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QUALITY FUNCTION DEPLOYMENT (QFD)

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ABSTRACT

Quality Function Deployment (QFD) is a product development methodology that "deploys" the Voice of the Customer throughout the product development process. A cross-functional team implements QFD by creating a series of one or more matrices, the first of which is referred to as the *House of Quality* (HOQ). These matrices relate customer wants and needs to an extensive set of product features. A set of metrics is developed to measure how well sets of product features are meeting customer needs, and the product's design specifications are identified and prioritized.

QFD enables the entire product development team to prioritize their development activities in a systematic, analytical way. It helps them work together to achieve a common view of the relationship between customer needs and product design. It

provides an "audit trail" which reminds people, both new and old to the project, as to why past decisions were made. The QFD process stretches the product development team's thinking as to which activities are most critical toward creating a winning product or service. It also improves communication among members of the product development team. The result is a product that is thoughtfully designed right from the beginning, cutting down the need for later rework and reducing development time and costs.

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DEFINITION

QFD is a product development methodology whose objective is to "deploy" the Voice of the Customer (see WIEM05-020) throughout the product development process. It is most often carried out by a cross-functional team (see WIEM05-041) that creates and populates a series of one or more matrices, the first and most common of which is referred to as the *House of Quality* (HOQ). When completed, these matrices relate customer wants and needs (the Voice of the Customer, or VOC) to an extensive set of product features. A set of metrics is developed to measure how well any given set of product features is meeting customer needs. These metrics are then used to identify and prioritize the product's design specifications (see WIEM05-049).

DESCRIPTION AND COMENTARY[1]

QFD is believed to have been developed in the early 1970s at a Japanese shipbuilding firm. Its objective was to provide a systematic way of dealing with the many complexities and trade-offs inherent in all of the design decisions faced by product developers. After considerable study and a number of improvements by several important Japanese academics, it later migrated to the Japanese auto industry and then to the US auto industry by the mid-1980s.[2] Today, it is used in almost every type of industry and application imaginable – products and services, consumer (B2C) and commercial (B2B), high tech and low tech, etc.

QFD is best carried out by an active cross-functional team whose job it is to complete one or more of a series of matrices which lead to a set of insights about how best to create a winning product or service and how to prioritize their research and development activities going forward. Many QFD practitioners believe that it is the process of debate itself among the cross-functional team members in trying to reach consensus on all of the various entries into the matrix where most of the learning takes place.

A rigorous view of QFD employs not just one matrix (the original House of Quality), but four matrices. These sequentially relate:

- *Customer Needs* to *Performance Measures*
- *Performance Measures* to *Features or Solutions*
- *Features or Solutions* to *Parts Specifications*
- *Parts Specifications* to *Manufacturing Processes*

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[1] Significant portions of this article are drawn from an MIT Sloan Courseware document by John R. Hauser, "Notes on "Engineering" Product Design," MIT, Cambridge, MA 2008. John R. Hauser and MIT Sloan grant a non-exclusive right to use this material in this description of QFD. John R. Hauser and MIT Sloan retain a non-exclusive right to this material.

[2] Hauser, John R. and Don P. Clausing (1988), "The House of Quality," *Harvard Business Review*, 66, 3, (May-June), 63-73.

A variation on the second of these matrices is called Pugh Concept Selection, developed by Professor Stewart Pugh in the UK. This variation attempts to evaluate different product concepts against the key performance measures, with the objective of incrementally moving toward an ideal concept.

There are many different styles of conducting QFD, and almost no two practitioners follow exactly the same process. A particularly lively debate has to do with the importance of completing all four matrices, with many practitioners arguing that most of the value is derived from the first matrix alone.

It is well recognized that customers choose products based on how well the products fulfill their perceived needs. New product development teams must select product features to fulfill those perceived needs.

Figure 1 illustrates a stylized House of Quality (HOQ) completed by Puritan-Bennett, a medical device manufacturing company, when they were redesigning a medical instrument called a spirometer (a device that measures lung capacity). The HOQ begins with a formal study of perceived customer needs called the "Voice of the Customer." The Voice of the Customer identifies customer needs such as "the product is easy for the physician to hold while taking measurements on a patient." In the Puritan-Bennett example, interviews with physicians, technicians, nurses, and patients identified 25 strategic customer needs. These are listed on the left-hand side of the matrix. But all needs are not equally important. The customers would much prefer that some needs be fulfilled even if it means that other needs are not fulfilled as well. The Voice of

the Customer, in addition to defining customer needs, also measures the importance of each need. In Figure 1 these importances are listed to the right of the customer needs. In addition, the HOQ lists on the right how each existing product (for PB, SM, or WA – three manufacturers) fulfills the customer needs. For example, WA does extremely well on the important customer need of affordability, while PB does poorly. The diagram shows that affordability is a high priority need. < Figure 1 near here >

The remainder of the HOQ is reasonably self-explanatory. The product development team lists performance measures at the top of the house. For spirometers a performance measure might be the weight, diameter, or number of minutes required to clean it.

