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Ministry of Higher Learning and  
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## ***TOPOGRAPHIC SURVEY OF RUHENGRI***

### ***INSTITUTE OF HIGHER EDUCATION IN RWANDA***

*A dissertation submitted to the Faculty of Administration Sciences and  
Computer Technique in partial fulfilment of the requirements for the award  
of the Bachelor of Science in Surveying and Geomatics Sciences at Université  
Privée Africaine Franco-Arabe (U.P.F.A.)*

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### CERTIFICATION

This is to certify that the thesis entitled: “*Topographic survey of Ruhengeri institute of higher education in Rwanda*” Submitted by **NSENGIYUMVA Jean Yves** to the **Université Privée Africaine Franco-Arabe (U.P.A.F.A.)** for the award of Bachelor of Sciences (Bsc) in Surveying and Geomatics Sciences under my direct supervision and guidance. The work embodied in this thesis is original and has not to my knowledge been published or submitted in part or full for any other Degree of this or other University.

**Prof. Naon BETABOALE**  
Signature and names of Supervisor

.....  
Signature and names of Head of Department

Submitted for the Project Examination held in May, 2021 at UPAFA

## DECLARATION

I, **Jean Yves NSENGIYUMVA**, declare that the content of this thesis is my own work except where acknowledged. It has never been presented or submitted anywhere else for any other or similar award at any other university or institution of high learning.

**Jean Yves NSENGIYUMVA**  
Student names and Signature

## **DEDICATION**

I would gladly dedicate this project work to:

Almighty God who never leaves me in my daily life, all my educators; for their inspiration and for shaping us in accomplished people and all friends and relatives who contributed in my studies and strong life.

## **ACKNOWLEDGEMENT**

Above all, I owe much thanks to God the Almighty who create and control the universe, for protecting and guiding each and every step of our lives. May these simple words express our respect to him.

I deeply recognize again the warm welcome and facilitation of Ruhengeri institute of higher education while I have been collecting the data on site.

My sincere gratitude goes to my supervisor, Prof Naon BETABOALE for having given me an opportunity to work under his guidance and provided his technical and wise advice, suggestions and corrections that made this project fruitful.

I then send my most sincere thanks to my family for their invaluable care, encouragement and support throughout my studies.

## ABSTRACT

Topographic survey must have the highest priority in all countries, whether developed or developing. Topographic Survey is a field exercise and is granted the student the opportunity to put in practice what they learnt theoretically. This in this regard we have carried out the topographic survey of Ruhengeri institute of higher education during three weeks. The research had an objective to produce a topographic map of Ruhengeri institute of higher education, identifying and mapping the contours and existing features of Ruhengeri institute of higher education such as buildings, streets, trees, etc.

This research was done with some methods such as closed loop traverse. This type of closed traverse begins at a point of known control, moves through the various required unknown points, and returns to the same point. Two groups, one for the INES3 to INES1, other one for the INES4 to INES1 participated in this research, each group had total station. The establishment of control networks is the most fundamental operation in the surveying of large or small areas of land. Control networks comprise a series of points or positions which are spatially located for the purpose of topographic surveying, for the control of supplementary points, or dimensional control on site.

The results show the topographic map of Ruhengeri institute of higher education with their contours, features (streets, manholes, trees, buildings...), this map is at scale of 1/40 on the paper. It has 1<sup>st</sup> order contours in blue color and 2<sup>nd</sup> order contours in red color. The interval of 1<sup>st</sup> order contours is one and 2<sup>nd</sup> order contours is 0.5 but is shown in the legend.

The Ruhengeri institute of higher education is on low altitude where there are contours apart each other's, and it is on high altitude where there are the contours close each other's.

**Key words:** Contours, Topographic survey, Control networks

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## LIST OF SYMBOLS AND ABBREVIATIONS

**INES-Ruhengeri:** Ruhengeri Institute of Higher Education

**GPS:** Global Positioning System

**GIS:** Geographical Information System

**DEM:** Digital Elevation Model

**DTM:** Digital Terrain Model

**US GS:** united States Geological Survey

**DGPS:** Differential Global Position System

**3D:** Three Dimensions (x, y, z)

**USCS:** United State Coast Survey

**NGS:** National Geodetic Survey

**USDC:** United State Department of Commerce

**ALTA:** American Land Title Association

**ACSM:** American Congress on Survey in and Mapping

**CAD:** Computer-Aid Drafting

**IG:** Interactive Graphics

**IFS:** International Federation of Surveyors

**DFID:** Department for International Development

**BC:** Before Christ

**UK:** United Kingdom

**CP :** control point

**i.e:** id est

**e.g:** exempla gratia

**etc:** et caetera

## **CHAPTER 1: GENERAL INTRODUCTION**

### **1.0. Introduction**

This chapter covers background of the study, problem statement, purpose of the study, research objectives, research question, scope and limitation of study, significance of the study and finally organization of the study.

### **1.1. Background of the study**

During the 20th century, the term “topographical survey” appears to be American in origin. The earliest detailed survey in the United States was made by the “topographical Bureau of the army, during the war of 1838, which became the crops of topographical engineers in 1838.

After the work of national mapping was assumed by the U.S. Geological Survey in 1878, the term topographical remained as a general term for detailed surveys and mapping programs, and has been adopted by most other nations as standard.

The term topography originated in ancient Greece and continued in ancient Rome, as the detailed description of a place. In classical literature this refers to writing about a place or places, what is now largely called 'local history'. In Britain and in Europe in general, the word topography is still sometimes used in its original sense.

Beginning in the late eighteenth century, detailed military surveys in Britain were called “ordinance surveys and this term was used into the 20<sup>th</sup> century as genetic for topographic surveys and maps.

The earliest scientific surveys in France were called the Cassini maps after the family who produced them over four generations.

In the 20th century, the term topography started to be used to describe surface description in other fields where mapping in a broader sense is used, particularly in medical fields such as neurology.

In a broader sense, topography is concerned with local detail in general, including not only relief but also natural and artificial features, and even local history and culture.

This meaning is less common in America, where topographic maps with elevation contours have made "topography" synonymous with relief. The older sense of topography as the study of place still has currency in Europe.

