UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

ENHANCING LOCATION AWARENESS OF METER READERS USING MOBILE GPS IN A MOBILE METER READING APPLICATION

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DECLARATION

I hereby declare that this research proposal is my original work and has not been presented or is due for presentation for any award at any learning Institution.

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Signature:- é é é é é é é é é é é é é é ..**Date:** ....

DEDICATION

I dedicate this entire family for their moral support during the preparation of this research report.

ACKNOWLEDGEMENT

I feel greatly indebted to the almighty GOD for enabling me to do this research. I would like to acknowledge the inspirational instruction and guidance of my Supervisor Dr. A. Kahonge for his tireless guidance and entire teaching staff of University of Nairobi School of Computing & Informatics for both moral and technical support they granted me during my studies.

Special thanks go to my family members for their unrelenting moral and financial support.

May God bless you all.

DEFINITION OF TERMS/ ABBREVIATION AND ACRONYMS

MMRA- Mobile Meter Reading Application

App- Application

KEWASCO- Kericho Water and Sanitation Company Limited

SPSS- Statistical Package for Social Science

WSPs Water Service Providers

GIS- Geographical Information System

GSM- Global System for Mobile Communication

GPS Geographical Positioning System

ABSTRACT

With the tremendous growth of the technology, people have more opportunities to use the new technology in their daily life as well as work in the practical environment, the main goal of this paper was to comprehend GSM- GPS relation and how GSM can take advantage of the GPS infrastructure to enhance location awareness of meter readers. Mobile GPS MMRA is a technology mechanism where the Mobile Application is designed to assist field Assistants to record meter readings so as to enhance accuracy in data capture, subsequently upload to the core billing system some of the objective of this paper was to assess the performance of Mobile GPS Receiver at different geographical topology, to conduct comparative study on Mobile GPS Receiver with GPS Receivers (Garmin) and finally to develop a prototype that will show Anomalies when a meter reader fails to visit customerǿs connection hence reduce complaints and billing anomalies. This paper sought to investigate the literature review from GSM and GPS relation and GPS functionality in relation to this study, its objective and other related literature review

The study adopted descriptive and case study designs where descriptive research design aimed at providing insights into the research problem by describing the variables of interest as well, Using Kericho Water and Sanitation Company Ltd as the case study a target population of 38 from Kericho Water and Sanitation Company Ltd was used to derive 27 respondents being the sample size. Questionnaires and observation sheet was administered to GIS section and the general sample size. The researcher also administered interviews for top managers of the firm. Data analysis was done using Excel and finally the findings were presented in tables and graphs.

From the research findings itǿs evident that the Mobile GPS MMRA has eliminated billing anomalies related to meter reading. The same has reduced the billing process by approximately 3 days, also from the study Mobile GPS receiver can be enhanced with the use of GSM infrastructure by turning mobile data on.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

With the tremendous growth in technology, people have more opportunities to use the new technologies in their day to day life as well as work place in the practical environment, Telecommunication industries especially in mobile phones are moving into an era where underlying Applications, data and video usages are important as voice usages. In other words, it is slightly moving from mere communication-oriented services such as voice calls to more complex content-oriented services (Vesa, 2005). Nowadays, Mobile Phones are not used for voice services only, but also for data services such as rapid applications, texts messaging, gaming, download music, payment services, etc. Therefore, the future of the mobile Applications is expected to count on mobile services (Carlsson et al., 2006).

GPS (Global Positioning System) is a network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring distance from the satellites (Garmin, 2000). GPS now has been widely used by surveyors, commercial fishermen, recreational and so on to keep track of their current locations, find their way to a specified location and know what direction to take to get to the intended destination.

Billing as well is a critical function for all Water Service Providers towards getting a meter read, meter reading even though it looks simple, is far from simple and involves processes that can give various problems. Most problems seen are as a result of flawed processes attributed by meter readers who fabricate readings from the field. Calculation errors, delays in system updating and fault tracking issues are the major problems that companies find difficult to find answers for. This paper suggests a GPS enabled mobile based system to collect process and notify consumers about consumption. Kericho Water and Sanitation Company (KEWASCO) is among the top WSPs in Kenya mandated to provide Water and Sanitation Services within Kericho County and its environs. Their customers pay for these services offered by KEWASCO through a post-pay mechanism, i.e. connected residents use/enjoy the services and pay for the amount used at the end of every month.

1.2 Statement of the Problem

In order to determine and build statements for invoice generation, the company has a substantial task of determining how much each customer consumed for the specific month. This process was normally carried out by Mobile Application recording of meter reading by field Assistant who are mandated to visit every connected resident and record the months reading to be used in generating monthly bills. The readings are captured using mobile application and later transferred to classified master registers and finally uploaded to the billing system by the billing officer. The process does not have a feature to determine where the readings are taken from hence there is no way to ascertain if the field assistant actually visited the premise or not hence this process gives a lee way for meter readers to fabricate meter readings without necessarily visiting each and every connection hence leading to billing anomaly.

1.3 Proposed Solution

This paper suggests a mobile based system to collect process and notify consumers about consumption. The system is reliable, efficient and accurate to suit the requirements of the company. The proposed solution uses evolving GPS Mobile Technologies features to enable mobile meter reading App to capture readings including the GPS Coordinates of the customer, The burden on the Meter Reader is lessened and the objective of this being to eliminate inaccuracy and fasten the process of billing, Also MMRA will as well take readings including the coordinates of the Meter and compare with GIS master coordinates, this process will eliminate ‘Cooking’ of data by Field Assistants.

1.4 Objectives

1. To assess the performance of Mobile GPS Receiver at different geographical topology.
2. To conduct comparative study on Mobile GPS Receiver with GPS Receivers(Garmin)
3. To assess the impact of implementing GPS feature in Mobile meter reading Application to Billing process.
4. To develop a prototype that will show meter reader's field Anomalies hence reducing complaints and billing anomalies.

1.5 Research Questions

1) What geographical features may hinder performance of Mobile GPS receiver?
2) What infrastructure will enable Mobile GPS receivers to match with dedicated GPS receivers?
3) Will the new Mobile GPS meter reading improve billing process and customer complaints

1.6 Justification

Mobile services have indicated to create a tremendous spectrum of business opportunities both within and outside the Organization. A complete implementation of GPS MMRA is of paramount importance, it ensures the process is in line with KEWASCO strategic plan in ensuring enhanced location awareness for meter readers.as well accurate metering is achieved up to 90% accuracy guaranteed in billing. On the other hand this will reduce the billing cycle by almost a week and the overall customer complaints will be reduced. It will also assist in the formulation of clear functional and administrative framework of communication and reports of the companyôs mandate on service delivery to customers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

GPS (Global Positioning System) is a network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring distance from the satellites (Garmin, 2000). GPS now has been widely used by surveyors, commercial fishermen, recreational and so on to keep track of their current locations, find their way to a specified location and know what direction to take to get to the intended destination.

With the enhancement of GPS tracking system, there came out works like transportation survey. For instance, (Kracht, 2004) Kracht combined the technologies of GPS and GSM in his work,Tracking and Interviewing Individuals with GPS and GSM Technology on Mobile Device. In contrast to other typical tracking system, Kracht, introduced active tracking where people can response to the questionnaires given while they are traveling in order to add additional information to the recorded GPS/GSM recorder track. It has been showed that parallel GPS/GSM tracking is a good opportunity to fill incomplete GPS tracking data (Kracht, 2004). The use of GPS/GSM tracking with the usersô response has provided an alternative to more practical approach rather than requesting the users to wear technical equipment like GPS receiver in a long time period that could be a burden and burdensome for them.

Another project based on Computer-assisted self-interviewing (CASI) is described in Using Global Positioning Systems and Personal Digital Assistants for Personal Travel Surveys by Murakami this project combined Global Positioning Satellite (GPS) and Geographic Information Systems (GIS) technology with small hand-held computers (Personal Digital Assistants PDAs). This project was developed in order to improve the quality of travel behavior data, and reducing respondent burden like time on the telephone for reporting travel information (Murakami, 1996). It was found that using CASI combine with GPS technology enable the improvement of overall survey data quality in travel behavior studies. The project was developed by attaching the GPS Garmin antenna/receiver to PDA serial port and finally connects this attached equipment to the vehicle electrical system via vehicle cigarette lighter.

Location Activated Nomadic Discovery (LAND) this project aims to significantly enhance the accessibility of tourist information by offering a mobile system that delivers media rich information tailored to the user according to context (Taylor, 2000). This was achieved when visitors are able to navigate 3D mapping data presented on their PDA screen by of course means of GPS. LAND is a database driven application hosted on a server and accessed on a mobile, networked device. Static data, such as mapping data, were stored on the PDA whereas dynamic data such as destination management information were delivered on the fly using a wireless service (Taylor, 2000). According to an April 2006 survey, 22 States are currently using GPS monitoring systems (ICAOS, 2006). GPS is most commonly used to track sex offenders, but some states are using GPS to monitor other high-risk offenders. For example, New Jersey and California are contemplating GPS monitoring in domestic violence cases, Delaware uses GPS to track movements of juveniles under house arrest; and Pasco County, Florida, is using GPS for pretrial inmates to reduce jail overcrowding (Perlman, 2005).

