Quality Function Deployment

Suppose that a company has a product in the market, and they want to bring out the next generation (new model) out. This happens continually for most companies – e.g. a company making cell-phones, rice cookers, electric fans, digital cameras, toys, etc. The company designers may come up with many possible improvements or variations. Which ones should be incorporated into the new product?

Quality function deployment (QFD) was first practiced in 1970's as a system by a Mitsubishi engineer, Yoji Akao, at the Kobe shipyard in Japan. The method allows a design team to:
(i) Identify customer needs regarding a product and their relative importance
(ii) Map the customer needs into specific engineering requirements in the product
(iii) Identify the design components/modules that must be modified/changed/added for each need
(iv) Prioritize the design modifications that must be made to maximize the customer benefit at a given cost.

A graphical approach is used, and the diagram that is used (Figure 1) is often called the ***'house of quality'***.

QFD analysis works in the following stages:
(i) Determine the ***customer requirements*** (**CR**'s). These are stated as customer/user characteristics, e.g. faster, smaller, lighter, better sounding, different color, ….
(ii) ***Prioritize*** the customer demands (based on statistical analysis of customer surveys).
(iii) Translate the customer needs into technical specifications, i.e. measurable engineering requirements. The tech specs are also called ***technical parameters*** (***TP****'s*).
(iv) Complete the ***relationship matrix***: the goal is to associate which technical features of the product have an effect on (or contribute towards) each need of the customers.
(v) ***Benchmarking***, or analyzing competing products: rank the competing products in terms of customer satisfaction and technical performance.

(vi) ***Rank relative technical difficulty*** of achieving each technical specification.

(vii) Complete the 'roof': identify the ***inter-relations between different TP's***. Note that increasing one requirement may increase, have no effect on, or decrease one or more design requirements. Thus, achieving a given design requirement may require some conflict resolution (i.e. design modification, or optimization).

(viii) Determine the ***engineering specification target values***. This is based on customer requirements as well as on the values for the benchmarked products.

(ix) ***Prioritize*** the requirements: the goal is to improve the most critical design issues first.

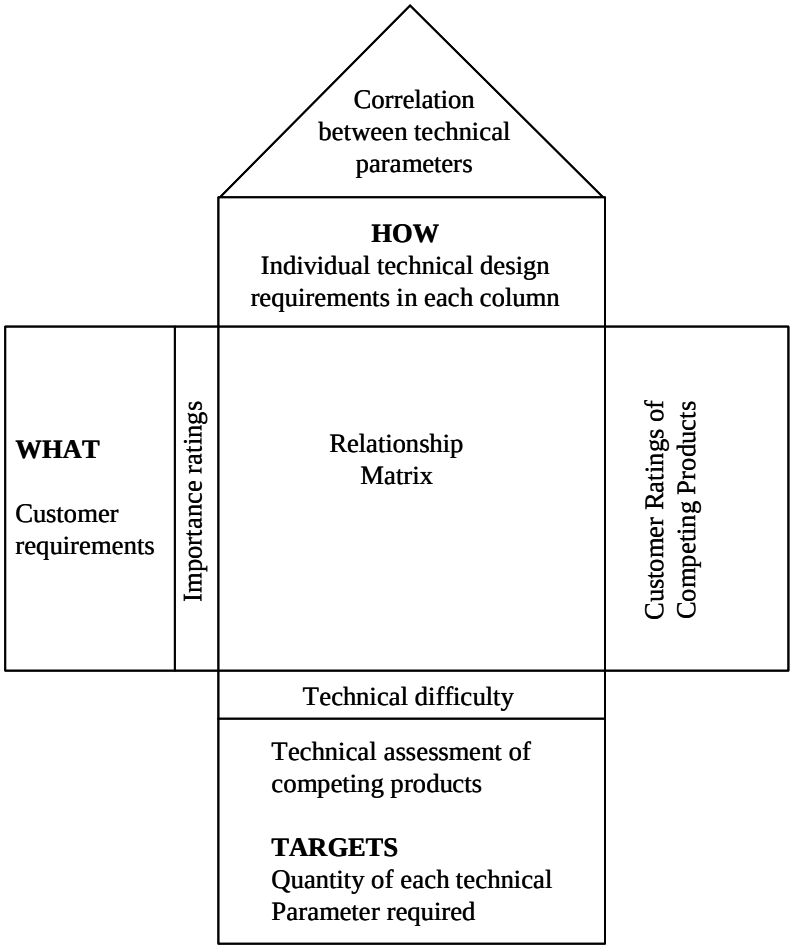


Figure 1. Structure of the "House of Quality"

Example

Figure 1 shows an electrical appliance: an Ice-tea maker. We will use the QFD to study how to improve its design. The operation is as follows: Add tea leaves to the steeping basket, and cool water to the tank, and switch on the machine. The water from the tank enters the heating chamber, where an electrical coil boils it. The steam pushes the how water through a tube to the steeping basket. The hot water seeps through the tea leaves, and the tea drips down into the jar. Finally, the ice-tea is prepared by adding sugar, lemon, and ice to the tea in the jar, and mixing.

Figure 2. Ice tea maker

Based on surveys, the customer requirements are identified; subsequent analysis of the surveys yields the relative importance. Based on the engineering analysis of the design, the corresponding technical features that must be modified are identified. Usually, for each customer requirement, there will be one or more technical feature. Also, the correlation between the CR's and TP's are noted by marking arrows (UP-arrow means positively correlated, i.e. increasing the TP value will increase the CR; DOWN-arrow indicates negative correlation).

