



A Model to Develop a New Smartphone by Using Concurrent Engineering and Quality Function Deployment Methods

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Abstract

The aim of the study is to propose a model that will set a baseline for a further comprehensive research to find the effects of “Concurrent Engineering (CE) coupled with Quality Function Deployment (QFD) techniques for the development of a new smartphone” on the product life cycle and the level of customer satisfaction. The design of a new smartphone has been selected as the research case. Companies need to develop new products as fast as possible in order to be successful. Thus, it is required to grab competitive advantage by means of continuous review of new product development techniques since mobile communication technologies are so dynamic in many aspects. CE is considered to be one of the methods used to shorten product design and deployment time. Besides concurrent engineering, deploying the correct product with better quality regarding the customer needs is also targeted. This study is the initial part of an ultimate overarching project that focuses on making the smartphone development process faster and efficient using CE. QFD method is utilized to transfer and to fulfill customer requirements into the product development phases. We propose a model to develop a new smartphone using both QFD and CE techniques.

Keywords: CE, Smartphone, QFD

Introduction

New product development has never been as complex as now. Head spinning technological advances is leading to various and constantly changing dynamic customer demands at lower cost with increased performance [30]. Quick change of technology and obsolescence, which comes with the increased usage of COTS sources, shortens the lifespan of the most products and therefore capturing the market share before others enables an organization to hold onto market. Morgan showed that delivering a product to market before rivals bring great market share along with a lot of competitive advantages [28]. At that point Concurrent Engineering (CE) is shown as one of the solutions to shorten new product development and to deploy to market the product [24]. Deploying the correct product that will meet the consumer needs is another important issue to be taken care of. The dynamic and quickly changing nature of consumer needs are to be taken into account in order to hold more market share than competitors [26]. At this point Quality Function Deployment is one of the tools to be used.

CE and QFD are both tools and methods that will shorten the design cycle of the correct product required by the consumers. Therefore these two methods are complementing each other. In this research we focused on blending those two methods and investigated the outcome. We used smartphone technology as our use case. While there are two dominant smartphone models that are taking the world's most market share we still believe that there is enough room to improve considering the open ended technological advances in consumer electronics and user needs.

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Scope, Aim and Assumptions of the Research

Scope

The scope of this research is to set a case study to develop a new affordable smartphone for especially young and middle age generation in Turkey with medium level income. We have used Concurrent Engineering and QFD techniques within the research explaining their advantages and strong sides.

Aim

The aim of the study is to propose a model that will set a baseline for a further comprehensive research to find the effects of “CE coupled with QFD techniques for the development of a new smartphone” on the product life cycle and the level of customer satisfaction.

Assumptions

There are some assumptions in the study. Firstly, QFD results are based on the internal customers of the firm (employees of the operator) because the new smartphone development process must be executed secretly and so it seems impossible to do that with real customers. In the study, we assumed that the target market is young and middle-aged customers (16-55 years old) with medium level income.

Concurrent Engineering and Quality Function Deployment

Concurrent Engineering

CE is defined as simultaneous design and implementation of all processes used in product development, marketing and deployment. It includes all or a subset of the processes from concept development to after-sell services and eventually out of service processes, as US Department of Defense mentions it as “cradle-to-grave consideration” [28]. We can consider CE as an alternative to traditional waterfall method. At waterfall method all major processes follow each other and each process use the output of the previous process as input. Simultaneous integration in cross-functional departments that are responsible for different aspects of product development is key factor for successfully implementing CE. In CE, cross-function teams do not wait for each other but instead work together and contribute to each other’s work from the beginning till end.

According to Smith, the CE is inevitable outcome of primarily several factors: specialized engineering trainings, development in the communication technology and ease of access to information and last but not least increased competitive environment to reduce the product lead time as well as to increase quality [28]. As the heat of the competition increases the emphasis is focused from lower costs to shorter production times.

There are different levels of implementing CE, from low level of complexity to high level. While low level of complexity involves less different functional groups, the latter requires more different functional groups to involve in design process. Higher concurrency brings faster lead times for new product design however such approach also introduces higher complexity, and more management risks along [28].