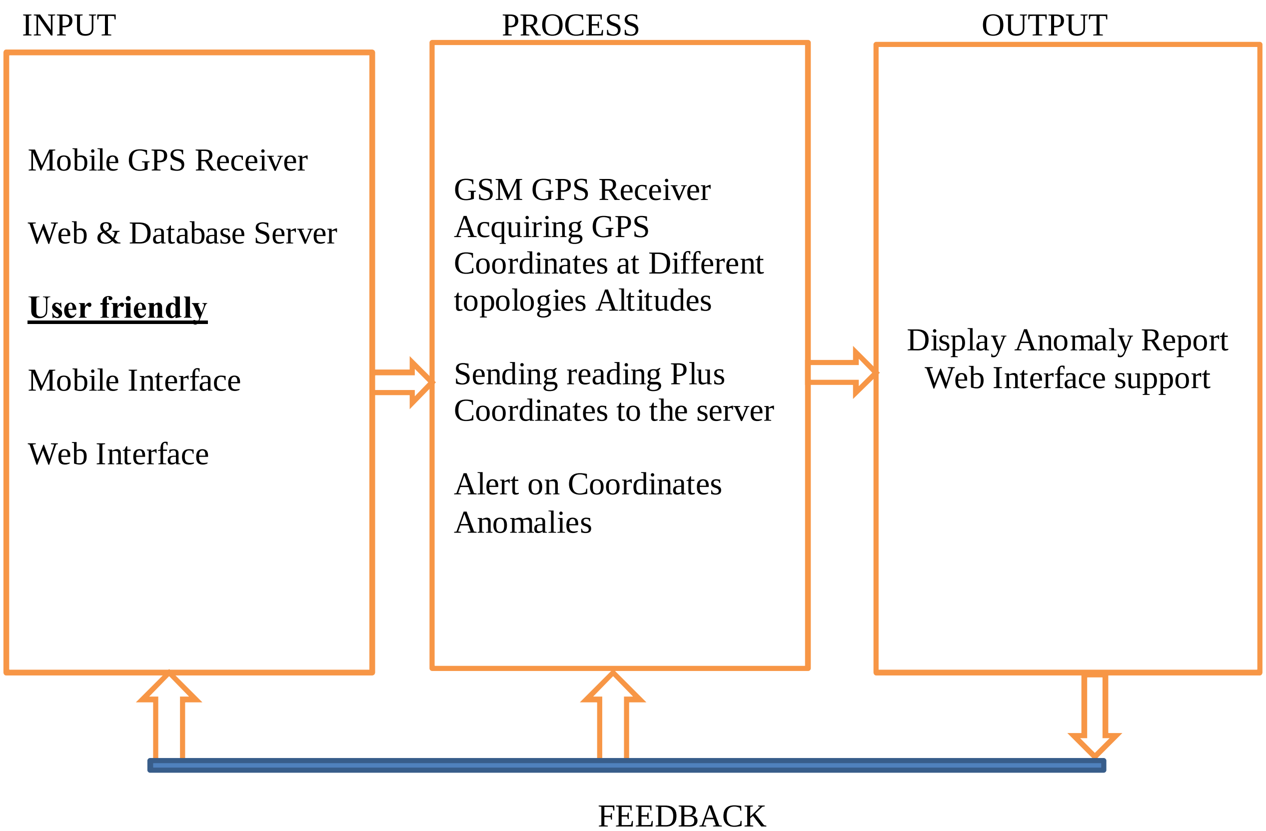
Despite its prevalence in the field, GPS monitoring has not been the subject of much formal evaluation. However, a recent study in Maryland found that staff training in the use of the technology was inadequate; the system often emitted false readings, hardware failed repeatedly, and batteries routinely died. Nonetheless, researchers determined that GPS aided in the early detection of risky behaviors before offenders committed new crimes (MTOP, 2004). Several other California assessments reinforce these findings (Perlman, 2005). Another recent study found this technology resulted in significantly reduced technical violations, reoffending, and absconding.

The addition of Global Positioning System (GPS) receivers to wildlife radio telemetry necks has enabled automated recording of animal position information that has largely overcome seasonal, daily and weather related observational biases associated in traditional wildlife telemetry studies. Automated data collection reduced the stress and biases associated with repeated disturbance of study animals and decreased positional errors of animal locations. Refinements in hardware, software and the deactivation of selective availability have reduced positional error to 10 m or less under optimal conditions (Johnson & Barton, 2004). This level of accuracy generally exceeds the spatial resolution of satellite imagery and Geographic Information Systems (GIS) data layers used to model habitat. (Rempel & Rodgers, 1997).

Despite these advantages, GPS receivers often fail to obtain a position under dense forest canopy or when topography blocks signals from orbiting satellites (Gerlach & Jasumbach 1989). Ignoring this issue, when evaluating data from GPS-collared animals, provides a biased view of habitat use towards areas of favorable GPS reception (Rempel *et al.* 1995). In light of these findings, he examined the GPS Position Acquisition Rate (PAR) across the Cascade Mountain range of Washington State for incorporation into a habitat analysis of GPS collared mountain goats.

2.1.1 Conceptual framework

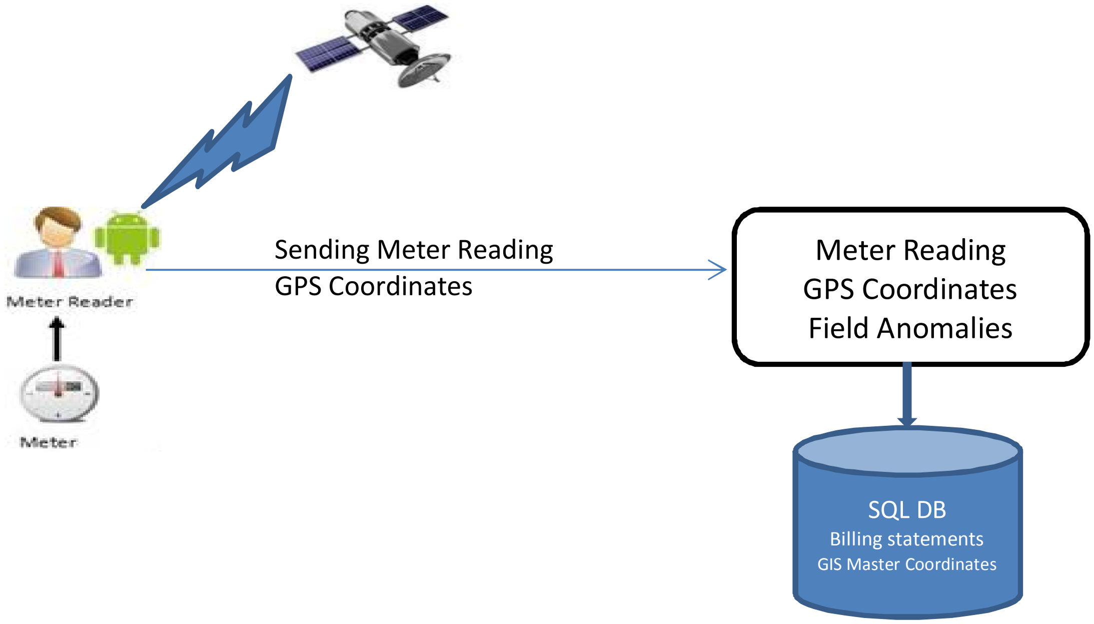
Figure 2.1 Conceptual Framework



From the Conceptual framework above the input being the Mobile receiver used to acquire coordinates and web interface to assign routes to the meter readers the processing point is where the topology changes at different altitudes the GSM GPS receiver will acquire coordinates including the meter reading and send the information to the master database, the point at which comparison will occur between acquired GPS coordinates with Master coordinates after which this will flag out reading which are off the accepted range.

2.1.2 System Architecture

Figure 2.1.2 Showing system Meter reading Architecture



2.2 HOW DOES GPS WORK

2.2.1 The Space Segment

Currently, there are 27 satellites in the orbit in which 24 units are put in operation while remaining three units are used as backup (Ash, 2004). These satellites are situated about 12 000 miles above the earth surface. Such high altitude will result to better global coverage. The satellites are arranged in their orbit. GPS satellites travel at the speed of 7 000 miles an hour as well as circle the earth twice a day in orbit and transmit signal to earth simultaneously. GPS receiver on earth will normally receive signal from four satellites at any given time. U.S Department of Defense launched the first GPS satellite in 1978 and in 1994 a full constellation of satellites was accomplished. The U.S Department of Defense is therefore responsible for the GPS management and maintenance by performing satellites replacement by launching it into orbit since each satellite was believed to last for about 10 years. The satellites were powered by solar energy and there are backup batteries available in the space there to ensure the system is running appropriately.

2.2.2 The Control Segment

As the name suggests, the control segment function is to control the GPS satellites by tracking them and then providing them with corrected orbital and clock (time) information (Garmin,2000). In order for the segment to perform its task, five control stations are assigned around the world in which four unmanned monitoring and one master control station. Monitor stations track GPS satellites data and send it to the master control station. The master control station corrects the data should there is be any error, and then send it back the GPS satellites via two transmitting antennas situated at the monitor stations.

2.2.3 The User Segment

The user segment consists of users like the military personnel, hikers, boaters, surveyors among others around the world who wish to determine their current location on earth. Two types of services are available such as Standard Positioning Service (SPS) and the Precise Positioning Service (PPS) (Natrah, 2004).

In order for GPS to work, it has to identify two important elements these being the satellites locations and the distance from you. The GPS will transmit signal to earth while circling the earth twice a day. As for the satellites locations, the GPS receiver manipulates coded information like directory data and data received from the satellites. Directory data simply refers to the approximate positions of satellites transmitted periodically by the satellites as they are circling the earth. GPS receiver stores this information in its memory.

As for the distance information on the other hand, distance formula is calculated. The formula is:

Distance = Velocity x Travel Time

Notice that the GPS receiver currently has the satellites location and distance. The userøs position on earth can be determined by conducting distance measurements from other satellites. Userøs 2D position (latitude and longitude) and track movement. Using GPS can be calculated if the GPS receiver receives signal from at least three satellites. Meanwhile, userøs 3D position (latitude, longitude and altitude) however can also be calculated if the GPS receiver receives signal from four or more satellites. In other words, the more signal from satellites it receives, the more accurate the outcome would be. The importance of userøs position information is so that other essential information such as speed, bearing, sunrise and sunset time, track and many more can be calculated as well.

