real breakthrough could be achieved.

The new ISO 16355 International Standard for QFD was published in 2017. An expert guidance provided by the standard is the use of analytic hierarchy process (AHP) for doing quantification (Mazur, 2017). Whilst QFD provides a practical method for processing with qualitative data, the excellent mathematical formulation of AHP supplements QFD with a quantitative mechanism for making valid deployments and performing in a comprehensive way. QFD is organic. It evolves with the development of the industry. From the case of the CRM system, we could notice that Blitz QFD® together with AHP greatly help organizations on addressing a much wider scope of business matters and activities. They would let companies enjoy higher efficiency and greater effectiveness on using QFD for adding their competitiveness.

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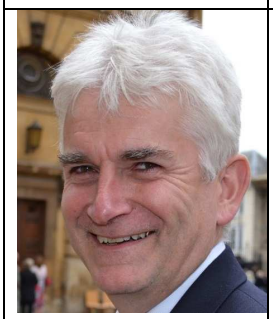
Authors' Backgrounds

	***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.*
	***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.*
	***Dr. Kim Stansfield*** *is Akao Prize Winner 2016. Following Bachelors, Masters and Doctorate degrees in materials science and technology, Kim started his career in the Composites Group of the UK's Royal Aerospace Establishment before moving to Lucas Engineering and Systems in the early 1990s to work on development of an automated design and manufacturing system for complex composite components. Here he learned Japanese TQM methods including QFD. Over the following 20 years he worked in automotive and aerospace control systems and subsequently large Enterprise IT Systems applying QFD and DFSS approaches to development. In 2016 he joined Warwick University WMG as a senior teaching fellow. He has been the UK representative for the development of the ISO 16355 standard for QFD since 2010. He also has joined the recently formed INCOSE Working Group on 'Systems Engineering Quality Management'. He is a Chartered Engineer, a member of the IET and INCOSE and a QFD Black Belt®.*