## **1.2. Problem statement**

Many properties have considerable problems with regards to improper bounding, miscalculations in past surveys, titles, easements, and wildlife crossings. Also many properties are created from multiple divisions of a larger piece over the course of years, and with every additional division the risk of miscalculation increases the result can be abutting properties not coinciding with adjacent parcels, resulting in hiatuses (gaps) and overlaps. Many times a surveyor must solve a puzzle using pieces that do not exactly fit together. In these cases, the solution is based upon the surveyor's research and interpretation, along with established procedures for resolving discrepancies.

This essentially is a process of continual error correction and update, where official recordation documents countermand the previous and sometime erroneous survey documents recorded by older monuments and older survey methods.

Many institutions have not the topographic map to indicate their contours, locations and their features for someone who visit firstly those institutions, Ruhengeri institute of higher education as the institution of applied sciences has many people, friends, visitors, students who don't know its features such as buildings, streets, gardens and others. This research showed the topographic map of Ruhengeri institute of higher education.

## **1.3. Research Objectives**

### **1.3.1. Main objectives**

The main objective of this report is to produce the topographic map of Ruhengeri institute of higher education.

### **1.3.2. Specific objective**

By the time, this report has many objectives. Some of them are:

1. To carry the field survey in Ruhengeri institute of higher education,
2. To show the boundary lines area, and its location on a map,
3. To produce high-quality map with different features.

## **1.4. Research questions**

- ❖ What are the coordinates (X, Y, and Z) of Ruhengeri institute of higher education?

- ❖ What are the boundary lines area of Ruhengeri institute of higher education and its location on map?
- ❖ What are the features of high quality map of Ruhengeri institute of higher education?

## **1.5. The interest of the study**

### **1.5.1 Personal interest**

The importance of this research is that it covers some studies course of engineering. This research provided a better understanding of a topographic map; topographic survey; control networks and contours. It will help the researcher to acquire some knowledge to conduct an applied research.

### **1.5.2 Academics and scientific interest**

This research will inspire the students to look for effective strategies to produce topographic maps for different plot in the line of government goals, it can also help others student as guidance who wish to understand well the principle of topographic map.

### **1.5.3. Socio-economic interest**

The result of this research will be helpful to the government for implementing the project at a reasonable cost and will help to find the location of different terrain features.

## **1.6. Scope and limitation of the research**

The study was limited in Ruhengeri institute of higher education and the study is concerning topographic map no physical plan was provided.

## **1.7. Organization of the research**

This research is made up by five chapters.

**CHAPTER 1: General introduction** which deals with Introduction, problem statement, research objectives, significance of the study, scope of the research and finally organization of the study.

**CHAPTER 2: Literature review** to give all the details and theories concerning the topographic survey.

**CHAPTER 3: Materials and Methods** which deals with the methods, procedures, the definitions of the instruments that will be used for the investigations and, the methods and techniques used to collect all the data required.

**CHAPTER 4: Results** which deals with the presentation of the findings.

**CHAPTER 5 : Discussions** which deals which deals with interpretation of the findings, conclusions and recommendation to state the output of the research.

## **CHAPTER 2: LITERATURE REVIEW**

### **1.0. Introduction**

This chapter gives all the details and theories concerning the topographic survey. It is a source of secondary data through surveying books, scholarly articles, and any other sources relevant to a particular issue, area of research, or theory, and by so doing, provides a description, summary, and critical evaluation of these works in relation to the research problem being investigated.

### **2.1. History of topographic survey**

Surveying helps determine accurately the terrestrial or three-dimensional space position of points and the distances and angles between them using leveling instruments such as theodolites, dumpy levels and clinometers.

Even though remote sensing has greatly sped up the process of gathering information, and has allowed greater accuracy control over long distances, the direct survey still provides the basic control points and framework for all topographic work, whether manual or GIS-based.

In areas where there has been an extensive direct survey and mapping program (most of Europe and the Continental US, for example), the compiled data forms the basis of basic digital elevation datasets such as USGS DEM data. The original American topographic surveys (or the British "Ordnance" surveys) involved not only recording of relief, but identification of landmark features and vegetative land cover. Remote is a general term for geodata collection at a distance from the subject area (Sankey et al., 2018).

#### **2.1.1. The meaning words about topographical survey**

Topographic survey is a survey conducted to obtain the data needed for the preparation of topographic map. This data consists of the horizontal and vertical locations of the features to be shown on the map. Topographic Surveys are used to identify and map the contours of the ground and existing features on the surface of the earth or slightly above or below the earth's surface (i.e. trees, buildings, streets, walkways, manholes, utility poles, retaining walls, etc. Topographic Surveys require "bench marks" to which ground contours are related, information regarding surface and underground utilities, determination of required setbacks, etc. (Collier et al.,2003).



### 2.1.1.1. Topography

A field of planetary science comprising the study of surface shape and features of the Earth and other observable astronomical objects including planets, moons, and asteroids. It is also the description of such surface shapes and features (Collier et al., 2003).

### 2.1.1.2. Photogrammetry

**Photogrammetry** is a measurement technique for which the co-ordinates of the points in 3D of an object are determined by the measurements made in two photographic images (or more) taken starting from different positions, usually from different passes of an aerial photography flight. In this technique, the common points are identified on each image.

### 2.1.1.3. Contour lines

**Contour lines** are a combination of two line segments that connect but do not intersect; these represent elevation on a topographic map, they are simply horizontal lines that pass through points of equal elevation on map.

The chief characteristics of a topographic map are its graphic depiction of surface relief. The most common way of showing the terrain or shape of the ground on a two-dimensional map is to use a series of contour lines (Brown et al.2003).

A contour line is simply a horizontal line that passes through points of equal elevation on a map. The lines, of course, are only imaginary; they are not really seen on the ground. They are drawn on the paper to give the impression of a third dimension that shows hills, ridges, and valley, as well as steep or gentle slopes. The only contour that would actually be visible from a “bird’s-eye” or plan view of the ground would be an ocean or Lake Shoreline, or the shoreline around an island, where water meets land.

- **The general rules of contours;** the following facts about elevation contours are useful for drawing or interpreting contour line patterns.

1. The contour lines never end; they eventually must loop around and close on themselves, either within or beyond the mapped area.
2. The ground is assumed to slope, or change in elevation, at a uniform rate between two adjacent contour lines.