In order to successfully implement CE, there are two fundamental actions to be done. First, cross-functional integration must be fully ensured. Collaboration of people from different functional groups and quick resolution of conflicts, if arises, is the core of essential integration. Such



achievement is not an easy one in an organization where teamwork culture is not mature yet. All functional groups must be lead and directed towards a common goal and integration must be fully controlled by the manager in order to achieve a full integration between different functional groups in CE. Secondly, managers have to find ways to improve design practices in the organization. New technological advances in communication, design, business processes are often adapted to CE design processes. That would also bring the necessity to train people to use such practices effectively. For example, Computer-Aided-Design (CAD) is one of the most often used recent methods. Physical layout and work conditions are also another important factors in implementing CE. Managers have to adjust the level of CE implementation taking the level of design expertise of people in the organization as well as the complexity and the type of the product and customer type [28].

With CE, lead-time to deploy a new product to market is remarkably reduced as the quality of the product is increased [16]. Market research and other methods to understand the real customer needs are introduced into product development in the early design phase and hence the quality of the product is increased in terms of meeting the customer needs [11]. The number of defects in both product and processes are decreased at design by taking manufacturing capabilities into account [28].

While CE is promising shorter lead-time to market new products with higher quality, it does not come for free. It is expensive to implement CE. It requires more resources at the beginning of the product development. There is also a potential risk of frequent rework of the product design since earlier concurrent work with less complete information [25]. In some cases, especially in R&D projects, inclusion of the contribution of latter stage processes into product design in earlier phases may slow down the product design. Loch pointed out 4 managerial challenges in CE implementation as task definition, scheduling and timing, coordination and integration of tasks with proper exchange of information and finally support process establishment inside the organization [18].

QFD

Quality Function Deployment (QFD) is a “method to transform qualitative user demands into quantitative parameters, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process.”[1] QFD is used to transform the customer needs into system requirements. Customer needs are captured by using methods such as Voice of customers in terms of expectations, preferences and aversions of customers from the product.

After the Second World War, the concept and methods of QFD was developed as a follow-on outcome of the transformation of the Statistical Quality Control (SQC) into Total Quality Control (TQC)[1]. In 1960s, when the quality assurance was a well known subject used but implemented after the product was actually manufactured, Akao raised the question to set certain quality checks at design phase even before the production starts. The concept of Quality Deployment (hinshitsu tenkai) was first published in 1972 [2] in the form of quality tables, which was inspired from the idea of Oshiumi (Oshiumi Kiyotaka, 1966). With his own words, Akao described the Quality Deployment as a methodology of “converting user demands into substitute quality characteristics, determining the design quality of the finished good, and systematically deploying this quality into component quality, individual part quality and process elements and their relationships”[1]. However it was only 1980s when the concept of QFD was introduced in Europe and USA.



With QFD, the quality assurance focus has shifted from process-oriented approach to design-oriented approach. The quality aim is moved from after production defect exploitation to before production, design and planning phases. QFD also provided a common language in terms of practices and outcomes to be used by all stakeholders, especially designer engineers [1].

QFD is implemented with a set of phases starting from understanding customer needs to system requirements, designing, planning production processes and setting performance measures for production and maintenance. House of Quality is one of the tools used to translate user needs into system requirements [14].

House of Quality (HOQ) is a tool to convert customer needs into technical system requirements as well as to compare different design and product candidates, so the design engineers focus on the most important aspects of the new product. HOQ, embody 6 different sections.

First part represents the structured customer needs, which are the outcome of the Voice of Customer process. Raw customer needs are structured in similar sets of requirements based on affinity of the needs and most likely those needs are to be labeled with a new requirement segment name. Second part of HOQ is the planning matrix. This part quantifies the customer needs and priorities those needs based on the customer's performance perception of the existing products in terms of meetings needs. This part also allows adjustment of different figures of quantification process. Third part of HOQ is technical requirements matrix. This is the top floor of the HOQ. This part represents the engineering characteristics of the customer needs in terms of the production companies' understanding. In another words it is the translation of customer needs into measurable technical system requirements. Fourth part of the HOQ is the relationship matrix. This part is the main body of HOQ and it is 2 dimensional matrixes. On one side the user needs (WHAT) reside while other dimension is the technical requirements (HOW). Each cell in the matrix represents the relationship level value of each user need to each technical requirement.

