UNIVERSITY OF NAIROBI

DEVELOPMENT OF A MOBILE GIS DATA COLLECTION SOLUTION

A Case Study of Kenya Power Prepaid Meter Project

Bv

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Declaration

This Project Report is my original work and has not been presented for a Degree any other University:

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Date

S i g n a t u r e ^_

This Project Report has been submitted for examination with my approval University Supervisor:

Name: Professor J.B.K. Kiema

Date /fl^Zof'f

Signature

Dedication

This work is dedicated to my mum Rose who passed on a love of reading and respect for education.

Acknowledgements

Special thanks go to my supervisor Professor John Bosco Kyalo Kiema. As my advisor, Prof. Kiema provided guidance, insightful comments and encouragement throughout the course of preparing for and conducting the research. His belief in me was astounding.

My thanks go to ESRI Eastern Africa, for financial support and providing a perfect setting for conducting this study. I am grateful to my colleagues at ESRI Eastern Africa who generously contributed their time and operational expertise. Thanks to David my line manager for his patience and provision of GNSS equipment and Eng. John Wekesa of Kenya Power for providing data, support and facilitating the field test. 1 am grateful to Laban Ndungo, who provided guidance in programming and scripting.

Thanks to many friends who cheered me on from the beginning, and special thanks to my family for their support and prayers throughout the process and for their pride in this accomplishment.

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TABLE OF CONTENTS

List of Tables

f

List of Figures

Abstract

Mobile GIS is the expansion of GIS technology from the office into the field. It enables field personnel to capture, store, update, manipulate, analyze and display geographic information. Traditionally, the processes of Field data collection and editing have been time consuming and error prone. Field edits were performed using sketches and notes on paper maps and forms. Once back in the office, these Field edits and measurements were reduced manually and Finally entered into digital systems. The result has been that data has often not been up to date or accurate. The main objective of this study was to develop a field data collection solution to support specific GIS field tasks and projects which was aimed at ensuring that attribute and spatial data was up to date and accurate with little or no redundancy.

Mobile GIS integrates three essential components; Global Navigation Satellite Systems (GNSS), rugged handheld computers, and GIS software. Bringing these technologies together made the enterprise database directly accessible to field based personnel whenever and wherever required. The system developed is based on existing GIS (Field and Office software) and Hardware (GNSS Receiver), using existing software Development Kit (SDK).The functionality of the system was customized to Fit into user desired field to office scenario.

The development of the solution entailed creation of data collection form that was user friendly and based on existing database structure, a script to perform checks within the existing database before updating or adding new attribute and spatial information and a barcode scanner to read meter information automatically.

The approximately automatic system resulted in Kenya Power prepaid meter database, being updated quickly with no redundancy, adding position information to attribute data, and reducing human errors in information collecting process.

Abbreviations

CAD	Computer Aided Design
DBMS	Database Management System
DGNSS	Differential Global Positioning System
ESRI	Environmental System Research Institute.
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
KETRACO	Kenya Electricity and Transmission Company
PDA	Personal Digital Assistant
SBAS	Satellite Based Augmentation System
SDK	Software Development Kit
USB	Universal Serial Bus
GSM	Global System for Mobile Communications
GPRS	General Packet Radio Service
INS	lnertial Navigation
RTCM	Radio Technical Commission for Maritime Services
UMTS	Universal Mobile Telecommunications System
EGNOS	European Geostationary Navigation Overlay Service
WAAS	Wide Area Augmentation System
MSAS	Multi-functional Satellite Augmentation System

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study-

Kenya Power is a limited liability company which transmits, distributes and retails electricity to customers throughout Kenya currently, it runs and maintains infrastructure which serves over 1 million customers.

With the creation of Kenya Electricity and Transmission Company (KETRACO) whose core business is to plan, design, build, operate and maintain new electricity transmission lines and associated substations that will form the backbone of the National transmission Grid. Kenya Power mandate is now focused on distribution and customer service.

In the quest to improving customer service Kenya Power has embarked on rolling out of prepaid metering system. For consumers to easily access power, the utility company has undertaken pilot projects which were launched in April 2010, and 15,317 meters had already been installed in a number of city estates by December 22, 2010. The estates covered so far include Villa Franca, Sportsview, Kibera Highrise, Imara Daima, Fedha, Tasia, Njiru Waroma, Njemuwa and Jemwa Kasarani. Others are Nyayo Embakasi, Baraka, River Bank, Mountain View, Woodley, Jamhuri II, Kibera, Muguga Green, Hirani, Kahawa Sukari and individual plots within Kasarani.

Findings of a recent customer satisfaction study shows that many prefer the prepaid system because it gives them the power to control their consumption hence the need to transfer domestic customers to prepaid metering. However, it is envisioned that large power customers like industries, factories and other big institutions, will remain in the post-paid system.

The availability of reliable customer information and spatial location of the meters and utility poles have proven critical in decision making and planning. Therefore Kenya Power has advised its contractors to provide GNSS coordinates of the location of the installed prepaid meters.

However, location information from the contractors is often unreliable more specifically there is usually a mismatch when spatial data is merged with customer information obtained from the existing customer database.

In recognition of the power of mobile GIS to support accurate spatial and attribute data collection and the need for reliable spatial information to aid decision making and planning. Kenya Power has procured 70 mobile GNSS data gathering units, and has tendered for more GNSS units for use in the National rollout of the prepaid meters.

1.2 Statement of the Problem

Traditionally, GIS has been used in Kenya Power for mapping of infrastructure among them utility poles, power lines and points of distribution. This data is mainly obtained from hardcopy survey and CAD drawings obtained from both contracted surveyors and Kenya Power surveyors. This data is georeferenced and ported into Facility Database System which has visualization component in terms of CAD view and database component where queries can be carried out and descriptive information obtained.

However, the location of the customer meters were never captured and field personnel relied on addresses provided from the meter application details and field experience to service and support customers. In as much as the utility poles location was obtained from the Facility Database, updating this data has been a challenge in that what exists is as built details. For instance whereas the current location of a pole might be known the current status may not be known e.g. is it worn out, is it leaning, does it need repair or replacement and so on.

In the initial pilot projects for prepaid meters attribute data was obtained from existing customer database. Coordinates of meters were then taken separately using handheld GNSS units and later the two datasets were merged and input into GIS. However this method was found to be error prone and time consuming considering all the processes of downloading, merging and verification of data.

In pursuit of improved customer service and the roll out of prepaid meters, spatial, attribute and temporal accuracy have been defined as key in planning and decision making. Kenya Power has therefore taken advantage of advances in mobile computing, GNSS and G1S technology.

The Mobile GIS approach will help in minimizing the errors, ensure timely update of data, and efficient data collection cost effectiveness with high spatial and attribute accuracy with an option of tweaking the system to fit into Kenya Powers' field to office workflow.

1.3 Objectives of the Study

1.3.1 General Objective

To develop a customized data collection solution to support Kenya Power field activities and the mobile workforce

1.3.2 Specific Objectives

The specific objectives of the research are:

i. To design user interface for capturing new data, updating existing data and querying collected data on meters and customer details.

ii. Customize, GIS field Software (ESR1 ArcPad) to support Kenya Power data collection workflow.

iii. Integrate GNSS Unit (Trimble Nomad) barcode scanner capability with the field Software.

1.4 Significance of the Study

The advantages of the mobile GIS system will include reliable information. With a backdrop of a map in the field device and the inbuilt GNSS receiver, spatial and attribute accuracy is guaranteed.

With automation and customization of the mobile GIS systems, the field data collection schema is a replica of the office system database schema as such it enables flow of data from the office to the field in a seamless manner with little or no redundancy on the data collected.

