Analysis of Android OS Smart Phones Using Failure Mode and Effect Analysis

Dr. K. Vijayalakshmi
Caledonian College of Engineering,
Muscat, Sultanate of Oman

Abstract- Android Operating system in smart mobiles is a most popular OS in all over the world. However, failure in hardware and software in smartphone is a matter of concern for all of its users. The effect of failure leads to problem in mobiles, customer dissatisfaction, cost ineffective, poor marketing for manufacturer etc. The cause and effect of failure analysis will help the user and manufacturer to understand the system more effectively and also to avoid the failure as much as possible. This paper deals about the failure mode and effect analysis of the smart phone which uses Android 4.4 operating systems. The study is based on the statistics taken from the smart phone user volume of 25 numbers. Depending on more volume of the user, the accuracy of failure and effect analysis will increase effectively. According to this study, it is identified that more risk is on mobile phone shell in hardware and memory access violation error in software.

Keywords – Android OS, Smart phone, Failure Mode and Effect Analysis (FMEA), Risk Priority Number (RPN)

I. Introduction

Android is an operating system based on Linux Kernel developed by Google. Android OS is most popular for touch screen devices such as smart phones and tablet computers. According to the statistics, the sale of Android based devices is more than Windows, iOS and Mac OS in 2012, 2013 and 2014. Android is very popular technology which is available readymade and also available in low cost. Android's user friendly nature has attracted many product developers to develop their smart phone using this technology. Android is used in hundreds of millions of mobile devices in more than 190 countries around the world. Android gives a good platform for creating apps and various games for its users. The interface is using touch inputs like swiping, tapping, pinching etc. It has certain internal hardware such as accelerometers, gyroscopes and proximity sensors. In Android 4.4 at least 512 MB RAM is required. Android 4.4 requires a 32 bit ARMV7, MIPS or X86architecture processor with an open GLES 20 compatible graphics processing unit. There are variety of OS used in mobiles such as Android, iOS, Windows, Firefox, Sailfish, Tizen , Symbian palm OS, Ubuntu touch, Blackberry, Bada etc. Android uses Linux kernel which is unix like operating systems is free and open source software. There are varieties of kernel modules like network, graphics sound and input which are very much useful in smart phones.

A smartphone contains more advanced computing capabilities than a basic feature mobile. Normally a smart phone contains personal digital assistant, a media player, a digital camera, GPS navigation unit etc. The Android based smart phone contains touch screen, web browsing, Wi-Fi, motion sensor etc. According to the user there are variety of failure found in Android based smart phones. There are several types of model in smart phones which use Android software systems so that it is impossible to specify the exact problem in a particular model. So it is planned to analyze a failure study about general Android based smart phones using failure mode and effect analysis.

II. Literature Review

L.M.C Marques [3] from university of Ljublijana analyzed FMEA in mobile phones. The report analyzed a mobile's hardware using FMEA technique. He found Risk Priority Number (RPN) for various hardware and found failure on phone shell to be given top priority in failures. So manufacturers should concentrate on phone shell when they are designing a smart phone which is the main result of his case study.

Liu,W. and Li, H. [4] analyzed the weak point of a cellular phone at design stage using ANSA and LS_DYNA. A cellular phone was dropped on a granite floor from 1 meter height and did face drop, corner drop and edge drop. The integrity of the split was investigated using ANSA and LS_DYNA tool which are advanced CAE pre-processing tools. They found that the impact of stress increase in cover glass and other glass layers. They found the shock absorbing pad which is attached to the camera is reducing the impact load on lens of the cameras.

Tay , R et.al [6] analyzed the performance of mobile device terminals using failure mode effect analysis. They found the Radio Frequency(RF) performance using SEMCAD X software. They found that effects of component changes , metallic coating, materials parameters and interconnections are affecting the performance of Radio Frequency distribution. They concluded that the knowledge on the performance reliability is important to set the correct expectation of the device.

Cinque,M etal [1] published an article titled "How do mobile phones fail? A failure data analysis of Symbian OS smart phones" in 2007. He analyzed the software failures like freeze, self-shutdown, unstable behavior, output failure and input failure. He found that memory access violation errors and heap management lead more problems in Symbian OS smart phones They collected failure data from 25 phones over the period of 14 months. He found that mostly user experience a failure of freeze or self-shutdown in every 11 days. Further Cinque,M studied enabling online dependability assessment of Android smart phone in 2011 [2] . He discussed the logging platform for the collection of failure data in his article.

