QUALITY FUNCTION DEPLOYMENT

Introduction

Dr. Mizuno, professor emeritus of the Tokyo Institute of Technology, is credited with initiating the quality function deployment (QFD) system. The first application of QFD was at Mitsubishi, Heavy Industries, Ltd., in the Kobe Shipyard, Japan, in 1972. After four years of case study development, refinement, and training, QFD was successfully implemented in the production of mini-vans by Toyota. Using 1977 as a base, a 20% reduction in startup costs was reported in the launch of the new van in October 1979, a 38% reduction by November 1982, and a cumulative 61% reduction by April 1984. Quality function deployment was first introduced in the United States in 1984 by Dr. Clausing of Xerox. QFD can be applied to practically any manufacturing or service industry. It has become a standard practice by most leading organizations, who also require it of their suppliers.

Quality function deployment enables the design phase to concentrate on the customer requirements, thereby spending less time on redesign and modifications. The saved time has been estimated at one-third to one-half of the time taken for redesign and modification using traditional means. This saving means reduced development cost and also additional income because the product enters the market sooner.

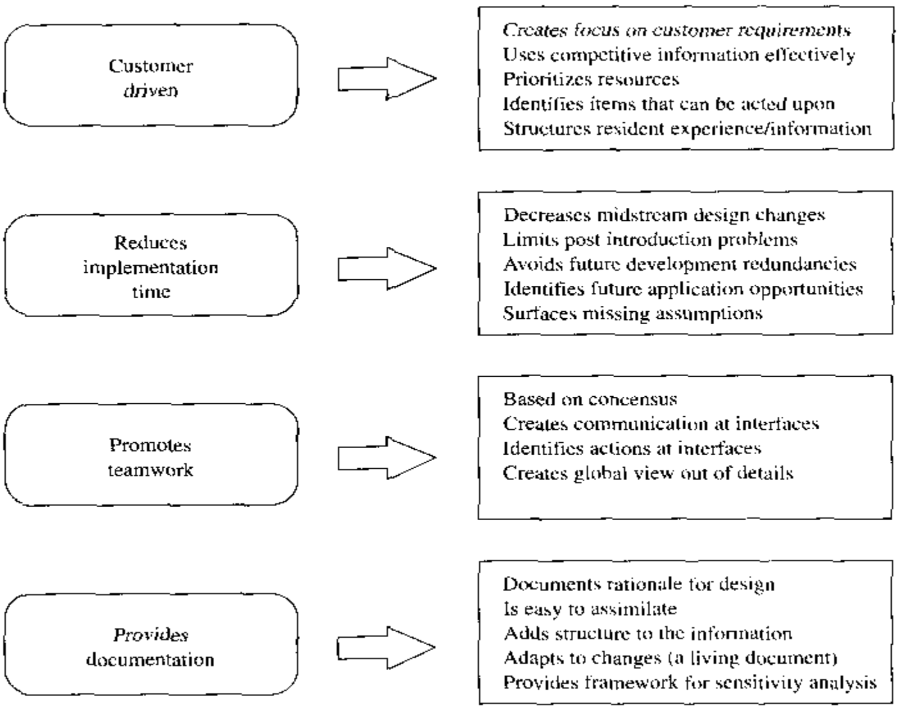

Figure 1- Benefits of QFD

Benefits of QFD

Quality function deployment was originally implemented to reduce start-up costs. Organizations using QFD have reported a reduced product development time. For example, U.S. car manufacturers of the late 1980s and early 1990s needed an average of five years to put a product on the market, from drawing board to showroom, whereas Honda put a new product on the market in two and a half years and Toyota did it in three years. Both organizations credit this reduced time to the use of QFD. Product quality and, consequently, customer satisfaction improve with QFD due to numerous factors depicted in Figure 1.

Customer Driven

Quality function deployment looks past the usual customer response and attempts to define the requirements in a set of basic needs, which are compared to all competitive information. All competitors are evaluated equally from customer and technical perspectives. This information can then be prioritized using a Pareto diagram. Management can then place resources where they will be the most beneficial in improving quality. Also, QFD takes the experience and information that are available within an organization and puts them together as a structured format that is easy to assimilate.

Reduces Implementation Time

Fewer engineering changes are needed when using QFD, and, when used properly, all conflicting design requirements can be identified and addressed prior to production.

This results in a reduction in retooling, operator training, and changes in traditional quality control measures. By using QFD, critical items are identified and can be monitored from product inception to production.

Promotes Teamwork

Quality function deployment forces a horizontal deployment of communication channels. Inputs are required from all facets of an organization, from marketing to production to sales, thus ensuring that the voice of the customer is being heard and that each department knows what the other is doing. This activity avoids misinterpretation, opinions, and miscues.

Provides Documentation

A database for future design or process improvements is created. Data that are historically scattered within operations, frequently lost and often referenced out of context, are now saved in an orderly manner to serve future needs. This database also serves as a training tool for new engineers.

House of Quality

The primary planning tool used in QFD is the house of quality. The house of quality translates the voice of the customer into design requirements that meet specific target values and matches those against how an organization will meet those requirements. Many managers and engineers consider the house of quality to be the primary chart in quality planning.

