European Research Studies,
Volume XII, Issue (2) 2009

Application of Quality Function Deployment on an Alternative Transportation System (Paratransit System)

By

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Abstract

Quality Function Deployment (QFD) methodology is applied in the planning of new products/services or the improvement of existing products/services, with the active participation of all departments of the organization, minimizing the initial time of planning and also the cost of planning, with parallel minimization of the failure possibilities of the product/service to enter the market. The basic idea behind this method is to take into serious consideration the "Wants" of the customers, so that they can be translated to engineering characteristics of the product/service. The methodology was introduced in Japan in the late '60s and about 15-20 years later entered USA, while it is now applied in many organizations in Europe. In our work, we will apply QFD in the planning of an alternative transportation system (paratransit) in a "Kapodistrian" Municipality which constitutes many villages.

Keywords: *Quality Function Deployment, House of Quality, Paratransit System, Voice of the Customer, Engineering Characteristics.*

1. Introduction

In our Era, Organisations have to plan and implement strategies that will not only allow them to survive but will provide them capabilities to be more competitive and become leaders. In order to achieve this, they have to make strategic decisions which are in the majority of cases too complex and difficult and involve risk and many times conflicts. To overcome such difficulties, the organisations can use several methodologies that can support making the proper decisions.

Quality Function Deployment (QFD) is such a methodological tool with great popularity that is used for the development of new products or services or the improvement of existing ones. QFD started and evolved in Japan in the late 60s' and according to Ghiya, Bahill and Chapman (1999: 593) nowadays it is used by the majority of the major companies in Japan. QFD entered as a methodology in the USA about 15-20 years after Japan and now is an important products' and services' development tool there and also in Europe.

QFD is used for improving quality, reducing the number of new products that fail to successfully enter the markets and reduce the costs for the development of products and services, reduce the time between the new product (or service) concept and the final product (or service) that is released to the market and improving the competitiveness of the organisations. According to Hauser and Chapman (1988: 65) and as shown in Figure 1 in Appendix 1, preproduction and start-up costs in Toyota were reduced by more than 60% between 1977 when QFD was not applied and 1984 when QFD was well implemented.

The idea behind QFD is to take into serious consideration the "Wants" of the customers or otherwise *the Voice of the Customer*. "A main goal of QFD is to translate customer demands into target values for the engineering characteristics of a product" (van de Poel, 2007: 21). According to Franceschini and Rosetto (1995: 270), the main goal of QFD is to maximise the satisfaction of customer, by making the needful tradeoffs of several design features of a product (or service).

QFD has many variations and is used in normal or extended form (well detailed, subject to existence of enough information from surveys, secondary market research, etc.). Its general format is expressed by the *House of Quality* (HOQ), which is the basic design tool of QFD, as it can be seen in Figure 2 in Appendix 1. "The house of quality is a kind of conceptual map that provides the means for interfunctional planning and communications" (Hauser and Clausing, 1988: 63). According to the same authors (1988: 64) HOQ is needed when the company wants to have all teams (marketing, designing, and manufacturing) to work together and talk about the new products / services and the improvement of products / services.

As described by van de Poel (2007: 22-23), it contains on the left the "What's" or otherwise *the Voice of the Customer (VOC)*. On the centre top we have the "Hows" which are the *Engineering Characteristics (EC)*. In between we have the relationship matrix of VOC and EC (with usually the values of 9 –strong correlation-, 3 –medium correlation- and 1 –weak correlation- or 0 –no correlation- (logarithmic scale with 3 base)). On the right we have the Degree of Importance (DoI), the scoring of our product, the competition, the planned score (takes values between 1 and 5), the Rate of Improvement (RoI) (planned/current score), the Sales Point (SP) (usually takes the values of 1 or 1.2 or 1.5), the absolute weight (DoI * RoI * SP) and the related weight (derived by the absolute weight to sum a total of 100%). Below the relationship matrix of VOC and EC we have the "How much" which include the absolute weights and the relative importance of the ECs, and the corresponding values of the competition and we can also add the target values of EC. Finally on the top we put the Roof of the HOQ which contains the correlation of the several ECs and as Hauser and Clausing mention (1988: 67), it specifies the characteristics that have to be improved collaterally and also the tradeoffs of some ECs.

At this point it is important to mention that the "How much", which is the score of each EC gives the degree of importance of that EC. In general, low scored EC receive less consideration, although they "may be necessary for contractual or other reasons" (Ghiya, Bahill and Chapman, 1999: 596) and although they may not add value for the customer, without them the product or service may face serious acceptance problems in the market. In order to satisfy the customer, serious attention is paid to the high scoring ECs.

A good QFD implementation involve many matrices (usually four phases) similar to the one in Figure 2 in Appendix 1. In Figure 3 in Appendix 1 the relationship of the four QFD matrices is represented according to Ghiya, Bahill and Chapman (1999: 594), in which we start with the VOC related to the EC (Quality Characteristics) (Phase I). The next matrix gets EC on the place of VOC and replaces them by the Product Characteristics (Phase II). In Phase III Product Characteristics take the place of EC and are replaced by the Manufacturing Processes. The last ones take the place of Product Characteristics in Phase IV and are replaced by the Quality Controls. In each matrix after the first (HOQ), the absolute weight of the previous matrix becomes the DoI. In Figure 4 in Appendix 1 the four phases QFD are shown in a similar way by Korayem and Iravani (2008: 480), as used in the design and manufacture of industrial robots. The first of the four matrices is the HOQ. This way the QFD is applied to the whole process of idea to the final product / service.

"The house helps the team to set targets. … The house relieves no one of the responsibility of making tough decisions. It does provide the means for all participants to debate priorities" (Hauser and Clausing, 1988: 68).

