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Quality Function Deployment and Value Engineering Applications in Smartphone Cost Management

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ABSTRACT

The integration of Quality Function Deployment (QFD) and Value Analysis (VA) into your product improvement process helps in developing the products that customers want and value, characterized as QUALITY/COST. Considering cost in the product development process is an imperative issue. Different features of an item and ways to produce it are resolved in the design stage. This helps careful consideration in all phases of the design activities. While VE achieves this purpose by lowering the costs and increasing the value for the customers, and QFD takes into account all the needs and requirements of the customers and attempts to fulfil them, which subsequently may lead to the increase in product/service satisfaction of the customers. This study will describe the customer assessment process including an electronic survey, the deployment through the house of quality to a function analysis, multiple cost modelling studies, and the design concepts that were created and proposed to the smartphone design.

Keywords: Functional Evaluation, Cost Coefficient, Value Coefficient, House of Quality, Quality Function Deployment (QFD), Product Improvement.

INTRODUCTION

Quality Function Deployment (QFD)

QFD is an approach that provides a means for making an interpretation of customer necessities into the proper Technical Attribute (TA) for every phase of product development and production [1]. House of Quality (HOQ) has been considered for cost management in the design phase. QFD was originally proposed through collecting and analysing the customer surveys to develop products with higher quality in order to meet customer needs. The primary functions of QFD are product development, quality management and customer need analysis. The major benefits of using QFD are:

i. QFD helps the entrepreneurs by reengineering the cross-functional contributions between the customer demands and what the company can provide to obtain new product design.

ii. QFD expands consumer satisfaction by ensuring that customer demands are brought into the product development process.

iii. Critical production process was never neglected.

iv. It would enlarge the chance of success, produce higher quality products, and decrease the cost and the time consuming in the product development.

Value Engineering (VE)

Value Engineering is a specialized and economic strategy which studies on the most proficient method to accomplish the fundamental capacity with the least cost. The primary thought of Value Engineering is to improve the value of the product by analysing the functions of the product or service, establish the worth of those and provide the necessary functions to meet the required performance [2]. Value Engineering is usually applied in the analysis and design of a product. VA/VE's emphasis on achieving the required functions at the least cost, separates it from the Lean and Six Sigma methodologies. Value Engineering minimizes material waste, time, and product cost while achieving the customer requirements. The formula of calculating the value is V=F/C, Where, V stands for value coefficient, F stands for functional coefficient, and C stands for cost coefficient.

In this study, we concern on value coefficient, whose V>1or V<1. If V=1, that proposes the cost matches the function, it is an impeccable circumstance. In the event that V>1, that recommends the cost of the function is low or the capacity is overflow, sometimes it is brought on by the high cost of other components. On the other hand, if V<1, that recommends the cost is on the high side or the capacity is lacking. In the event that V=0, that proposes the part can be combined or excluded.

Concept of Integration

Value Engineering (VE) and QFD have distinctive acclimatization. The fundamental objective of V.E is the reduction of operational costs in the principle and support process of an organization whereas the QFD concentrates on the customer needs and necessities and tries to realize advancements in the product design in a way that more customer satisfaction is obtained. This technique looks for changes to product process with greater value to customer needs [3]. By integration of these two function oriented techniques in a decision-making process may lead to the new product development which not just appreciates a higher quality by the clients additionally forces less costs on the production, a variable which adds to the price stability/ cheaper product/ service cost prices.

Integration of QFD and VA have a several elements which give an extremely sound premise:

i. A mixed control group for extreme effectiveness.

ii. Specific objectives are a key component.

iii. A product definition is required to scope of project.

iv. Concentrate on the imperative few instead of the unimportant numerous. (Pareto's Law).

v. Customer focused.

VALUE ENGINEERING ANALYSIS OF THE SAMSUNG GALAXY NOTE 3

A case study of a Smartphone is discussed in which the material and design of components is changed according to the value engineering methodology. In this case study, it is observed that the unnecessary increase in cost is due to the use of expensive material, increase in variety of hardware items, oversize of material etc. We have selected some parts from Cell phone i.e. touchscreen & glass, battery, camera, connectivity, NAND (Memory Card), SDRAM, processor, power mgmt., Non-electric parts, Supporting Materials, other etc. and we have applied value engineering technique for the cost reduction of these components of Samsung Galaxy Note 3 through calculating the Functional coefficient, Cost coefficient and Value coefficient for the cost reduction of these parts of Smartphone. Therefore, using Value Engineering technique, Design modification and material change for touchscreen glass, processor, non-electric parts and supporting materials is suggested in this case study and thereby which cost reduction is achieved [4].