The team then considers each high priority customer need, such as "IT Compatibility," and, in the center of the house, indicates how each performance measure affects the fulfillment of that need. For example, small diameter may make it easier for someone to hold (positive relationship), but take longer for someone to clean (negative relationship). Some teams indicate the relationships with symbols (●, ◐, ○), others with numbers (± 9, ± 3, ± 1), and still others with simply + or –. The HOQ is a guide; any quantification must be tempered with qualitative judgment.

The triangular roof of the HOQ holds interactions between performance measures. For example, it is likely that a larger diameter is positively correlated with a higher weight product, and thus a "somewhat related" relationship would be noted at the intersection box between them in the roof. At the bottom of the HOQ are costs, technical feasibility, benchmarks and, possibly, metrics (engineering measures) that are performance goals for this project.

Early applications used large numbers (hundreds) of customer needs and design features, but building the HOQ with that many needs is an arduous task. QFD has become somewhat controversial in many organizations due to the time, effort, and (some would argue) tedium involved. Fortunately, there is now excellent software and a number of interesting shortcuts available to combat these problems. For example, the HOQ has evolved through the use of "Turbo HOQ" to a representation that is more "just in time." When the team considers a customer need, it fills in the design features to which that need is linked.

Though QFD can involve a good deal of effort, there are a number of key benefits to be derived from the use of QFD:

- It allows teams to prioritize their development activities in a systematic, analytical way that puts the customer first, as opposed to through a political free-for-all that relies on which customer, salesman, or officer can shout the loudest and exert the most power.

- It takes advantage of cross-functionality in an orderly, truly participative way, enlisting the support of all major functions within the organization toward a common view.

- It provides an "audit trail" which reminds people, both new and old to the project, as to why certain decisions were made in the past.

- It often results in a prioritization which is highly unexpected and different from the conventional wisdom held by the company and many of the participants before engaging in QFD, thus stretching the team's thinking as to which activities are most critical toward creating a winning product or service.

Having noted the benefits, let us turn to some examples showing why and how QFD can be helpful in the product development process.

Much of the effort involved in QFD is devoted to the relationship of customer needs to features during the QFD process. Why is it so hard to relate customer needs to

engineering features? Consider a liquid dishwashing detergent (for washing dishes by hand). It is basically a chemical product. Customers buy it to clean their dishes. But what does "clean" mean to customers in the context of dishes and how do customers judge that their dishes are clean? It is unlikely that they use a magnifying glass or a scientific instrument to measure the light reflected from the dishes, although an engineer might use those instruments to test a dishwashing product's performance. It is also unlikely that the customer will read and understand the chemical ingredients. More likely, the customer will use some subjective means to determine "clean." This might mean holding dishes up to the light or it might simply mean that there is no noticeable dirt on the dishes – a minimum requirement. Tactile cues, such as running fingers along a dish to detect the presence of grease, may play a role. In addition, the customer might derive peripheral cues, such as the clarity of the water in the sink (after washing dishes) or the amount and type of bubbles that are still around when the dishes are done and ready to be rinsed. The scent of the dishwater or of the dishes might be another cue to cleanliness.

But "clean" might not be the only perceived need. The customer might care about the ease of use, the "feel" of the water while washing the dishes, the scent of the liquid, the effect of the dishwashing liquid on skin, the ease of storing the bottle (or package), whether or not the washing causes the dishes to deteriorate, how much is needed to wash a sink full of dishes, or whether the liquid imparts a perceived taste to the dishes. It is not enough to engineer the best-cleaning liquid. The product development team must

engineer the entire customer experience. This includes the liquid itself as well as the packaging and any advertising image.

Consider another example – engineering a telephone-service center to provide great service. The development team may design the physical space, select the telephonic equipment, and design protocols. The development team may also design a personnel policy, training, and a monitoring/reward system. Consider the monitoring/reward system. One major financial service provider determined that customers did not like to wait. They instituted metrics and rewarded the service providers to minimize the number of rings before answering, avoid transferring customers, and answer the customers' questions as rapidly as possible. Unfortunately, the service representatives soon figured out how to "game" the system: answer the phone quickly, avoid a transfer even if the service provider did not know the answer, and get off the phone as quickly as possible. In fact, the metric was improved by giving incomplete and unhelpful answers.

The financial services firm responded. Service providers were now given incentives to stay on the phone until the customer got an answer. One metric was the number of minutes per hour that the service provider was on the phone. The service providers responded. They were never off the phone. Breaks were taken while the customer was on hold.