The structure of QFD can be thought of as a framework of a house, as shown in Figure 2.

The parts of the house of quality are described as follows:

The exterior walls of the house are the customer requirements. On the left side is a listing of the voice of the customer, or what the customer expects in the product. On the right side are the prioritized customer requirements, or planning matrix.

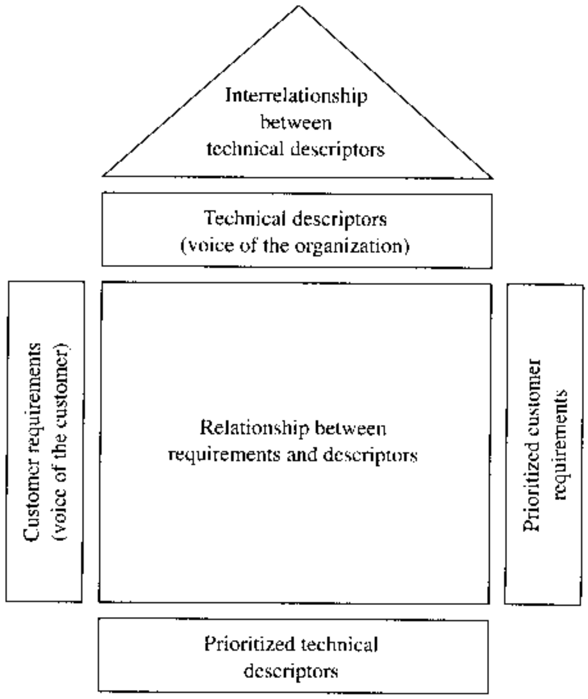

Figure 2 – House of Quality

Listed are items such as customer benchmarking, customer importance rating, target value, scale-up factor, and sales point.

The ceiling, or second floor, of the house contains the technical descriptors. Consistency of the product is provided through engineering characteristics, design constraints, and parameters.

The interior walls of the house are the relationships between customer requirements and technical descriptors. Customer expectations (customer requirements) are translated into engineering characteristics (technical descriptors).

The roof of the house is the interrelationship between technical descriptors. Tradeoffs between similar and/or conflicting technical descriptors are identified.

The foundation of the house is the prioritized technical descriptors. Items such as the technical benchmarking, degree of technical difficulty, and target value are listed.

This is the basic structure for the house of quality; once this format is understood, any other QFD matrices are fairly straightforward.

Building a House of Quality

The matrix that has been mentioned may appear to be confusing at first, but when it is looked at by parts, the matrix is significantly simplified. A basic house of quality matrix is shown in Figure 3. There is a considerable amount of information contained within this matrix. It is easier to comprehend once each part is discussed in detail.

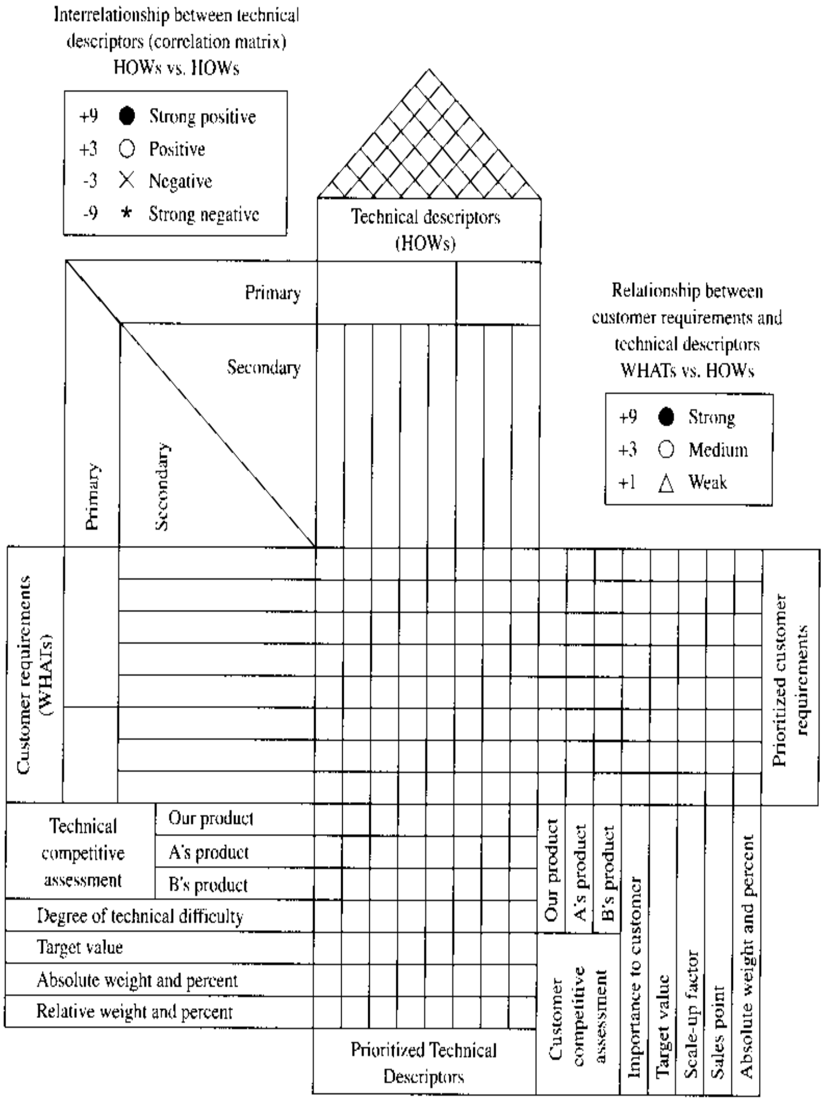

Figure 3 – Basic House of Quality Matrix

Step 1-List Customer Requirements (WHATs)