2. Application of the QFD model to a new service (Paratransit System)

During an Interreg IIIC program, in 2005-2006, (funded by EU), a project under the title "Connected Cities" aiming to sustainable mobility was implemented. A session was the Development of "Paratransit System" (PS) for rural areas (a Municipality constituted by many villages). We applied QFD on that new service. The project expanded for testing through FP6 program (funded by EU) under the title "InMoSion" and it is currently under implementation. The empirical data are not available at the present and they are expected after completion of the project by its coordinators, approximately by end of 2009.

The idea behind the PS is to develop a Transportation system for the inhabitants of a region that would combine the advantages of the Bus-System and the Taxis-System, for the benefit of the customers. PS can take special care for disabled people. Ziliaskopoulos (2006a & 2006b) gives a brief analysis of the PS and the results of a related Work-Shop at the web pages of the above mentioned project. As this is a new system many issues had to be solved, and it would need a new Organisation, Vehicles, Drivers, Offices, a Dispatcher, Electronic Devices, Powerful Computer Systems and Sophisticated Software for the calculations of the optimal routes, good marketing and communication. The new System should also ensure its feasibility, as it would have to compete with the private taxis and the busses-system, with the last one in most cases in Europe being semi-subsidised by the state. Petamidis (2006) presented briefly the possibility for the deployment of such a System in Municipality of Philippi (a rural Municipality, constituted by many villages). PS in Municipality of Philippi, could include not only ordinary users but also visitors to the Healing baths, Tourists (between different monuments in Philippi), special groups for alternative tourism in Philippi, transportation to neighbour municipalities, transportation to the KTEL bus-stations, students to schools, students to afternoon activities, transportation within villages for the big ones, Municipal Bureau employees for their activities, transportation form villages to the bazaar, transportation for special events (cultural, etc.). Tsoukalidis (2008) gave a brief description of proposals for the feasibility of such a PS and named funding factors of PS, including the users, KTEL for the users moving to the bus-stations, bazaar merchants and shop-owners for their customers that used PS, the private tutorial schools and state funding.

To study the System, beside the Algorithms and Software Design and other related issues a survey using six surveyors took place in Municipality of Philippi, in early 2006, on the 2% of the population (221 fulfilled questionnaires).

Due to lack of available information and resources in this case applying all four phases of QFD is impossible, therefore and as described by Ghiya, Bahill and Chapman (1999: 598) the "Hows" are replaced by "How can we solve it".

According to the survey and other secondary information, the VOC gives us the Customer "Wants", which we put on the left of the HOQ (Collect me from the desired point - a "TAXI" feature, Collect me at the desired time - a "TAXI" feature, Transport me to the desired point - a "TAXI" feature, Transport me straight to the desired point - a "TAXI" feature, Attractive Price - a "BUS" feature, Provide Driving Safety - a general demand, Provide Security for my children (if alone) - a general demand, Inner Vehicle Good Conditions - a general demand a more "TAXI" feature, Automatic Tickets/Payment System - a "BUS" feature, Environmentally Friendly - a general demand.

The above customer "Wants" will be correlated in the relationship matrix with the Engineering Characteristics (EC – "Hows") which we put on the centre top.

The ECs for our Paratransit System are: a) Up to 8 passengers / vehicle: This is the vehicle's capacity of the suggested system (capacity). In its more general form the System could also have few vehicles with capacity of 16 passengers, but this is a perspective we do not study here. b) Sophisticated Software – ICT: This is a need for the design and implementation of software that uses special algorithms to solve the systems of equations for the optimal routes that minimise the time between departure and arrival point, reduces to minimum the use of the vehicles to reduce the cost of the system and have more vehicles available at any time of the day. c) Ease to enter the vehicle (low profile): This is a special feature useful for people with mobility difficulties. d) Automatic Payment System: This is a characteristic to link the ticket cost to alternative solutions for funding the system, some of which are shown above. e) Application Cost (Staff – Conservation Excluded): This is the Cost of the Paratransit System, which include the fixed assets costs and also Variable costs, excluding the staff cost and the conservation costs. f) Staff Cost: This is the cost for the staff of the Paratransit System. g) System Conservation Cost: This is the Cost to keep the System functional and safe.

We correlate the "Wants" with the "Hows" using the symbols "**Θ**", "**O**" and "▲" which take the values "9" (strong correlation), "3" (medium correlation) and "1" (weak correlation) respectively. For no correlation we keep the cells blank.

On the right of the HOQ, as described above, we put the score for every "Want" for the following Fields in the same sequence:

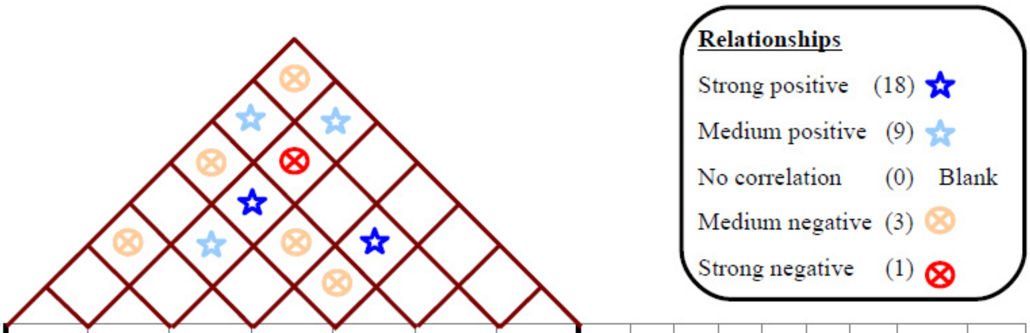
- DoI according to the survey and secondary information (to give total 100),
- The current solution is scored by 1 (currently no application is in use).
- The competitors are the Taxis and the Busses (values between 1 and 5).
- Planned score for our solution (values between 1 and 5)
- RoI for our case gives the same figure with the planned value
- SP takes the values of 1 or 1.2 or 1.5
- The absolute weight is the product of DoI, RoI and SP
- The related weight is calculated from the absolute weight to give a total of 100%.