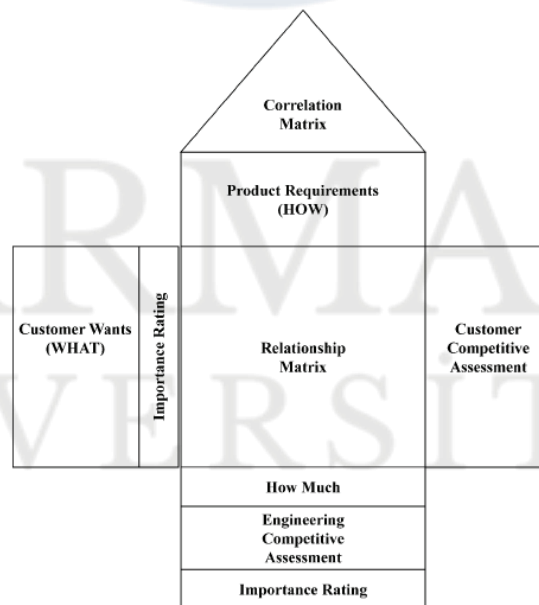


Figure 1. House of Quality



The roof of the HOQ is the fifth section and it represents the information regarding the relationship between each technical requirements creating correlation matrix. How one requirement does affects the other one is the point, which the roof matrix is addressing. The affect may be improving or deteriorating, in other words positive or negative direction.

The last section of the HOQ is the bottom floor, target matrix. This part includes technical priorities, benchmarks and targets. This part is the augmentation of all the matrices in the HOQ. The technical priorities are calculated from the requirements, benchmarks values are calculated from the competitive products and finally target metric values are calculated for each requirement by using all metrics found so far.

Smartphone Market Overview

Market Review

With the advent of 3G (Third Generation Mobile Communication Technology) at the beginning of 2000s, people started enjoying the mobility and being connected everywhere. It has enabled people to obtain information on mobile environment and to handle many processes much easier via mobile internet. Today mobile phones are used to satisfy a lot of needs of people. Security, social interaction, information search, management of daily life, video communication, e-learning, e-commerce, location based services and even many health services makes only a small set of the mobile communication facilities [8]. Especially with the launch of iPhone in 2007, smartphones started to present much more mobile experience thanks to their rich visual interfaces and contentful applications. Thus, it has completely changed traditional mobile phone concept and performed various functions by means of development in the third party applications [32].

QFD and CE Applications in Smartphone Market

QFD is considered to be a form of concurrent engineering tool that has been successfully applied in the manufacturing sector in the United States and Japan [15]. The implementation of QFD along with concurrent engineering has been highlighted by many researches. Ho and Lin have focused on developing methods on using CE and QFD for Original Development Manufacturing (ODM) [9]. Tsuda showed another application of CE with QFD techniques while focusing on the integration of features [29]. Qian showed an extensive review of CE models with dependent and interdependent stages of processes [25]. Fine et.al. showed a goal approaching approach to optimize multiple goals while implementing CE, in which case goals are to optimize designs of product, process and supply chain [5]. Piedras et.al. showed another product development model using CE and QFD together and proposed a model with an holistic quantitative approach for product-process optimization [22]. Sun showed that the methods being used to assure quality used with concurrent engineering speeds up the product design process as well [27]. Kusar et.al. showed that different level team structures are necessary based on the scale of the project. While big projects to require 3 level team structures, 2 level team structures is enough for medium and small size product development projects [17]. Prasad proposed a different model, in which CE and QFD is implemented, named as concurrent function deployment (CFD). He proposed to implement 6 value set, namely “functionality (quality), performance (X-ability), tools and technology (innovation), cost, responsiveness, and infrastructure (delivery)”, to implement in parallel rather than serial [23]. At the same time Brad showed similar approach to implement CE and QFD at the same time, and named this approach as Concurrent Multifunction Deployment (CMFD) [4]. Ho et.al. proposed another model using CE and QFD model together for Original Design Manufacturing (ODM) business [9]. Pal et.al. proposed another application of QFD with Analytic Network Process (ANP) specifically for rapid prototyping [20]. Pheng et.al. proposed a model of QFD and CE in design and build project which is rarely studied in the literature [21].