Quality function deployment starts with a list of goals/objectives. This list is often referred as the WHATs that a customer needs or expects in a particular product. This list of primary customer requirements is usually vague and very general in nature. Further definition is accomplished by defining a new, more detailed list of secondary customer requirements needed to support the primary customer requirements. In other words, a primary customer requirement may encompass numerous secondary customer requirements. Although the items on the list of secondary customer requirements represent greater detail than those on the list of primary customer requirements, they are often not directly actionable by the engineering staff and require yet further definition. Finally, the list of customer requirements is divided into a hierarchy of primary, secondary, and tertiary customer requirements, as shown in Figure 4. For example, a primary customer requirement might be dependability and the corresponding secondary customer requirements could include reliability, longevity, and maintainability.

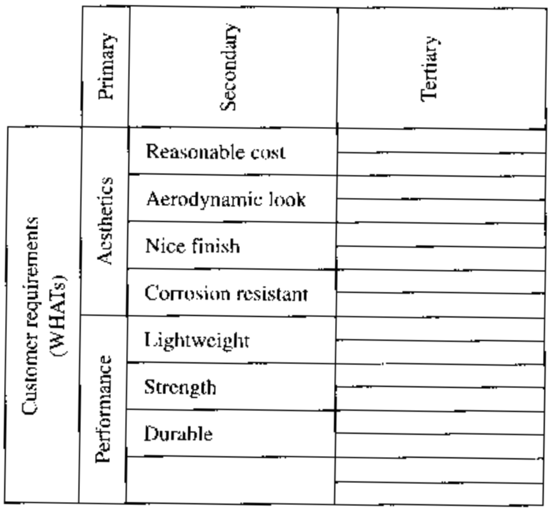

Figure 4 – Refinement of Customer Requirements

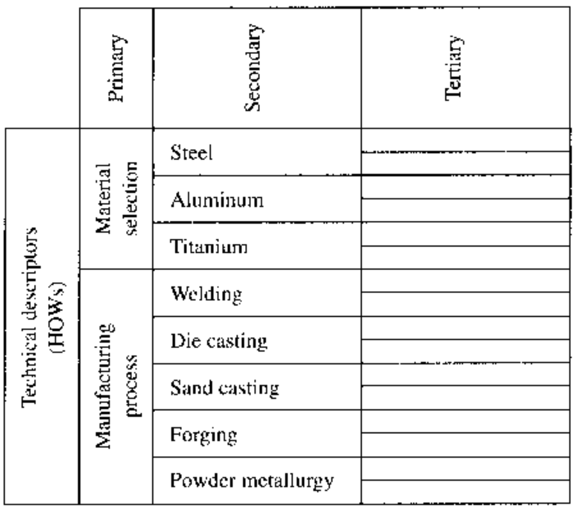

Figure 5 – Refinement of Technical Descriptors

Step 2-List Technical Descriptors (HOWs)

The goal of the house of quality is to design or change the design of a product in a way that meets or exceeds the customer expectations. Now that the customer needs and expectations have been expressed in terms of customer requirements, the QFD team must come up with engineering characteristics or technical descriptors (HOWs) that will affect one or more of the customer requirements. These technical descriptors make up the ceiling, or second floor, of the house of quality. Each engineering characteristic must directly affect a customer perception and be expressed in measurable terms.

Further definition of the primary technical descriptors is accomplished by defining a list of secondary technical descriptors that represent greater detail than those on the list of primary technical descriptors. This is similar to the process of translating system-level engineering specifications into part-level specifications. These secondary technical descriptors can include part specifications and manufacturing parameters that an engineer can act upon. Often the secondary technical descriptors are still not directly actionable, requiring yet further definition. This process of refinement is continued until every item on the list is actionable. Finally, the list of technical descriptors is divided into a hierarchy of primary, secondary, and tertiary technical descriptors, as shown in Figure 5.