With the additional components of the mobile devices like camera, barcode scanner a richer set of attribute data is collected. Furthermore it standardizes field data collection and data management.

Essentially, the customized mobile GIS approach will help in minimizing the errors, timely update of data, efficient data collection, cost effectiveness and high spatial and attribute accuracy.

1.5 Limitations of the Study

The foreseen limitations to this study include and are not limited to the following: The solution implementation will depend heavily on ESRI. ArcPad Studio development platform and Trimble Data collection Hardware devices which forms the basis of the existing Kenya Power system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Mobile GIS is the expansion of GIS technology from the office into the field. It enables field personnel to capture, store, and update, manipulate, analyze, and display geographic Information.

Traditionally, the processes of field data collection and editing have been time consuming and error prone. Geographic data has travelled into the field in the form of paper maps. Field edits were performed using sketches and notes on paper maps and forms. Once back in the office, these field edits and measurements were reduced manually and finally entered into digital systems. The result has been that data has often not been as up-to-date or accurate as it could have been, (www.esri.com/mobile)

Mobile GIS integrates three essential components; Global Navigation Satellite Systems (GNSS), rugged handheld computers, and GIS software. Bringing these technologies together makes the enterprise database directly accessible to field based personnel whenever and wherever it is required, (www.trimble.com/mgis)

2.2 Kenya Power and its mandate

Kenya Power is a limited liability company which transmits, distributes and retails electricity to customers throughout Kenya. It is responsible for ensuring that there is adequate line capacity to maintain supply and quality of electricity across the country.

Kenya Power has undergone changes over the years due to changes of regulations in the energy sector and they key players in the electricity subsector are:

- Ministry of Energy (MOE): Sectoral policy, supervision and interventions
- Energy Regulatory Commission (ERC): Enforcing regulations, licensing power companies, customer protection, approving power purchase agreements and tariff reviews
- Kenya Electricity Generation Company (KenGen): Largest electricity Generation Company that is majority Government owned

* Rural Electrification Authority (REA):
  Implementation of the Rural Electrification Program (scheme construction)
* Kenya Electricity Transmission Company Ltd. (KETRACO):
  Development and ownership of new transmission lines
* Geothermal Development Company (GDC):
  Established in 2009 to develop geothermal steam fields for subsequent use in Geothermal electricity generation by generation companies
* Kenya Power:Generation at offgrid stations, power purchase, transmission. Distribution on and retail sales of electricity

Kenya Power focus is now distribution and retailing of electricity and having more than 1,500,000 customers who consumed over 5,432 gigawatt hours of electricity in the financial year 2008/2009, Efficiency of the transmission and distribution network continues to be enhanced in both technical and non-technical aspects. Technical improvements include re-conductoring of lines, installation of capacitors, and construction of additional feeders and substations. Non-technical improvements include introduction of electronic meters, improvement of meter reading accuracy, fraud control and resolution of billing anomalies, (www.kplc.co.ke)

2.3 Kenya Power Existing Field to Office Workflow

The existing Kenya Power solution consists of Mobile component comprising of Trimble Nomad Handheld field computer integrated with GNSS Receiver and ArcPad field software. Whereas the office component consists of ArcGIS Desktop software, existing data on customers and GNSS location is stored in Microsoft Access database which is read in ArcGIS desktop software. The schema of the data structure is checked out from the ArcGIS Desktop to the mobile device, after collecting data in the field using ArcPad software, gathered data is checked in and it updates the MsAcess database and the data in ArcGIS software as a whole.

These software and hardware components form the basis for workflow as shown in figure 1.

2.3.1 Nomad Handheld GNSS Receiver

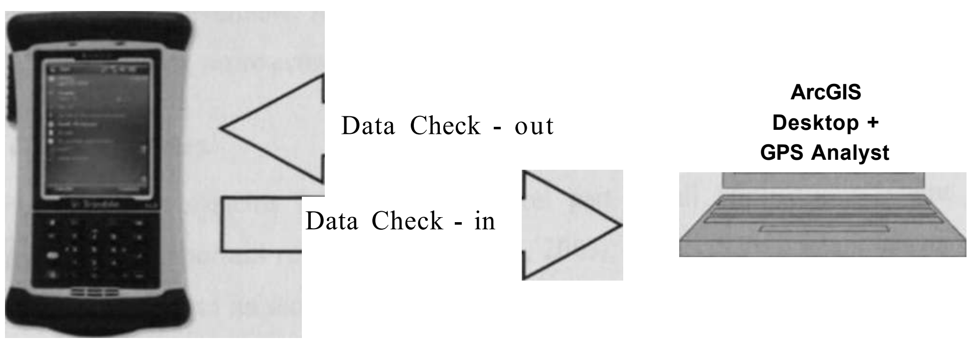
The Nomad is a high-yield GNSS receiver offering 2 to 5 meter positioning accuracy in real time or I to 3 meter postprocessed with a 3.5 inch display, barcode scanner and a 3 megapixel camera enabling the workforce to augment their GPS information with photographs while performing GIS data collection, maintenance, and inspection activities

2.3.2 Field Software

ArcPad field software provides a platform to capture Geographic data and interact with the GNSS Reciever whereas GPScorrect extension allows reception of correction measurement from various sources including SBAS.

2.3.3 Office Software

ArcGIS Desktop software provides a platform to prepare data collection schema, visualization, data management and analysis whereas GPS analyst extension provides tools for postprocessing and validating GNSS data.



Trimble Handheld computer loaded with ArcPad • GPScorrect captures data from the field.

Data Transfer operation done between the GPS device and Desktop Computer

Post Processing and Analysing GPS data in the Desktop Computer

Figure 1: Field to Office Workflow

However the system has a number of limitations.

i. When capturing data using the ArcPad it does NOT allow, update of spatial location of a feature for instance if the initial coordinates captured were wrong. However attribute information can be updated.

ii. Nomad Handheld GNSS Receiver has a barcode scanner where one can update prepaid meter details by simply scanning. However, this cannot be read directly by ArcPad.

2.4 Recent Development in Mobile GIS

GNSS/GIS Field data collection is a perennial problem for cartographers, surveyors, engineers and researchers. Until recently, the tools available for mapping applications have been bulky in size and weight, expensive, and difficult to learn.

Tremendous advances have taken place in GNSS technology (receivers), data collection hardware, and field data collection software. The integration between GNSS and other related technologies such as telecommunications (GSM, GPRS, UMTS), the Geographic Information Systems (GIS) and Inertial Navigation (INS) has created numerous applications. Many research efforts have been exerted in order to find each new application to promote the quality of our life using the GNSS benefits (Lohnert et al., 2001; Al-Bayari and Sadoun, 2005).

Not only has the autonomous GNSS accuracy improved, but the data collectors have become smaller, lighter, and less expensive. The software has become cheaper and easier to learn. In addition, for applications involving offsets, lower priced laser range finders have become available. All of these advances have made the GNSS/GIS data collection tasks easier, more economical and faster to complete.

2.5 GNSS Receivers

Satellite navigation systems has become integral part of all applications where mobility plays an important role (Heinrichs et al., 2005). GNSS development has an interesting aspect due to its sensitive nature. Considerable events or developments are always subject to a couple of differentiators, technological developments and political decisions.

As for the past developments, GPS launched a variety of techniques, products and, consequently, applications and services. The milestone of satellite navigation is the real time positioning and time synchronization. For that reason the implementation of wide-area augmentation systems has allowed a significant improvement of accuracy and integrity performance. WAAS, EGNOS and MSAS provide over US, Europe, Japan and parts of Africa useful augmentation to GPS, GLONASS and Galileo services (Mulassano, et al., 2004).