Below the relationship matrix of VOC and EC we have the "How much" where we calculate:

- The absolute weight (total score) of each EC as the sum of the total correlation scoring of each "Want". The score for each "Want" is the product of its correlation with the specific EC and the DoI. "The total score for each column is an indication of the importance of that characteristic in measuring customer's satisfaction" (Ghiya, Bahill and Chapman, 1999: 596).
- The Relative Weight which is calculated from the absolute weight (above) to give a total of 100% (normalisation).
- The absolute weight of the competitors for the same EC (one row for each competitor), which are calculated similarly.
- The Target weight (score) in the next row remains blank (not used it in our case).
- Below we calculate the rank of each EC score to measure its importance. This will allow us to decide, subject to the available budget, on which "Hows" we will deploy by priority.

Finally on the top we put the Roof of the HOQ which contains the correlations and tradeoffs between the several EC, using the symbols "☆" (Strong Positive - 18), "☆" (Medium Positive - 9), "⊘" (Medium Negative - 3), "⊘" (Strong Negative - 1) and blank cells (No correlation – 0).

Below we give the HOQ as calculated (we used OpenOffice Calc 2.4.1).



CUSTOMER WANTS / ENGINEERING CHARACTERISTICS	Up to 8 passengers / vehicle	Sophisticated Software – ICT	Ease to enter the vehicle (low profile)	Automatic Payment System	Application Cost (Staff – Conservation Excluded)	Staff Cost	System Conservation Cost	Degree of Importance	Current Solution	Competitor 1 (TAXIS)	Competitor 2 (Buses – KTEL)	Plan	Improvement Rate	Sales Point	Absolute Weight	Relative Weight
Collect me from the desired point	▲	Θ			Θ	Θ		14	1	5	2	5	5	1,5	105,0	0,17
Collect me at the desired time	O	Θ			Θ	Θ		14	1	5	2	4	4	1,5	84,0	0,14
Transport me to the desired point					Θ			14	1	5	2	5	5	1,5	105,0	0,17
Transport me straight to the desired point	▲				O	O		14	1	5	2	3	3	1,5	63,0	0,10
Attractive Price	O	Θ		Θ	▲	▲	O	14	1	1	4	4	4	1,5	84,0	0,14
Provide Driving Safety		Θ			O	O	Θ	7	1	4	4	4	4	1,2	33,6	0,06
Provide Security for my children (if alone)			Θ	▲		O	Θ	10	1	1	1	4	4	1,5	60,0	0,10
Inner Vehicle Good Conditions	▲					Θ	Θ	7	1	4	3	4	4	1,2	33,6	0,06
Automatic Tickets/Payment System				Θ	O			4	1	1	2	5	5	1,2	24,0	0,04
Environmentally Friendly	O	Θ			▲		Θ	2	1	2	2	5	5	1,0	10,0	0,02
Absolute Weight	125	459	90	172	469	422	276									
Relative Weight	0,06	0,23	0,04	0,09	0,23	0,21	0,14									
Competitor 1 (TAXIS) Values	0	0	0	0	48	63	153									
Competitor 2 (Buses – KTEL) Values	0	0	30	18	87	94	63									
Target																
Rank:	6	2	7	5	1	3	4									

Notes:

Sales Point: 1 or 1,2 or 1,5

VOC-EC Correlation Matrix: Θ, O, ▲, Blanc	
Θ	9
O	3
▲	1
	0

From the HOQ we make some serious conclusions:

According to the relative weight of the "Wants", as shown also in the graph in Figure 5 in Appendix 1, the most important ones are to have the solution at the desired point (departure and arrival) (0,17) to be collected on time (0,14) and the system to have an attractive price (0,14).

According to the Rank of the ECs the most serious characteristic is the Application Cost which includes mainly the fixed assets cost and variable costs.

Next is the cost for the software and ICT, which is important for making the system work properly and meet its scope. Third characteristic in importance is the Staff cost.

It is important to mention that the Ranking is only an indication of the importance of the characteristics and works as a guideline.

Other important conclusions are the relationships and the tradeoffs of the ECs, which we do not valuate in this study.

3. Questioning for the implementation of PS

From the information retrieved from the analysis above some serious questions regarding the feasibility of the implementation of a PS in a small Municipality with many villages are raised.

- The First is the option of having in the PS some vehicles with bigger capacity.
- The second is if we should consider TAXIS to enter the PS as operators also (with special terms complying with the purposes of PS) and reduce the cost of PS.
- The third is the possibility to use the PS in greater regions. By doing this the Vehicles of the PS could be used more in peak, as in different periods there are different / intension needs in other areas in neighbor municipalities. In this case we should also benefit by using the Control/monitoring centre and the ICT / software for greater number of customers. Finally we would manage to have reduced staff cost per served inhabitant (without quality deduction for the offered services)
- The fourth is the use of alternative funding sources that minimize the cost.

4. Comment on the utility of the model and highlight of the encountered problems

As in all methodologies QFD has advantages and disadvantages. In literature we find many researchers implementing sophisticated methods to improve QFD so that it becomes more effective in various cases. Below we provide some problems we faced during our work.

The first problem using QFD was the fact that during the survey the potential users of the PS had in mind the competitors and could not get clearly the picture of the new proposal. This was understood to affect somehow their answers and relatively the DoI. This is a general problem in QFD process as surveys always lead to uncertainty during quantification of the collected information. According to Kannan (2008: 329), this uncertainty problem can be reduced by using Fuzzy Logic, as fuzzy numbers can reproduce the subjectivity of the people. In Figure 6 in Appendix 1 a good example of Fuzzy numbers is given. Kannan (2008: 331) applied Fuzzy QFD (FQFD) to a product and compared it to traditional QFD process to conclude that the last produces ratings that are near the upper limits (inflated), while FQFD expressed in values ranges provide a better picture.