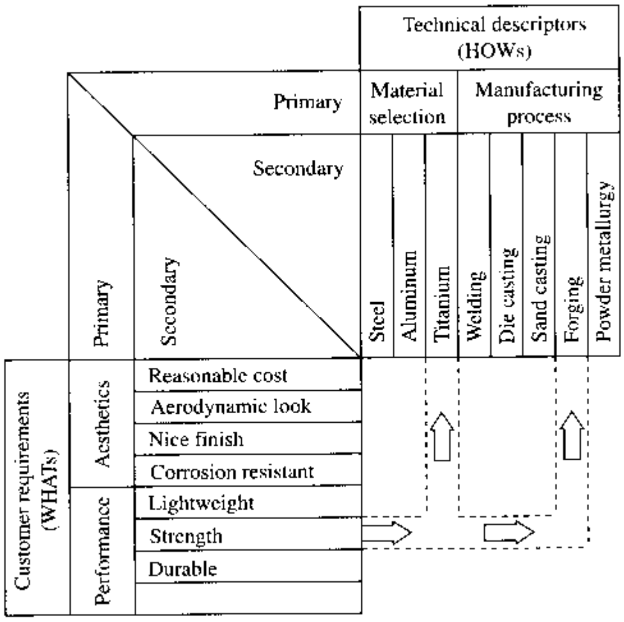

Figure 6 – Structuring an L-shaped diagram

Step 3-Develop a Relationship Matrix Between WHATs and HOWs

The next step in building a house of quality is to compare the customer requirements and technical descriptors and determine their respective relationships. Tracing the relationships between the customer requirements and the technical descriptors can become very confusing, because each customer requirement may affect more than one technical descriptor, and vice versa.

Structuring an l-shaped diagram

One way to reduce the confusion associated with determining the relationships between customer requirements and technical descriptors is to use an L-shaped matrix, as shown in Figure 6. The L shape, which is a two-dimensional relationship that shows the intersection of related pairs of items, is constructed by turning the list of technical descriptors perpendicular to the list of customer requirements. The L-shaped matrix makes interpreting the complex relations very easy and does not require a significant amount of experience.

Relationship matrix

The inside of the house of quality, called the relationship matrix, is now filled in by the QFD team. The relationship matrix is used to represent graphically the degree of influence between each technical descriptor and each customer requirement. This step may take a long time, because the number of evaluations is the product of the number of customer requirements and the number of technical descriptors. Doing this early in the development process will shorten the development cycle and lessen the need for future changes.

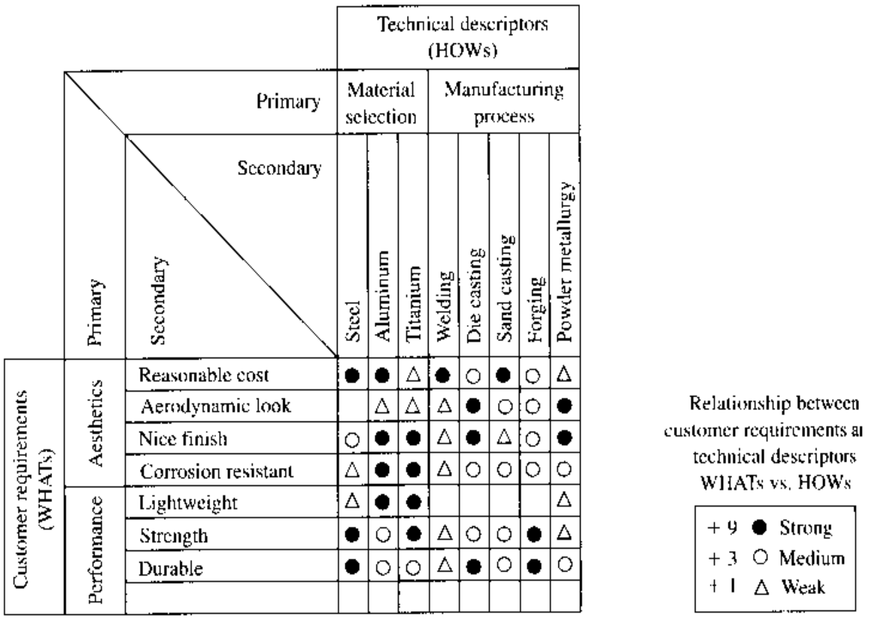

Figure 7 – Adding Relationship Matrix to the House of Quality

It is common to use symbols to represent the degree of relationship between the customer requirements and technical descriptors. For example,

- A solid circle represents a strong relationship.
- A single circle represents a medium relationship.
- A triangle represents a weak relationship.
- The box is left blank if no relationship exists.

It can become difficult to comprehend and interpret the matrix if too many symbols are used. Each degree of relationship between a customer requirement and a technical descriptor is defined by placing the respective symbol at the intersection of the customer requirement and technical descriptor, as shown in Figure 7. This method allows very complex relationships to be depicted and interpreted with very little experience.

The symbols that are used to define the relationships are now replaced with numbers; for example,

• =9

o =3

Δ =1

These weights will be used later in determining trade-off situations for conflicting characteristics and determining an absolute weight at the bottom of the matrix.

After the relationship matrix has been completed, it is evaluated for empty rows or columns. An empty row indicates that a customer requirement is not being addressed by any of the technical descriptors. Thus, the customer expectation is not being met. Additional technical descriptors must be considered in order to satisfy that particular customer requirement. An empty column indicates that a particular technical descriptor does not affect any of the customer requirements and, after careful scrutiny, may be removed from the house of quality.