3. The ground higher (or lower) than the contour elevation is always on the same side on the contour line.
4. Closely spaced contour lines represented steeper slopes than widely spaced contours of the same interval.
5. They never close one another or branch into two contours of the same elevation. They may overlap and appear to meet only at a vertical wall or cliff.
6. At any point, a contour line runs perpendicular to the steepest ground slope; surface water flows downhill at right angles to the contour lines.
7. Contour lines run roughly parallel to streams, and they cross the stream.
8. Contour lines form us pointing downhill when they cross over the crest or ridge of a hill.
9. Perfectly straight or uniformly curved contour lines, with even spacing, generally pass through constructed facilities such as highway or railway embankments, dams and levees, canals, and other cultural features.
10. Depression contours enclose low ground, such as a hole or excavation with no drainage outlet the lowest contour in the hole is marked with hachures (Brown et al.2003).

#### **2.1.1.4. Map**

**Map** is way of representing of a two dimensions' surface, (a paper, a computer monitors etc.) any real world location or object.

#### **2.1.1.5. Scales**

**Scales** expresses the ration between distances in the map and those in reality.

- **Drawing scales;** the scale of a map refers to the ration or relationship between the length of a line on the drawing and the actual distance that the line represents in the field.

Map scales may be expressed in the form of equivalence, such as 1 in =2000ft; this means that a length of 1 in on the map represents a distance of 2000 ft on the ground. This sometimes called an engineer's scale (Brown et al.2003).

#### **2.1.1.6. Drawing the map**

Drawing the map; the features chosen to be included on the map depend, of course on its purpose and are usually specified before the survey is begun. Ordinarily, all data obtained by the survey

are included because the cost of the survey is high, and the map may eventually be used for purposes never considered when it is first made.

The objective, of course is to draw the map at a scale that will allow it to be read and used for its intended purpose with the desired accuracy. Usually, a rough sketch is made of the perimeter of the control system along with the controlling external topographic observations (Brown et al.2003)

#### **2.1.1.7. The topographic Map**

The topographic Map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines in modern mapping but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man –made features.

Topographic map serves as the basis for the planning, layout, and design of most civil engineering (infrastructures) and architectural projects; for this reason, a topo survey is also sometimes called an engineering survey or a preliminary survey. Top map are, of course, also used for other purposes such as for military, geological, archeological, and related applications. In general, there are two basic categories of map such as Area maps and Strip maps (Schofield, W. 2001)

Area maps such as site plan are essential for the planning, and design of projects such as residential subdivisions, airports, and reservoirs. Strip maps are needed for the planning and design of linear transportation facilities such as highways, railroads, and all kinds of pipelines.

- Control for an area map usually consists of both a loop traverse for horizontal positions and a network of benchmarks for elevations.
- Control for strip map usually consists of a long connected traverse and a line of benchmarks, both usually running along the approximate centerline of the project.

As previously discussed, the Topo maps must show the positions and elevations of natural and cultural features such as streams, ground contours, buildings and roads. Accordingly, it is necessary to make horizontal and vertical measurements that connect, or tie, these features to the control system (Schofield, W. 2001).

#### **2.1.2. There are two common methods of completing a topographic survey**

They are:

1. Conventional
2. Aerial

- **A conventional survey** is done by land surveyors on the surface of the land, usually with an instrument called a **total station**. Some surveyors now may also use a survey grade GPS unit to do this type work.
- **An aerial topo survey** is done from aerial photos taken from an airplane or helicopter at a certain distance above the ground. The aerial photos are then viewed together to form a stereo pair that allows the mapper to “visualize” the ground surface.
- **Computer Softwares:** Such as Cover10 and AutoCAD

### **2.1.3. The topo survey procedures**

There are several ways in which data can be collected in the field for determining the elevations and horizontal positions of points that are to be plotted on a map. The method used depends primarily on the purpose of the survey, the required accuracy and scale of the map, and the size of the area to be covered. In this section, two of the most common field methods are discussed—the grid method and the radial method. For relatively large land areas, photogrammetric mapping methods are usually applied; general discussion (Schofield, W. 2001)

### **2.1.4. Common topographic features**

Summits, saddles (low points in ridges), Depressions, Valley profiles, Ridge profile, Boundary and building corners, profiles along toes (bottoms) of slopes, profiles along browns of hills (tops of slopes), profiles along shoulders.

Because the ground rarely slopes uniformly, the accuracy of the map depends on how small a change in slope is considered significant for the interval desired. The ability to recognize and select control points, so that the desired map accuracy can be obtained with a minimum of field work, is a skill that develops with experience (Collier et al., 2003)

### **2.1.5. The standard map features**

The following items should always be included on a topo map, independent of its purpose;

1. A statement of scale and graphical indications of scale
2. A suitable title block and legend
3. A North arrow
  - Scale: the importance of a statement of scale, such as 1 in=50ft, or a representative fraction such as 1/600 should be obvious, particularly if the map will be used to read meaningful distance or location data.

- Title: A appropriate title is required, of course, to completely identify the map.

General, the title should contain the following;

1. Identification and location of the area mapped.
2. Named of the individual or company for whom the map is made.
3. Name of the surveyor or engineering firm making the map, including licence number.
4. Names of the drafts person and responsible engineer or surveyor.
5. Date of the survey and/or map preparation.

The title may be placed in any suitable location on the map, although the lower right-hand corner of the sheet is most common. Often, the statement of scale and/or graphical bar scale is included as part of the title (Collier et al., 2003).

North Arrow: for proper orientation when reading and using a map, it must have a noticeable (but not excessively ornate) north arrow.

#### **2.1.6. Objective of topographic mapping**

1. An objective of topography is to determine the position of any feature or more generally any point in terms of both a horizontal coordinate system such as latitude, longitude, and altitude. Identifying (naming) features and recognizing typical landform patterns are also part of the field.
2. A topographic study may be made for a variety of reasons: Geological exploration have been primary motivators to start survey programs, but detailed information about terrain and surface features is essential for the planning and construction of any major civil engineering, public works, or reclamation (Collier et al., 2003).

#### **2.1.7. The Methods topographic map can be prepared automatically**

Topographic map can be prepared automatically, using a method commonly called computer-aid drafting (CAD). Surveyors are using modern CAD systems to produce high-quality maps, as well as plats.

From x, y, z coordinates that are stored electronically in the computer. The array of data is called a digital terrain model. The data can be collected in the field using “total station” equipment, including an electronic field book.

A typical CAD work station consists of a keyboard, digitized boards printer, plotter, and Monitor for graphic display. The graphic display screen can be used on even for subdivision design;

This process is called “interactive graphics (IG). Portions of large drawings can be windowed, or viewed on the screen at enlarged scales for interactive design. The finished map is prepared on a drum plotter using vellum or Mylar sheets, laser plotters provide the ability to produce different line weights and colors (Collier et al., 2003).