With the elimination of Selective Availability (SA), autonomous accuracy is much better. Today, a single standalone receiver can provide an accuracy of between 10-15 meters. It is also now possible with the use of DGNSS service to obtain sub meter accuracy in real time. This eliminates the need for post processing. This DGPS service is available through the use Satellite Based Augmentation System (SBAS).

This system obtains corrections from more than one reference station. Reference stations collect the base station GNSS data and relay this data in RTCM SC-104 format to a Network Control Centre, which sends the information to a geostationary satellite for verification. The verified information is sent to the roving GPS receiver to ensure it obtains GNSS positions in real time.

2.6 Handheld Computers

The traditional units for GNSS data collection use either an onboard storage memory or an external data logger. In most cases, the software on these units is extremely complicated and difficult to learn. The data collectors are vendor specific to GNSS engines only and cannot be used for any other applications. The units come with a proprietary operating system which makes modifications difficult to incorporate. These units have slower processors thus making the manipulation and processing of data and maps impossible or very slow. Also, the small screen size limits the display of data without scrolling down or panning. Additionally the units have very low battery life and are expensive to replace.

With the introduction of Palm Pilots followed by Microsoft's launch of a pocket PC operating system, a new generation of handheld computers or Personal Digital Assistants (PDA's) have flooded the market. It is now possible to use these lightweight handheld PDA's, with GNSS/GIS data collection software, for field applications. Two technologies have allowed users to move with mobile computing power, portable computers and wireless communication, computers are shrinking, allowing them to be handheld with impressive computing capabilities (Chen and Kotz. 2000). In addition, regular windows based laptop PC's are now available in ruggedized waterproof versions. One can use these PC's for mapping applications in tough outdoor environments. Windows operating systems has also resulted in a quick and easy GNSS/GIS integration with these devices.

2.7 Data Collection

The traditional data collection software was difficult to learn and vendor specific to their GNSS engine only. The new generation software such as fieldworker. Solo, ArcPad, Sitemate, Patchworks, and Composer has revolutionized data collection.

Today, the new generation of software offers the user various options that can be used for his or her applications. The software is very economically priced and has the capability to add background maps or digital orthophotos. Most of the new generation software allows the user flexibility to use any type of GNSS engine beginning from a low priced recreational type unit to a high accuracy survey grade unit. The software has the capability of reading from 2 serial ports allowing the user to employ a GNSS receiver as well as an additional sensor, such as a laser range finder. The software can also accept digital camera input allowing the user to capture not only the location data but also the actual picture of the feature. Once the location, features and attribute data have been collected, all of the data can be exported in different GIS formats, such as shape files. Most of the new generation of software has a version available for Windows as well as a Pocket PC operating system. This results in a much shorter learning curve.

2.7 Software Customization

Effective mobile GIS workers require applications and tools that have been customized for a specific field task or project. Today most software vendors provide software development kits (SDK), which can be used for creating custom solutions for mobile GIS applications and tasks as well as integrating unsupported external devices. This allows extension of the functionality of the software and customizing it to fit to desired field to office scenario.

2.7.1 Key concepts and definitions in Mobile Computing

Applets: Applets provide a way of delivering a map independent mini-application without having to alter field mapping software configuration. Applets can contain toolbars, forms, and system object event handlers that access the ArcPad Object Model through scripts. Applets always have the file extension .APA, and may also consist of an associated .JS or .VBS file containing JScript or VBScript code, respectively, that is called from within the applet.

Layer definition: Layer definitions provide a way of delivering customizations that are loaded with data. Typically, this would include data entry forms with associated scripts to handle data entry validation and other features offered on the forms.

Extensions: Extensions allow developers to expand the range of data formats, positioning services, rangefinders, cameras, projections, and datum transformations supported in field mapping software. For example, if your application requires data in an unsupported map projection, you could write an extension to accomplish this. Developers can also create utility extensions that expose any desired low level functionality, normally accessible only via C/C++ code.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The study area was selected as Sportsview Estate in Kasarani, Nairobi North, which is one of the areas pilot areas for the prepaid metering system. Out of 3,518 meters. 840 have been converted to prepaid meters and of these only 154 have GNSS coordinates recorded figure 2 shows an image of the study area.

Figure 2: Image of the Study Area

3.2 Project Approach

The general approach adopted in this study is shown in figure 3.

Need Assesment

Create Feature
Class or shapeMe
based on Existing
data

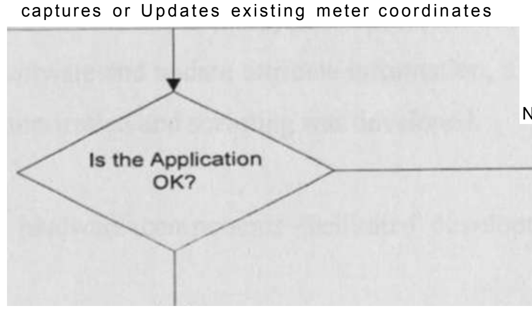
Develop a data collection schema
(Structured attribute table)

Import the Checked out data
schema to ArcPad Studio

Create Custom Data
collection form based on the
data schema

Write a scnpt that Updates both attribute and Spatial Data

- Read Meter details using barcode scanner
- Validates the collected data
- Enforce data integrity with domains and subtypes
- Picks Valid GPS Coordinates
- Checks if coordinates Exists and if Not it captures or Updates existing meter coordinates



NO

YES

JL

(A working Prototype i

Figure 3: Methodology

From the user needs assessment it was found that the customer information already exist with some having location information and others Not, on the other hand there were some records which were repeated or mismatched with location information.

To address these issues, the system to be developed should exhibit the following characteristics:

i. Update the spatial records only i.e. coordinates of the prepaid meters without GNSS coordinates since customer details already exist.
ii. Update the prepaid meter numbers using the barcode reader contained by the Nomad GNSS Receiver and if the GNSS coordinates do not exist then it puts in the coordinates else prompts that the meter exists and whether one wants to update the coordinates or Not.
iii. If no record of the meter exists then it captures the coordinates as a new feature and prompts one to enter attribute details on the data collection form.

However the current system has a number of limitations.

i. When capturing data using the ArcPad it does NOT allow, update of spatial location of a feature for instance if the initial coordinates were wrong. However one can update attribute information.
ii. Nomad Handheld GNSS receiver has a barcode scanner where one can update prepaid meter details by scanning, however this cannot be read directly by ArcPad.

To overcome the above limitation and allow the system update GNSS coordinates, read barcode from GIS field software and update attribute information, a user friendly interface data entry form , customization and scripting was developed.

The following software and hardware components facilitated development of the mobile mapping solution.

3.2.1 Nomad 900 GXE Handheld GNSS Receiver

The Trimble Nomad 900G series of integrated GNSS handhelds offer all-in-one convenience in a device engineered for superior performance in harsh environments. They offer full compatibility with a variety of Mapping & GIS software and a choice of configurations to match existing workflows.

Its key features include a huge 6 GB of Flash storage, 128 MB of RAM, a powerful **806** MHz processor, Wi-Fi and Bluetooth technology wireless connectivity, a Secure Digital (SD) slot for removable cards, and a 3.5 inch VGA display. With a variety of configuration options, including a cellular modem, a 5 MP digital camera with integrated flash, a laser barcode scanner, and Compact Flash (CF) and USB expansion options. It also has a high yield integrated SBAS capable GNSS receiver that delivers reliable 1 to 3 meter accuracy in low multipath environments.