III. Application Failure Mode and Effect analysis for Android OS smart Phones

According to the research published by square trade (available at www.wired.com [5]), there is malfunction in all smart phones. The following figure1 shows their research related to the malfunction of various smart phones. Also they pointed various devices malfunction in 12 months which is shown in figure 2.

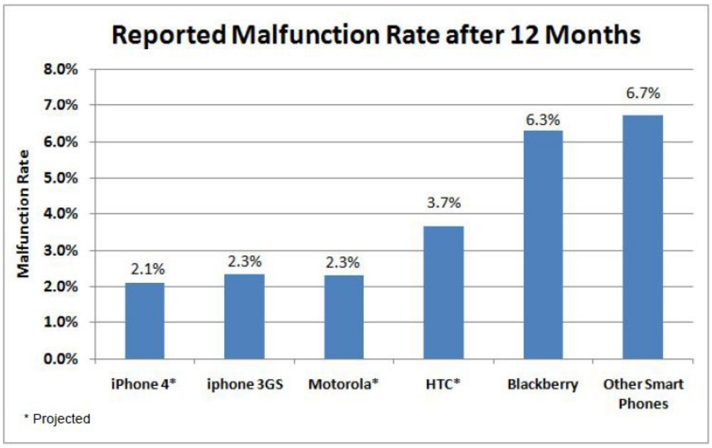

Figure1 Malfunction Rate in various Smart phones as per www.wired.com [5]

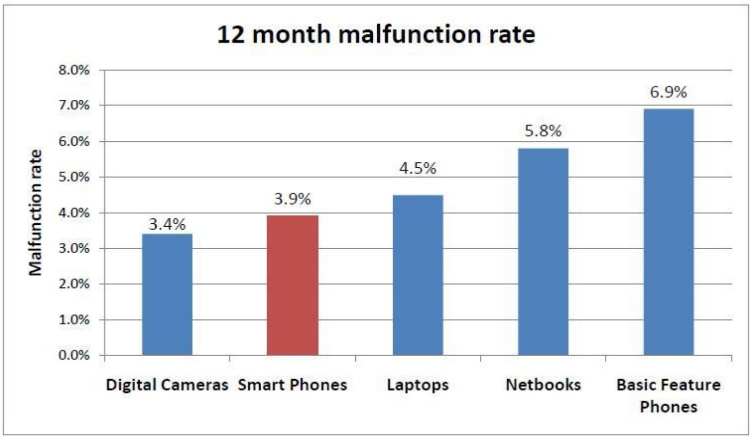

Figure 2 Malfunction Rate in various smart gadgets as per www.wired.com [5]

In general, there are two types of failure in mobile phones. One is due to accident and another is due to malfunction of hardware or software. The Square trade has taken study in various smart phones and published their statistics in their websites. The figure 3 shows overall failure rate due to accident and malfunction as per www.wired.com[5].

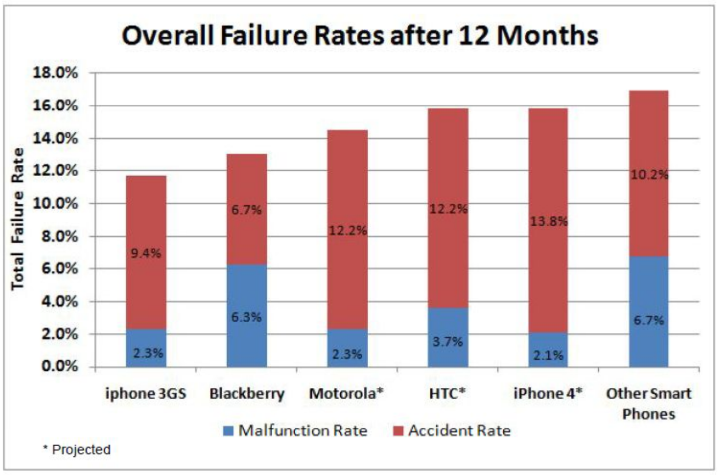

Figure 3 Overall Failure rate due to accident and Malfunction as per www.wired.com [5]

A. Failure Mode and Effect Analysis – An overview

FMEA can be used in all phases of the system lifecycle from requirement specification to design, implementation, operation and maintenance. Most benefit from the use of FMEA can be achieved at the early phases of the design, where it can reveal weak points in the system structure and thus avoid expensive design changes. The FMEA process starts from the identification of scope of the system and its functions. Figure 4 explains the main phases of FMEA. After the subject for FMEA is confirmed, the next step is to identify the potential failure modes in a gradual way. The technique of brainstorming has often proven to be a useful method for finding failure modes. In the next phase, the effects and causes of potential failures are determined. The cause and effect diagram can be used to help in these phases. After detecting possible causes and effects, the risk analysis is done. The final step is to document the process and take actions to reduce the risks due to identified failure modes.