### **2.1.8. The final product from a topographic survey is a map**

With all of the required features shown along with the contours representing elevations. An electronic map may also be supplied to an Engineer and/or Architect for their use in further design. The final map may be traced from the working drawing on which the traverse and radial shorts were plotted; the control system can be omitted from the final drawing for clarity. Often, the work is done in ink (colored inks may sometimes be used to improve the appearance of a special-purpose map. Black ink might be used for buildings and roads, blue ink for water, green ink for vegetation, and brown ink for contour lines (Collier et al., 2003).

### **2.1.9. The topographic symbols**

The use of consistent symbols for representing small-scale topographic features is important for the clarity of the map; on large-scale map, the features can usually be recognized and are easily labeled. Symbols are useful for indicating the location of trees, for distinguishing between roads and swamps, and for accomplishing similar purposes (Collier et al., 2003).

## **2.2. History of surveying**

The oldest historical records in existence today that bear directly on the subject of surveying state that this science began in Egypt. Herodotus recorded that sesostris (about 1400 B.C) divided the land of Egypt into plots for the purpose of taxation.

Annual floods of the Nile River swept away portions of these plots, and surveyors were appointed to replace the boundaries. As a consequence of this work, early Greek thinkers develop the science of geometry. Their advance, however, was chiefly along the lines of pure science.

For many years Heron’s work was the most authoritative among Greek and Egyptian surveyors. Significant development in the art of surveying was by from the practical-minded Romans, whose best-known writing on surveying was by Frontius.

In the 18<sup>th</sup> and 19<sup>th</sup> centuries, the art of surveying advanced more rapidly. The need for maps and locations of national boundaries caused England and France to make extensive surveys requiring accurate triangulation; thus geodetic surveying began. The U.S.C.S (now the National Geodetic

Survey: N.G.S) of the U.S.D.C was established by an act of congress in 1807. Initial its charge was to perform hydrographic surveys and prepare nautical charts (Schofield, W. 2001).

### 2.2.1. Surveying

**Surveying** which is also interchangeably called geomatics has traditionally been defined as the science, art, and technology of determining the relative positions of points above, on, or beneath the Earth's surface, or of establishing such points. In a more general sense, however, surveying (geomatics) can be regarded as that discipline which encompasses all methods for measuring and collection information, and dissemination a variety of resulting products to a wide range of clients (Schofield, W. 2001). Surveying has been important since the beginning of civilization. Its earliest application was in measuring and making boundaries of property ownership.

Today the importance measurement and monitoring our environment is beginning increasingly critically our population expands, land values appreciate, our natural resources and human activities continue to stress the quality of our land, water, and air.

Recognizing the breadth and importance of the practice of surveying, the IFS recently adopted the following definition:

**A surveyor** is a professional person with the academic qualifications and technical expertise to conduct one, or more, of the following activities:

- To determine, measure and represent the land, three-dimension objects, point-fields, and trajectories;
- To assemble and interpret land and geographically and economically related information;
- To use that information for the planning and efficient administration and management of the land, the sea and any structures thereon;
- To carry out urban and rural development and land management; and,
- To conduct research into and develop them.

#### ✓ **Detailed Functions**

The surveyor's professional tasks may involve one or more of the following activities, which may occur either on, above or below the surface of the land or the sea and may be carried out in association with other professionals.

1. The redetermination of the size and shape of the earth and the measurements of all data needed to define the size, position, shape and contour of any part the earth and monitoring any change therein.
2. The positioning of objects in space and time as well as the positioning and monitoring of physical features, structures and engineering works on, above or below the surface of the earth.
3. The determination of the position of the boundaries of public or private land, including national and international boundaries, and the registration of those lands with the appropriate authorities.
4. The design, establishment and administration of geographic information systems (GIS) and the collection, storage, analysis, management, display and dissemination of data.
5. The planning, development and redevelopment of property, whether urban or rural and whether land or buildings.

### **2.2.2. Importance of surveying**

Surveying is one of the world's oldest and most important arts because, as noted previously, from the earliest times it has been necessary to mark boundaries and divide land. Surveying has now become indispensable to our modern way of life.

The results of today's surveys are used to:

1. Map the Earth above and below sea level
2. Prepare navigational charts for use in the air, on land, and at sea
3. Establish property boundaries of private and public lands
4. Develop data banks of land use and natural resource information which aid in managing our environment.
5. Determine facts on the size, shape, gravity and magnetic fields of the Earth;
6. Prepare charts of our moon and planets (Schofield, W. 2001).

### **2.3. Traverse computation**

#### **2.3.1. Introduction**

The survey procedure known as traversing is fundamental to much survey measurement. The procedure consists of using a variety of instrument combination to create polar vector in space that is 'lines' with a magnitude (distance) and direction (bearing).

These vectors are generally contiguous and create a polygon which conforms to various mathematical and geometrical rules (which can be used to check the fieldwork and computations).



The equipment used generally consists of something to determine direction like a compass or theodolite, and routine methods of data reduction again to reduce the possible occurrence of errors (Schofield, W. 2001).

The most fundamental of these checks is to perform a closed traverse that is a traverse that starts and finishes on either the same point or known points, (similar in concept to a level run).

### **2.3.2. The function of traverses**

Traverses are normally performed around a parcel of land so that features on the surface or the boundary dimensions can be determined. Often the traverse stations will be revisited so that perhaps three-dimensional topographic data can be obtained, so that construction data can be established on the ground. A traverse provides a simple network of 'known' points that can be used to derive other information.

#### **Objective of traversing:**

- To know the advantages of bearing and their use in various survey works.
- To be familiar with the checks and errors in a closed traverse and solve them.
- To be familiar with various types and methods of traverse surveying for detailing.
- To know well about the traverse computation and be fluent in it.

### **2.3.3. Types of traverse**

There are two types of traverse used in survey:

- Open traverse, and
- Closed traverse (this traverse starts and ends at stations of known control)

There are two types of closed traverse

- Polygon traverse: closed on the starting point and
- Link traverse: closed on a second known point (Schofield, W. 2001)

## **CHAPTER 3: MATERIALS AND METHODS**

### **3.0. Introduction**

This chapter is a summary of what is to be on the field. It gives a framework of how the research study is to be conducted. In it the adopted research method is discussed and even the location to where the study is done, the data collection and the analysis of data is also considered.