Cost Distribution

The Smartphone consists of different components and cost of each component divided by the total cost of the Smartphone assembly can gives the proportion of total costs of each components, then cumulate the proportion of total costs of each components one by one can we get the cumulative proportion of total costs. According to above process, we can calculate the result of ABC analysis of the Smartphone, as table 1 shows. According to the principle of classification, if cumulative proportion of total costs of the component is between 60%-70%, the component is classified as the A classification, if it is between 15%-20%, the component is classified as the B classification, and if it is near 10%, the component is classified as the C classification.

Table1. *ABC Analysis of the Smartphone Components*

Name of Component	No.	Proportion of the Total No.	Current Cost In $	Proportion of Total Cost	Cumulative proportion of total cost	Classification
Touchscreen & Glass	1	6%	61.00	26.24	26.24	A
Battery	1	6%	6.50	2.80	29.03	B
Camera	1	6%	15.00	6.45	35.48	B
Connectivity	1	6%	14.00	6.02	41.51	A
NAND (Memory Card)	2	11%	15.00	6.45	47.96	C
SDRAM	1	6%	10.00	4.30	52.26	C

Processor	1	6%	49.50	21.29	73.55	C
Power Mgmt./Audio	1	6%	6.50	2.80	76.34	A
Non-Electric	3	17%	10.50	4.52	80.86	B
Supporting Materials	4	22%	31.50	13.55	94.41	C
Other	2	11%	13.00	5.59	100.00	C
Total	18	100%	232.50	100		

Functional Evaluation

Step 1: Defining Functional Importance Coefficient

Computing the functional importance coefficient using absolute evaluation method needs 6 operators to review for each function. Sum up the grade of each function given by the 6 operators, and then calculate the importance coefficient using the total grade of each function given by the 6 operators to divide by the total grade of the smartphone assembly. The grade given by operators and the result of calculating the functional importance coefficient are just like table 2 shown. From the result, we can see that functional importance coefficient of support the computer is 31.17%, functional importance coefficient of easy to handle is 17.67%, functional importance coefficient of durable is 26%, functional importance coefficient of beautiful appearance is 25.17%.

Table2. *Calculation of Functional Coefficient*

Function of Galaxy Note 3	Expert Rating						General Comment Score	Functional Importance Coefficient
	A	B	C	D	E	F		
Support the Cell Phone	35	30	40	32	25	25	187	31.17%
Easy to handle	20	15	18	14	17	22	106	17.67%
Durable	25	30	22	25	28	26	156	26.00%
Beautiful Appearance	20	25	20	29	30	27	151	25.17%
Total	100	100	100	100	100	100	600	100%

Step 2: Calculating the Functional Evaluation Coefficient of Key Components

The operators are asked to grade for each function of each component, the total grade of each function is 100, which is shown in table 3. Then calculate the functional coefficient of each component shown in table 4 by multiplying functional importance coefficient which is shown in table 3 and the functional proportion coefficient which is shown in table 3.

Table3. *Functional Distribution of the Key Component of Galaxy Note 3*

Name of Component	Functional Items			
	Support the Cell Phone	Easy to handle	Durable	Beautiful Appearance
Touchscreen & Glass	15	30	20	40
Battery	20	0	10	0
Camera	20	0	5	5
Connectivity	5	10	10	0
NAND (Memory Card)	10	0	0	0
SDRAM	0	5	5	0
Processor	10	25	25	20
Power Mgmt./Audio	15	15	20	5
Non-Electric	0	0	0	0
Supporting Materials	0	10	5	30
Other	5	5	0	0
Total	100	100	100	100

Table4. *Functional Evaluation Coefficient of the Key Components of the Cell phone*

Name of Component	Functional Items				Functional Evaluation Coefficient
	Support the Cell Phone	Easy to handle	Durable	Beautiful Appearance	
Touchscreen & Glass	0.0468	0.0530	0.0520	0.1007	0.2524
Battery	0.0623	0.0000	0.0260	0.0000	0.0883
Camera	0.0623	0.0000	0.0130	0.0126	0.0879
Connectivity	0.0156	0.0177	0.0260	0.0000	0.0593