3.2.2 ArcPad

ArcPad is a field data collection software which provides a good mix of functionality, such as GNSS integration and background image display; interoperability with existing GIS data and applications; and customizations, such as data-entry forms and project-specific toolbars.

3.2.2 ArcPad Studio

ArcPad Studio is a development platform for ArcPad. It provides a range of customization options. Users or system integrators can easily create custom toolbars, data entry forms and default configuration files. More advanced developers can create new tools, applets and extensions. One can build new customization files from scratch or modify existing files to suit needs at hand. It allows scripts to be associated with object events that may occur in the background while ArcPad is running.

Extensions can be developed using C++ to expand the range of data formats, input devices, projections, and datum transformations recognized beyond those offered in the core product. Once extensions are installed, the new functionality appears in ArcPad just like any other core functionality

ArcPad studio was used in this project to create user friendly data collection form, write script to update spatial data and barcode scanner measurements to be read inside ArcPad.

3.2.3 ArcGIS Desktop Software

ArcGIS Desktop is a suite of integrated applications that create, edit, import, map, query, analyze and publish geographic information. ArcGIS Desktop was used in this project to create data collection schema based on Kenya Power data, this schema was checked out as layer, the layer was then exported to ArcPad studio formed the basis of custom data collection form.

3.3 Data Sources, Softw are and Hardware

The source of data used for this study was obtained from the Kenya Power, Customer Service Department, Prepaid meters pilot Project. Whereas the software and Hardware (Nomad GNSS receiver) were obtained from ESRI Eastern Africa. The project was executed in a personal computer with the following specifications

Item	Description
processor speed	800 MHz
Random Access Memory (RAM)	3 Gigabytes (GB)
Hard disk Storage	80 GB
Operating System	Microsoft Windows 7

Table 1: Computer Specifications

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter gives a detailed description of the how the project objectives were achieved. It describes how the mobile GIS solution was developed which incorporated design of custom data entry form and writing of the customization code.
The primary method of implementation was to design, develop, and test a prototype for data collection and update.

ArcPad is mobile field mapping and data collection software which formed the basis of the solution. Although ArcPad is designed to be flexible, one may want the ArcPad interface to reflect their own preferences. ArcPad can be customized in different way, some of which include:

- Always load the same geographic data when ArcPad starts.
- Create new toolbars that contain built-in and custom tools.
- Design custom forms to streamline data collection in the field.
- Build applets to accomplish the organization's unique goals.
- Write scripts that interact with ArcPad's internal objects.
- Develop extensions to support new file formats, positioning services, rangefinders, cameras, projections, and datum transformations.

Based on user scenario, there may be need for one to develop a customized working environment for by changing or creating toolbars, forms, and default configurations, and so on to help work in the most efficient way. In addition, one can provide additional functionality by linking code to perform various functions not provided by the out of the box application. The approach adopted involved designing a custom data collection form, a script to interact with ArcPad internal objects to allow update of spatial information and an extension to interact with barcode scanner.

4.2 Data Entry Form

Creating custom data entry form

a) Checking out schema based on existing data.

To ensure that there is no conflict and smooth update of data from the field and what exists on the database, a data collection schema was created from existing data meaning that the fields existing in the database is what appears in the data entry form.

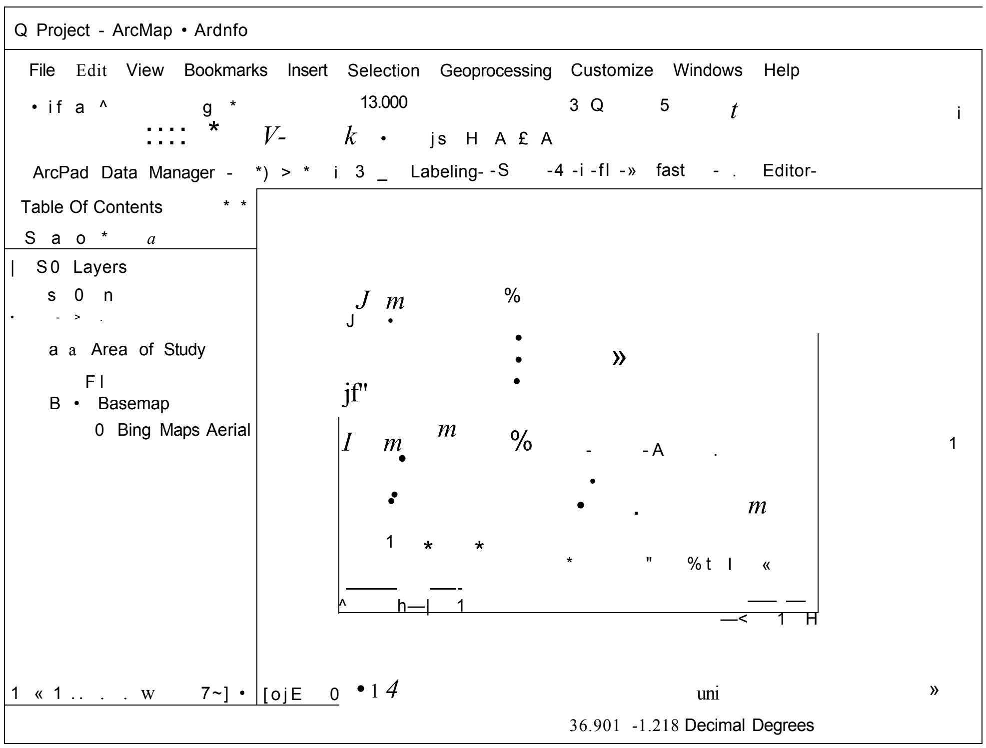


Figure 4: Spatial View of the meters

The data schema was checked out from the database based on the feature classes (Homogeneous collection of common features, each having the same spatial representation) in this case meters which were represented as points.

Home - School Project
El B KPLC
SI Q KPLC_PREPAID
ffl Q VBSCRIPT
B 3 KPLC.Prepaid
Ml Area
ED Meters
S ID Kasarani
ft ID Kasarani-xlsx
5 M Project
Q Project
IB ID Project Proposal
ffl S Folder Connections
ffl *m* Toolboxes
ffl Database Servers
ffl Database Connections
ffl © GIS Servers
ffl Eg Tracking Connections