The second problem was our subjectivity on the correlation of VOC and

ECs, the Relationship between different ECs, the DoI values (although the survey was seriously considered), the valuation of each of the “Wants” for the Competitors of the proposed system and the values of the Sales Point.

The third problem for using QFD was the set values of the relation between “Wants” and “Hows”. The use of the 9-3-1 (Weber’s law) correlation values emphasises on the Strong Relationship. Ghiya, Bahill and Chapman (1999: 603) did sensitivity analysis testing in a product and found out that QFD is robust enough in small changes of the correlation values. We did sensitivity analysis by deemphasising the Strong Correlation (**Θ**) from 9 to 7 and then 9 to 6 and then changed the base of the logarithmic scale from 3 to 2 and used the of 4-2-1 instead of 9-3-1 and the Rank of the ECs remained unchanged for the first case while for the second and the third one a small change occurred, as in the case presented by the authors above. The results are shown in Appendix 2.

The fourth problem was that the users’ “Wants” were not similar for all. In other words we took their preferences as collective ones, while it is not exactly like that. van de Poel (2007: 32) gives a good example of that paradox, which is the case of a product with three features (colour, size, shape), taking respectively the values of red or green, large or small and flat or bumpy. In this case as shown in Table 1 in Appendix 1 we can not take the collective approach as “the most preferred product is actually disliked by all customers” (van de Poel, 2007: 32).

The fifth problem was the fact that this was an innovative service in a rural area, thus we had no evidence for its acceptance and if it could be workable at all. The sixth problem was that the solution was a new service that was not in use and there were no existing users; only potential ones. This loads the innovation with high risk, especially when knowing that its initial and functional cost is high. As the designers and decision makers will involve various tradeoffs (like the “low-profile” of the vehicles or their capacity) it is vital such trade offs not to lead to failure. According to Raharjo, Brombacher and Xie (2008: 254), QFD is highly subjective because it is applied before the design of new products / services or improvement of existing ones, thus many parameters are taking values that are estimated. Thus, if the input values of the parameters are not as close to reality as possible QFD results will be problematic. To eliminate this problem “a method or approach that is capable to systematically analyse and accurately quantify those subjective experience and judgements of the QFD team is highly required” (Raharho, Brombacher and Xie, 2008: 254). At this point the literature suggests that Failure Mode Effects Analysis (FMEA) should be used. “Interlinking the QFD with the FMEA technique was felt to be necessary to highlight any related trade-offs or areas of concern, which might require a review of the design and implementation” (Almannai, Greenough and Kay, 2008: 503)

The seventh problem was that although the intention was the satisfaction of the customer, “fulfilling customer expectations to a great extent do not necessarily imply a high level of customer satisfaction.” (Chen and Chiu, 2007: 453) as according to Matzler *et* al (1996) as cited in Chen and Chiu (2007: 453) the perception of quality is related to the type of expectation. To overcome this problem the Kano’s model can be used as described by the Chen and Chiu (2007: 453) which uses positive questions about the feeling for certain characteristics and negative questions for their absence. In Figure 7 in Appendix 1 the Diagram of Kano’s model is shown.

The eighth problem was that we used only Phase 1 of the QFD (the HOQ), as actually the majority of the organisations does, as we were not in position to proceed to the next phases QFD process, thus “the technical requirements are generally defined in very broad terms” (Kovach and Cho, 2008: 350), as we can verify from the ECs we used in our case.

The ninth problem was that we did not integrate the financial issues and actually the feasibility of the system. To overcome such a problem, Chen, Chang and Chou (2008) incorporated the methodology of Balanced ScoreCard (BSC), among with the methodology of Theory of Constrains (TOC) into Fuzzy QFD, “to ensure that the service process design simultaneously meets the needs of employees, shareholders and customers” (Chen, Chang and Chou, 2008: 664). In Figure 8 in Appendix 1 we provide the related design framework.

5. Conclusion – Discussion

Our work did lead to some questioning and the produced results are in accordance with the ones, Ziliaskopoulos (2006a), that did outcome on a related Workshop for PS. It is important to compare the results of the QFD methodology we applied, with the empirical data, after the completion of the testing of the PS and its analysis.

QFD is proven to be a popular and successful tool to enhance the quality of a new or redesigned or improved product or service by reducing the initial design cost and consumed design time for the customers’ satisfaction. However the complexity of the modern products/services and the Needs and “Wants” of the customers require the use of a more sophisticated version of QFD or the use of QFD in combination with other techniques.