2.6 Current GPS Applications

Since the US Military made GPS available for civil use, the technology and its applications in the commercial sector have flourished. Today GPS is used for navigation, scientific research, law enforcement, fleet monitoring as well as many leisure activities. The technology is so versatile it can be used for basically any outdoor activity. There are even golf GPS devices which display the layout of each hole and your location on the course .Many new cars have GPS devices installed to assist in navigation (Holden, 2004) and car rental companies use them so a carós location can be found at all times. Scientists are using GPS to calculate the movement of tectonic plates, arctic ice sheets and volcanic activity (search Mobile Computing.com, 2003). Products which monitor the movements of individuals are currently available in the US and have been available for some years. (Wherify 2005) is a company which specializes in location based services and products. One of their products is the one which has a GPS receiver encapsulated inside a small mobile phone. This device does not need to be locked on to a person but instead relies on the individualós dependency on the phone. This is not too difficult in modern society as mobile phones have become so essential to our daily lives. GPS is also useful to track the movements of certain groups of people. According to (Shimizu et al, 2000) people under parole are sometimes ordered to wear GPS receivers so their current position is always known and to ensure they do not leave a certain area. Using GPS tracking for these and similar purposes is beneficial and are examples of how GPS can assist social groups.

2.7 GPS Limitations

Satellite positioning (GPS) is an alternative technology, which gives better results in open area (it recently became 10 times more accurate because a military scrambling called SA was turned off) (Hardy, 2000). Despite of its significant capability of obtaining valuable information as explained earlier, GPS itself has some limitation that we must take into consideration. The signal travels by line of sight in which it is able to pass through clouds, glass and plastic but will not pass through physical solid objects such as mountains, building and so on resulting to not accurate outcome. In addition, GPS is not so good in cluttered areas like city centers where the signal from the sky is shielded or confused by echoes (Hardy, 2000). As an alternative of this drawback, other improved systems were introduced such as DGPS (Differential Global Positioning System) and WAAS (Wide Area Augmentation System).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides the research design to be utilized for the study and why, the target population from which data were obtained to answer the research questions, sampling and sampling procedures that were employed in the study, data sources and instruments, data collection procedures, data analysis and presentation.

3.2 Research Design

A research design is the plan according to which the researchōs participants are identified and to collect information from them.

The study adopted descriptive and case study designs where descriptive research design aimed at providing insights into the research problem by describing the variables of interest as well as providing answers to questions like: Who? What? When? Where? How? Descriptive research design was used when collecting information about peopleōs attitude, opinion, habit or any other variety of education or social issues and the design reports the way things are at the present (Mugenda , 1999)The adopted designs was preferred since it is simpler to use and convenient.

A descriptive study is concerned with determining the frequency with which something occurs or the relationship between variables these were appropriate because the study sought to investigate GSM- GPS relation and how GSM can take advantage of the GPS infrastructure to enhance location awareness of meter reader as it involved description of events in a carefully planned way.

3.3 The Target Population

According to (Ngechu, 2004), a population is a well-defined or set of people, services, elements, events, group of things or households that are being investigated. This definition ensures that population of interest is homogeneous. Population studies are more representative because everyone has equal chance to be included in the final sample that is drawn. (Mugenda, 2003).The target population should have observable characteristics, to which the researcher intends to generalize the results of the study.

The target population of the study consisted of senior staff and key management personnel of Kericho Water and Sanitation Company Ltd. They were categorized as staff working at KEWASCO in various hierarchical capacities and were presented as given in the table below:

Category	**Population**
GIS	7
ICT	4
Commercial Meter Readers	10
Technical Field Officers	5
Management	6
HOD Section Heads	6
Total	**38**

Table 3.1 Showing Target Population for the research

3.4 Sampling Procedure and Sample Size

Sampling is the statistical data collection method where a few units of a whole population are selected and results obtained on the basis of this few units are generalized for the whole population (Mugenda, 2003)

The sampling plan described how the sampling unit, sampling frame, sampling procedures and sample size for the study. The sampling frame described the list of all population units from which the sample was selected.

The researcher used stratified sampling technique to select a sample size from the target population of 38 in Kericho Water and Sanitation Company Ltd. From the above population, the sampling frame was divided into homogenous subgroups; hence stratified random sampling were used to obtain the sample.The subgroups consisted of heads of departments and key staff in the public utility firm.The respondents were then selected from each subgroup randomly.The random sample size constituted 10% marginal error of the total population accepted and 95% confidence Level .This sample size were diverse,generalizable and produced accurate results that were interpreted with certainty.Based on this, a sample size of respondents were selected.

Using the Formula Sample Size(SS)

According to (Israel 1992) Sample size can be derived using the formula below

95% confidence Level transalate to 1.96 Z-Score

$SS=(Z\text{-}Score)^2 * Sd^2/(Marginal\ error)^2$

$SS=1.96^2 * 0.5^2/0.1^2=96$

Adjusted SS=SS/1+[SS-1]/Population

Adj SS=96/(1+([96-1]/134))

Sample Size=27

3.5 Data Collection Tools and Techniques

Data was collected from both primary and secondary sources. From primary sources, a questionnaire marked *Appendix I* included closed and open-ended questions. Closed ended questions were used in an effort to effectively use time and other resources and to facilitate an easier analysis as they are in their immediate usable form. Open-ended questions were also used to encourage the respondents to give an in-depth response and better view of all relevant information. By using open-ended questions, a respondentôs reactions gave an insight to their feelings, background, hidden motivation, interest and decisions. The questionnaire was administered using a drop and pick later method to the respondents, Interview schedules were used particularly from the firmôs top administrative structure, observation Sheet Marked Appendix II also was used to try and compare performance of the Mobile GPS receiver at different topology.

From secondary sources, data was collected from Kericho Water and Sanitation Company Ltd documents such as strategic plans, policy papers, annual reports and conference presentations. Piloting study was done to verify the reliability and validity of the questionnaires. The purpose of the pilot study was to remove any irrelevant questions items, to gain knowledge on how to administer the instruments and to focus the questionnaire so that the right information was collected. After the pilot study, the researcher then proceeded to administer the questionnaire.

3.6 Validity

Validity indicates the degree to which the instrument measures the constructs under investigation (Mugenda, 1999) it also refers to the extent to which the instrument measures what it purports to measure. Validity is the degree by which the sample of test items represents the content the test is designed to measure, three validity tests were factored in these are: - Content validity, Concurrent validity and Construct validity.

Content validity refers to the degree to which the instrument fully assesses or measures the construct of interest. Content validity, which was employed by this study, is a measure of the degree to which data collected using a particular instrument represents a specific domain or content of a particular concept. Expert opinion was sought to comment on the representativeness and suitability of questions and give suggestions of corrections to be made to the structure of the research tools. Construct validity defines how well a test or experiment measures up to its claims. A test designed to measure depression must only measure that particular construct, not closely related ideals such as anxiety or stress.

To establish validity of the research instruments, the researcher sought the opinion of experts in the field of study so as to improve the content validity of the data that were collected. It also facilitated the necessary revision and modification of the research instruments, thereby increasing the validity.

3.7 Data analysis

The study involved both quantitative and qualitative data. The study examined the collected data to make inferences through cleaning and editing to eliminate repetitions and inconsistencies, classification on the basis of response homogeneity and subsequent tabulation for the purpose of inter-relating the variables. After data was checked for completeness ready for analysis, it was coded according to the themes to be researched on.

Data analysis and interpretation was based on descriptive statistics such as measures of location (mean) and measures of dispersion (standard error mean) as well as inferential statistics mainly multi-linear regressions, Pearson correlation, factor analysis and Analysis of

Variance. Data processing and analysis was finally done through use of quantitative techniques.

3.8 Data Presentation and Analysis

After data analysis information was presented tables and a Graphical presentation of the same was used.

3.9 Ethical Issues

Due to sensitivity of some information collected, the researcher upheld a moral obligation to treat the information with utmost propriety. Since the respondents might be reluctant to disclose some information, the researcher needed to reassure the respondents of confidentiality of the information given. The researcher also emphasized the importance of the study to the public utilityøs leadership. Researcher also conducted a briefing to respondents on details of the study.

CHAPTER FOUR

4.0 RESULTS AND FINDINGS

4.1 Introduction

This chapter presents results gathered from the research design that was utilized for the study and why. The target population from which data was obtained to answer the research questions, sampling and sampling procedures that was employed in the study, data sources and instruments, data collection procedures, data analysis and presentation.

The research findings for the study was obtained from different sources as highlighted below; questionnaires, field observation and interviews so as to enable researcher to achieve the object of the study

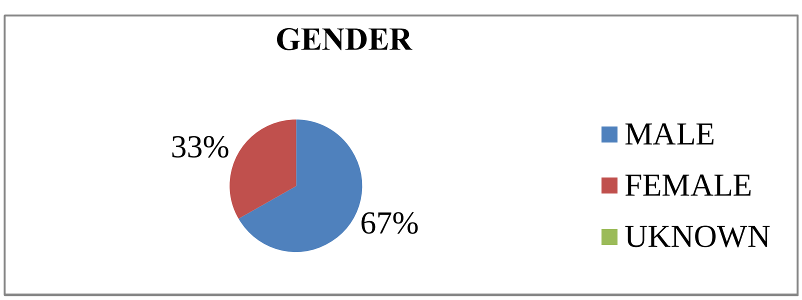
4.2 Response Rate

The study targeted 27 respondents in collecting data with regard to the use mobile GPS to enhance location awareness of the meter readers. From the study, 21 respondents out of the 27 sample respondents filled-in and returned the questionnaires making a response rate of 77.77%. According to Mugenda (2003) a response rate of above 60% is considered appropriate for credible results. This reasonable response rate was achieved after the researcher made personal calls and physical visits to remind the respondent to fill-in and return the questionnaires

4.3 Gender of the respondents

The study sought to find out the gender of the respondents. According to the findings, 67% of the respondents were male while 33% were female: This implies that majority of the employees dealing with meter reading and field officers under investigation were majorly male as depicted by the findings.(refer to figure 4.1 gender of the respondents below)