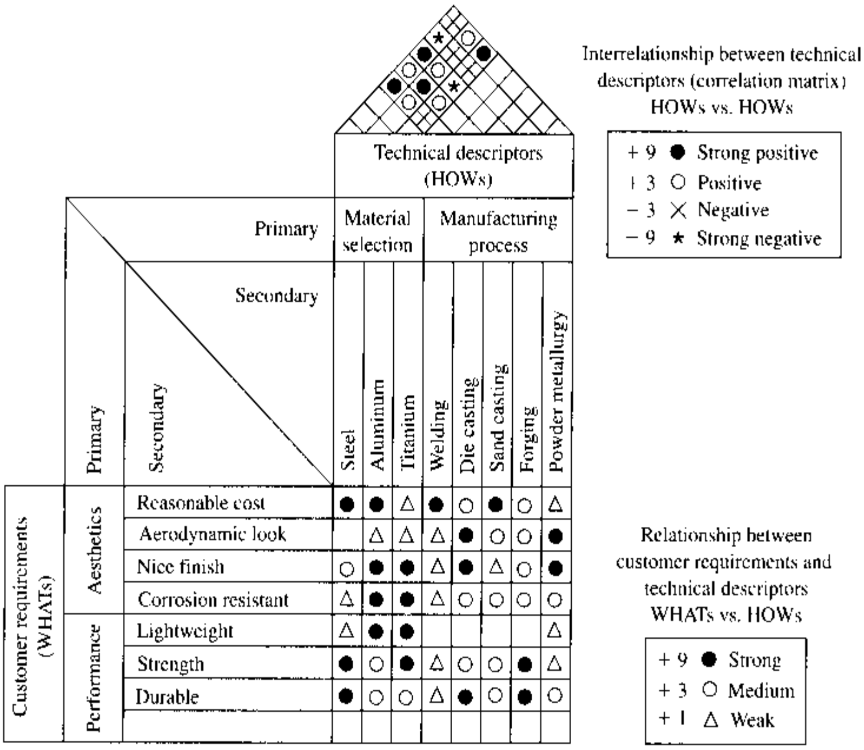

Figure 8 – Adding Interrelationship Matrix to the House of Quality

Step 4-Develop an Interrelationship Matrix Between HOWs

The roof of the house of quality, called the correlation matrix, is used to identify any interrelationships between each of the technical descriptors. The correlation matrix is a triangular table attached to the technical descriptors, as shown in Figure 8. Symbols are used to describe the strength of the interrelationships; for example,

- A solid circle represents a strong positive relationship.
- A circle represents a positive relationship.
- An X represents a negative relationship.
- An asterisk represents a strong negative relationship.

Step 5-Competitive Assessments

The competitive assessments are a pair of weighted tables (or graphs) that depict item for item how competitive products compare with current organization products. The competitive assessment tables are separated into two categories, customer assessment and technical assessment, as shown in Figures 9 and 10, respectively.

CUSTOMER COMPETITIVE ASSESSMENT

The customer competitive assessment makes up a block of columns corresponding to each customer requirement in the house of quality on the right side of the relationship matrix, as shown in Figure 9. The numbers 1 through 5 are listed in the competitive evaluation column to indicate a rating of 1 for worst and 5 for best. These rankings can also be plotted across from each customer requirement, using different symbols for each product.

The customer competitive assessment is a good way to determine if the customer requirements have been met and identify areas to concentrate on in the next design. The customer competitive assessment also contains an appraisal of where an organization stands relative to its major competitors in terms of each customer requirement. Both assessments are very important, because they give the organization an understanding on where its product stands in relationship to the market.