In smartphones market, it is significant to apply quality techniques in a fast and correct way in order to meet the necessities of product/service market since the demands are dynamic and unsteady. This will also assure the firms to consume their resources in the right way. Although CE and QFD practices have been applied to the products and services of smartphones, any specific study regarding the design of the phones have not been found during the literature survey. This shows the lack of combination of the CE and QFD applications in this industry. More information regarding application of these techniques in mobile communication industry is going to be given in detail in this section.

The QFD application in the mobile phone technology dates back to 2000s, when Nokia and Ericsson was the two leading mobile device manufacturer [33]. The results of those academic and industrial researches not only enabled these two companies to understand the customer needs and eventually to develop as best as they can to hold onto market but also to develop effective development processes [31].

Since 2000, along with Nokia and Ericsson, there have been numerous mobile device manufacturers in the market. However within last decade two manufacturers leads the market, namely Apple and Samsung. Currently there are more than 1 billion smartphone users in the world. On average, those two companies share the %40 of the market. LG, Lenovo, Huawei and Xiaomi are following them on average 15% market share in aggregate. Each one of those companies is in a fierce competition to capture as much market share as possible. More than one billion consumer increases the appetite. Hence, such competition forces each company to touch the consumer and serve the best product [4][6][7][12][19].

Proposed Model

In the recent years, smartphones have been promoted seriously depending on quick development of mobile communication and mobile internet. The smartphone popularity in the world has also affected Turkish market. High ratio of young population in Turkey is the most important factor that gives the market remarkable acceleration with respect to global market. For instance, the leader mobile network operator of Turkey had only 2 million smartphones used by its subscribers at the end of 2010. This number reached 9.6 million with the increase of 380% by the end of 2013. Therefore, the firm's smartphone penetration ratio ascended to 30% [1]. This ratio is so similar in whole market of Turkey as well.

Three mobile network operator companies in Turkey have launched individual initiatives to design and produce smartphones for the potential customers. Each has unique business models to design and produce the smartphones. Within the scope of this research we focused on only one of the operator's way of production. Following chapter defines the current model to develop operator branded smartphone.

Current Model to Develop a New Smartphone

In 2010 the firm started to launch its own smartphones to the market as the leading operator in the market while it had been going on selling world renowned smartphones such as iPhone and Samsung Galaxy series in Turkey. T-series (such as T30, T40 and T50) are the smartphone models launched with the operator's own brand between 2011 and 2014. The firm targeted on mid and low level income customers who are between the ages of 16-55 and having a smartphone first time.



Requirement Analysis

Customer requirements and demands are playing main role in this point. In the current situation, market trends and market research applied by third parties are making the operator oriented in the smartphone requirements. These requirements shape the product features. In addition, some leading smartphone manufacturers in the global market mentioned above are important role models for the operator to develop a smartphone with respect to their requirement. Therefore, sometimes it can cause some failure cases in the market because the firm needs to have its own methodology to be performed amongst target segment in order to obtain accurate voice of customer.

Design

The operator determines the smartphone designs in terms of software and hardware before the mass production. Software selection is limited by the ODM's choice because the operator is not involved in the whole process of software development after the request is sent. Thus, ODM's suggestions are leading this process. The hardware design is more important at first sight according to the customer and smartphone's design should meet customer expectations as well. The operator utilizes the dominant smartphone design, which is already launched by global smartphone manufacturers so as to attract the most of customers in the target segment.

Production

The firm uses two equipment manufacturers in production of these smartphones. One of these companies is the ODM vendor which is producing devices for the operator. The other company is the manufacturer of chipset, the most important component of smartphone.

The firm has used Original Design Manufacturing (ODM) outsourcing business model in production and development process of its own smartphones, operator branded. Although the firm has an ODM department to handle this business model, it uses outsource ODM vendor from new product development to the distribution of products. The advantage of the ODM outsourcing business model is that the firm can save organic resources by way of commissioning product design and manufacturing to selected ODM vendor. In many industries, ODM customer does not get involved in its ODM vendor's product development activities and simply relies on the design and manufacturing capabilities of the ODM vendor to acquire the product. However, it is slightly different in the telecommunication sector due to strict competition and necessity of perfect product to meet customers' requirements.

The firm is more involved in its ODM vendor's product development activities to obtain a higher-quality product on time at a competitive price. This requires close cooperation between the operator and its ODM vendor. This study focuses on this scenario to make the process faster and efficient using Concurrent Engineering. The firm's new T-series smartphone (TX) project is selected in the case study.