Figure 4.1: Gender of the respondents



4.4 Age of the respondents

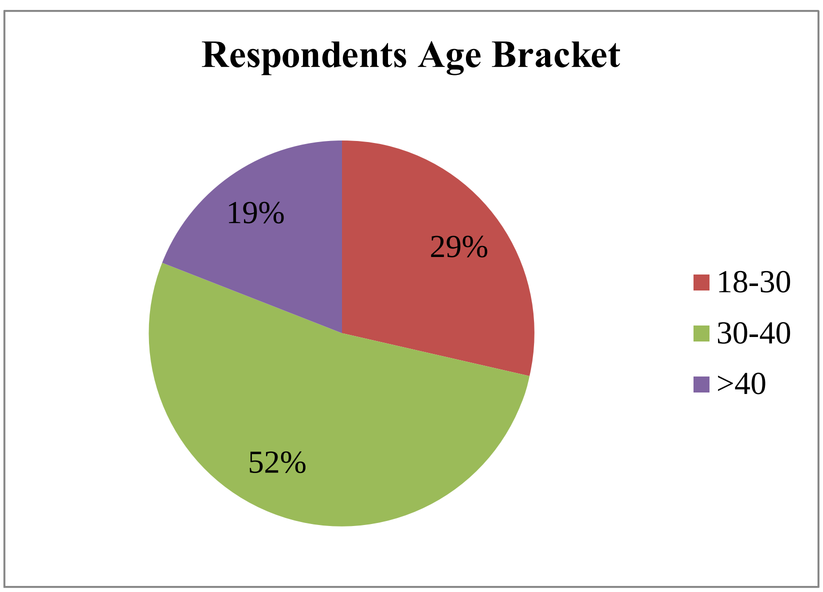
The study sought to find out the age of the respondents. From the findings, 52 % of the respondents are aged between 30-40 years, 29% of the respondents were aged 18-30 years, and 19% of the respondents were above 40 year. From the findings it can be deduced that majority of the staff in the organization are made up of old employees of age between 30-40 years. It can be drawn that most of these employees are not flexible enough to visit every customer connection hence the need to track them to ensure that the visit every connection.

Respondents of age between 18-30 years of age need to be trained so as to keep up with the new technology of GPS Mobile meter reading (Refer to table 4.1 Age of the respondents below)

Table 4.1: Age of the respondents

Respondents Age Bracket		
Age Bracket	Frequency	Percentage
18-30	6	29%
30-40	11	52%
>40	4	19%
Total	21	100%

Figure 4.2: Age of the Respondents



4.5 Department of work

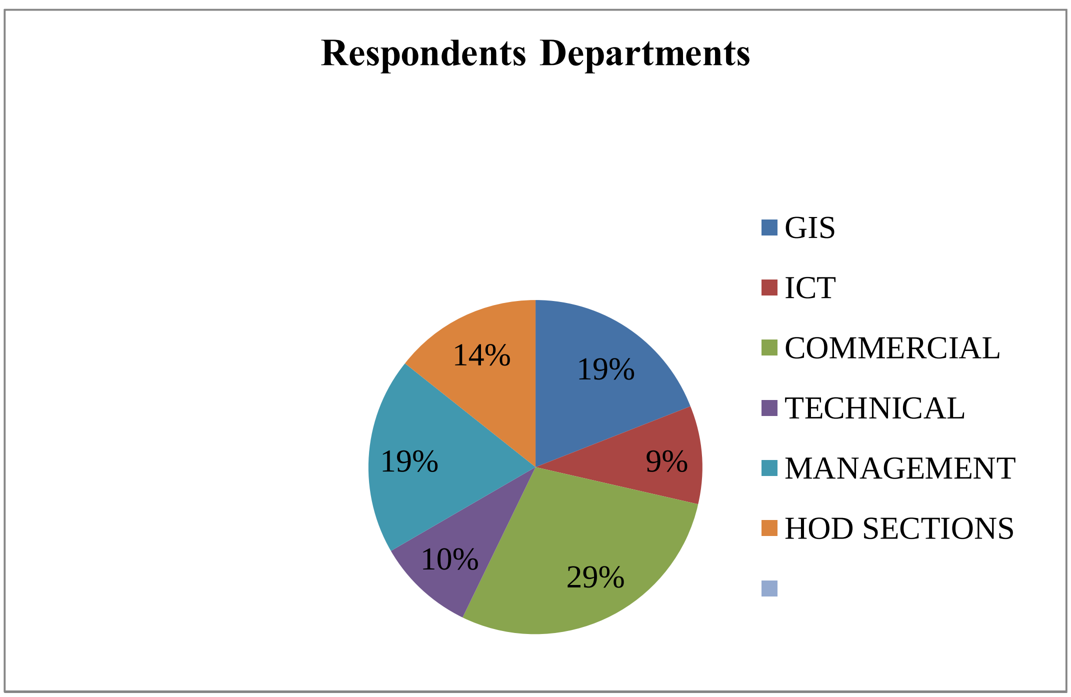
The study sought to find out the department the respondents work in. According to the findings, 19 % of the respondents worked in GIS department, 10 % of the respondents worked in ICT department, 29% of the respondents worked in Commercial department, 10 % of the respondents worked in Technical department, and 19 % of the respondents are management while 14% as the section heads.

From the findings its evident that majority of the employees were from the commercial department this can be attributed to the fact that the core implementation of GPS mobile meter reading is mostly affecting the commercial department. (Refer to Table 4.2 Department the respondents work in below)

Table 4.2: Department the respondents work in

Respondents Departments		
Department	Frequency	Percentage
GIS	4	19%
ICT	2	10%
COMMERCIAL	6	29%
TECHNICAL	2	10%
MANAGEMENT	4	19%
HOD SECTIONS	3	14%

Figure 4.3: Department of the Respondents



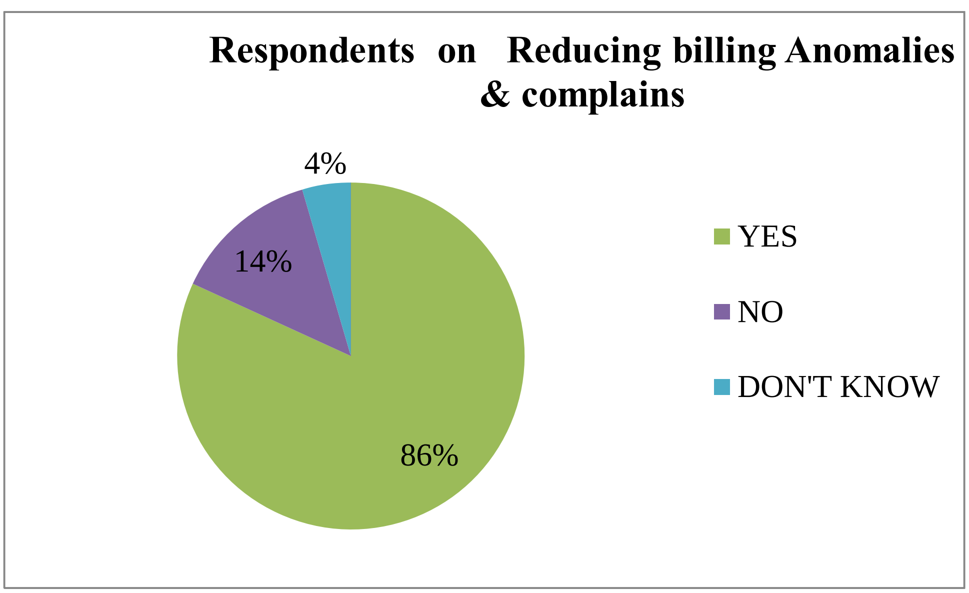
4.6 Billing anomalies

The study sought to find out whether the mobile GPS MMRA reduces the billing anomalies normally generated due to meter reading errors which in turn reduces the customer complains, According to the findings 86 % of the respondents believes that use of GPS MMRA enhances meter readersô location hence reducing billing anomalies which on the other hand reduces customerôs complaints,15% of the respondents do not believe this can reduce the anomalies while a smaller percentages of 5% do not know if this can reduce or Not as depicted in the table below(Refer to Table 4.3 Respondents on billing Anomalies)

Table 4.3: Respondents on reduction of Billing Anomalies

Respondents on Reducing billing anomalies & complains		
Response	Frequency	Percentage
YES	18	86%
NO	3	14%
DON'T KNOW	1	5%

Figure 4.4: Respondents on Billing Anomalies & complains



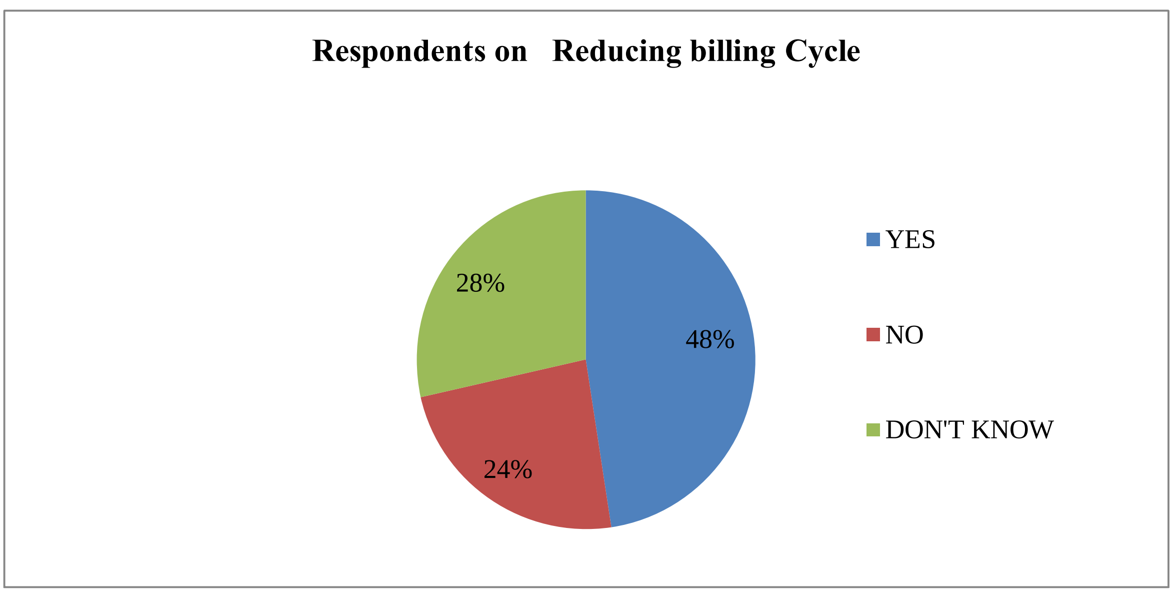
4.7 Reduction of Billing Cycle

The study sought to find out whether the mobile GPS MMRA will reduce the billing cycle and by how many days, from the findings a greater percentage of 48% of the respondents believe that the use of Mobile GPS MMRA will reduce billing process by approximately up to 3 days, 24% of the respondents does not think this will reduce the billing cycle while quite a bigger percentage of 28 are not aware if this will reduce or not this is because the technology could be new to them hence they cannot ascertain that. (Refer to Table 4.4 Respondents on reduction of Billing Cycle with days)