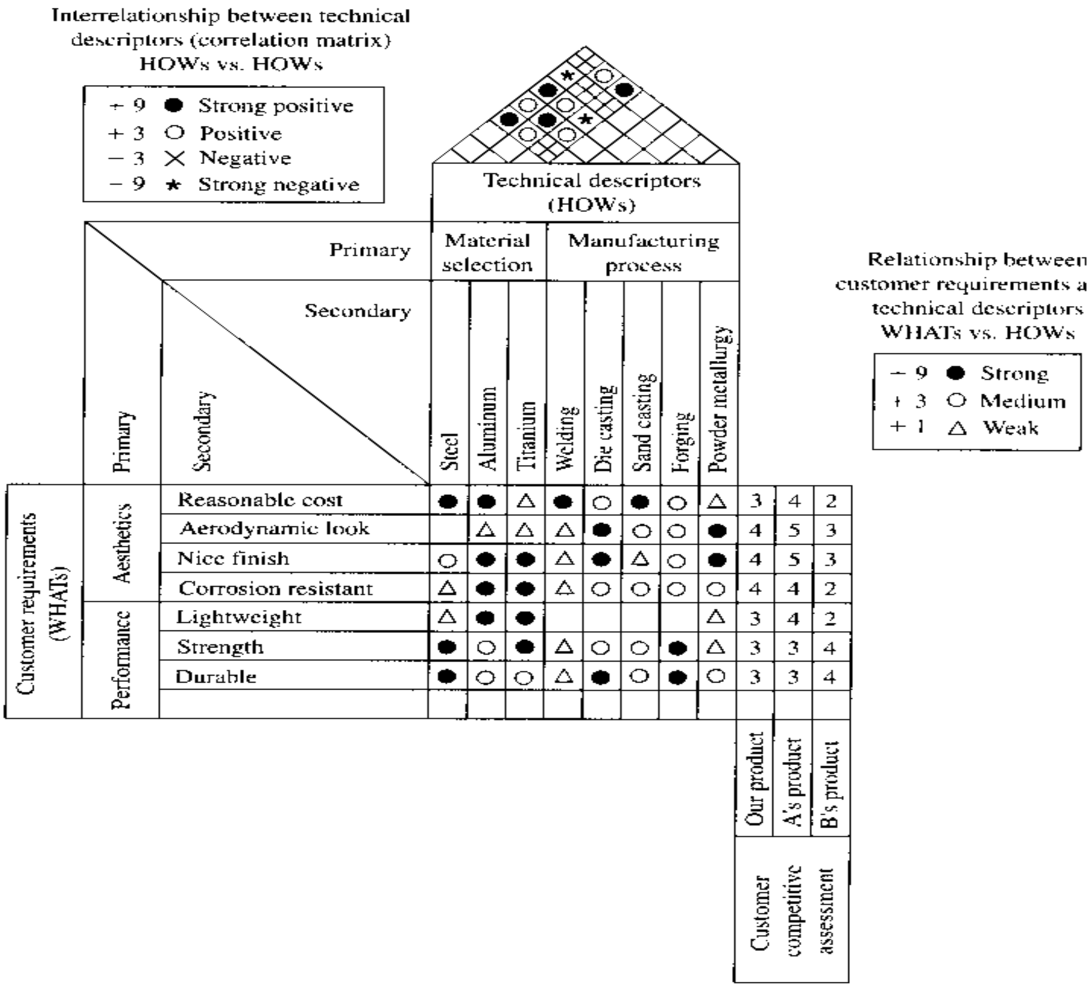

Figure 9 – Adding Customer Competitive Assessment to the House of Quality

Technical competitive assessment

The technical competitive assessment makes up a block of rows corresponding to each technical descriptor in the house of quality beneath the relationship matrix, as shown in Figure 10. After respective units have been established, the products are evaluated for each technical descriptor.

Similar to the customer competitive assessment, the test data are converted to the numbers 1 through 5, which are listed in the competitive evaluation row to indicate a rating, 1 for worst and 5 for best. These rankings can then be entered below each technical descriptor using the same numbers as used in the customer competitive assessment.

The technical competitive assessment is often useful in uncovering gaps in engineering judgment. When a technical descriptor directly relates to a customer requirement, a comparison is made between the customer's competitive evaluation and the objective measure ranking.

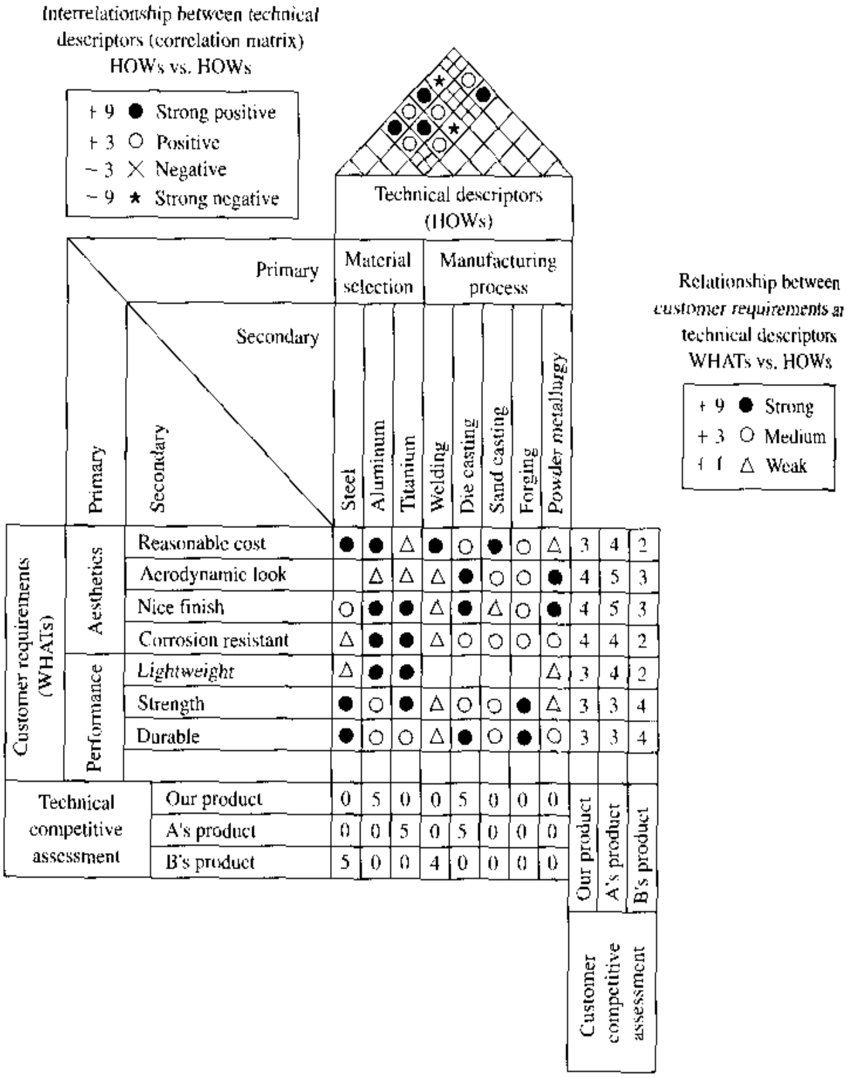

Figure 10 – Adding Technical Competitive Assessment to the House of Quality

Customer requirements and technical descriptors that are strongly related should also exhibit a strong relationship in their competitive assessments. If an organization's technical assessment shows its product to be superior to the competition, then the customer assessment should show a superior assessment. If the customer disagrees, then a mistake in engineering judgment has occurred and should be corrected.