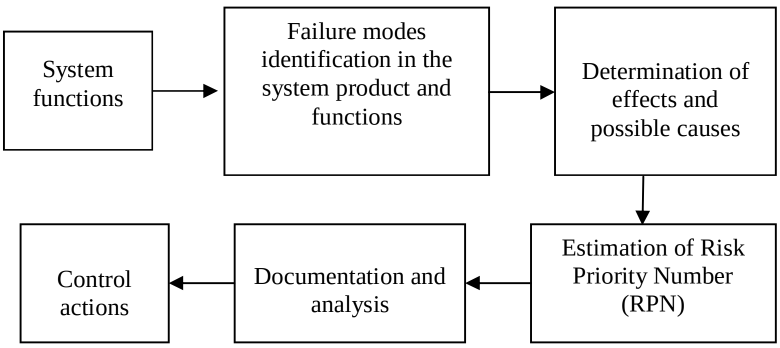

Figure 4 Phases of FMEA

A. (a) Software FMEA (SWFMEA)

The identification of the failure modes of software system and its effects on the system behavior is known as software FMEA. Software includes programs and their execution as tasks that control various system functions. Software also includes the program interfaces with the hardware. Software can be embedded as a function component in a self-contained system (mobile phones, microprocessor system, PLC system, embedded systems etc., executed on software). The SWFMEA is used to find out the list of relevant failure modes, the causes for those failures and their consequences.

A. (b) Hardware FMEA (HWFMEA)

Performing FMEA for hardware system is usually more straightforward operation than what it is for software system. Failure modes of components such as sensors, relays and resistors in an automation system are generally well understood. The mechanical, electrical and electronics components are supposed to fail due to some reason such as wearing, ageing, over load or unanticipated stress. The analysis may not always be easy, but at least the safety engineers can rely on data provided by the component manufacturers, results of tests and feedback of available operational experience.

B. Reliability of Software and Hardware

Reliability is increased when failure rate is decreased. It is important to recognize that there is a difference between hardware failure rate and software failure rate. For hardware (Figure 5), when the component is first manufactured, the initial number of faults is high but then decreases as the faulty components are identified and replaced or the components stabilize. The component then enters the useful life phase, where minimum faults are found. As the component physically wears out, the fault rate starts to increase. This curve is often called as bath tub curve in the reliability literature.

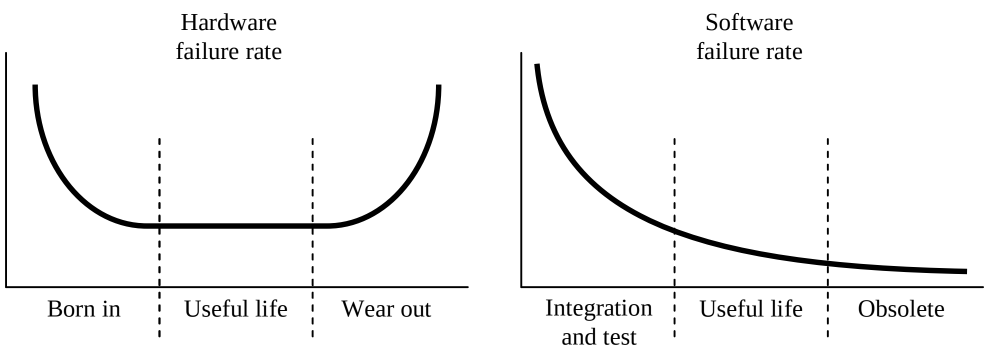

Figure 5 Hardware and software reliability curves

For software (Figure 5), the error rate is at the highest level at integration and initial level tests. As it is tested, errors are identified and removed. This removal continues on releasing successive versions, assuming no new errors are introduced. At one stage, fault rate will come down to lowest level. Software does not have moving parts and does not physically wear out as hardware, but it may become obsolete or useless due to the arrival of new software.