Table 4.4: Respondents on reduction of Billing Cycle

Respondents on Reducing billing Cycle		
Response	**Frequency**	
YES	10	
NO	5	
DON'T KNOW	6	
DAYS		
3 days	5	
7 days	3	
> 7 days	1	
DON'T KNOW	1	

Figure 4.4: Respondents on reduction of Billing Cycle



4.8 Performance of Mobile GPS receiver at different Altitudes

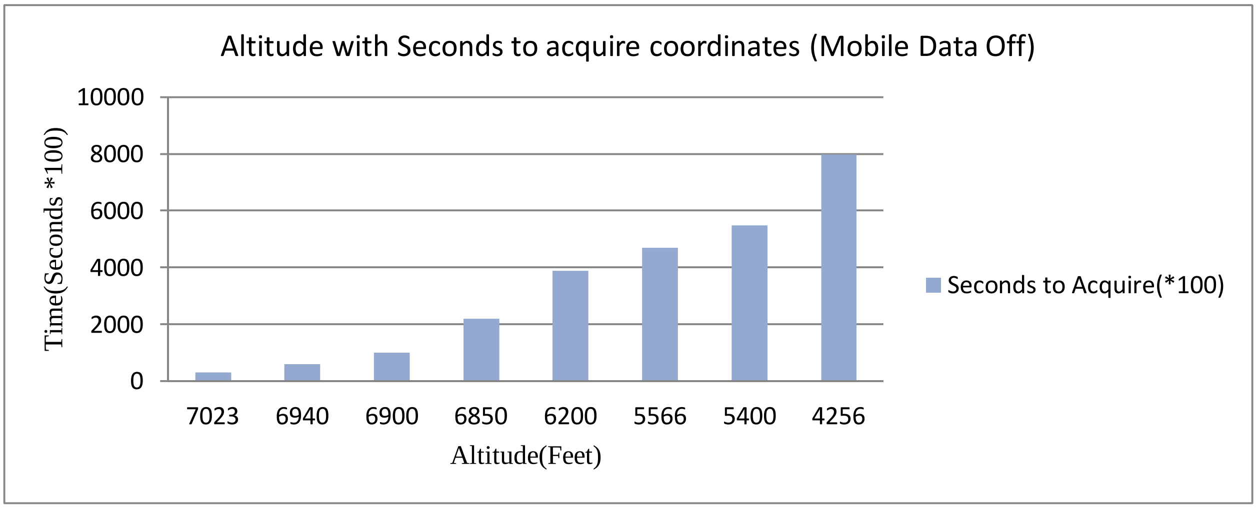
4.8.1 Performance of Mobile GPS receiver at different altitude (Mobile Data OFF)

The study sought to find the performance of mobile GPS receiver at different random altitudes when the mobile data is off. From the findings at high altitude of 7023 feet it takes an average of 3 seconds to acquire Latitude Degrees and Longitudinal degree (GPS Coordinates) and at low altitude of 4256 feet it takes an average of 80 seconds to acquire the GPS coordinates. Hence from these findings it can be deduced that at low altitude and Mobile data off Mobile GPS receiver experienced challenges in acquiring GPS coordinates hence this may render the Meter reading process slow if not improved. (Refer to Table 4.5 Mobile GPS receiver at different Altitudes and seconds to acquire coordinates).

Table 4.5: Mobile GPS receiver at different Altitudes and seconds to acquire coordinates

Mobile GPS Receiver at different altitude		
Altitude(feet)	Seconds to Acquire(X100) AVG	Seconds
7023	300	3
6940	600	6
6900	1000	10
6850	2200	22
6200	3900	39
5566	4700	47
5400	5500	55
4256	8000	80

Figure 4.5: Mobile GPS receiver at different Altitudes and seconds to acquire coordinates



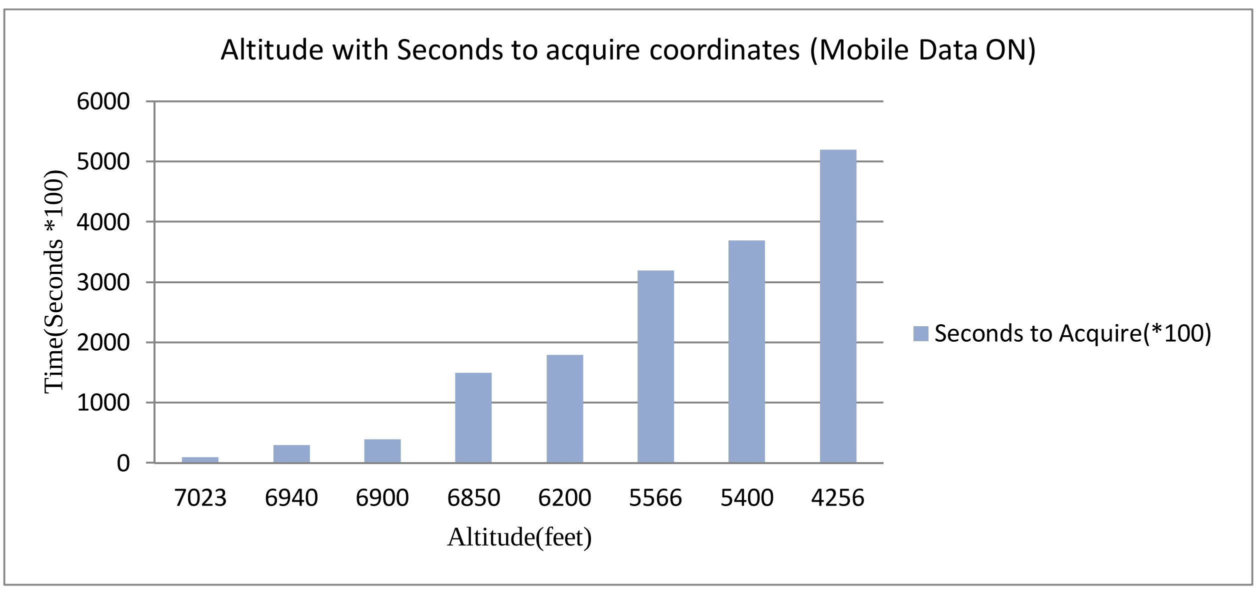
4.8.2 Performance of Mobile GPS receiver at different altitude (Mobile Data ON)

The study sought to find the performance of mobile GPS receiver at different random altitudes when the mobile data is ON. From the findings at high altitude of 7023 feet it takes an average of 1 second to acquire Latitude Degrees and Longitudinal degree and at low altitude of 4256 feet it takes an average of 52 seconds to acquire the GPS coordinates. Hence from these findings it can be deduced that with mobile data On Mobile GPS receiver has reduced the number of seconds it takes to acquire GPS coordinates even at low altitude as compared to when Mobile data is off hence the performance of Mobile GPS receiver can be improved using GSM infrastructure. (Refer to Table 4.6 Mobile GPS receiver at different Altitudes and seconds to acquire coordinates (Mobile Data ON)).

Table 4.6: Mobile GPS receiver at different Altitudes and seconds to acquire coordinates

Mobile GPS Receiver at different altitude Topology		
Altitude(feet)	Seconds to Acquire(*100) AVG	
7023	100	1
6940	300	3
6900	400	4
6850	1500	15
6200	1800	18
5566	3200	32
5400	3700	37
4256	5200	52

Figure 4.6: Mobile GPS receiver (Mobile Data On) at different Altitudes and seconds to acquire coordinates



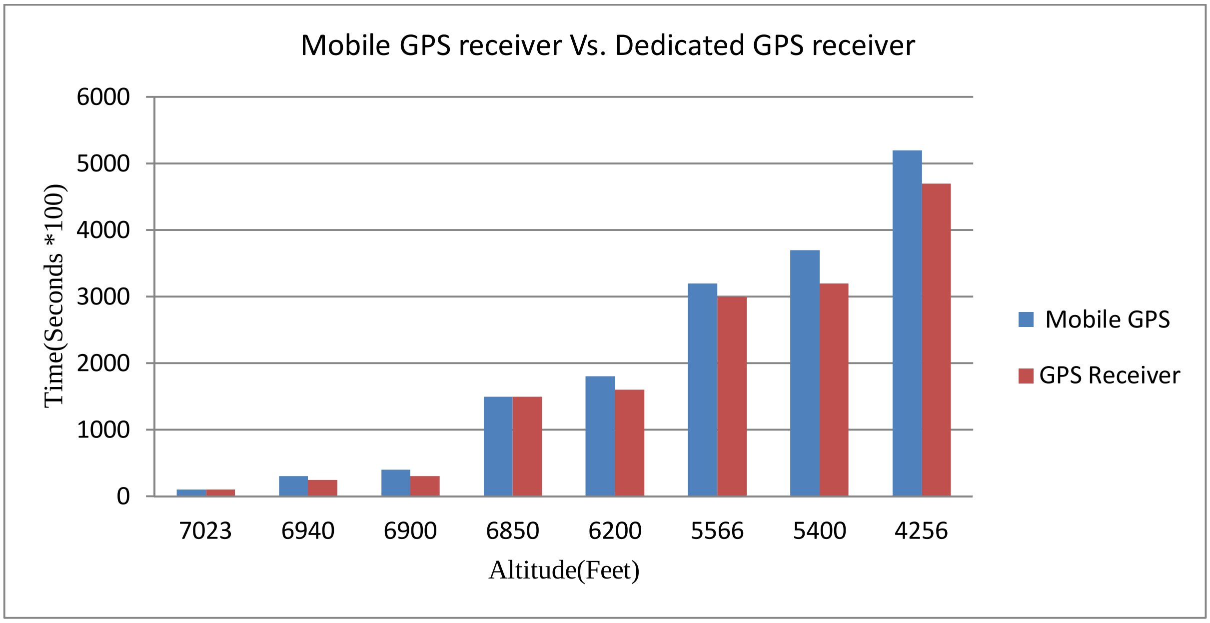
4.8.3 Performance of Mobile GPS Receiver (Mobile Data ON) Vs. GPS Receiver