Figure 5: Data Structure

Figure 5 indicates how the data was structured in the Geodatabase

Table

'J- <&•

Meters

SRN	ran	Account	Statu*	TartfT	Deb!		SUPPLY LOCATION
2301	5375	CORRECT	SITUATI	DC	<Null>	LAWRENCE WAIGI KAMAU	030 SPORTS VIEW ESTATE ES"
2430	'5375	CORRECT	SITUATI	DC	<Null>	SIMON KANGETHE NMAM	28KASARAM SPQRTSVEW EST]
2035	5375	CORRECT	SITUATI	DC	<Null>	OBAD1AH KARIUW KJRITU	032 SPORTS VEW ESTATE ES'
2284	5375	CORRECT	SITUATI	DC	<Null>	PETER KARIUKI KAMAU	033 SPORTS VEW ESTATE ES'
2311	5375	CORRECT	SITUATI	DC	<Null>	KALA NGUNGUI KHO	034 SPORTS VEW ESTATE ES'
2352	5375	CORRECT	SITUATI	DC	<~Null>	KALA NGUNGUI KHO	034 SPORTS VEW ESTATE ES"
2352	15375	CORRECT	SITUATI	DC	<Null>	KALA NGUNGUI KHO	034 SPORTS VEW ESTATE ES'
2352	5375"	CORRECT	SITUATI	DC	<NuH>	KALA NGUNGUI KHO	034 SPORTS VEW ESTATE ES'
2186	5375	CORRECT	SITUATI	DC	<NUII>	MARY APONDI WAHONYA	117 KASARAM SPORTV1EW ES'
2343	5375	CORRECT	SITUATI	DC	"<Null>	MARY APONDI WAHONYA	117 KASARAM SPQRTVIEW ES'
2359	15375	CORRECT	SITUATI	DC	<Null»	NNANGUTTU PETER WAN	PLOT 93 KASARAM
2350	5375	CORRECT	SITUATI	DC	<Null>	NNANGUTTU PETER WAN	PLOT 93 KASARANI
2384	5375	CORRECT	SITUATI	DC	<NuH>	ANN WANJIKU NGUGI	PLT 94 KASARANI
2067	15375	CORRECT	SITUAJI	DC	<Null>	JOSIAH NYAWARA OGINA	060 KASARAM SPQRTSVEW Ei
2077	5375	CORRECT	SITUATI	DC	UNiHT	MARY MUTHANJE NJINE	069 KASARANI SPORTSVIEW ES
2093	5375	CORRECT	SITUATI	DC	<Nu»>	DAVID KUR1A MUKARU	PLOT 51 SPORTSVIEW KASAF
2151	5375	CORRECT	SITUATI	DC	<NU«>	FAITH NJERI MURIITHI	026 KASARANI SPQRTSVEW E!
2151	5375	CORRECT	SITUATI	DC	<Null>	KIMANI CHARLES F KAMA	026 KASARAM SPQRTSVEW Ei
2151	5375	pnoocrT	SITUATI	DC	<NuH>	BROWN6ARK ENG SYSTE	026 KASARAM SPORTSVIEW Ei
		in				I VTMA I'tAI/MtVI kCAKIMm	I me VA4ADAU COOOTC\«CW cc

7 • H (0 out of 153 Selected)

Meters

Figure 6: Sample of Database Table

Figure 6 indicates database table of existing Kenya Power customers.

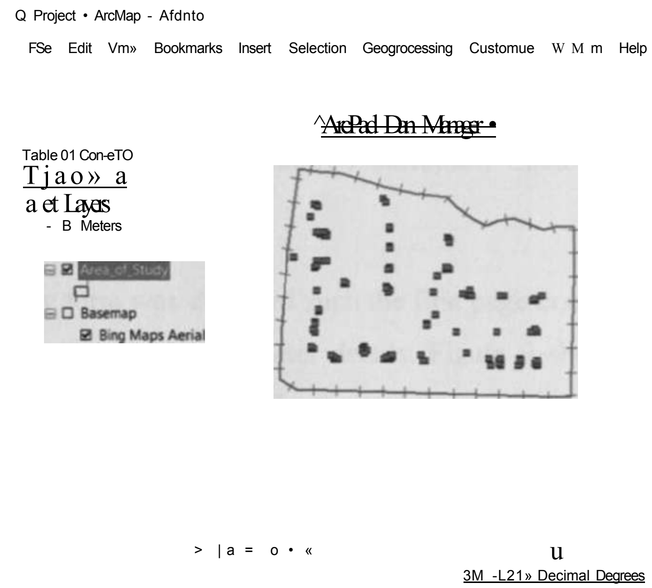


Figure 7: Geodatabase schema

The schema was checked out using ArcPad data Manager for customization in ArcPad studio as shown in figure 7.

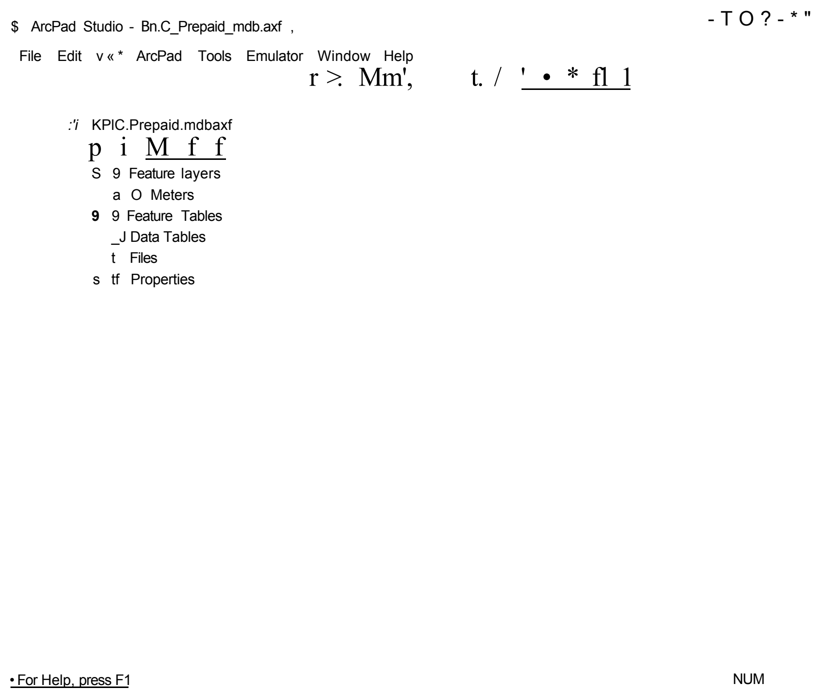


Figure 8: ArcPad Studio Interface

The schema consists of definition layer which is the spatial object and Object properties as presented in figure 8.

b) Creating Edit Form

Edit forms replace the Feature Properties dialog box and are used for data entry, such as updating the values of a feature's attributes. Each edit form created must be associated with a specific layer.

The data entry form was designed such the first page consist of the old meters details and the second page prepaid meter details. Figure 9 shows how the procedure was carried out. by executing modification using control properties and page properties provided for in the ArcPad studio.

Meters
Form Page Control Layout
Pag* 1 Page 2 | Page 31
meterjype
Removal_Readings
PRE_PAY_M_No
Transform® r_Numb<
|ate_o»_PPMJnst| jp 6/13/2011
Lattude
Longitude
>m
OK Cancel

Meters
Form Page Control Layout
Page 1 Pag*2|page3|
Meter Status
Removal Readings
Prepayed Meter No
Transformer No
Date of Installation 6/14/2011
LatAide
Longitude
Altitude I "
OK Cancel

Figure 9: Customizing data collection form

form Page Control Layout
IOld Meter Detaiii) P,tp»d Meter Pettis | Location |
Senal Number
Account Status
Tail
Debt
Customer Name
Supply Loca»on
Meter Number
OK Cancel

Meters
Form Page Control Layout
Old Meter Detail Prepaid Meter Details ILocabon
Meter Stats
Removal Readings
Prepaid Meter No
Transformer No
Date of Insolation 6/14/2011 _iJ
Longitude
OK Cancel

Figure 10: Customized data collection Form

Customized data entry Form showing: Old Meter Details, Prepaid Meter Details and Location, with the field simplified for ease of use by the field staff as displayed in figure 10.