C. Application of FMEA in smart phone modules

The various part of a smart phone system is given in the figure 6.

The stringent requirements of high performance, high reliability and low cost demand different type of hardware and software needed to market smart mobiles. In this work, an attempt is made to analyze the various failure modes and effects for hardware and software of a smart system. The major hardware failure modes in a smart phone are identified and listed as follows.

Hardware failure modes :

Failure mode-1 Keyboard
Failure mode- 2 Battery
Failure mode- 3 Mobile phone shell
Failure mode- 4 Screen/display
Failure mode- 5 Power supply unit

Software Failure Modes:

Failure mode- 6 Freeze
Failure mode- 7 Self-shut down
Failure mode-8 Unstable behavior
Failure mode-9 Input/ Output failure
Failure mode-10 Failure data logger

Table 1 shows the various possible failure modes, causes of failures and its effects on the overall system function. From Table1, it is necessary to calculate the most critical failure modes of the smart phone. Critical failure modes are identified by calculating the Risk Priority Numbers (RPN). The RPN of every failure modes are identified by performing criticality analysis.

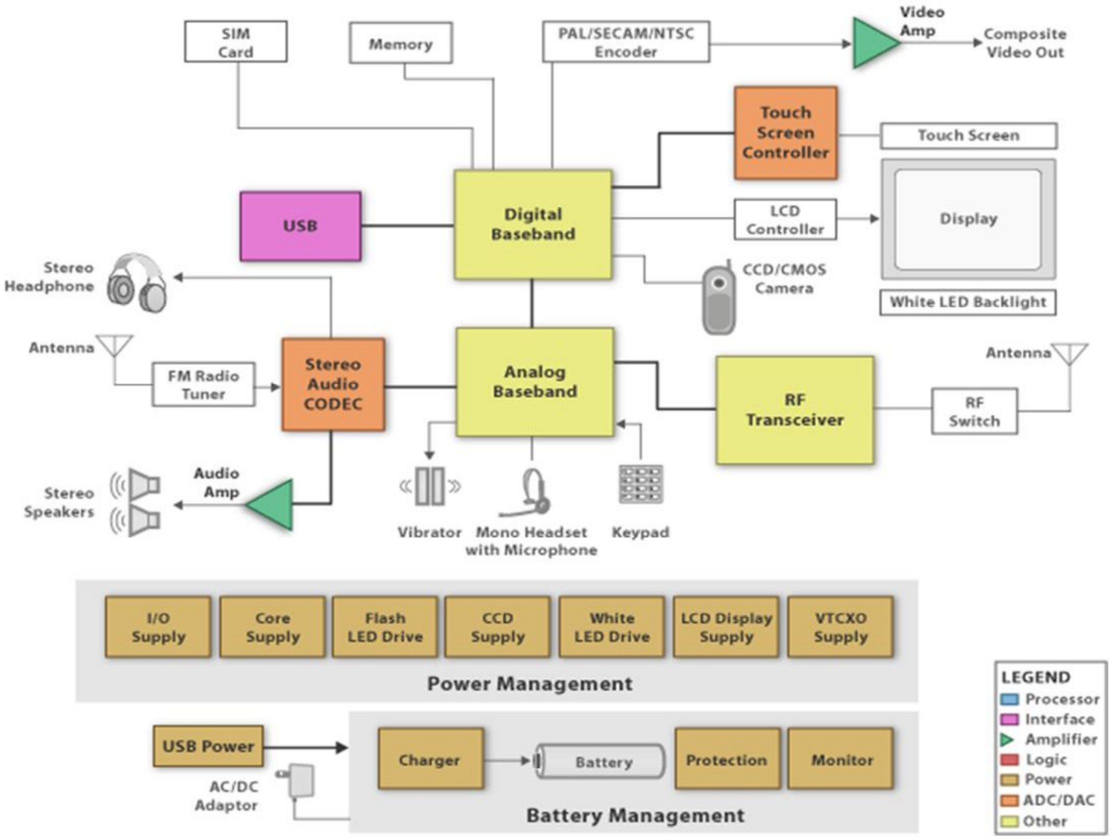

Figure 6 Various parts of a smart phone [7]