Step 6-Develop Prioritized Customer Requirements

The prioritized customer requirements make up a block of columns corresponding to each customer requirement in the house of quality on the right side of the customer competitive assessment as shown in Figure 11. These prioritized customer requirements contain columns for importance to customer, target value, scale-up factor, sales point, and an absolute weight.

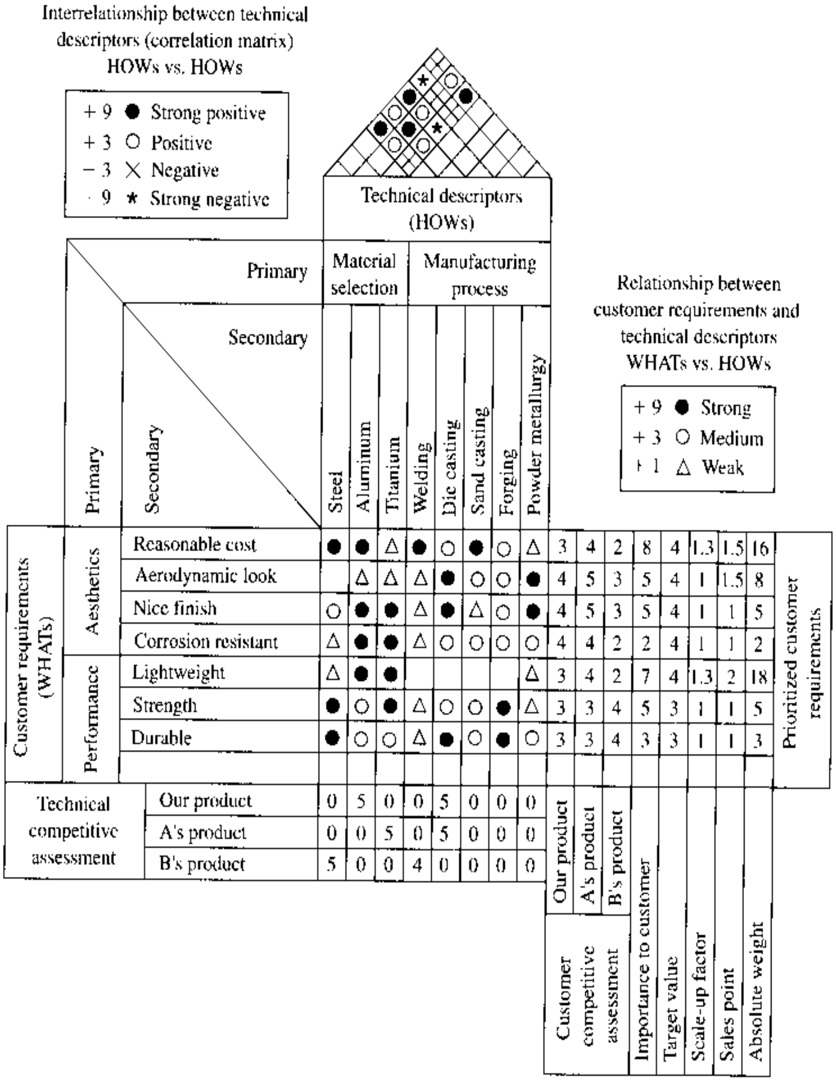

Figure 11 – Adding Prioritized Customer Requirements to the House of Quality

Importance to customer

The QFD team-or, preferably, the focus group-ranks each customer requirement by assigning it a rating. Numbers 1 through 10 are listed in the importance to customer column to indicate a rating of 1 for least important and 10 for very important. In other words, the more important the customer requirement, the higher the rating.

Importance ratings represent the relative importance of each customer requirement in terms of each other. Assigning ratings to customer requirements is sometimes difficult, because each member of the QFD team might believe different requirements should be ranked higher. The importance rating is useful for prioritizing efforts and making trade-off decisions.

TARGET VALUE

The target-value column is on the same scale as the customer competitive assessment (1 for worst, 5 for best can be used). This column is where the QFD team decides whether they want to keep their product unchanged, improve the product, or make the product better than the competition.

SCALE-UP FACTOR

The scale-up factor is the ratio of the target value to the product rating given in the customer competitive assessment. The higher the number, the more effort is needed. Here, the important consideration is the level where the product is now and what the target rating is and deciding whether the difference is within reason. Sometimes there is not a choice because of difficulties in accomplishing the target. Consequently, the target ratings often need to be reduced to more realistic values.