The study sought to find the performance of mobile GPS receiver (mobile data is ON) as compared with dedicated GPS receiver (Garmin) .Using the improved Mobile GPS receiver compared with the dedicated GPS receiver subjected to same altitudes and from the results a variance of +5 seconds is evident from the table below even though dedicated GPS receiver still prove to be more superior in terms response time it takes to acquire coordinates but with minimal variance with Mobile GPS receiver.

Table 4.7: Mobile GPS receiver Vs. Dedicate GPS receiver

Mobile GPS Receiver VS GPS Receiver		
Seconds to Acquire(*100) AVG		
Altitude(feet)	Mobile GPS	GPS Receiver
7023	100	100
6940	300	250
6900	400	300
6850	1500	1450
6200	1800	1700
5566	3200	3000
5400	3700	3600
4256	5200	5000

Figure 4.6: Mobile GPS receiver Vs. Dedicated GPS receiver



The table below shows the variance in seconds when Mobile GPS receiver is compared with Dedicated GPS receiver. An average of 2 seconds variance can be deduced when the two devices are subjected to same altitudes and same conditions.

Table 4.8: Mobile GPS receiver Vs. Dedicate GPS receiver

Mobile GPS Receiver at different altitude Topology			
	Seconds to Acquire(*100) Averaged		
Altitude(feet)	Mobile GPS receiver	GPS Receiver	Variance
7023	100	100	0
6940	300	250	0.5
6900	400	300	1
6850	1500	1500	0
6200	1800	1600	2
5566	3200	3000	2
5400	3700	3200	5
4256	5200	4700	5
		Average	**2**

4.9 System Evaluation Results

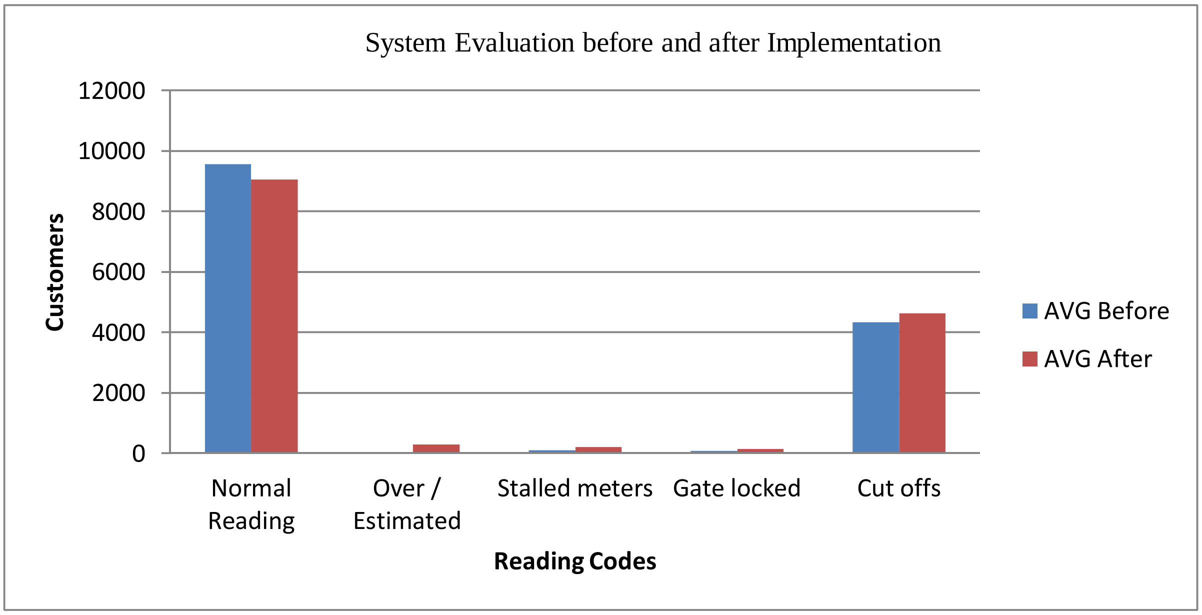
4.9.1 Performance Anomalies assessment

The study sought to assess the impact of implementing mobile GPS MMRA as compared with when the App does not have a mechanism of tracking meter readers. From the findings it is evident that after the implementation of mobile GPS MMRA it definitely highlight on several reading codes in relation to billing from the field i.e. Normal Reading, Over / Estimated, Stalled meters, Gate locked and cut offs.it is evident that Normal readings has reduce as other parameters in the field increases this shows that this meter readers are visiting all connections that why they can explore on other reading codes.

Table 4.9: System Evaluation before and after Implementation

	Before			After		
Parameter Billing Anomalies	**Oct**	**Nov**	**AVG**	**Dec**	**Jan**	**AVG**
Normal Reading	9435	9681	9558	9112	9025	9069
Over read / Estimated	48	11	30	282	303	293
Stalled meters	90	110	100	208	213	211
Gate locked	74	103	89	114	185	150
Cut offs	4232	4461	4347	4568	4684	4626

Figure 4.7: System Evaluation before and after Implementation



4.9.2 Usability

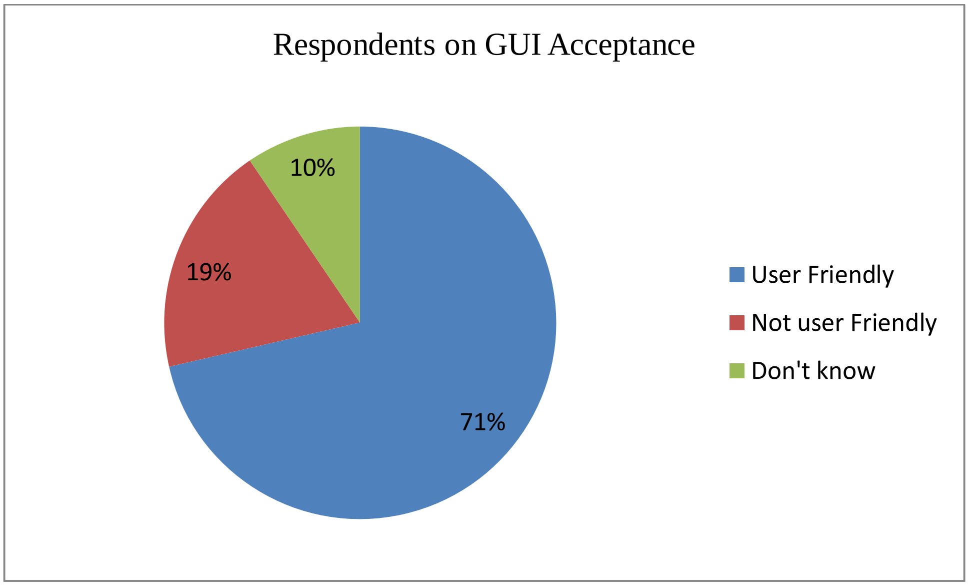
The study sought to find out whether Mobile GPS MMRA is user friendly and how receptive it is to the user. It sought to establish the user satisfaction response in relation to GUI, Navigation and Visibility of the system. Testing was performed under controlled experimental conditions and produces empirical evidence to inform design development. The table below depicts some of the feedback from users as per the usability parameters above.

a) Graphical User Interface Acceptance

Table 4.10: Respondents on System GUI Acceptance

Respondents on GUI Acceptance		
Response	**Frequency**	Percentage
User Friendly	15	71%
Not user Friendly	4	19%
Don't know	2	10%

Figure 4.8: Respondents on System GUI Acceptance

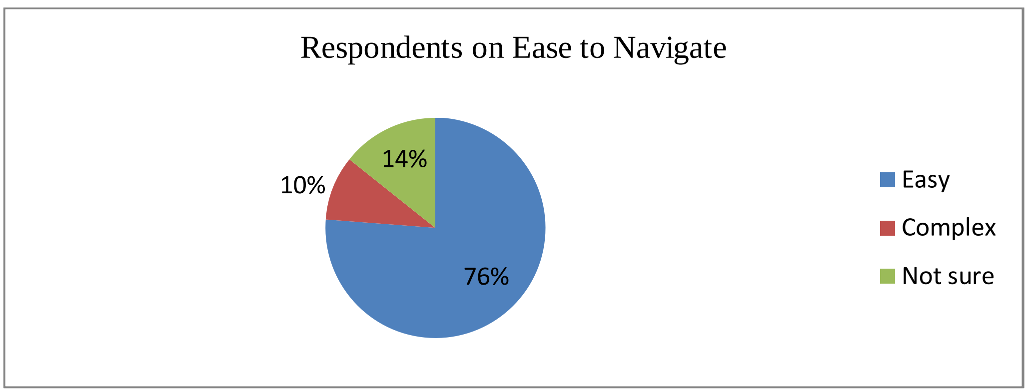


b) Ease to Navigate

Table 4.11: Respondents on ease to Navigate

Ease to Navigate		
Response	**Frequency**	Percentage
Easy	16	76%
Complex	2	10%
Not sure	3	14%