	Relative importance	↑ Temp of water in steeping basket	↑ Time water is in contact with tea	↓ Vol of water in tank	↓ Temp of exiting hot tea	↓ Time needed to add tea	↓ Time to clean product	↓ Total volume	↑ Max size of brew	↓ Hottest temp outside container
Stronger tea	9	9	9							
Easy to add ice	5			9	9					
Easy to add tea	5					9				
Easy to clean	3						9	5		
Easy to store	3							9	5	
Brew large amount	2								9	
Steam must not escape	2	△3								9

Figure 3. Steps (i)-(iv) of the QFD process described above.

NOTES:
1. The correlation between the CR's and TP's is shown as number values: 9 means high correlation, 5 means moderate, and 3 means weak. A blank cell means that the correlation is negligible (or zero). [Some companies may use different ratings].

2. Meaning of arrows: e.g., if the 'Time to clean product' is decreased, then 'Easy to clean' rating will increase. Similarly, if the 'Hottest temperature outside the container' is increased, it will decrease the rate of condensation, and more steam will escape from the machine (i.e. objective of 'Steam must not escape' is decreased).

A good convention is to always write the CR's in terms so that "higher/more is better". In this case, you can interpret the arrows as whether the ideal design wants to maximize the corresponding TP (UP arrow), or minimize it (DOWN-arrow).

3. Numerical values for relative importance are derived from customer survey results.

Now we proceed to the next steps: Benchmarking and analysis based on engineering and technical evaluations of what TP's we can aim to modify by changing some design modules.

The technical difficulty of each objective is assigned a numerical rating by the engineers who are in charge of the design of the modules related to this parameter. The team also consults each other to standardize their relative ratings.

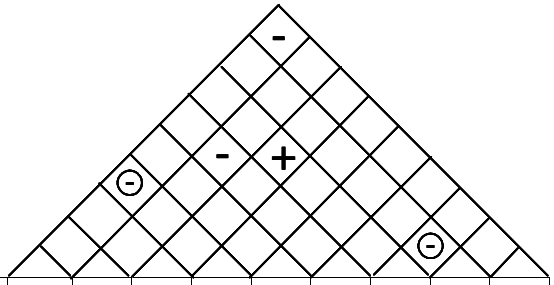
NOTES:

1. Technical difficulty values are relative numbers assigned by engineering teams
2. The right hand side shows comparison of consumer preferences to design of competing products. These numbers are relative, and based on statistics from customer surveys.
3. The 'roof' of the House is completed by identification of inter-related TP's – there are four types of inter-relationships of concern, these are described in the table below.

⊕	strong positive	increase in one will increase the other by similar amount
+	positive	increase in one will increase the other a little
-	negative	increase in one will decrease the other a little
⊖	strong negative	increase in one will decrease the other by similar amount

When there are negative correlations, the re-design will involve some conflict resolution. This means that either a compromise solution must be found by formulation and solving of some optimization problem, or some design modules may need to be re-designed so as to eliminate the conflict.

4. The technical importance is computed as Σ(relative importance)x(correlation rating). Thus the importance of "Temperature of water in steeping basket' = 9x9+2x3 = 87.



		Relative importance	Temp of water in steeping basket ↑	Time water is in contact with tea ↑	Vol of water in tank ↓	Temp of exiting hot tea ↓	Time needed to add tea ↓	Time to clean product ↓	Total volume ↓	Max size of brew ↑	Hottest temp outside container ↓	Mr Coffee Ice Tea Maker	West Bend Ice Tea Maker
Stronger tea		9	(9)	(9)								4	1
Easy to add ice		5			(9)	(9)						3	3
Easy to add tea		5					(9)					3	3
Easy to clean		3						(9)	(5)			3	3
Easy to store		3							(9)	(5)		4	3
Brew large amount		2								(9)		3	3
Steam must not escape		2	△3								(9)	4	1
Technical difficulty			3	4	1	3	3	2	3	3	2		
Measurement units			C		cup	C	sec	sec	ft^3	qt	C		
Target values			98	8.0	3	44	0	30	0.2	3	?		
Objective Measures	West Bend Ice Tea Maker		98	<<	4.8	88	5	20	.4	2	100		
	Mr Coffee Ice Tea Maker		?	8	4.8	?	1	20	.2	2	?		
Technical Importance	Absolute		87	81	63	45	45	27	36	27	18		
	Relative		1	2	3	4	4	6	5	6	8		

Figure 4. Step (v)-(ix) of the QFD procedure for the Ice Tea Maker example

How to use the House of Quality

Once the house is completely constructed, it provides a guideline for decisions on which design features should be modified or upgraded first. If there is unlimited time and money, we would like to upgrade all the features that can be technically improved. However, this may not be the best strategy:

(a) A competitor may introduce a new product and capture some of the potential market while we are trying to improve our product.

(b) It may be better to provide sequential upgrades to tempt earlier users to buy a new machines once in every few time periods (for example, digital camera companies used this technique very effectively in the last few years).

Thus, with budget and time constraints, the House of quality provides the design team with information to prioritize the important (in terms of customer demand) design changes.

Major Reference: Chapter 7 of the textbook, Product Design, Otto and Wood