Ultimately, the financial services firm talked to the service providers and understood their needs. Service providers were not happy with gaming the system. They wanted to serve customers but felt that the metrics prevented them from doing so. In response, the firm began using more qualitative metrics based on monitoring and on

customer satisfaction scores. Service providers started to maximize the customers'

perceived needs – the customers wanted their questions answered correctly. Efficiency

was a secondary criterion.

Many other examples abound. Fulfilling customer needs is important to the

success of a new product, but it is difficult to achieve. It is especially difficult in a

complex product such as an automobile or a high-end copier. An automobile may take

1,000 person-years to design – millions of decisions need to be made. Even an office

copier may require close to 10,000 critical engineering decisions. Effective product

developers want every one of those decisions to be focused on the customer.

Since customer needs drive the entire QFD process, it is critical that the list of

customer needs be complete, or important factors in product design may be omitted. The

Voice of the Customer (VOC) is a term used in business to describe the process of

capturing a customer's requirements (see WIEM05-020). The Voice of the Customer is a

product development technique that produces a detailed set of customer wants and needs

which are organized into a hierarchical structure, and then prioritized in terms of relative

importance and satisfaction with current alternatives. It involves both qualitative and

quantitative market research among current and potential customers. Sometimes

practitioners are tempted to gather the Voice of the Customer in a very cursory way for

reasons of time, budget, or lack of interest in what their customers have to say. This is

rarely a good strategy – the quality of the output depends upon the quality of the input.

Gathering a good Voice of the Customer takes time and knowledge of sample design,

recruiting of research respondents, good interviewing techniques, the ability to translate

interview output into a useful set of needs, etc. For practitioners new to the VOC

process, it is good practice to obtain some training by experienced VOC practitioners before attempting to conduct this research, or to outsource this task to them.[3]

Another major benefit of QFD is that it improves communication among members of the product development team. Here is an example. In the early days of QFD, MIT Sloan researchers studied its implementation at Ford Motor Company.[4] Two teams were chosen. Each was working on a similar, but different, component of a new automobile and each team was otherwise similar in skills and team members. Both teams reported to the same managers. One team used the QFD / House of Quality; another team used Ford's standard phase review process. Over the course of the product development cycle, the MIT Sloan researchers measured the amount and type of communication among team members. The results are given in Figure 2 (from Griffin and Hauser 1992). < Figure 2 near here.>

Overall, there was significantly more communication by members of the QFD team. Deeper analysis revealed that QFD focused its communications within the team – both within functions and between functions on these interfunctional teams. The only type of communication reduced by the HOQ was that between the QFD team and management. Even deeper analysis showed that the phase-review team engaged in significantly more "up-over-down" communication. For example, an engineer at Ford might communicate a design change to his/her manager who would communicate that design change to a manager at a supplier who would, in turn, communicate the design

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[3] For more information, see the International Encyclopedia entry on The Voice of the Customer.
[4] Griffin, Abbie, and John R. Hauser (1992), "Patterns of Communication Among Marketing, Engineering and Manufacturing -- A Comparison Between Two New Product Teams," *Management Science*, 38, 3, (March), 360-373.

change to an engineer at the supplier. In the HOQ team the Ford engineer communicated directly to the engineer at the supplier.

Figure 2 is just one example of the success of the various means to enhance communication among product development team members concerning the relationship between perceived customer needs and engineering design features. Figure 2 is based on QFD, but there are many other ways to affect communication during the product development process. For example, Wind, et al. (1989)[5] provide an excellent example of how conjoint analysis was used to design "Courtyard by Marriott." They show how, in addition to the usual quantification of trade-offs, conjoint analysis was used to link the features of the hotel to perceived customer needs. Green, Krieger, and Wind (2004) provide another example where conjoint analysis was used to design the EZPass (FastLane) electronic toll payment system.[6]

The important lesson here is that such communication must occur if successful products are to be designed. It is far more efficient and effective to incorporate the Voice of the Customer into the new product development process proactively, and early on, through a systematic process such as QFD, than it is to redesign the product after an unsuccessful launch.

BIBLIOGRAPHY

Akao, Y. and Mizuno, S. (1994) *QFD: The Customer-Driven Approach to Quality Planning & Deployment*. Tokyo: Asian Productivity Organization.

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[5] Wind, Yoram, Paul E. Green, Douglas Shifflet, and Marsha Scarbrough (1989), "*Courtyard by Marriott:* Designing a Hotel facility with Consumer-Based Marketing Models," *Interfaces*, 19, (January-February), 25-47.
[6] Green, Paul E., Abba Krieger, and Jerry Wind (2004), "Thirty Years of Conjoint Analysis: Reflections and Prospects," in Jerry Wind and Paul E. Green, eds., *Market Research and Modeling: Progress and Prospects, a Tribute to Paul E. Green*, (New York, NY: Kluwer Academic Publishers).