Figure 4.9: Respondents on ease to Navigate

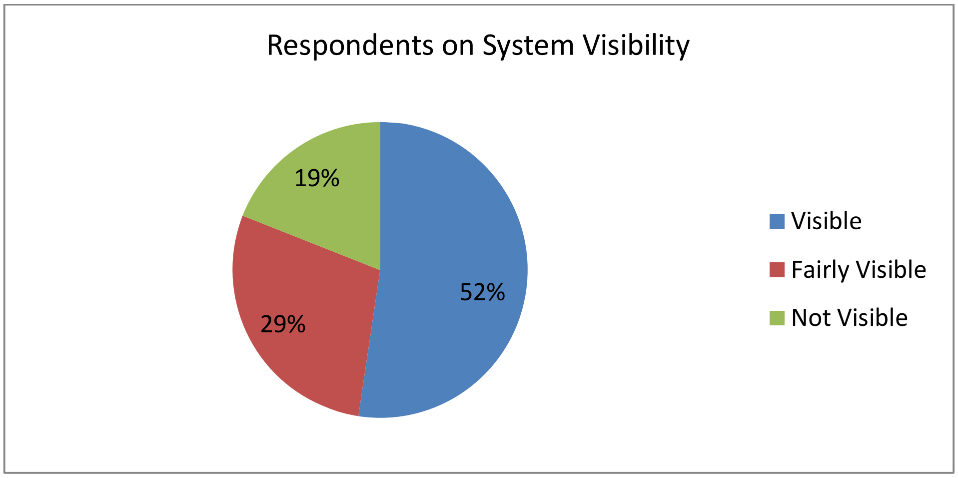


c) Visibility

Table 4.12: Respondents on application Visibility

Ease to Navigate		
Response	**Frequency**	Percentage
Visible	11	53%
Fairly Visible	6	29%
Not Visible	4	19%

Figure 4.10: Respondents on System Visibility



d) System Usability Discussion

From the above usability parameters administered to the system user it can be deduced that from the GUI 71% of the users find the overall system to have a good user interface that is easy to interact, 19% of the system users are of the opinion that the overall system does not have a good interface to interact while 10% of the users have donꞌt know. From this assessment the research can easily conclude that majority of the users are comfortable using the system without ignoring the remarks raised by the 19% system usersô i.e. color scheme of the interface interactive screen and some highlighted that the system is congested.

On the other hand 76% of the users find the system easy to navigate from on point to another while 10% of them find challenges navigating from one point to another, 14 % arenꞌt sure as they still require more time to analyze the system.

On the visibility of the system especially for the mobile application 52% of the users have no problem with font size used, 29% are partially comfortable with the screen visibility while 19% have issues with screen visibility. 29% and 19% of the system users is as a result of aging workforce of the employees.

Also from the system evaluation the meter readers were interviewed and from the interview it can be deduced that mobile GPS receiver experience delays in acquiring GPS coordinates under this conditions; lower altitudes, densely forested area, caves, basements and inside buildings.

CHAPTER FIVE

5.0 CONCLUSIONS AND FURTHER WORK

5.1 Conclusions

From the research findings the following conclusions can be drawn based on the study research questions and objectives as concluded below.

5.1.1 What geographical features may hinder performance of Mobile GPS receiver?

From the research findings the following conclusions can be drawn based on the study objectives On effectiveness of Mobile GPS receiver at different altitudes mobile GPS receiver experience challenges acquiring coordinates at low altitudes but from the study this can be improved by turning on data to enable the system to rely on GSM infrastructure at low altitudes hence improving on its performance at different topologies and different altitudes. From the study it is evident that at lower altitude, densely forested area, caves (valleys), and basements and inside buildings, mobile GPS receiver performance is stalled hence takes more time to acquire GPS coordinates.

5.1.2 Will the new Mobile GPS meter reading improve billing process and customer complaints?

On the impact of implementing GPS feature in Mobile meter reading Application to Billing process, from the study the researcher can conclude that full implementation of GPS feature on Meter reading app have reduced billing anomalies related to meter reading because meter readers are forced to visit every connection hence avoiding a situation of fabricating readings. This also have reduced the billing cycle because less errors are being corrected before billing is completed hence this means more revenue to the company and less personnel to handle billing process as less verification is required. On the other hand more readings codes is explored and the true picture in the field is established as meter readers are force to visit every connection in the field.

5.1.3 What infrastructure will enable Mobile GPS receivers to match with dedicated GPS receivers?

On the comparison of mobile GPS receiver with dedicated GPS receiver, Dedicated GPS receiver has proved to more reliable in acquiring GPS coordinates, however on the performance evaluation of mobile GPS receiver, the study revealed that using mobile GPS receiver while mobile data is off can be less effective and tends to take more time to acquire GPS coordinates at different altitudes and topology while on the other hand the study revealed that turning on mobile data boosts the performance of the mobile GPS receiver.

Hence from the study itös evident that turning on mobile data enabled the GPS receiver to use the GSM infrastructure to acquire coordinates so as to match its performance with dedicated GPS receiver, GSM infrastructure and clear line of sight to GSM base station are some of the infrastructures that boosts the performance of the Mobile GPS receiver.

5.2 Recommendations for further Work

From the findings the study recommends the following further researcher;

The study recommends that a similar study be carried to find out whether the same results will be obtained at even lower altitudes and different topologies.

Further research should be carried on the possibility of deploying MMRA to Dedicated GPS receiver so as to further improve accurate GPS coordinates.

Further research should be carried on the possibility of improving mobile GPS receiver so as to reduce coordinates acquisition time.

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Appendix I:

QUESTIONNAIRES

I am a postgraduate student at University of Nairobi School of Computing & informatics undertaking Master degree in Distributed Computing Technology (MSc DCT). I am carrying out an academic research on: understand GSM- GPS relation and how GSM can take advantage of the GPS infrastructure to enhance location awareness of meter reader in Water Service Providers, Case of Kericho Water and Sanitation Company Limited. This research is purely aimed for academic purpose and the information provided will be treated with utmost confidentiality. Kindly fill this questionnaire to the best of your ability Thank you.

Sample Questionnaires

Key

- ✓ Please put [**X**] where appropriate
- ✓ **MMRA** - Mobile Meter Reading Application

Section A: Personal Data

1. Gender
   - ☐ Male
   - ☐ Female
2. Age bracket
   - ☐ 18 ï 30
   - ☐ 30 ï 40
   - ☐ Over 40
3. Department:-é é

Section B: General Questionnaires

a) How often do you use GPS Receivers to collect GPS Coordinates?
   - ☐ Often
   - ☐ More Often
   - ☐ Less Often
   - ☐ Not at all

b) How long have you used GPS Receivers?
   - ☐ More than a Year
   - ☐ More than 6 months
   - ☐ Less than 6 months

c) Which GPS receiver do you commonly use?
   - ☐ GPS data loggers Receiver
   - ☐ GPS Mobile Receiver
   - ☐ Donôt Know

d) Do think GPS receivers are accurate at all altitudes and topology?
   - ☐ Yes

☐ No

☐ Not sure

e) Do you believe the use GPS MMRA will reduce billing anomalies and complains?

☐ Yes

☐ No

☐ Donôt Know

f) Do you feel the use of GPS MMRA will infringe on your privacy?

☐ Yes

☐ No

☐ Donôt Know

g) Do you think the use of GPS MMRA will ease the work of Meter Readers?

☐ Yes

☐ No

☐ Donôt know

h) Will the use of GPS MMRA Reduce the Billing Cycle?

☐ Yes

☐ No

☐ Donôt know

a) If Yes, by approximately how many days

☐ One day

☐ Three Days

☐ More Than a Week

☐ Donôt Know

i) Do you think the use of Mobile Phone will impact the social life of users?

☐ Yes

☐ No

☐ Donôt know

j) Would you recommend the same GPS MMRA to another Water Service Provider? (WSP)

☐ Yes

☐ No

☐ Not Sure

k) What is your general view about the GPS MMRA usage in KEWASCO?

é ..

Appendix II:

a) **Observation Sheet**

	Mobile GPS Observation			
Altitude(M)	Longituddes(Decimals)	Latitude(Decimals)	Seconds to Acquire	Accuracy

b) Comparison Observation Sheet

Mobile GPS Receiver at different altitude Topology		
	Seconds to Acquire	
Altitude(feet)	Mobile GPS	GPS Receiver

Appendix III:

System Evaluation Questionnaires

1) **How is the Graphical User Interface of the system?**

Parameters	**Cross (X) Where appropriate**
User Friendly	
Not user Friendly	
Don't know	

2) **How is the Navigation of the system from one point to another?**

Parameters	**Cross (X) Where appropriate**
Easy	
Complex	
Not sure	

3) **Do you have challenges seeing the content on the system screen?**

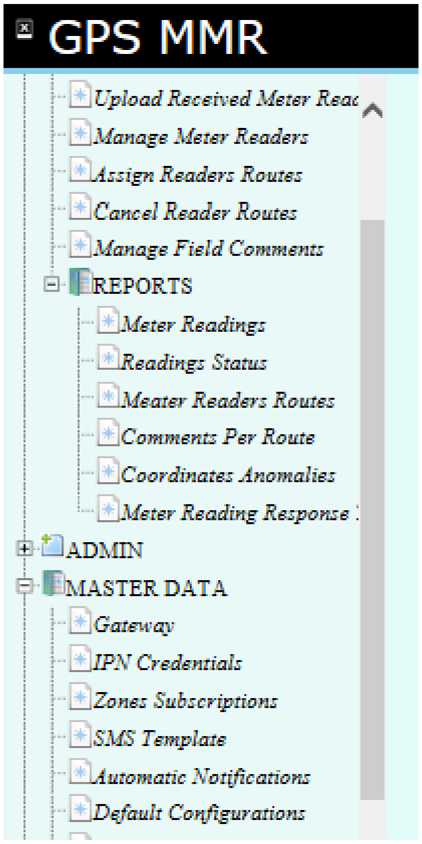
Parameters	**Cross (X) Where appropriate**
Visible	
Fairly Visible	
Not Visible	