IV. CRITICALITY ANALYSIS

After predicting the failure modes from brainstorming, the relative measure of consequences of a failure mode and its frequency of occurrences should be estimated. This is achieved by criticality analysis in the failure modes. Criticality analysis is a procedure by which each potential failure mode is ranked according to the combined influence of severity and probability of occurrence. Here the failure modes are ranked by Risk Priority Number (RPN). Risk priority number is usually calculated as the product of severity, occurrence and detection. Severity considers the worst potential consequence of a failure determined by the degree of injury, property damage, or system damage that could ultimately occur. Occurrence is the rating scale that shows the probability or frequency of failure. Detection is the probability of failure being detected before the impact of the effect is realized. The RPN of each failure modes is determined from the brainstorming process. In the brainstorming process, experts give the values for each failure mode. The severity, occurrence and detection are pre-assigned in the range of 1 to 10. Here 1 represents less effect, 10 represents the most dangerous effect. These values are assigned for the parameters of severity, occurrence and detection. The RPN for each failure mode is calculated and tabulated in Table 2.

Table 1 FMEA in Android OS Smart Phones

HARDWARE				
Failure modes	**Functions**	**Failure causes**	**Failure effects**	**Effects on system**
Keyboard	Allow the user to execute operations	Due to accidental falls, water infiltration, wrong utilization and manufacturing error	Incapability to execute actions	No operation or wrong data
Battery Failure	Provide energy and sustainability to the phone	Due to inappropriate use of battery, over charging and aging	No power on, risk of explosion and need frequent charging	Constant shut down, Less charged time and lead to malfunction of software and hardware
Mobile phone shell	Covering and protecting the internal components	Low material quality, manufacturing design errors	Poor aesthetic look, low resistance and not comfortable to the user	Broken frequently, more external scratches, less anti stress factor, low withstanding power in falls and less water resistant
Screen/display	To interact with user, protection for internal display	Low material quality and manufacturer error	Incapability to interact with other functions	Black screen, color change, Low image quality, external scratches, poor resolution and Low thermal withstanding quality
Power supply unit	To supply DC power to all components	Manufacturing Error	Incapable of supply of electricity to the internal circuits	Low resolution image, Short circuit and Poor internal connectivity
SOFTWARE				
Failure modes	**Conditions**	**Failure causes**	**Failure effects**	**Effects on system**
Freeze	Sudden software hanging	Due to more operation, poor memory capacity, less software quality	Malfunction and hanging	Not able to operate the required function and Improper Output
Self-shut down	Sudden shut down accidently	Poor battery or software problem or memory access violation error	Create problems for various hardware and	Frequent shut down or Improper Output

			malfunctions of software	
Unstable behavior	There is no stable output in apps	Due to Operating system or poor Apps software quality	Malfunction or Hanging of system	Improper Output
Output failure	No output for the given Input	Input hardware Problem (Touch screen, button etc.) software problem	Malfunction	Improper Output
Failure data logger	Error output for the given Input	Internal hardware problem or software problem	No Data	No output or Improper output

Table 2 Calculation of RPN for hardware/software components

Failure modes	Severity	Occurrence	Detection	RPN	Rank Number
HARDWARE					
Failure mode - 1	8	6	4	192	4
Failure mode - 2	8	7	4	224	2
Failure mode - 3	5	8	8	320	1
Failure mode - 4	9	6	2	108	5
Failure mode - 5	8	5	5	200	3
SOFTWARE					
Failure mode - 6	8	7	6	336	2
Failure mode - 7	8	7	7	392	1
Failure mode - 8	8	4	2	64	5
Failure mode - 9	9	5	3	135	3
Failure mode - 10	9	3	3	81	4

IV. Results and Discussion

According to table 2, the failure mode and effect analysis is done for both hardware and software of Android smart phone. Based on study, it is taken only the main failure which was reported by the identified users.