References

1) Almannai, B., Greenough, R. and Kay, J. (2008), A Decision Support Tool Based on QFD and FMEA for the Selection of Manufacturing Automation Technologies, Robotics and Computer-Integrated Manufacturing, Vol. 24, Issue 4, p. 501-507.
2) Cheng, B.W. and Chiu, W.H. (2007), Two-dimensional Quality Function Deployment: An Application for Deciding Quality Strategy Using Fuzzy Logic, Total Quality Management and Business Excellence, Vol. 18, Issue 4, p. 451-470.
3) Cheng, C.H., Chang, Y.H. and Chou, S.Y. (2008), Enhancing the design of air cargo transportation services via an integrated fuzzy approach, Total Quality Management and Business Excellence, Vol. 19, Issue 6, p. 661-680.
4) Franceschini, F. and Rossetto, S. (1995), QFD: The problem of Comparing Technical/Engineering Design Requirements, Research in Engineering Design, Vol. 7, Issue 4, p. 270-278.
5) Ghiya, K.K., Bahill, A.T., Chapman, W.L. (1999), QFD: Validating Robustness, Quality Engineering, Vol. 11, Issue 4, p. 593-611.
6) Hauser, J.R. and Clausing, D. (1988), The House of Quality, Harvard Business Review, Vol. 66, Issue 3, p. 63-73.
7) Kannan, G. (2008), Implementation of Fuzzy Quality Function Deployment in an Automobile Component to Improve the Quality Characteristics, Quality Engineering, Vol. 20, Issue 3, p. 321-333.
8) Korayem, M.H. and Iravani, A. (2008), Improvement of 3P and 6R Mechanical Robots Reliability and Quality Applying FMEA And QFD Approaches, Robotics & Computer-Integrated Manufacturing, Vol. 24, Issue 3, p. 472-487.
9) Kovach, J. and Cho, B.R. (2008), Solving Multiresponse Optimisation Problems Using Quality Function-Based Robust Design, Quality Engineering, Vol. 20, Issue 3, p. 346-360.
10) Petamidis, B. (2006), Innovative Transport Systems for the better connectivity of remote rural areas. Suitability of a paratransit system deployment in Philippi area.
11) URL: http://connectedcities.eu/downloads/showcases/pt_philippi.pdf [accessed on 8 Oct 2008].
12) Raharjo, H., Brombacher, A.C. and Xie, M. (2008), Dealing with Subjectivity in Early Product Design Phase: A Systematic Approach to Exploit Quality Function Deployment Potentials, Computers & Industrial Engineering, Vol. 55, Issue 1, p. 253-278.
13) Tsoukalidis, I. (2008), An Alternative transportation system – feasibility issues, unpublished conference speech, presented at the 1st Open Conference of the research project "InMoSion - Science Shop for Innovative Mobility Solutions for Mobility Challenged Europeans", Philippi.
14) Van de Poel, I. (2007), Methodological problems in QFD and directions for future development, Research in Engineering Design, Vol 18, Issue 1, p. 21-36.

15) Ziliaskopoulos, A. (2006a), Showcase Workshop. Paratransit Transport Systems, [Available at - http://connectedcities.eu/downloads/showcases/pt_workshop_minutes.pdf, accessed 8 October 2008].
16) Ziliaskopoulos, A. (2006b), Workshop: Paratransit Transport Systems in the Municipality of Philippi, [Available at - http://connectedcities.eu/downloads/showcases/pt_workshop_results.pdf , accessed 8 Oct 2008].

Appendix 1 – Figures and Tables

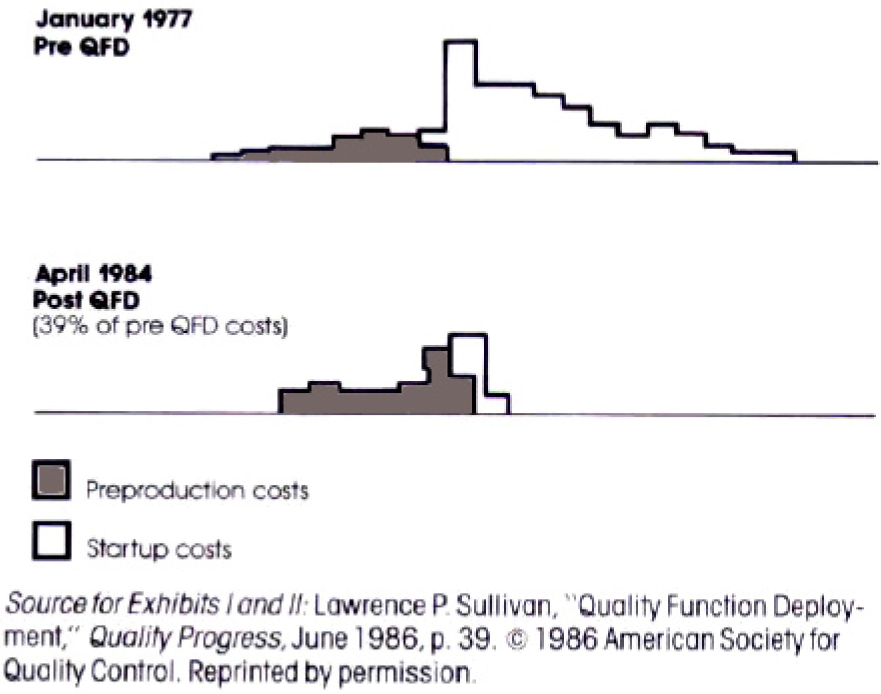


Figure 1 Startup and preproduction costs at Toyota Auto Body before and after QFD (Hauser and Clausing, 1988, Exhibit I).