### **3.1. Study design**

The study used both qualitative and quantitative methods to collect secondary and primary data from clustered projects. It further probed to gain deeper understanding for purposes of answering the research questions and adequately address the research objectives. In conducting the study, stratified random sampling procedure was used on urban-rural divide of projects implemented. In addition, sample size elements selection was done through project categorization into individual-community projects. The study involved relevant documents analysis, examining data types and sources, defining data collection procedure, outlining fieldwork activities, data collection and analysis and data processing procedures.

### **3.2. Description of the area of study or study setting**

The area of study is located in Musanze district, The Ruhengeri Institute of Higher Education (INES) is located in Musanze district precisely Musanze Sector at three kilometers from Musanze city. INES buildings are located at 600 meters from National Road (Musanze- Rubavu) near to Musanze Cave.

Research activities were carried out in Ruhengeri institute of higher education, situated in North province, Musanze district, Rwambogo Cell in Gakoro village. It is located on Latitude of 4833984, 568N; Longitude of 456708, 372E and elevation of 1878.608 m with an area of about 45728,559527 km<sup>2</sup>. Economical activities of people living around Ruhengeri institute of higher education are commerce, livestock, and agriculture. Highly yield in agricultural sector is due to use livestock manual and good climate available for crops as well as enough amount of rain throughout year. As we know volcanic regions containing reserved organic matter in the soil also this influence higher yields. The relief seems to include/understand two more or less distinct areas which are an area of high altitude with up 1950 m of altitude and another of low altitude reaching on average 1600m of altitude. Climate is in general of the wet type, precipitation is relatively abundant throughout year going from 1100 to 1500mm of rains.



Figure 3.1: Aerial view of Ruhengeri institute of higher education



Figure 3.2: Geographical map of Ruhengeri institute of higher education

**The limitation of Ruhengeri institute of higher education with cardinals points (four main points of the compass).**

- The East, there are cave, secondary school, ground of foot ball
- The Western, there are: road, commercial houses, residential houses
- The Northern, there are small forest, and INES Botanic Garden
- The South, there are the main road Musanze-Rubavu, Musanze secondary school, small forest.

**3.3. Choice of methodology**

A successful research depends on the choice of convenient methodology used in that research. If you have carried out a convenient research methodology, it's very easy to get good results. Some

information is necessary to be able to determine the methodology used. The study is a descriptive research survey design that was meant to describe the topographic map making. The researcher gathered information and attempted to explain the problem as it were in the field.

### 3.4. Data types

#### 3.4.1. Primary data

The data was obtained from the field using the following tools:

- ❖ Direct interviews and enquiries from Ruhengeri institute of higher education students and staff
- ❖ Carrying out site visits for on the spot observations and direct observation on existing facilities.
- ❖ Taking photographs of such visited existing facilities and producing diagrams for illustrative purposes of such.

#### 3.4.2. Secondary data

This data was obtained from work that was already done in this area of study. Sources of information were:

- a) Textbooks focusing on the research topic.
- b) Past theses and projects
- c) Sessional papers
- d) Newspapers and Journal
- e) Use of the internet for further information and data collection.
- f) Internationally recognized and accepted research encyclopedia

### 3.5. Softwares

Table 3.1: List of softwares used during the project

Methods/function	Names of computer programs
Writing	Ms. word 2013
Topographical analysis	Google Earth Pro ArcGIS 10.3 Covadis & AutoCAD 2007
Documents review (soft copies)	Acrobat Reader Microsoft Office 2016

### 3.6. Tools used during the project

Table 3.2: List of tools used during the project

Methods/function	Tools
Topographical survey	Total station, GPS
GIS modelling	Various Shapefiles, Gasabo orthophoto, Digital elevation model of Gasabo

### 3.7. Data collection procedure

#### 3.7.1. Survey measurement units

In general metric system of measurement was used and all distances and elevations were expressed in meters following the best engineering and construction practices. Angular measurement (zenith angle and horizontal angle) will be in degrees, minutes and seconds.

#### 3.7.2. Field survey

Field survey was carried out in Ruhengeri institute of higher education establishment by use of total station and (GPS GARMIN was used to find the geographic position coordinates of the two first position of total station (references or benchmark).

Table 3.3: Topographic data of INES3 and INES1

Poin ts	X	Y	Z	Co de	Points	X	Y	Z	Co de
INE S3	456826. 436	4833965. 791	1875. 407		P305	456706. 017	4834072. 275	1879. 726	26
INE S1	456708. 372	4833984. 568	1878. 608		P306	456706. 118	4834072. 598	1879. 694	26
INE S1	456708. 312	4833984. 577	1878. 189		P307	456706. 634	4834072. 491	1879. 734	26
ME S1	456708. 322	4833984. 577	1878. 189		P308	456706. 935	4834073. 263	1879. 671	26
P1	456820. 766	4833964. 348	1875. 333	16	P309	456706. 176	4834073. 649	1879. 674	26
P2	456802. 836	4834013. 38	1876. 65	16	P310	456705. 934	4834073. 232	1879. 664	26
P3	456798. 319	4834011. 351	1876. 825	16	P311	456705. 57	4834073. 323	1879. 649	26
P4	456801. 05	4834004. 204	1876. 671	16	P312	456708. 568	4834073. 92	1879. 807	1
P5	456795. 613	4834001. 865	1876. 647	16	P313	456707. 402	4834071. 199	1879. 784	1
P6	456798. 489	4833995. 237	1876. 459	16	P314	456701. 846	4834073. 388	1879. 687	1