In-House Tests

Prototype devices are subjected to some tests by technical units of the firm and analyzed in detail before their launch.

Keeping the device details secret has high importance in the mobile communication sector because of fierce competition. Therefore, prototype devices are tested formally by the firm's technical and non-technical employees internally as well as they use these smartphones in their daily lives. Consequently, defects and development areas are informed to the ODM vendor and



the firm keeps providing feedbacks until the mass production phase. Technical teams (engineers) perform functionality and network performance tests for the devices. On the other hand, non-technical employees (sales and marketing teams) use these phones with the end user perspective.

Methodology to Develop Model

In order to get high-quality products from ODM vendors, it is necessary for the operator to implement an effective and efficient product development process which allows them to work with their ODM vendors concurrently in designing and manufacturing their smartphones with operator brand [9]. By integrating QFD and CE into the proposed methodology, we believe that the operator will be able to carry out its product development with ODM vendor more effectively and launch good-quality smartphones into the market on time.

Product designs are the most efficient when the R&D team, engineering team, purchasing team, process engineering team, product management team, logistics team and after-sales service team are all involved. Thus, team working and the relationships between departments in the firm are taken into consideration with an important approach [13].

Before the product development phase, customer requirements are the most important input. These requirements are converted into system's engineering characteristics. In the parts of deployment phase, engineering requirements are translated into part characteristics [9]. In the firm a detailed survey and study had been executed to understand customer requirements regarding smartphones. It enabled the firm to hear *Voice Of Customer* (VoC) much more closely in the way of a new smartphone development and launch in the market.

Customer questionnaire was arranged in order to collect the VoC. Target customers being included in the project were the employees from sales, marketing, vendor management, device test and network quality assurance departments. As explained above, these persons had the experience of using T21 and T30 respectively.

Initially, focus group meetings were performed with the attendance of network quality assurance and device testing teams and then important features of a smartphone were discussed among these groups. Customer satisfaction criteria were derived from the meetings including Ease of use, Switch speed between interfaces, Visuality (interface), Internet connection rate etc.

In the foreground of these satisfaction criteria for smartphones, non-technical teams from sales, marketing and vendor management department attended in the customer questionnaire. The biggest factor affecting this choice of this questionnaire group was that these persons were more interacting with the real customers of the firm. In the A section of questionnaire, the level of importance was calculated from average of replies to the customer requirements. In the B section of questionnaire customers were asked to evaluate the satisfaction levels of T21 and T30 smartphones for their expectations. Eventually, arithmetic average was calculated from all replies.

The brainstorming meetings executed amongst device testing and network quality assurance departments enabled the determination of technical requirements that will satisfy the customer demands. Basic technical features were determined as an outcome of those meetings some of which includes Network technology supported by device, operating system, hardware design, software design, processor power etc.

Another questionnaire was utilized in order to measure the correlation level between customer and technical requirements as well. This study made clear in which level each technical specification meets customer requirements. How technical features affect each other was handled



in correlation matrix under the roof of HOQ. A number of weak or strong positive correlations were found between many technical specifications of smartphones.

At the final step Kano questionnaire was arranged among the group who initially attended to the QFD questionnaire at the beginning of the study. Then, customer requirements for smartphone were categorized properly based on the replies to the Kano questionnaire. This process was performed by allocating them to the three sets of requirements: basic, linear and attractive requirements.

After execution of Kano Model with the QFD Quality Management Technique, new smartphones should be designed according to the results. The smartphones are suggested to have the below mentioned properties as a result of this QFD study:

- The usage of the newest version of Google Android operating system
- The design of a user friendly interface
- The addition of shortcuts to the main screen (like Google search)
- Higher capacity battery, preserving the hardware design
- Higher touch-screen sensitivity via IPS technology
- The use of a larger screen in hardware design (minimum 4 inch)

CE Model for the Mobile Network Operator

As mentioned before ODM outsourcing is an appropriate and cost effective method for the operator to develop its own smartphone because of limited resources and capabilities in this area. Know-how is the main lack of the firm because its primary business is not smartphone development and production. In addition, it has no specific product development process for ODM outsourced product development. So, the current process is only based on ODM vendor's development process.