NAND (Memory Card)	0.0312	0.0000	0.0000	0.0000	0.0312
SDRAM	0.0000	0.0088	0.0130	0.0000	0.0218
Processor	0.0312	0.0442	0.0650	0.0503	0.1907
Power Mgmt./Audio	0.0468	0.0265	0.0520	0.0126	0.1378
Non-Electric	0.0000	0.0000	0.0000	0.0000	0.0000
Supporting Materials	0.0000	0.0177	0.0130	0.0755	0.1062
Other	0.0156	0.0088	0.0000	0.0000	0.0244
Total	0.3117	0.1767	0.2600	0.2517	1.0000

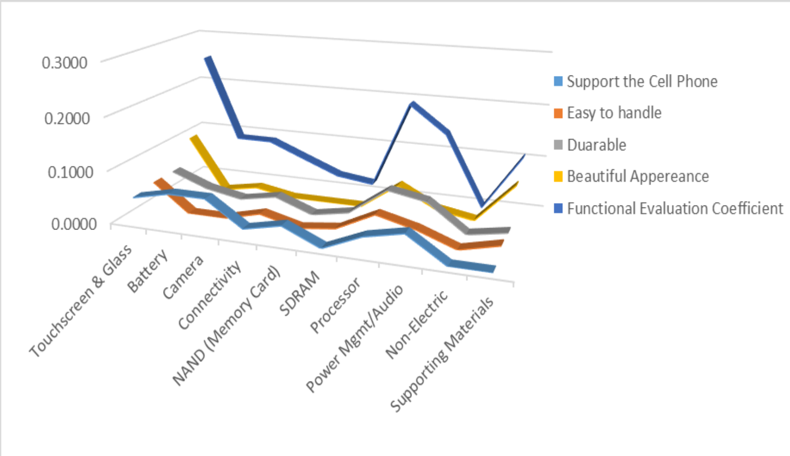


Figure1. *Functional Evaluation Coefficient of Smartphone*

Step 3: Defining the Cost Coefficient

Calculating the cost coefficient of the 11 key components according to their current cost, the result is shown in table 5.

Table5. *Cost Coefficient of Components*

Name of Components	Cost in $	Cost Coefficient
Touchscreen & Glass	61.00	0.2624
Battery	6.50	0.0280
Camera	15.00	0.0645
Connectivity	14.00	0.0602
NAND (Memory Card)	15.00	0.0645
SDRAM	10.00	0.0430
Processor	49.50	0.2129
Power Mgmt./Audio	6.50	0.0280
Non-Electric	10.50	0.0452
Supporting Materials	31.50	0.1355
other	13.00	0.0559
Total	232.50	1.0000

Step 4: Calculating the Value Coefficient

The 11 key components' value coefficient can be calculated according to functional evaluation coefficient table (table 4) and cost coefficient table (table 5), which as table 6 shown, in order to determine the target of improvement. Based on the value coefficient of components, the order of the components to be improved is noted or marked down as shown in table 6.

Table6. *Value Coefficient of Components*

Name of Component	Functional Evaluation Coefficient (F)	Cost Coefficient ©	Value Coefficient (V)=F/C	Order of Improvement
Touchscreen & Glass	0.2524	0.2624	0.9621	7
Battery	0.0883	0.0280	3.1596	10
Camera	0.0879	0.0645	1.3627	9
Connectivity	0.0593	0.0602	0.9840	8
NAND (Memory Card)	0.0312	0.0645	0.4831	3

SDRAM	0.0218	0.0430	0.5076	4
Processor	0.1907	0.2129	0.8956	6
Power Mgmt./Audio	0.1378	0.0280	4.9302	11
Non-Electric	0.0000	0.0452	0.0000	1
Supporting Materials	0.1062	0.1355	0.7836	5
other	0.0244	0.0559	0.4367	2

Step 5: Result of Value Analysis

According to the value coefficient of the 11 key components shown in table 6, we can come to a conclusion: (1) NAND, SDRAM, processor, supporting materials and others are the main components need to be improved, for their value coefficients are less than 1, which means the function are too less or the cost are too much. (2) Touchscreen, Connectivity are need not to be improved for their value coefficients are close to 1 which means the function and the cost are nearly the same. (3) The coefficients of Battery, Camera, Power Mgmt. /Audio are more than 1, which means the cost is already lower compared with function that has already met the needs.