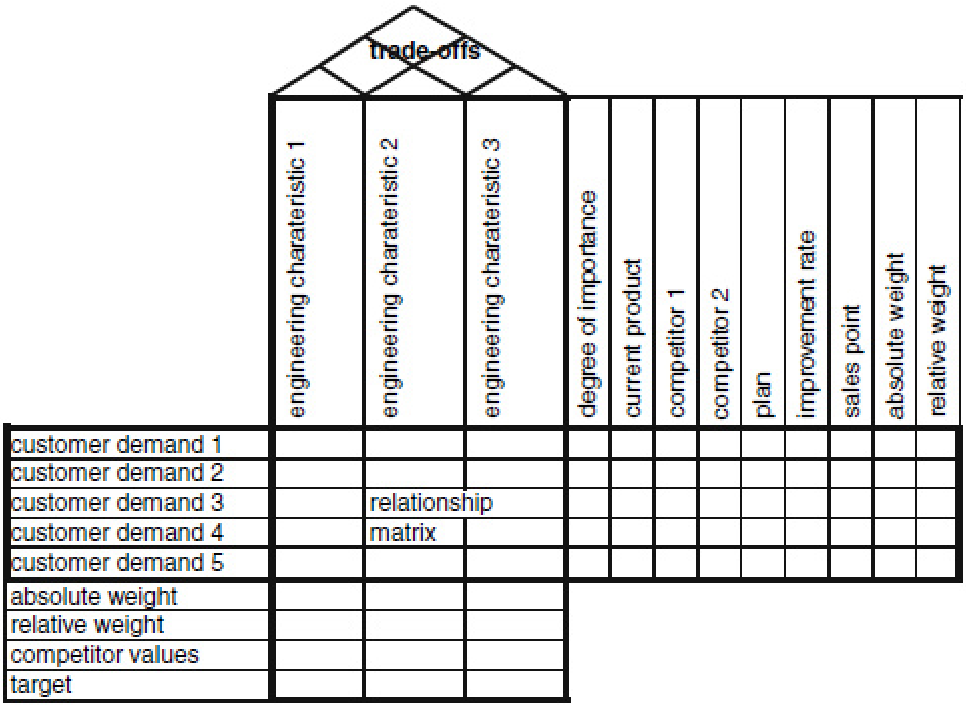


Figure 2 House of Quality (van de Poel, I., 2007: Fig 1)

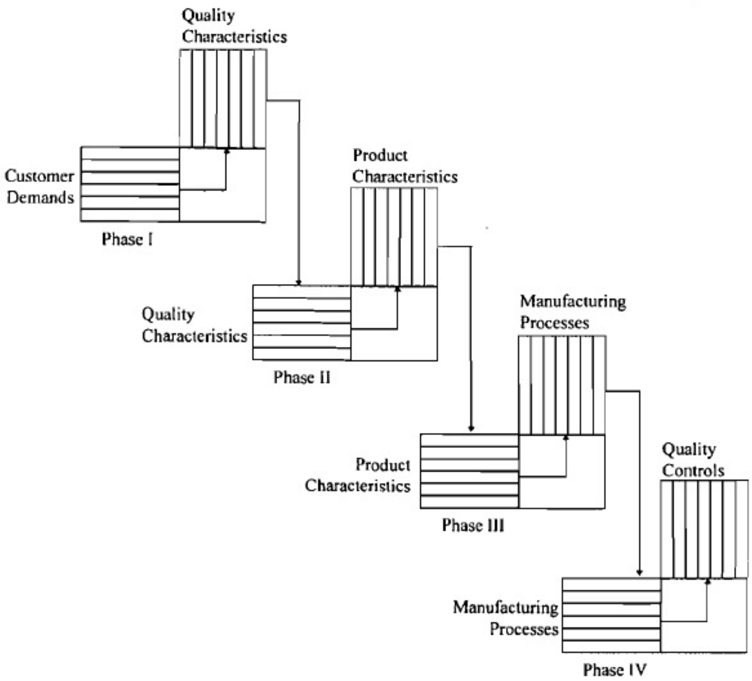


Figure 3 Relationship of the four QFD charts (Ghiya, Bahill and Chapman, 1999: Figure 1)

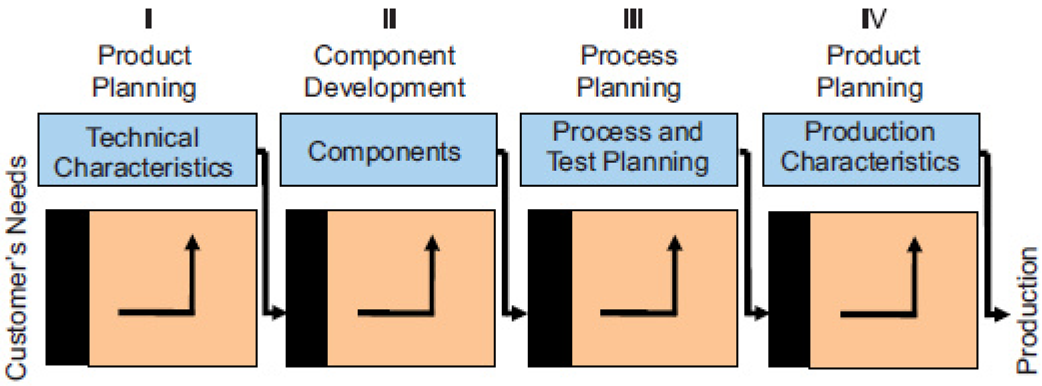


Figure 4 Relations between the four matrixes of QFD (Korayem and Iravani, 2008: Fig. 14)