A dedicated project team assigned from the operator is needed to concurrently participate in its ODM vendor's product development process. Component suppliers also need to get involved in development concurrently to assist the firm and vendor in solving quality issues, so that the product development schedule can be kept on time. In the smartphone development the main component suppliers are the chipset (processor) manufacturers such as Qualcomm, Intel, Mediatek and Nvidia companies.

The involvement of CE team members is essential at every stage of the proposed methodology. CE team members include a product manager, network quality engineer, device feature engineer, device test engineer, procurement engineer, ODM vendor team and ODM component supplier team. With these factors in mind, an outsourced product development methodology based on QFD and CE is proposed in this study. It is shown in Figure 2.

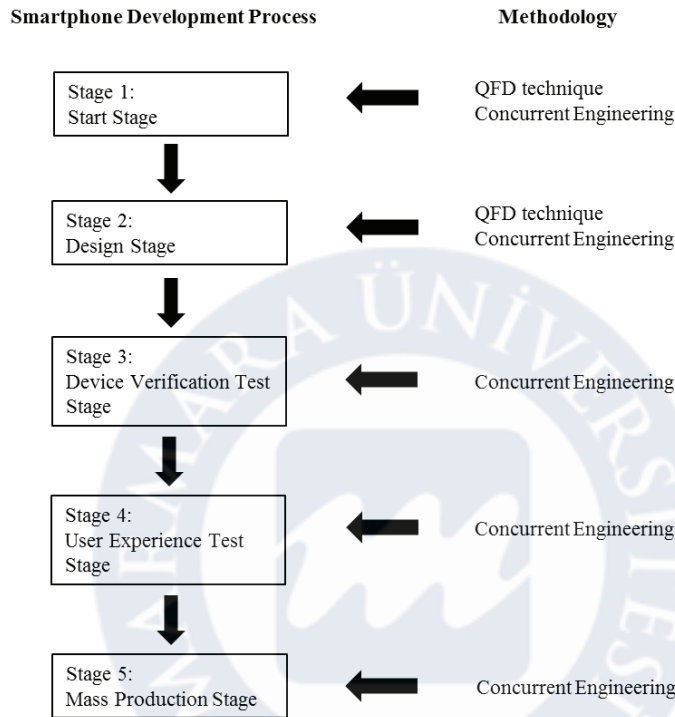


Figure 2. QFD and CE based smartphone development methodology for the operator

Stage 1: Start Stage

The purpose of start stage is to complete product marketing requirement specifications and arrange a kick-off meeting to announce new smartphone development to the ODM vendor and component supplier.

At the start stage, CE team needs to acquire marketing requirement specifications from customers in order to hear voice of customers. QFD study is utilized here to collect the voice of customer by means of customer questionnaire. It is also very important to inform CE team members in detail. Then technical requirement specifications determined in QFD study is the most significant item that will be announced to the ODM vendor and chipset supplier. Technical features required for the smartphone development are listed in the previous section. These are also called engineering specifications.

It is necessary for the operator's CE team to discuss the request with ODM vendor and component supplier so that they can wholly understand the requirements of the firm. The flow can be seen in Figure 3.

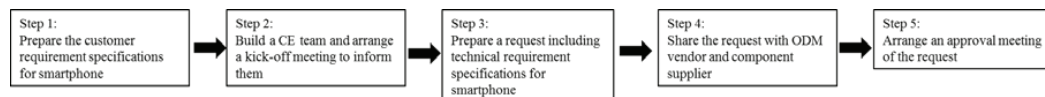


Figure 3. The process of the start stage



Stage 2: Design Stage

The purpose of the design stage is for the operator to integrate into the ODM vendor's smartphone design process. The identified vendor can start the development. In order to produce a higher-quality product, the operator, ODM vendor and chipset supplier need to hold a smartphone design-planning meeting to discuss design related issues concurrently. CE implementation among these groups enables them to create a strong product design plan. The flow can be seen in Figure 3. QFD is really useful tool for translating engineering specifications into necessary parts. The new smartphone should be designed according to the results of QFD Quality Management Technique executed by the firm.