P7	456793. 042	4833993. 176	1876. 64	16	P315	456690. 807	4834068. 876	1879. 504	1
P8	456795. 941	4833986. 613	1876. 2	16	P316	456688. 604	4834063. 131	1879. 833	1
P9	456790. 765	4833984. 962	1875. 687	16	P317	456667. 606	4834071. 393	1880. 314	1
P10	456792. 872	4833979. 002	1876. 265	16	P318	456663. 74	4834076. 581	1881. 253	5
P11	456799. 701	4833982. 025	1875. 846	16	P319	456645. 506	4834067. 021	1881. 428	5
P12	456799. 958	4833980. 712	1875. 848	16	P320	456621. 479	4834052. 371	1880. 943	5
P13	456783. 002	4833973. 682	1876. 279	16	P321	456626. 299	4834050. 546	1880. 933	40
P14	456782. 614	4833969. 475	1876. 057	16	ST3	456648. 668	4834065. 904	1881. 075	55
P15	456790. 555	4833967. 509	1875. 91	16	ST2	456678. 099	4834083. 144	1880. 611	
P16	456819. 689	4833964. 777	1875. 29	25	322	456659. 931	4834051. 586	1880. 151	31
P17	456817. 575	4833970. 581	1875. 418	25	323	456660. 34	4834048. 74	1880. 151	31
P18	456816. 217	4833974. 102	1875. 474	25	324	456664. 574	4834038. 258	1880. 061	1
P19	456813. 658	4833980. 697	1875. 643	25	325	456659. 475	4834041. 265	1880. 484	11
P20	456811. 771	4833985. 545	1875. 782	25	326	456652. 597	4834057. 361	1880. 831	11
P21	456810. 528	4833988. 756	1875. 92	25	327	456630. 925	4834048. 214	1881. 095	11
P22	456808. 776	4833993. 621	1876. 213	25	328	456667. 613	4834031. 988	1879. 944	13
P23	456807. 232	4833997. 518	1876. 373	25	329	456664. 704	4834035. 148	1880. 078	26
P24	456804. 412	4834001. 736	1876. 571	25	330	456663. 861	4834034. 869	1880. 061	26
P25	456801. 642	4834010. 122	1876. 707	25	331	456663. 566	4834035. 773	1880. 111	26
P26	456799. 379	4833999. 91	1876. 55	25	332	456664. 357	4834036. 099	1879. 878	26
P27	456796. 508	4833990. 363	1876. 491	25	333	456663. 579	4834036. 602	1879. 847	26
P28	456803. 968	4833986. 252	1875. 985	25	334	456662. 822	4834036. 208	1880. 086	26

P29	456794. 334	4833984. 066	1876. 227	25	335	456662. 389	4834037. 199	1879. 999	26
P30	456807. 95	4833975. 795	1875. 585	25	336	456663. 22	4834037. 568	1880. 031	26
P31	456812. 302	4833966. 42	1875. 416	25	337	456660. 866	4834040. 383	1880. 29	26
P32	456804. 026	4833967. 482	1875. 535	25	338	456659. 826	4834040. 043	1880. 424	26
P33	456797. 397	4833968. 531	1875. 644	25	339	456659. 562	4834041. 104	1880. 495	26
P34	456794. 529	4833968. 992	1875. 711	25	340	456660. 562	4834041. 491	1880. 317	26
P35	456789. 636	4833971. 568	1876. 063	25	341	456660. 165	4834043. 657	1880. 078	26
P36	456784. 969	4833971. 167	1876. 21	25	342	456661. 016	4834043. 965	1880. 142	26
P37	456805. 672	4833992. 268	1876. 297	26	343	456660. 678	4834044. 809	1880. 168	26
P38	456806. 953	4833993. 307	1876. 313	26	344	456659. 916	4834044. 463	1880. 17	26
P39	456806. 394	4833994. 849	1876. 318	26	345	456656. 53	4834052. 808	1880. 623	26
P40	456804. 553	4833994. 338	1876. 318	26	346	456655. 988	4834052. 546	1880. 625	26
P41	456804. 55	4833992. 98	1876. 336	26	347	456655. 58	4834053. 29	1880. 779	26
P42	456801. 339	4833994. 666	1876. 494	26	348	456656. 111	4834053. 582	1880. 717	26
P43	456803. 737	4833995. 733	1876. 413	26	349	456653. 434	4834058. 331	1880. 817	26
P44	456802. 039	4834000. 097	1876. 479	26	350	456653. 232	4834059. 153	1880. 877	26
P45	456799. 55	4833999. 04	1876. 449	26	351	456654. 035	4834059. 372	1880. 84	26
P46	456803. 012	4833999. 897	1876. 508	26	352	456654. 296	4834058. 66	1880. 865	26
P47	456803. 85	4834000. 214	1876. 501	26	353	456648. 644	4834056. 572	1880. 926	26
P48	456804. 153	4833999. 357	1876. 498	26	354	456648. 309	4834057. 229	1880. 959	26
P49	456803. 407	4833999. 038	1876. 475	26	355	456647. 392	4834056. 815	1880. 962	26
P50	456803. 16	4833998. 019	1876. 597	27	356	456647. 641	4834056. 182	1880. 963	26



P51	456797. 452	4834011. 295	1876. 91	2	357	456641. 652	4834053. 582	1881. 024	26
P52	456800. 286	4834004. 64	1876. 725	2	358	456641. 345	4834054. 184	1880. 99	26
P53	456794. 666	4834002. 223	1876. 708	2	359	456640. 19	4834053. 754	1881. 01	26
P54	456797. 325	4833995. 783	1876. 616	2	360	456640. 441	4834053. 065	1881. 006	26
P55	456792. 207	4833993. 613	1876. 606	2	361	456630. 697	4834048. 867	1880. 821	26
P56	456794. 838	4833987. 076	1876. 456	2	362	456630. 047	4834048. 621	1880. 762	26
P57	456789. 653	4833984. 927	1875. 603	2	363	456630. 366	4834047. 647	1880. 652	26
P58	456792. 171	4833978. 488	1876. 178	2	364	456662. 166	4834029. 71	1879. 907	13
P59	456783. 43	4833974. 832	1876. 835	2	ST4	456605. 714	4834038. 115	1880. 764	55
P60	456828. 751	4833960. 711	1875. 3	38	ST3	456648. 645	4834065. 889	1881. 077	
P61	456830. 805	4833960. 815	1875. 298	5	P365	456637. 871	4834032. 237	1880. 754	11
P62	456807. 95	4834015. 989	1876. 467	38	P366	456636. 939	4834019. 122	1880. 023	13
P63	456809. 077	4834018. 377	1876. 111	5	P367	456642. 428	4834021. 284	1880. 02	13
P64	456807. 558	4834018. 175	1876. 495	25	P368	456641. 768	4834022. 91	1880. 026	13
P65	456809. 015	4834016. 311	1875. 644	25	P369	456643. 971	4834002. 084	1879. 709	13
P66	456809. 663	4834013. 142	1876. 462	25	P370	456626. 797	4834014. 634	1880. 342	37
P67	456812. 927	4834004. 567	1876. 287	25	P371	456616. 325	4834007. 896	1880. 356	37
P68	456815. 498	4833998. 354	1875. 415	25	P372	456601. 415	4833998. 246	1880. 379	37
P69	456816. 805	4833994. 631	1875. 984	25	P373	456593. 365	4833993. 099	1880. 797	37
P70	456818. 099	4833991. 783	1875. 958	25	P374	456608. 24	4834007. 53	1880. 468	41
P71	456819. 242	4833988. 073	1875. 875	25	P375	456605. 363	4834011. 778	1880. 463	41
P72	456821. 582	4833982. 141	1875. 756	25	P376	456630. 88	4834022. 254	1879. 916	24