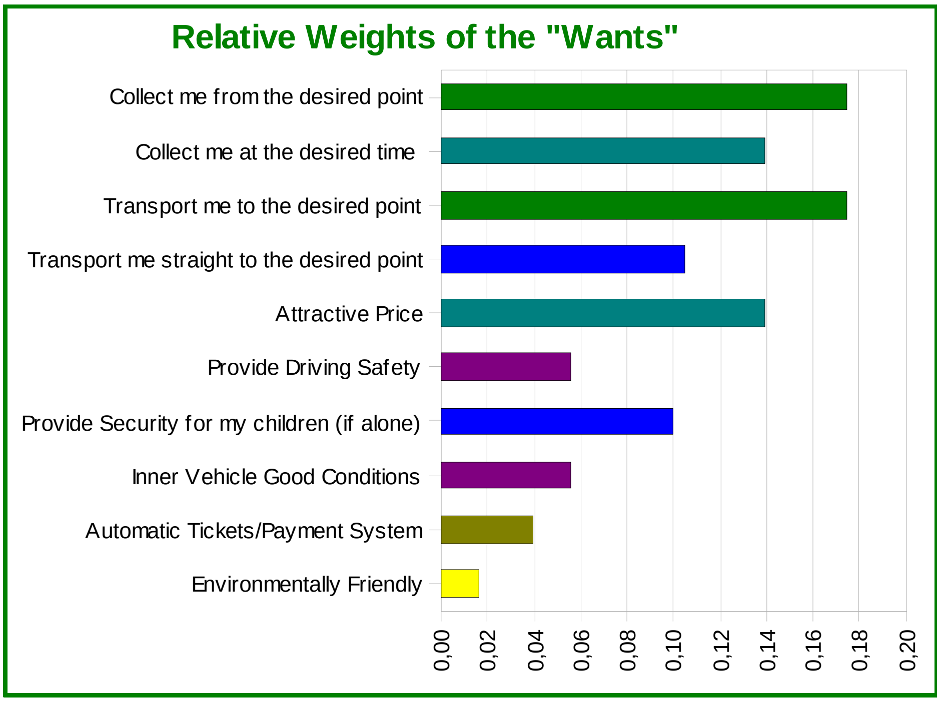


Figure 5 Relative Weights of the Voice of Customer ("Wants") for the Paratransit System (produced by the Authors, using OpenOffice.Org Calc, ver 2.4.1)

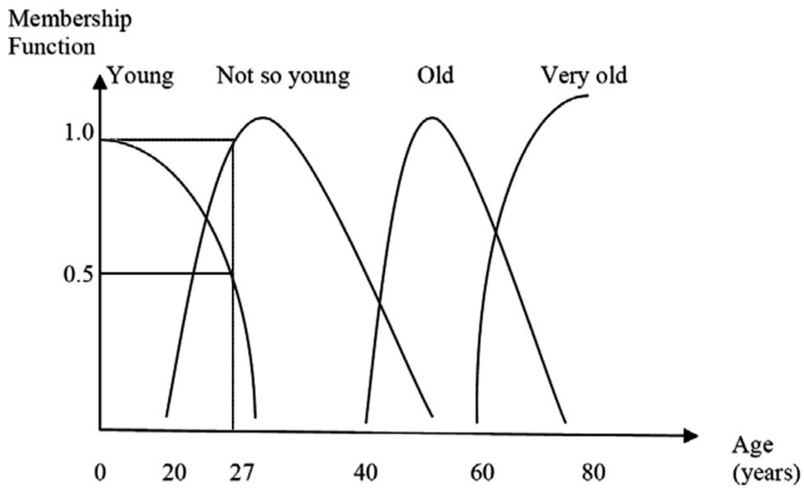


Figure 6 Fuzzy Numbers example (Kanan, G. 2008: Figure 4)

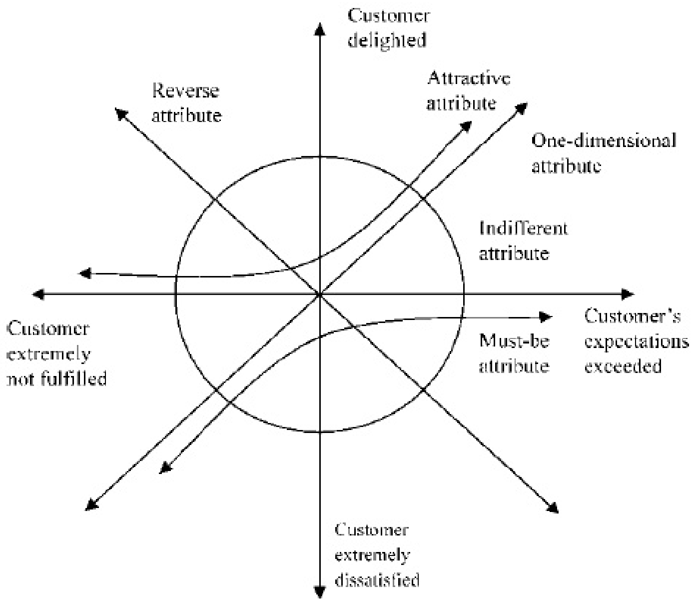


Figure 7 Diagram of Kano's 'two-dimensional' model (Chen and Chiu 2007: Figure 1)

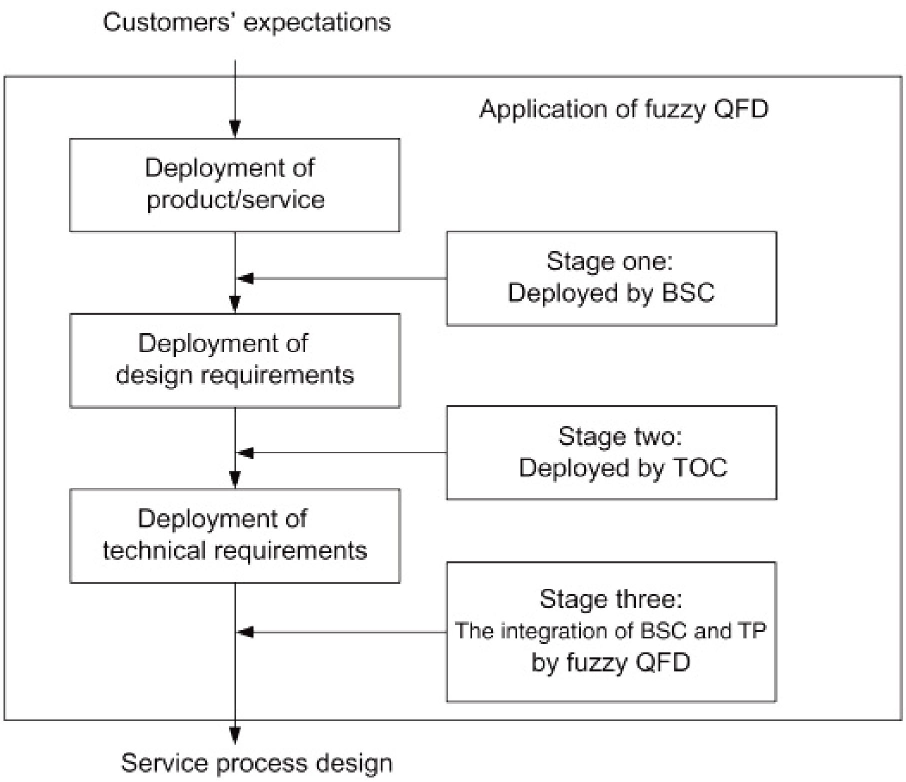


Figure 8 Design framework for integrating BSC and TOC into FQFD (Cheng, *et al*, 2008, Figure 4)

Preferences	Colour	Size	Shape
Customer 1	Red	Large	Flat
Customer 2	Red	Small	Bumpy
Customer 3	Green	Large	Bumpy
Collective	Red?	Large?	Bumpy?