Akao, Y. (2004) *Quality Function Deployment: Integrating Customer Requirements into Product Design*. New York, NY: Productivity Press, Inc.

Cohen, L. (1995) *Quality Function Deployment: How to Make QFD Work for You*. Reading, MA: Addison-Wesley Publishing.

Green, P. E., A. Krieger, and J. Wind. (2004) Thirty Years of Conjoint Analysis: Reflections and Prospects. In J. Wind and P. E. Green (eds.) *Market Research and Modeling: Progress and Prospects, a Tribute to Paul E. Green*. New York, NY: Kluwer Academic Publishers.

Griffin, A. and J. R. Hauser. (1992) Patterns of Communication Among Marketing, Engineering and Manufacturing -- A Comparison Between Two New Product Teams. *Management Science*, **38**, 3, (March), 360-373.

Hauser, J. R. and D. P. Clausing. (1988) The House of Quality. *Harvard Business Review*, **66**, 3, (May-June), 63-73.

Katz, Gerald. (2007) Quality Function Deployment and the House of Quality. In A. Griffin, and S. Somermeyer (eds.) *The PDMA Toolbook 3 for New Product Development*. Hoboken, New Jersey: John Wiley & Sons, Inc.

King, B. (1987) *Better Designs in Half the Time: Implementing QFD in America*. Methuen, MA: GOAL/QPC.

Wind, Y., P. E. Green, D. Shifflet and M. Scarbrough. (1989) *Courtyard by Marriott: Designing a Hotel facility with Consumer-Based Marketing Models. Interfaces*, **19**, (January-February), 25-47.

Figure Captions:

Figure 1. Illustrative House of Quality

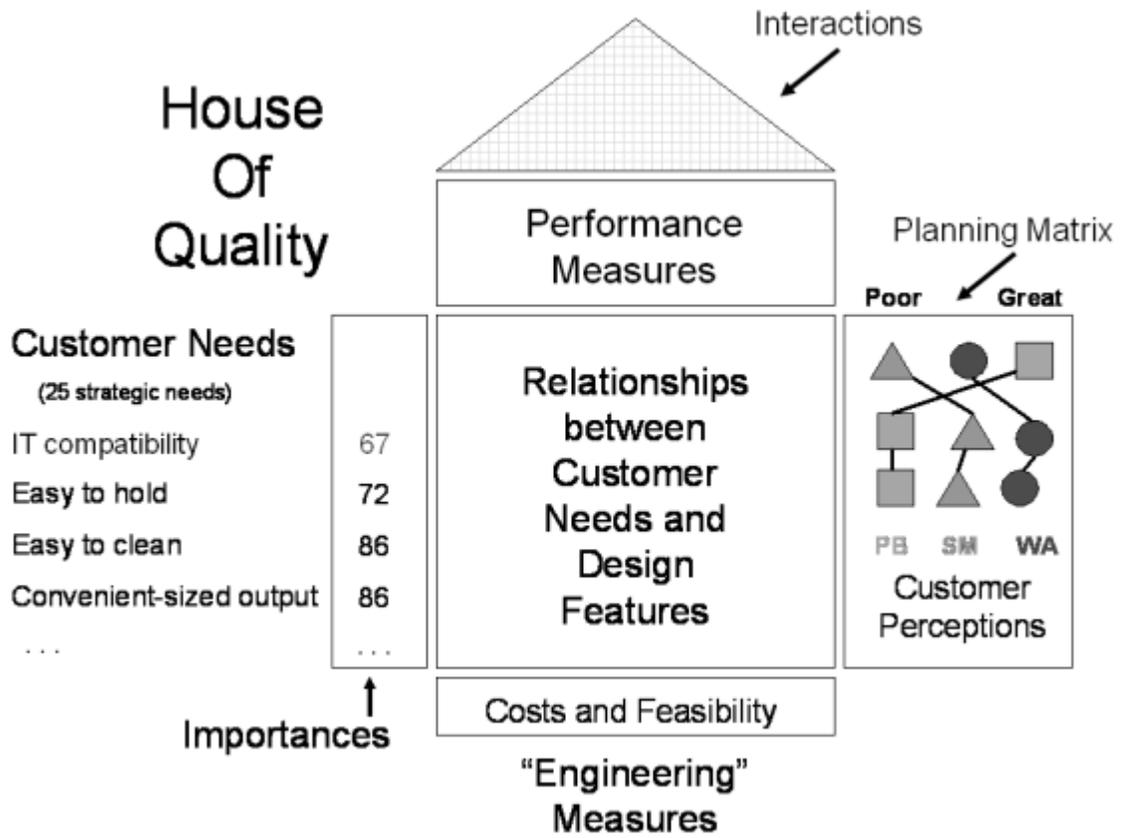**Figure 2. Communication at Ford**

Figures:

Figure 1:

Figure 2:

* Significant at the 0.05 level.

Communications per week