SALES POINT

The sales point tells the QFD team how well a customer requirement will sell. The objective here is to promote the best customer requirement and any remaining customer requirements that will help in the sale of the product. For example, the sales point is a value between 1.0 and 2.0, with 2.0 being the highest.

ABSOLUTE WEIGHT

Finally, the absolute weight is calculated by multiplying the importance to customer, scale-up factor, and sales point:

Absolute Weight = (Importance to Customer)(Scale-up Factor)(Sales Point)

A sample calculation is included in Figure 11. After summing all the absolute weights, a percent and rank for each customer requirement can be determined. The weight can then be used as a guide for the planning phase of the product development.

Step 7-Develop Prioritized Technical Descriptors

The prioritized technical descriptors make up a block of rows corresponding to each technical descriptor in the house of quality below the technical competitive assessment, as shown in Figure 12. These prioritized technical descriptors contain degree of technical difficulty, target value, and absolute and relative weights. The QFD team identifies technical descriptors that are most needed to fulfill customer requirements and need improvement. These measures provide specific objectives that guide the subsequent design and provide a means of objectively assessing progress and minimizing subjective opinions.

DEGREE OF DIFFICULTY

Many users of the house of quality add the degree of technical difficulty for implementing each technical descriptor, which is expressed in the first row of the prioritized technical descriptors. The degree of technical difficulty, when used, helps to evaluate the ability to implement certain quality improvements.

TARGET VALUE

A target value for each technical descriptor is also included below the degree of technical difficulty. This is an objective measure that defines values that must be obtained to achieve the technical descriptor. How much it takes to meet or exceed the customer's expectations is answered by evaluating all the information entered into the house of quality and selecting target values.

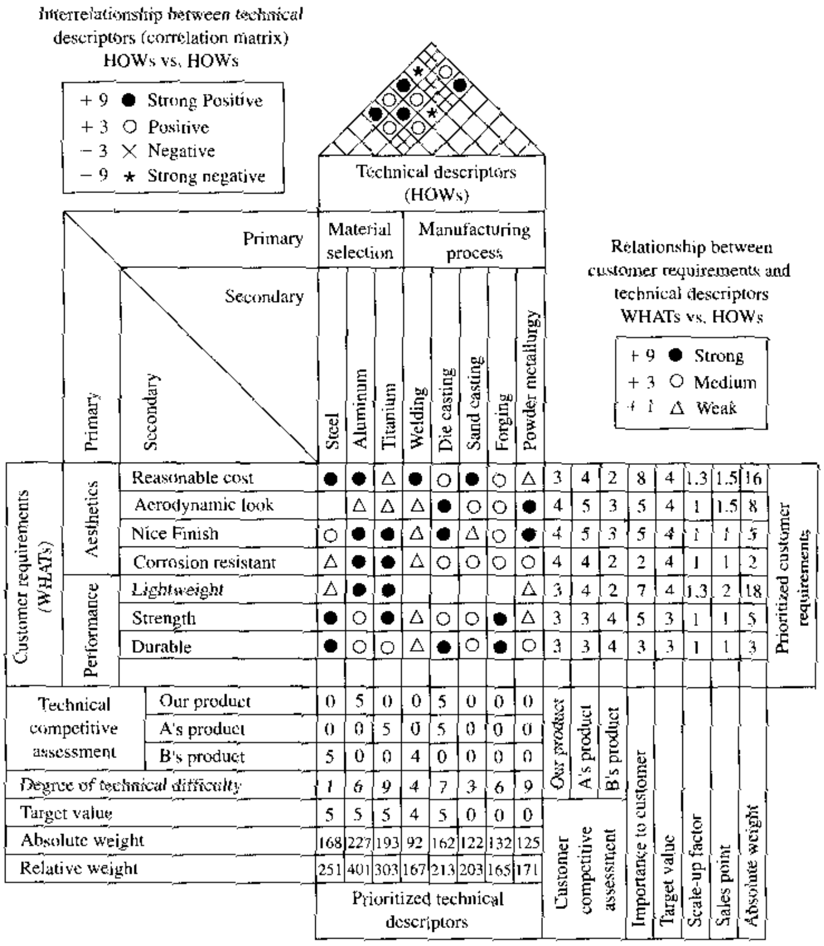

Figure 12 – Adding Prioritized Technical Descriptors to the House of Quality

ABSOLUTE WEIGHT

The last two rows of the prioritized technical descriptors are the absolute weight and relative weight. A popular and easy method for determining the weights is to assign numerical values to symbols in the relationship matrix symbols, as shown previously in Figure 8. The absolute weight for the j^{th} technical descriptor is then given by

$$a_j = \sum_{i=1}^{n} R_{ij} c_i$$

where

a_j = row vector of absolute weights for the technical descriptors (i = 1,…….,m)

R_{ij} = weights assigned to the relationship matrix (i = 1,….., n, j = 1,….., m)

c_i = column vector of importance to customer for the customer requirements (i=1, …., n)

m = number of technical descriptors

n = number of customer requirements

RELATIVE WEIGHT

In a similar manner, the relative weight for the j^{th} technical descriptor is then given by replacing the degree of importance for the customer requirements with the absolute weight for customer requirements. It is;