4.3 Scripting and Programming

The code that reads and updates meter details was written in Vbscript and implemented in ArcPad Studio as follows.

a) Pseudocode

```
1. Declare variables.

2. Check if GNSS Receiver is activated (on).

3. Activate the GNSS Receiver.

4. Read the GNSS Coordinates (If Not wait till position
   fix is obtained).

5. Key in Mandatory field (Meter Number) using Barcode
   scanner.

6. Check the Database for account details (Based on
   Meter Number).

7. If record exists update only spatial details
   (Latitude, Longitude and Altitude) and exit.

8. If the record does not exist capture it as new
   record and prompt for attribute details to be keyed
   in.
9. Save and end.
```

b) The Code explained

```
Option Explicit
```

Declaring Variable: This describes the words that represent Objects that will be used throughout the script

```
SUB onload
Dim objPg. m_pControls
Set m_pControls = ThisEvent.Object.Pages( 1 ).Controls
set objPg = ThisEvent.Object.Pages( 1)
'open C . M f_______________ : ' '
```

The script checks if the GNSS Receiver is activated (on) If it is NOT it activates the GNSS Receiver

```
If Not Application.GNSS.lsOpen Then
        Application.GNSS.Open
End If
'confirm GNSS is valid fix, copy values and disable controls
```

The script checks if the GNSS Receiver has position fix,if it does it picks Latitude, Longitude and Altitude

```
If GNSS.ISValidFix Then
        m_pControls("Latitude").text = GNSS.X
        m_pControls("Latitude").enabled = false
        m_pControls("Longitude").text = GNSS.Y
        m_pControls("Longitude").enabled = false
        m_pControls("Altitude").text= GNSS.Z
        m_pControls("Altitude").enabled = false
                else
```

If there is No position Fix the script asks you wait until you get a position fix.

```
        msgbox ('Turn on the GNSS and try again"), vbExclamation, "KPLC: GNSS
not available!"
        objPg.parent.Close(False)'close form without saving
        end if

end sub

sub checkexists
```

Checks if the record being saved is valid using the following criteria: Correct Layer (Dataset),If the record exist for update or new,and if the mandatory records have been keyed in.

```
dim objPg. m_pControls, custID, objSelLayer, objRS, objBkmrk, i. counter
Set m_pControls = ThisEvent.Object.Pages( 1 ).Controls
set objPg = ThisEvent.Object.Pages( 1)
Set objSelLayer = Application.Map.SelectionLayer
```

```
'If no feature has been selected, exit the subroutine
 If objSelLaver Is Nothing Then
       MsgBox "Make sure a layer is selected".vbExc!amation."KPLC: Selection
Null"
       objPg.parent.Close(False)'close form without saving
  Exit Sub
End If
 'Get the selected feature's geometric shape.
```

If the dataset exists the script makes it editable

```
Set objRS = objSel Layer. Records
If objSelLayer.CanEdit Then
       'Make it Editable
       objSelLayer.Editable = True
End If
custID = m_pControls("meter_no").text
```

The script checks if the Meter Number has been keyed in (this is a mandatory record)

```
if custID = "" then
       msgbox ("Read meter number and try again"), vbExclamation. "KPLC: Meter
number required!"
       objPg.parent.Close(False)'close form without saving
       Exit Sub
Else
```

The script checks if the meter number that has been keyed in exists in the database, if it does it updates the spatial content if NOT it creates a new record.

```
End If
       msgbox ("ArcPad will check if" & custID & " exists in "& objSelLayer.name
& " layer before saving. If not found, a new record will be created"), vblnformation.
"KPLC: Database"
end if
' Move to the first record of the recordset
objRS. MoveFirst

'loop until you reach the desired record
do until objRS.EOF
               if objRS. Fields("meter_no").Value = custID Then
                       m_pControls("CUST_NAME").text =
objRS.Fields("CUST_NAME"). Value
                       objRS.Fields("LATITUDE"). Value = GNSS.X
                       objRS.Fields("LONGITUDE"). Value = GNSS.Y
                       objRS.Fields("ALTITUDE"). Value = GNSS.Z
                       objRS. Update
               msgbox ("Existing customer details for meter no " & custID & " have
been successfully updated"), vblnformation, "KENYA POWER: Record updated"
```

```
                    'Aplication.StatusBar.Text = "KENYA POWER: " &
objRS.Fields("CUST_NAME").text & " successfully Updated" &
formatdatetime(now. vbLongTime)
                    objPg.parent.CIose(False)'close form without saving
                    Application.Map.Refresh(true)
                    set objSelLayer = nothing
                    set objRS = nothing
                    set custID = nothing
                    set objBkmrk = nothing
                    set m_pControls = nothing
                    set objPg = nothing
                    Exit Sub
              End If
              objRS.movenext
loop

msgbox ("New record - meter no " & m_pControls("meter_no").text & " created!"),
vblnformation. "Database"

end sub
```

c) Executing the Code

Click the Edit Script button ® on the ArcPad Studio toolbar. A new VBScript source code file named Layer l.vbs is created.

This code was implemented in ArcPad studio as indicated figure 11.

```
^ ArcPad Studio - [KPlCJforPBdmdb^afUyetvM]
Jgn* tm VMw ArcPrt Emulator Window He
a! U a > M 9
Option Explicit
SUB onload
Dim objpg, m_pconrrols
Sat mjcontrols = ThisEvent .Object.Pages C2) .Controls
sat objpg » ThisEvent.Object .Pagas(2)
 •open ars
f If Not Application.GPS.IsOpen Than
      Application. GPS .Open
End If
 'confirm OPS is valid fix, copy vaJuts and disable controls
aif GPS.ISValidFix Than
      m_pcontrols("txtLatitude") .text « GPS.X
      m_pControls f "txtLitituda' i-enabled » false
      m_p<ontro1sc "txtLongitude") .text - GPS.Y
      m_pcontrols< "txtLongitude") .enabled false
      mjcontrols ("txtAltltuda") .text - GPS.Z
      m_pcontrols( "txtAltitude") .enabled =• false
          else
      msgbox ("Turn on the GPS and try again"). vbExclamation, "KPLC: GPS not available!"
      objpg.parent.Close(False) 'close form without saving
      end if

end sub

sub checkexists
dim objpg, n_pControls, custID, ObjSelLayer, objRS, objBkmrk, 1, counter
Sat m_pControls - ThisEvent .Object .Pages (2) .Controls
sat obipg - ThisEvant.Object .Pagas(2)
BSat objSelLayer - Application.Map.SalectlonLayer
 •If no feature has bean salactad, exit tha subroutine
  If objSelLayer Is Nothing Then
      Msgsox "Make sure a layer is selected" .vbExclamation, "KPLC: selection Null"
      objpg.parent.Close(False) "close form without saving
      Exit Sub
HEnd If
   'Get the selected feature 's geometric shape.
 Sat objKS - objSelLayer.Records
aif ObjSelLayer.CanEdit Then
```

Figure 11: ArcPad Studio Implementation

d) Debugging

The Verify Tool was run to check the syntax of the code, this allows for checking of the lines that were incorrectly written.

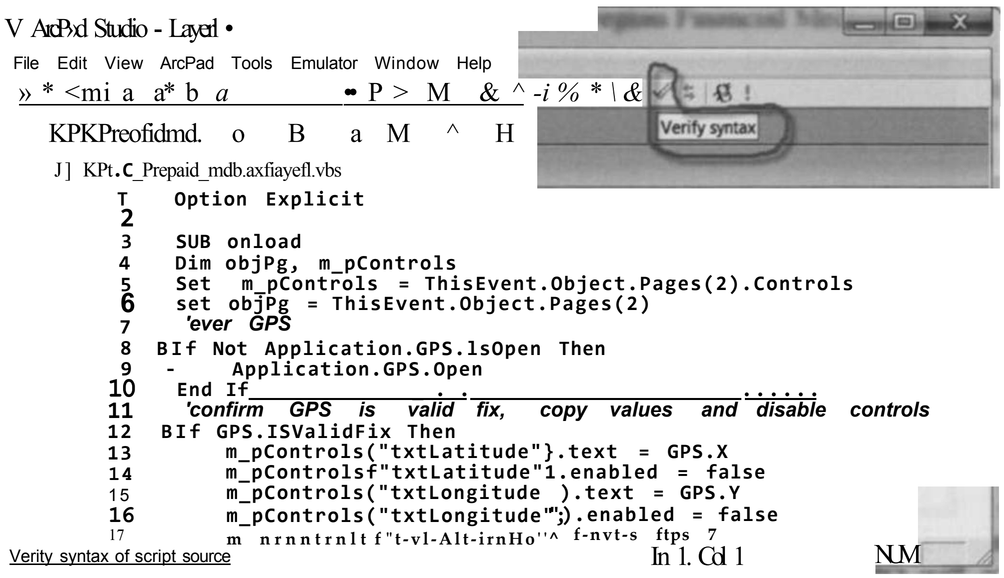


Figure 12: Code Implementation

Modifications were done until the syntax was correct by verifying using theverify syntax as shown in figure 12.

e) Deploying the customization to the mobile device

The customization was transfered out for the mobile data collection device using either using compile tool in ArcPad or alternatively, copying and placing them to the correct locations using Windows mobile device center as follows.