P73	456822. 783	4833978. 424	1875. 655	25	P377	456612. 16	4834047. 128	1880. 696	24
P74	456825. 458	4833971. 848	1875. 411	25	P378	456620. 961	4834036. 38	1880. 166	33
P75	456826. 943	4833967. 574	1875. 389	25	P379	456563. 456	4834018. 459	1881. 617	24
P76	456828. 373	4833963. 99	1875. 322	39	P380	456562. 731	4834018. 628	1882. 105	5
P77	456831. 505	4833950. 748	1875. 261	39	P381	456577. 165	4833994. 259	1881. 255	24
P78	456831. 588	4833953. 63	1875. 484	4	P382	456581. 195	4834019. 781	1881. 602	35
P79	456830. 909	4833955. 595	1875. 491	4	P383	456570. 957	4834019. 935	1881. 624	35
P80	456832. 574	4833956. 229	1875. 46	4	P384	456581. 032	4834009. 676	1881. 646	35
P81	456832. 378	4833957. 144	1875. 238	19	P385	456570. 738	4834009. 678	1883. 354	35
P82	456830. 926	4833960. 825	1875. 257	19	ST5	456587. 213	4833993. 302	1880. 809	55
P83	456823. 646	4833955. 187	1875. 291	16	P408	456630. 236	4833970. 172	1879. 884	40
P84	456822. 733	4833957. 749	1875. 282	16	P409	456645. 62	4833986. 535	1879. 421	40
P85	456807. 345	4833961. 372	1875. 43	16	P410	456646. 362	4833992. 15	1879. 437	40
P86	456782. 837	4833964. 686	1875. 974	16	P411	456637. 806	4833997. 789	1880. 406	37
P87	456774. 94	4833956. 485	1876. 353	16	P412	456644. 233	4834000. 8	1879. 62	
P88	456774. 433	4833960. 124	1876. 259	16	P413	456658. 205	4833973. 202	1879. 005	
P89	456778. 167	4833966. 011	1876. 094	16	P414	456687. 183	4833985. 529	1878. 669	
P90	456769. 582	4833969. 9	1876. 372	16	P415	456676. 289	4834011. 867	1879. 405	
P91	456773. 164	4833960. 95	1876. 668	16	P416	456674. 644	4834014. 858	1880. 054	13
P92	456768. 367	4833959. 078	1876. 723	16	P417	456654. 441	4834008. 419	1880. 268	13
P93	456770. 139	4833954. 827	1876. 476	16	P418	456657. 229	4834009. 589	1880. 263	13
P94	456765. 532	4833952. 911	1876. 527	16	P419	456657. 956	4834008. 029	1880. 27	13

P95	456767. 002	4833949. 698	1876. 548	16	P420	456660. 773	4834009. 178	1880. 27	13
P96	456781. 267	4833944. 249	1876. 147	16	P421	456660. 319	4834010. 842	1880. 281	13
P97	456807. 057	4833955. 024	1875. 698	16	P422	456667. 137	4834013. 741	1880. 305	13
P98	456808. 199	4833952. 359	1875. 563	16	P423	456649. 897	4834004. 531	1880. 065	13
P99	456810. 974	4833953. 552	1875. 498	16	P424	456687. 183	4833985. 507	1878. 62	30
P100	456813. 261	4833948. 562	1875. 424	16	P425	456693. 994	4833995. 113	1878. 59	30
P101	456820. 482	4833951. 369	1875. 18	16	P426	456697. 045	4834012. 652	1878. 958	30
P102	456820. 133	4833955. 279	1875. 134	25	P427	456693. 947	4834004. 198	1878. 603	30
P103	456815. 69	4833953. 484	1875. 231	39	P428	456693. 437	4833999. 515	1878. 592	30
P104	456808. 681	4833958. 753	1875. 502	25	P429	456686. 981	4834019. 263	1879. 227	30
P105	456798. 636	4833959. 306	1875. 574	25	P430	456676. 423	4834011. 781	1880. 136	30
P106	456796. 704	4833956. 281	1875. 689	25	P431	456683. 62	4834012. 412	1878. 672	27
P107	456784. 345	4833951. 554	1876. 798	25	P432	456684. 575	4834010. 859	1878. 631	27
P108	456776. 172	4833950. 771	1876. 389	25	P433	456685. 201	4834010. 041	1878. 663	27
P109	456773. 935	4833950. 987	1876. 462	28	P434	456686. 202	4834008. 772	1878. 747	27
P110	456770. 84	4833949. 638	1876. 576	28	P435	456685. 428	4833987. 25	1878. 685	
P111	456769. 667	4833952. 678	1876. 468	28	P436	456686. 181	4833985. 395	1878. 66	40
P112	456772. 843	4833953. 725	1876. 453	28	P437	456703. 554	4833975 096	1878. 096	6
P113	456773. 237	4833954. 765	1876. 384	33	P438	456697. 499	4833977. 251	1878. 42	6
P114	456774. 352	4833955. 51	1876. 42	26	P439	456700. 067	4833976. 57	1878. 277	6
P115	456774. 495	4833956. 12	1876. 405	26	P440	456691. 348	4833977. 611	1878. 44	6
P116	456775. 586	4833956. 324	1876. 344	26	P441	456680. 297	4833973. 017	1878. 411	6