Mobile GPS and GPS Receiver at different altitude Topology From GIS team

Mobile GPS Receiver at different altitude Topology								
Average								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	1.36	2.14	2.86	14.57	17.71	32.14	36.86	51.86
GPS Receiver	1.06	2.50	3.86	14.86	15.71	30.57	32.43	46.57
R001								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	0.5	1	4	16	15	28	36	50
GPS Receiver	1	2.5	5	12	16	31	33	44
R002								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	1.5	3	1	12	18	32	37	54
GPS Receiver	1.4	2.5	1	13	14	30	32	43
R003								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	1	2	3	16	17	30	35	53
GPS Receiver	1	2.5	1	14	18	28	36	47
R004								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	2	1	4	10	20	36	34	50
GPS Receiver	1	2.5	7	15	15	32	30	46
R005								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	1.5	1	5	15	17	35	39	52
GPS Receiver	1	2.5	5	18	16	33	33	47
R006								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	2	3	1	17	18	33	40	51
GPS Receiver	1	2.5	3	17	15	31	31	49
R007								
Altitude(feet)	**7023**	**6940**	**6900**	**6850**	**6200**	**5566**	**5400**	**4256**
Mobile GPS	1	4	2	16	19	31	37	53
GPS Receiver	1	2.5	5	15	16	29	32	50

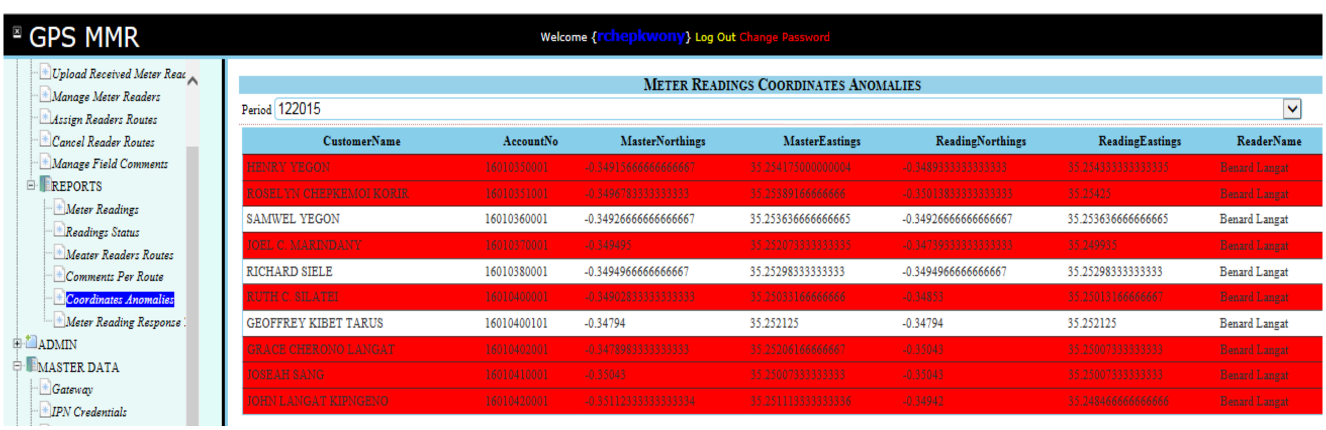
User Interfaces and Code Snippet

Navigation screen moving from one page to another



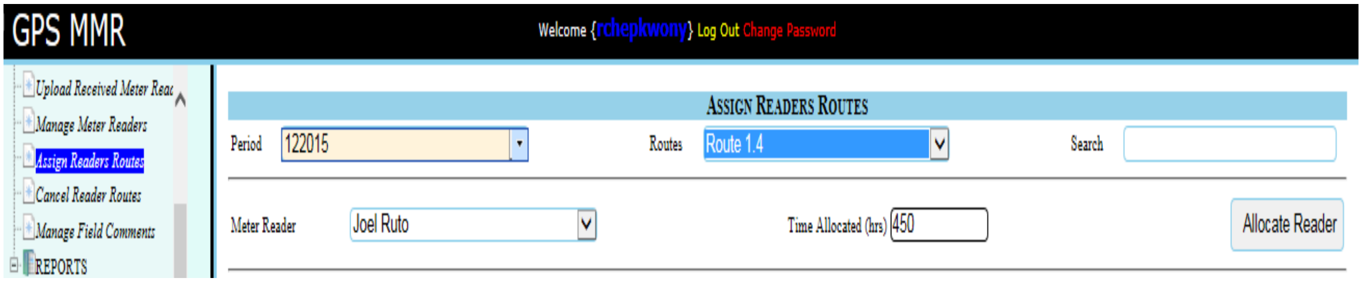
Coordinates Anomalies Report

The highlighted red shows variation from the meter points by comparing the readings coordinates with Customers master Coordinates
If the variation is not within the set boundary the system highlights it with red



Assigning meter readers routes

This is the interface for assigning routes to meter readers



Code Snippet

```
    SelectCommand="SELECT top 1000 tblLoggersOut.CustomerName,
tblLoggersOut.AccountNo, tblCustomersMasterCoordinates.Northings AS
MasterNorthings, tblCustomersMasterCoordinates.Eastings AS MasterEastings,
tblreadingsheetupload.northings AS ReadingNorthings, tblreadingsheetupload.eastings
AS ReadingEastings, VIEW_DL_MTREADER.ReaderName FROM tblLoggersOut
INNER JOIN tblreadingsheetupload ON tblLoggersOut.CustomerID =
tblreadingsheetupload.customerid INNER JOIN tblCustomersMasterCoordinates ON
tblLoggersOut.AccountNo = tblCustomersMasterCoordinates.CustomerId INNER JOIN
tblroutestometerreaders ON tblLoggersOut.RouteID = tblroutestometerreaders.routeid
INNER JOIN VIEW_DL_MTREADER ON tblroutestometerreaders.meterreaderid =
VIEW_DL_MTREADER.ReaderID WHERE (tblroutestometerreaders.Status = 1) AND
(tblLoggersOut.Period = @Period)">
```

Configuration Snippet

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
  For more information on how to configure your ASP.NET application, please visit
  http://go.microsoft.com/fwlink/?LinkId=169433
  -->
<configuration>
  <connectionStrings>
    <add name="ApplicationServices" connectionString="data
source=.\SQLEXPRESS;Integrated
Security=SSPI;AttachDBFilename=|DataDirectory|\aspnetdb.mdf;User Instance=true"
providerName="System.Data.SqlClient" />
    <add name="EQSMSConnectionString" connectionString="Data Source=RASTO-
ITM\SQLEXPRESS;Initial Catalog=CloudSyncSMS;User
ID=sa;Password=raskiches1987" providerName="System.Data.SqlClient" />
    <add name="CloudSyncSMSConnectionString" connectionString="Data
Source=RASTO-ITM\SQLEXPRESS;Initial Catalog=CloudSyncSMS;Persist Security
```

```
Info=True;User ID=sa;Password=raskiches1987"
providerName="System.Data.SqlClient" />
    <add name="CloudSyncSMSConnectionString1" connectionString="Data
Source=RASTO-ITM\SQLEXPRESS;Initial Catalog=CloudSyncSMS;User
ID=sa;Password=raskiches1987" providerName="System.Data.SqlClient" />
    <add name="CloudSyncSMSConnectionString2" connectionString="Data
Source=RASTO-ITM\SQLEXPRESS;Initial Catalog=CloudSyncSMS;Persist Security
Info=True;User ID=sa;Password=raskiches1987"
providerName="System.Data.SqlClient" />
  </connectionStrings>
  <appSettings>
    <add key="aspnet:MaxHttpCollectionKeys" value="15000" />
  </appSettings>
  <system.web>
    <compilation targetFramework="4.0">
      <assemblies>
        <add assembly="System.Web.Extensions.Design, Version=4.0.0.0, Culture=neutral,
PublicKeyToken=31BF3856AD364E35" />
        <add assembly="System.Design, Version=4.0.0.0, Culture=neutral,
PublicKeyToken=B03F5F7F11D50A3A" />
        <add assembly="System.Windows.Forms, Version=4.0.0.0, Culture=neutral,
PublicKeyToken=B77A5C561934E089" />
        <add assembly="System.Data.Entity, Version=4.0.0.0, Culture=neutral,
PublicKeyToken=b77a5c561934e089" />
      </assemblies>
    </compilation>
    <authentication mode="Forms">
      <forms loginUrl="~/Account/Login.aspx" timeout="2880" />
    </authentication>
    <membership>
      <providers>
        <clear />
        <add name="AspNetSqlMembershipProvider"
type="System.Web.Security.SqlMembershipProvider"
connectionStringName="ApplicationServices" enablePasswordRetrieval="false"
enablePasswordReset="true" requiresQuestionAndAnswer="false"
requiresUniqueEmail="false" maxInvalidPasswordAttempts="5"
minRequiredPasswordLength="6" minRequiredNonalphanumericCharacters="0"
passwordAttemptWindow="10" applicationName="/" />
      </providers>
    </membership>
    <profile>
      <providers>
        <clear />
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type="System.Web.Profile.SqlProfileProvider"
connectionStringName="ApplicationServices" applicationName="/" />
```

```
      </providers>
    </profile>
    <roleManager enabled="false">
      <providers>
        <clear />
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type="System.Web.Security.SqlRoleProvider"
connectionStringName="ApplicationServices" applicationName="/" />
        <add name="AspNetWindowsTokenRoleProvider"
type="System.Web.Security.WindowsTokenRoleProvider" applicationName="/" />
      </providers>
    </roleManager>
        <identity impersonate="false" />
  </system.web>
  <system.webServer>
    <modules runAllManagedModulesForAllRequests="true" />
  </system.webServer>
</configuration>
```