Table 1 "Preferences of three groups of customers with respect to colour, size and shape (van de Poel, I., 1996: Table 2)

Appendix 2 – Sensitivity Analysis

(a) Change of 9-3-1 to 7-3-1 rule

CUSTOMER WANTS / ENGINEERING CHARACTERISTICS	Up to 8 passengers / vehicle	Sophisticated Software – ICT	Ease to enter the vehicle (low profile)	Automatic Payment System	Application Cost (Staff – Conservation Excluded)	Staff Cost	System Conservation Cost
Collect me from the desired point	▲	Θ			Θ	Θ	
Collect me at the desired time	O	Θ			Θ	Θ	
Transport me to the desired point					Θ		
Transport me straight to the desired point	▲				O	O	
Attractive Price	O	Θ		Θ	▲	▲	O
Provide Driving Safety		Θ			O	O	Θ
Provide Security for my children (if alone)			Θ	▲		O	Θ
Inner Vehicle Good Conditions	▲					Θ	Θ
Automatic Tickets/Payment System				Θ	O		
Environmentally Friendly	O	Θ			▲		Θ
Absolute Weight	125	357	70	136	385	352	224
Relative Weight	0,08	0,22	0,04	0,08	0,23	0,21	0,14
Competitor 1 (TAXIS) Values	0	0	0	0	48	63	119
Competitor 2 (Buses – KTEL) Values	0	0	30	18	87	94	49
Target							
Rank:	6	2	7	5	1	3	4

Notes:

Sales Point: 1 or 1,2 or 1,5

VOC-EC Correlation Matrix: Θ, O, ▲, Blanc

Θ	7
O	3
▲	1
	0

The Rank of the ECs remains unchanged.

(b) change the rule 9-3-1 to 6-3-1

CUSTOMER WANTS / ENGINEERING CHARACTERISTICS	Up to 8 passengers / vehicle	Sophisticated Software – ICT	Ease to enter the vehicle (low profile)	Automatic Payment System	Application Cost (Staff – Conservation Excluded)	Staff Cost	System Conservation Cost
Collect me from the desired point	▲	Θ			Θ	Θ	
Collect me at the desired time	O	Θ			Θ	Θ	
Transport me to the desired point					Θ		
Transport me straight to the desired point	▲				O	O	
Attractive Price	O	Θ		Θ	▲	▲	O
Provide Driving Safety		Θ			O	O	Θ
Provide Security for my children (if alone)			Θ	▲		O	Θ
Inner Vehicle Good Conditions	▲					Θ	Θ
Automatic Tickets/Payment System				Θ	O		
Environmentally Friendly	O	Θ			▲		Θ
Absolute Weight	125	306	60	118	343	317	198
Relative Weight	0,09	0,21	0,04	0,08	0,23	0,22	0,13
Competitor 1 (TAXIS) Values	0	0	0	0	48	63	102
Competitor 2 (Buses – KTEL) Values	0	0	30	18	87	94	42
Target							
Rank:	5	3	7	6	1	2	4

Notes:

Sales Point: 1 or 1,2 or 1,5

VOC-EC Correlation Matrix:	Θ	6
Θ, O, ▲, Blanc	O	3
	▲	1
		0

Change of ECs Rank from 6/2/7/5/1/3/4 to 5/3/7/6/1/2/4. Of the first 3 ranked ECs (Application Cost, Sophisticated software, Staff cost) only the 2nd changed with the 3rd.

(c) change of the rule 9-3-1 to 4-2-1

CUSTOMER WANTS / ENGINEERING CHARACTERISTICS	Up to 8 passengers / vehicle	Sophisticated Software – ICT	Ease to enter the vehicle (low profile)	Automatic Payment System	Application Cost (Staff – Conservation Excluded)	Staff Cost	System Conservation Cost
Collect me from the desired point	▲	Θ			Θ	Θ	
Collect me at the desired time	O	Θ			Θ	Θ	
Transport me to the desired point					Θ		
Transport me straight to the desired point	▲				O	O	
Attractive Price	O	Θ		Θ	▲	▲	O
Provide Driving Safety		Θ			O	O	Θ
Provide Security for my children (if alone)			Θ	▲		O	Θ
Inner Vehicle Good Conditions	▲					Θ	Θ
Automatic Tickets/Payment System				Θ	O		
Environmentally Friendly	O	Θ			▲		Θ
Absolute Weight	95	204	40	82	234	216	132
Relative Weight	0,09	0,2	0,04	0,08	0,23	0,22	0,13
Competitor 1 (TAXIS) Values	0	0	0	0	32	42	68
Competitor 2 (Buses – KTEL) Values	0	0	20	18	66	66	28
Target							
Rank:	**5**	**3**	**7**	**6**	**1**	**2**	**4**

Notes:

Sales Point: 1 or 1,2 or 1,5

VOC-EC Correlation Matrix: Θ 4

Θ, O, ▲, Blanc
- O 2
- ▲ 1
- 0

We get the same ranking as previously.