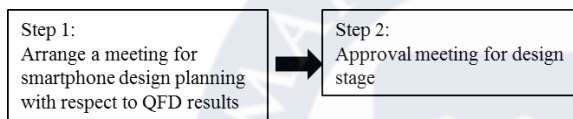


Figure 4. The process of the design stage

Stage 3: Device Verification Test Stage

The purpose of the device verification test stage is to have the operator's CE team test the prototype sample provided by the ODM vendor. After the design stage, ODM vendor sends a working sample to the operator, so that concerned team can verify whether the smartphone's network operational functions are in line with the technical requirement specifications defined in the start stage. To ensure the correct software and hardware design, CE team needs to execute network conformance and performance tests (NCPT) to check the prototype smartphone working with ODM vendor. The operator, ODM vendor and chipset supplier need to solve problems concurrently and keep the smartphone development schedule on time if there are any quality issues during the NCPT stage. NCPT process is managed by network quality engineer and device feature engineer amongst CE team members. The process can be seen in Figure 5.

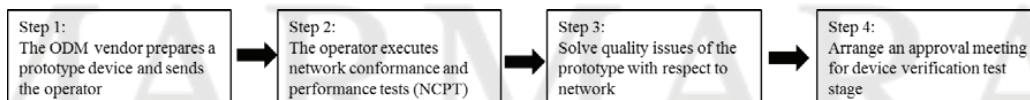


Figure 5. The process of the device verification test stage

Stage 4: User Experience Test Stage

The purpose of the user experience test (UXT) stage is to have the operator's CE team conduct the UXT on working smartphone samples provided by the ODM vendor. At this stage, ODM vendor prepares UXT samples and send them to the operator for testing with respect to the smartphone's user experience. These tests including some basic smartphone capabilities such as calling, SMS, MMS, internet, social media applications, camera, WiFi, Bluetooth etc. are performed by device test engineer. If there are any quality issues with the UXT samples, the operator needs to invite the ODM vendor and chipset supplier to concurrently handle these issues. The flow can be seen in Figure 6. The interaction and cooperation between the operator and ODM vendor is crucial to deal with quality issues of new smartphone before the production.

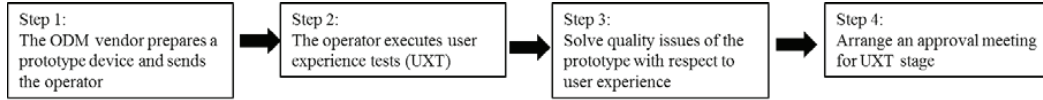


Figure 6. The process of the user experience test stage

Stage 5: Mass Production Stage

After fulfillment of the UXT stage, the ODM vendor can begin mass production. The operator needs to be present for the mass production to check smartphone product quality and ensure the delivery on time.

As explained above, the proposed methodology is composed of five stages. It offers a step-by-step procedure in order to assist the operator successfully execute ODM outsourced smartphone development with its ODM vendor.

Conclusions

Conclusions

First of all, smartphones have been analyzed from the customers' point of view using QFD method and the most important marketing requirement specifications and technical specifications have been determined. Later on the CE Model has been included in order to enable the operator to work concurrently with its ODM vendor and the chipset supplier. Finally, the concurrent engineering model for the mobile network operator has been built.

With the operator, ODM vendor and chipset supplier working closely on implementing the proposed methodology, it can be expected that the development and marketing of new smartphone on time in the market. The correct time to market is truly very important for the operator due to competitive environment in the smartphone sector.

Thanks to the emphasis on the CE cooperation amongst the operator, ODM vendor and chipset supplier, the competitive cost of smartphone with high quality can be successfully obtained. Especially to win the confidence of existing customers and attract new customers, the operator must ensure the high quality of its own branded smartphones.

As mentioned in the study, QFD and CE seem so complementary methodologies for each other in order to perform concurrent engineering application on a smartphone development because both methods provide fulfillment of customer wishes and requirements as well as reduction of new smartphone development time in all development phases.

Future Work to Do

This study consists of a proposal of the new smartphone development on the leading mobile network operator in Turkey based on CE and QFD methodologies. There are of course some assumptions in the study such that there are no selection process of ODM vendor and chipset supplier for the smartphone development and QFD results also come from the internal questionnaire applied in the employees of the operator because the new smartphone development process must be carried out with the high confidentiality inside the firm.



In the next study, this proposal can be realized within the firm and more concrete results can be observed and interpreted in terms of the success of concurrent engineering methodology on a smartphone development by the operator.

Another extension of this research would be to further implement QFD by using fuzzy logic theorem.

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