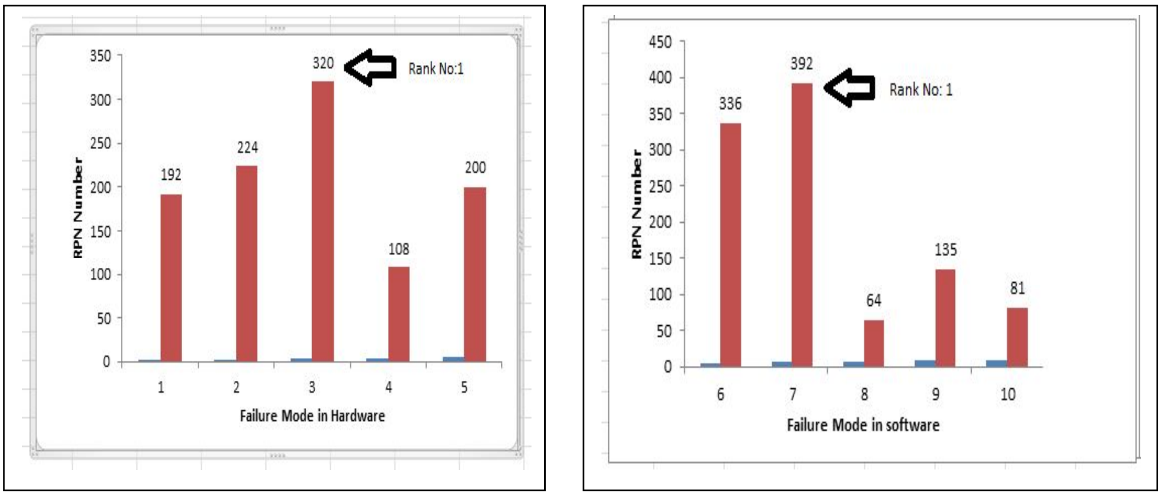

Figure 7 RPN number Range for different failure mode in Hardware and Software

The minor failures are not considered for FMEA analysis. Based on the Risk Priority Number, the mobile phone shell (failure mode -3) is ranked as No.1. This shows that top priority to be given for hardware in smart phone. If there is problem in the shell, it will lead more risk to the users. The same way the failure mode-7 is ranked as No.1 in software side. The self-shut down problem is most dangerous in software failure which leads to data loss or OS failure. So it is required to reload software again in smart phones. This will normally happen due to memory access violation error. So it is required to give more concentration on this memory access violation in smart phones. Figure 7 Shows the RPN Number range for various failure modes in hardware and software.

V. CONCLUSION

Normally, Android based smart phones are expensive because the facilities available for its users are more. So the failures due to various problems also lead to more service cost. The discussed analysis will help the user to identify more risk factors in Android smart phones. The result conclude that the mobile shell and memory access violation errors are having more risk in smart phones because these will make the phone damage or useless and also it leads to more service cost. The study also concludes that the manufacturer should give more care in the materials used for mobile shell and the software which are used for various applications.

REFERENCES

[1] Cinque,M., Cotroneo,D., Kalbarczyk and Iyer R.K.(2007), How do Mobile phone fail? A failure data analysis of Symbian OS smart phones, 37th Annual IEEE/IFIP International conference on Dependable systems and Networks, 25-28 June 2007, Edinburgh ISBN 0-7695-2855-4 pp. 585-594.

[2] Cinque, M.(2011) Enabling online dependability assessment of Android smart phone 41st Annual IEEE//IFIP International conference on Dependable systems and Network workshops , Hongkong 27-30, Junlie 2011, E-ISBN 978-1-4577-0373-7, pp 286-29.

[3] Luis Miguel Carreira Marques (2010) ‘ FMEA- Mobile phone’, university of Ljublijana , Available at : http://lrss.fri.uni_li_si/teaching/rzd/tutorials/marques2010_FMEA%20-%20mobile%20 phone.pdf

[4] Liu, W. and Li,H(2011) Impact analysis of a cellular phone with spilt Band , proceedings of 4th ANSA &ETAInternational conference, June 1-3, 2011, Makedonia palace, Thessaloniki, Greece.

[5] Square Trade Research brief (2010) Smart phone reliability : Apple iphones with fewest and major Andriod manufacturers not far behind , Available at : http://www.wired.com/images_blogs/gadgetlab/2010/11/ SquareTrade_cell_phone_comparison_study.pdf

[6] Tay, R., Chavannes, N., Futter,P, GII.Ng and Kuster,N.(2006) Failuremodes and effects Analysis(FMEA) on the RF performance of mobile device terminals ‘ Proceedings EUCAP 2006, France 6-10, Nov 2006, pp 1-6.

[7] Ronette Braithwaite and Tom Plotner (2008) F.M.E.A (Failure Mode and Effect Analysis) Eastern Illinois University Lecture Notes, Availabe at: castle.eiu.edu/~pingliu/.../discussion.ppt; Published in Mar 11,2008.