The GNSS device was connected to the PC via the USB, which Windows Mobile device center is installed. This is an application that enables synchronization of files from the desktop PC to the GNSS or any Mobile device that runs on Windows mobile.

Figure 13: Connecting the PC with the GNSS data collector

Copy p.

| Do you want to copy KPLC_Prepaid_Script.vbs to your device?

Your device might not be able play or view this file.

No, skip this file

4 Yes
Your file will be copied, but you might not be able to play or view it on your device.

Do this for all files Cancel

Figure 14: Copying the script to the GNSS Data Collector

The script and the associated customization files and data were transferred to the GNSS data collector as shown in figures 13 and 14.

4.4 Discussion of Results

The results of the various activities carried out during the study are presented. The discussions of results are organized first according to the problems identified and address the objectives identified in chapter I.

i. To design user interface for capturing new data, updating existing data and querying collected data on meters and customer details.

Custom User Interface

Figure 15 illustrates the custom user interface for capturing new data updating or querying meter and customer details. It essentially has old meter details, prepaid meter details and spatial location.

T ne re*"1' «< 1

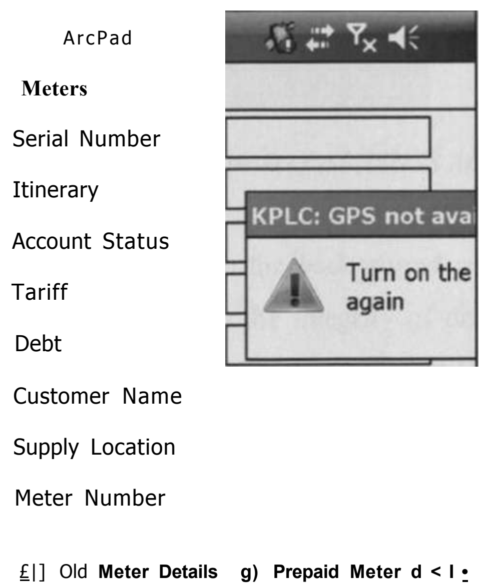


Figure 15: Custom Data entry Form interface

When ArcPad is powered on the GNSS device it automatically loads the data entry form as designed in the ArcPad studio, that is page 1 for Old Meter details while page 2 shows Prepaid meter details.

ii. **Customize, GIS field Software (ESRI ArcPad) to support Kenya Power's data collection workflow**

Script Execution

Ensuring the GNSS is Active and the coordinates have been captured as indicated in figure 16.

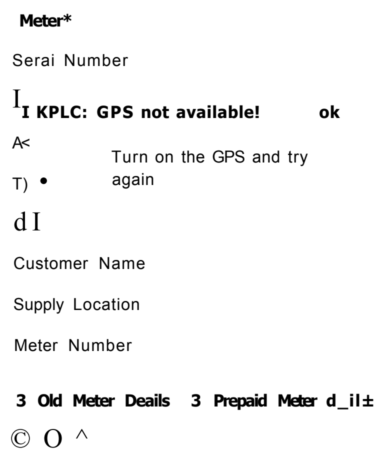


Figure 16: Script Execution in ArcPad (GNSS Activation 1)

As shown in figure 17 the script runs in the background and provides the caption **GNSS not available.** This is to improve the integrity of data collected such that a field officer will only capture data with spatial component (Latitude. Longitude and Altitude). This will ensure that all installed prepaid meters location is known by making spatial component mandatory before entering other details.

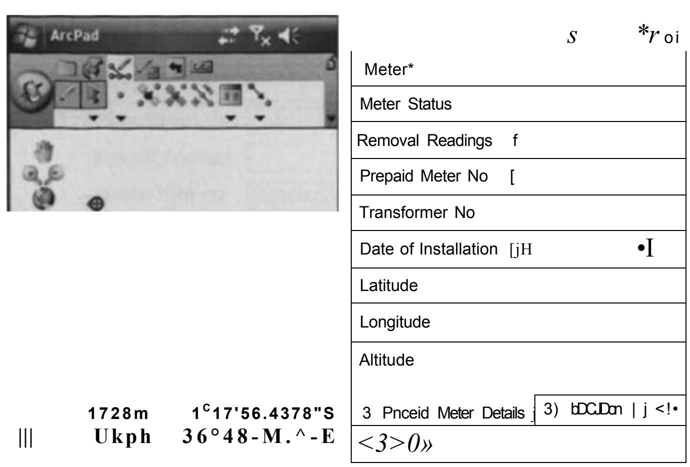


Figure 17: Script Execution in ArcPad (GNSS Activation 2)

Once the GNSS Position fix is obtained, the data collection form is **enabled** for data update or editing as shown in figure 17.

Since records of existing customers already exists in the database the script prompts one to provide meter details so that it can check the details of the customer as indicated in figure 18.

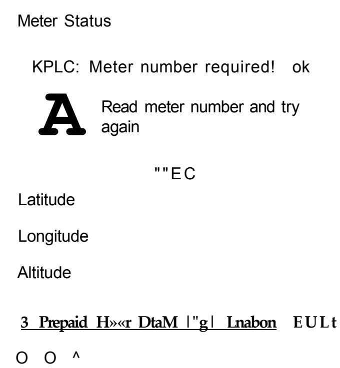


Figure 18: Script Execution in ArcPad (Enter Mandatory Field, Meter Number)

iii. Integrate GNSS Unit (Trimble Nomad) barcode scanner capability with the field Software

Using barcode scanner

Instead of entering the meter number manually in the device to check if it exists in the database, the barcode scanner was activated in the device to read the meter number as shown in figure 19.

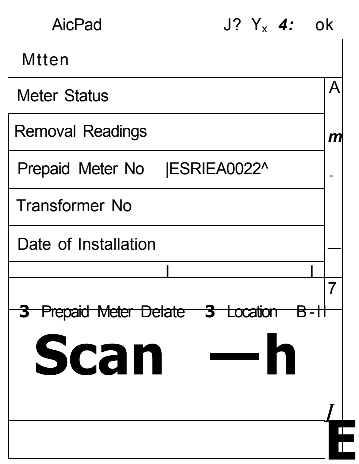


Figure 19: Script Execution in ArcPad (Read Barcode)

The barcode reads the meter number and inputs the details.
ii. iuirf ..»».

The script continues to be executed, the script checks if the record scanned or input exists in the database, if it DOES it updates the spatial component (Latitude, Longitude and Altitude) and exit.