Table7. *Target Cost of Components*

Name of Component	Functional Evaluation Coefficient (F)	Component Cost in $	Cost Coefficient ©	Value Coefficient (V)=F/C	Target Cost in $	Amount of Cost Reduction
Touchscreen & Glass	0.2524	61.00	0.2624	0.9621	49.98	11.02
Battery	0.0883	6.50	0.0280	3.1596	17.49	-10.99
Camera	0.0879	15.00	0.0645	1.3627	17.41	-2.41
Connectivity	0.0593	14.00	0.0602	0.9840	11.73	2.27
NAND (Memory Card)	0.0312	15.00	0.0645	0.4831	6.17	8.83
SDRAM	0.0218	10.00	0.0430	0.5076	4.32	5.68
Processor	0.1907	49.50	0.2129	0.8956	37.75	11.75
Power Mgmt./Audio	0.1378	6.50	0.0280	4.9302	27.29	-20.79
Non-Electric	0.0000	10.50	0.0452	0.0000	0.00	10.50
Supporting Materials	0.1062	31.50	0.1355	0.7836	21.02	10.48
other	0.0244	13.00	0.0559	0.4367	4.83	8.17
Total	1.0000	232.50	1.0000		198	34.50

IMPLEMENTATION OF QFD TECHNIQUE IN SMARTPHONE DESIGN PROCESS

In this part the implementation of the Model in a smartphone design is discussed. The referring smartphone was targeted on mid and low level customers, using smart phone for the first time. It uses two equipment manufacturers (IPhone 5S & Google Nexus 5) in production of these smart phones. The smart phone design has been analyzed in terms of software and hardware before the mass production. Customer requirements and demands are playing a major role in this point. Customer questionnaire is arranged in order to collect the voice of customer (VoC). Target customers being included in the project have usage experience of IPhone 5S & Google Nexus 5.

Identification of VOC

In order to identify customer requirements for this mobile design and development, focus group were formed and important characteristics of a smart phone were discussed amongst these technical groups. In addition, some other meetings were arranged with the team who is responsible for handling the competitor phones and acquired the information. For the discussions, eight most important customer requirements are identified and are categorized into basic, value-added groups. Ease of Use, User Interface are the two basic requirements [5]. For value-added groups there are two requirements, i.e., Switch speed between the interfaces, and Long Battery Life. For the excitement groups, it was identified Internet Connection rate, Variety of applications, Screen Size and Sensitivity of Touch screen should be attractive.

Identification of Technical Characteristics

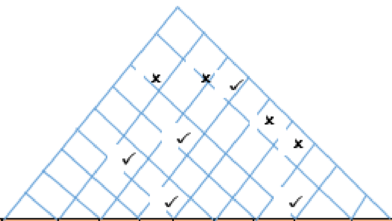
In order to identify technical characteristics that will satisfy the customer requirements, a group of people participated in a survey to locate the most important technical characteristics. Ten technical characteristics are identified, i.e. network technology supported by device, operating system, Hardware design, software design, processor speed, Display resolution, Memory capacity, connectivity and power consumption. These technical characteristics or requirements reflect the practical technical descriptions from design engineers' point of view. The customer requirements and technical characteristics are linked in the following HOQ.

Formation of House of Quality

The relationship between the above 10 factors and the 8 major demands of customers has been demonstrated in Table 8. The eight customer requirements are on the left of the HOQ and the ten technical characteristics are on the top of the HOQ as shown in Figure 6. As it is apparent, each factor may be related to more than one need/requirement of the customers. Since the effect of these factors on the customers' needs/requirements is not the same, so the effect of these factors has been shown using the (Θ = Strong) (O = medium) and (Δ = weak) symbols. In order to convert the qualitative values into quantitative ones for each strong, medium and weak cases the following numbers 9, 4 ,1 were selected respectively. Then the sum of each factors' effects within the total set of requirements were calculated through the value addition of effects. After the analysis of the interactive effects of these 10 factors – which is not of our concern here – the final value of the factors was estimated by adding the direct & indirect effects [6].