TW

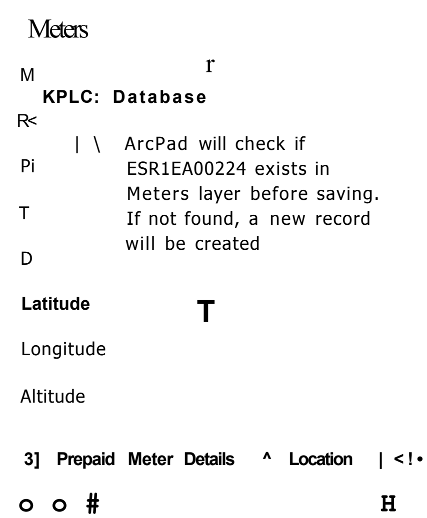


Figure 20: Script Execution in ArcPad (Check Records)

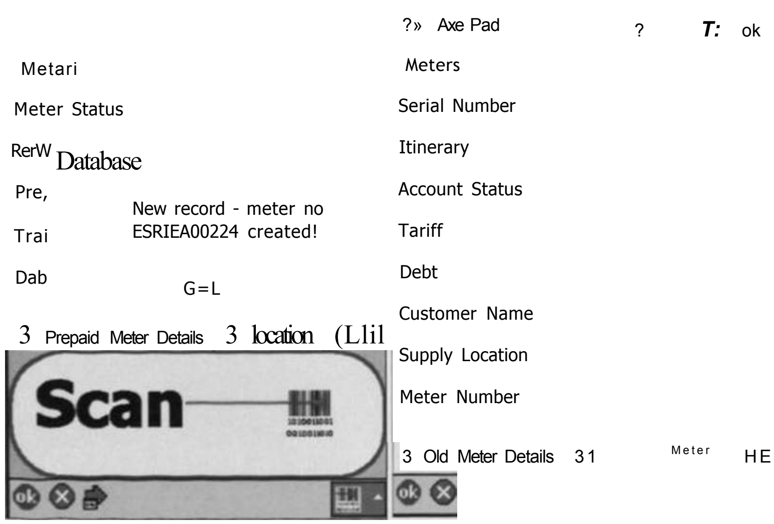


Figure 21: Script Execution in ArcPadfCreate a record if the record doesn 7 exist)

If the record DOES NOT exist it creates a new record of which one enters attribute information of the meter as shown in figures 20 and 21.

Else

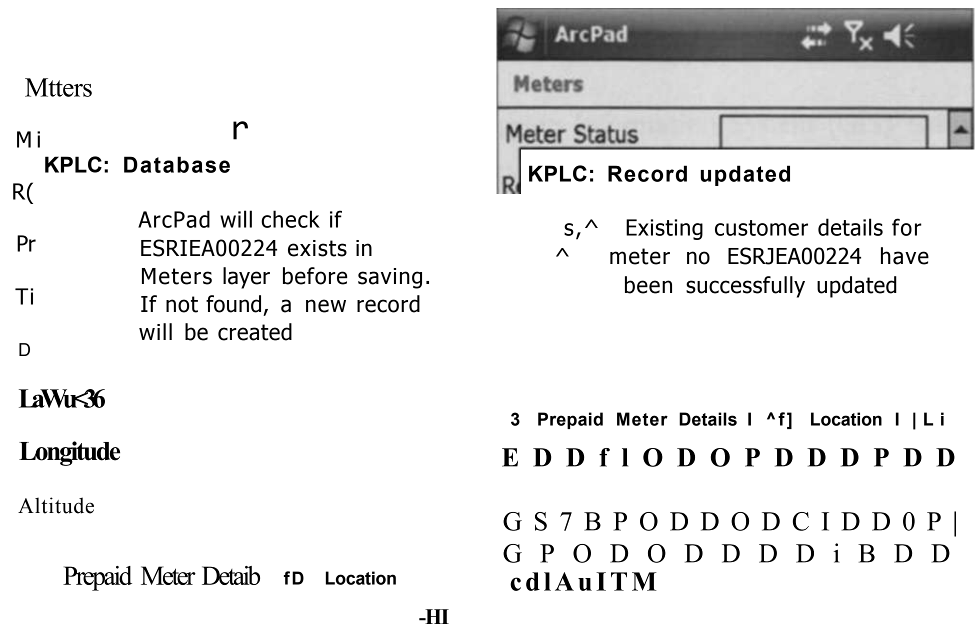


Figure 22: Script Execution in ArcPad (Update coordinates if the record exists)

If it DOES it updates the spatial component (Latitude,Longitude and Altitude) and exits-as indicated in figure 22.

The solution formed satisfied key workflows based on user scenario in this case Kenya Power's data collection workflow.

With automation and customization of the mobile GIS systems, the field data collection schema is a replica of the office system database schema as such it enables flow of data from the office to the field in a seamless manner with little or no redundancy on the data collected.

exits

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

Mobile GIS is the combination of Geographic Information System (GIS) software, Global Navigation Satellite System (GNSS), and mobile computing devices. It allows one to visualize information in a digital map. collect information where one observes it, and interact directly with the world, while improving productivity and data accuracy. The choice of the GNSS device (Hardware), field software and system computing capabilities is dependent on the user requirements. However it is nearly impossible to have Commercial off the shelf (COTS) software that meets every user need, Therefore a customized solution is usually designed to meet the user's specific requirements and provide specific functionality unique to the user's business process.
In this study a Mobile GIS data collection solution prototype to support Kenya Power field activities was designed and implemented.

5.1 Conclusion

In this Study a mobile GIS solution was designed and developed for Kenya Power considering information on the location, system, orientation and user scenario. Thus this system in addition to collecting and updating information seamlessly fits into the user workflow without disrupting the existing system of working.

The initial results were promising in that the meters database for Kenya Power was updated quickly with minimal or no redundancy. The key results obtained from mobile GIS solution proposed in this research include,

- Adding position information to attribute data
- Development of application which is quasi automatic which results in reduction of user direct involvement in the system therefore the susceptibility of human errors in information collecting process are significantly reduced.
- No need for traditional paper forms
- Little or no redundancy.

By using mobile GIS, the Kenya Power data on meters and customers can be quickly updated and evaluated thus minimizing errors, cost, time and manpower.

5.2 Shortcomings

The developed Prototype was based on ESRI ArcPad software and Trimble GNSS Hardware. In as much as it is open and extensible, the reality of translating, importing GIS or exporting data, scripts and codes between different systems is not easy, and to accompany institutional limitations, there are also technical limitations attached to de facto data standards. For instance to customize Kenya Power data collection form in ArcPad, one has to convert the existing data to SHP or AXF format (ESRI format). Essentially there are technical limitations with regard to the customizing or coding platform.

On the other hand, the solution development was based on Kenya Power's specific needs and the software and hardware in existence, though modification can be done to meet different user needs.

5.3 Recommendations

The data collection solution developed for Kenya Power was based on disconnected editing in that data is updated in the field. After this the Mobile device is brought to the office, connected to a PC and data uploaded to update the database. However, with the development of wireless technology connectivity is no longer a problem and therefore the solution can be extended further to support remote data update. This would allow the update to be done directly in the field in real-time basis.

Wireless communication for internet GIS access is now a key component of mobile GNSS units. With this component at hand real-time Field data capture and editing with the ability to remotely synchronize changes between the field and office allowing instant data viewing across the organization is key, keeping in mind that field staff require information from the office almost constantly and likewise push back information from the field to the office for rapid decision making.

In the densely populated flats differentiating one meter from another was difficult especially where meters were clustered together, however the meter number was used as the unique identifier such the different customer records could share the same GNSS coordinates. Secondly height information (Altitude) could be used for different customers in different floors.

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