Priority relationships are composed of two sections, the significance levels of the absolute and the relative technical requirements. These are the measurement for the How's. The use of the significance value is to determine priorities and direction for improvements of the How's [7]. The value of the significance level of absolute technical requirement (SL_ABS) represents the technical requirements necessary to meet the customer needs, and can be calculated by: SL _ ABS = ∑ (Value of relationship between customer requirements and Technical requirements x Important ranking value). The value of the significance level of relative technical requirements (SL_REL) can be calculated by: SL _ REL = (Significance level of absolute Technical requirement) x 100 / ∑ (Total of significance level of absolute Technical requirement).

Table8. *QFD for Smartphone Design*



✓	Positive Correlation
×	Negative Correlation

Θ	Strong	9
O	Medium	4
Δ	Weak	1

1	Disaffiliation
2	Weak
3	Medium
4	Good
5	Strong

Technical Requirements (How's) / Customer Requirements (what's)	Importance	Network Technology Supported by device	Operating system	Hardware Design	Software Design	Processor Speed	Display Resolution	Memory Capacity	Connectivity Capabilities like Bluetooth, Wi-Fi	Power Consumption	Customer Rating: □ Galaxy Note 3 (1)	Δ IPhone 5S (2)	O G Nexus 5 (3)	(Customer Comparative Evaluation) (4)	(5)		
Ease of Use	4		Θ	O	Θ	Θ		O	O	Δ			Δ	O	□	160	19.11
Switch speed between the interfaces	3	O	Θ		Θ	Θ	O					O	□		Δ	105	12.54
User Interface	5		Θ		Θ		Δ						Δ	□	O	95	11.35
Internet Connection rate	3	Θ	O	O	Θ	O		Δ	O	Δ			O	□	Δ	108	12.90
Variety of applications	4	Δ	Θ		O			O		O			Δ	O	□	88	10.51
Long Battery Life	5	O	O	Θ	O	Δ				Θ			Δ	□	O	155	18.51
Screen Size	3			Θ		Δ	O						Δ	O	□	42	5.04
Sensitivity of Touch screen	4		O	Θ	O	O							O	□	Δ	84	10.03
Technical Competitive Evaluation	5	O	Δ	Δ		O	O	□	□								
	4	Δ	O	□	Δ	□	□		O	Δ							
□ Galaxy Note 3	3	□	□		O	Δ	Δ	O	Δ	□							
Δ IPhone 5S	2			O	□			Δ		O							
O Google Nexus 5	1																
Absolute Importance		63	192	136	187	99	29	35	28	68	837						
Relative Importance		7.53	22.9	16.25	22.3	11.83	3.4	4.2	3.35	8.12	100						

CONCLUSION

In this study, the integration of QFD and V.E was examined in the product planning process. QFD process is implemented for product planning and to identify the product projection in the market with a list of solutions obtained from quality houses. The V.E process is performed for costs estimated and then the ratio of cost to value is calculated and the best alternative based on this ratio is selected. The value engineering analysis has been carried out on Samsung Galaxy Note 3 to reduce the price from $ 232.50 to $198 /- per piece. This can be achieved by the appliance of new sized material and new technology. The final amount of cost reduction helps in identifying the unnecessary investment into various components and rather increase the quality in the components where customers had keen interest like battery, camera and audio output, while achieve the best piece of $198 i.e., the price of a 16GB iPhone 5s, one of the major competitor to Samsung in the smartphone industry in the year 2013.

Smart phones have been analyzed from the customers' point of view, using QFD and the House of quality Model, and the most important specifications have been determined. "House of Quality" matrix perform a rigorous cost benefit analysis. It will help the mobile service development team weigh exactly which quality characteristics are most deserving of their limited service development dollars and which to avoid, taking into account the tough technological problems etc.

According to the analyses of the House of Quality, "Ease to use" is found to have the most weight with 19.11% relative importance amongst customer requirements followed by "Long Battery Life" with 18.51% relative importance ratios. When looked at the correlation of customer requirements and technical requirements, "Ease to use" is found to be possible via improvements in "Operating system" e.g. android is more user friendly than IOS (IPhone).

New smart phones will be designed according to the results of the QFD Quality Management Technique, supported by the HOQ Model. The phones are suggested to have the below mentioned properties as a result of this study: The usage of newer versions of Google Android operating system for much ease to operating the device, "Long Battery Life" while making possible improvements in hardware design, choosing the hardcore processors for better internet connections & switching speeds, the design of a user friendly interface, Higher touch-screen sensitivity via IPS technology, and the use of a larger screen in hardware design.

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