P11 7	456775. 849	4833955. 494	1876. 249	26	P442	456665. 317	4833965. 437	1878. 738	6
P11 8	456776. 641	4833955. 615	1876. 237	26	P443	456625. 668	4833946. 996	1880. 131	6
P11 9	456776. 557	4833956. 6	1876. 278	26	P444	456613. 915	4833940. 24	1879. 911	6
P12 0	456777. 565	4833956. 696	1876. 137	26	P445	456612. 63	4833939. 567	1879. 881	19
P12 1	456777. 68	4833955. 808	1876. 152	26	P446	456610. 495	4833943. 625	1879. 914	19
P12 2	456782. 277	4833957. 502	1875. 854	26	P447	456611. 698	4833938. 742	1880. 456	5
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P12 9	456786. 661	4833957. 212	1875. 714	26	P454	456692. 642	4833991. 154	1878. 584	7
P13 0	456786. 85	4833955. 223	1875. 748	26	P455	456694. 68	4833994. 766	1878. 503	7
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P13 2	456788. 374	4833954. 881	1875. 748	26	P457	456691. 223	4833976. 849	1878. 426	
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P13 4	456787. 488	4833956. 534	1875. 683	27	P459	456680. 033	4833942. 67	1878. 011	
P13 5	456783. 22	4833956. 282	1875. 863	27	P460	456665. 356	4833965. 301	1878. 724	
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P15 6	456787. 595	4834045. 381	1877. 735	16	P480	456729. 793	4833932. 133	1876. 671	33
P15 7	456786. 391	4834044. 348	1877. 791	25	P481	456731. 378	4833935. 103	1876. 634	26
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P17 3	456792. 436	4834050. 478	1877. 65	25	P497	456719. 587	4833931. 376	1876. 365	26
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P18 0	456757. 933	4834098. 359	1879. 128	25	P504	456715. 229	4833929. 368	1876. 303	26

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P18 3	456771. 299	4834075. 185	1878. 505	25	P507	456716. 133	4833934. 018	1876. 465	40
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P18 9	456753. 417	4834121. 161	1879. 457	19	P513	456736. 549	4833949. 882	1877. 492	3
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P20 7	456734. 302	4834044. 314	1878. 725	1	P531	456755. 112	4833960. 131	1876. 766	42
P20 8	456749. 395	4834058. 418	1878. 742	2	P532	456751. 823	4833958. 577	1876. 908	42
P20 9	456757. 986	4834061. 845	1878. 615	2	P533	456751. 508	4833957. 833	1876. 872	42
P21 0	456760. 65	4834055. 455	1878. 803	2	P534	456751. 109	4833956. 928	1876. 881	42
P21 1	456765. 343	4834057. 35	1878. 518	2	P535	456750. 547	4833954. 397	1876. 801	42
P21 2	456768. 018	4834051. 067	1878. 38	2	P536	456752. 072	4833950. 045	1876. 89	42
P21 3	456773. 326	4834053. 112	1878. 181	2	P537	456753. 148	4833948. 801	1876. 863	42
P21 4	456776. 053	4834046. 705	1878. 079	2	P538	456752. 054	4833945. 596	1877. 423	42
P21 5	456781. 77	4834049. 01	1877. 94	2	P539	456751. 233	4833946. 608	1877. 383	42
P21 6	456776. 361	4834047. 829	1878. 067	16	P540	456745. 57	4833944. 071	1876. 935	42
P21 7	456773. 697	4834054. 177	1878. 081	16	P541	456745. 669	4833942. 561	1876. 884	42
P21 8	456768. 446	4834051. 984	1878. 303	16	P542	456741. 846	4833947. 075	1876. 831	42
P21 9	456765. 712	4834058. 428	1878. 579	16	P543	456740. 716	4833950. 22	1876. 838	42
P22 0	456761. 109	4834056. 702	1878. 545	16	P544	456740. 234	4833951. 525	1876. 865	42
P22 1	456758. 352	4834062. 949	1878. 637	16	P545	456739. 407	4833951. 676	1876. 873	42
P22 2	456747. 012	4834058. 812	1878. 603	16	P546	456738. 629	4833952. 025	1876. 906	42



P22 3	456743. 803	4834060. 794	1878. 571	16	P547	456736. 637	4833952. 621	1876. 894	42
P22 4	456751. 972	4834096. 041	1878. 955	16	P548	456733. 134	4833951. 617	1876. 793	42
P22 5	456764. 16	4834075. 937	1878. 584	16	P549	456730. 37	4833956. 915	1877. 217	42
P22 6	456753. 323	4834089. 727	1878. 901	25	P550	456729. 238	4833957. 29	1876. 917	42
P22 7	456754. 263	4834079. 903	1878. 773	25	P551	456738. 924	4833965. 049	1877. 055	
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P24 4	456728. 294	4834088. 181	1879. 692	26	P568	456738. 468	4833971. 628	1877. 243	7



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P24 6	456735. 812	4834083. 968	1879. 635	26	P570	456747. 837	4833947. 313	1876. 907	23
P24 7	456736. 263	4834084. 627	1879. 542	26	P571	456746. 366	4833946. 63	1876. 906	23
P24 8	456736. 564	4834084. 498	1879. 539	26	P572	456706. 08	4834026. 984	1878. 716	
P24 9	456736. 944	4834085. 045	1879. 368	26	P573	456707. 054	4834026. 862	1878. 657	
P25 0	456737. 77	4834084. 742	1879. 362	26	P574	456699. 41	4834027. 998	1879. 037	
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P28 1	456685. 67	4834082. 304	1880. 237	25	P606	456721. 042	4834046. 506	1879. 248	1
P28 2	456693. 956	4834081. 412	1880. 014	25	P607	456724. 609	4834037. 448	1878. 606	1
P28 3	456694. 089	4834087. 043	1880. 167	25	ST9	456722. 608	4833977. 902	1877. 466	55
P28 4	456699. 614	4834088. 43	1880. 095	25	ST8	456723. 405	4833997. 024	1877. 82	
P28 5	456700. 494	4834081. 325	1879. 964	25	INES1- CLOSE	456708. 232	4833984. 522	1878. 294	29
P28 6	456704. 402	4834076. 602	1879. 88	25	INES3- CLOSE	456826. 315	4833965. 193	1875. 521	29

P28 7	456705. 625	4834084. 756	1879. 969	39				
P28 8	456702. 818	4834095. 655	1880. 358	25				
P28 9	456709. 335	4834097. 06	1880. 269	25				
P29 0	456709. 196	4834101. 203	1880. 364	31				
P29 1	456684. 917	4834089. 388	1880. 809	5				
P29 2	456681. 996	4834077. 157	1879. 456	27				
P29 3	456682. 877	4834075. 604	1879. 344	27				
P29 4	456683. 907	4834075. 248	1879. 382	27				
P29 5	456685. 035	4834073. 239	1879. 427	27				
P29 6	456694. 662	4834071. 394	1879. 622	26				
P29 7	456695. 413	4834071. 695	1879. 598	26				
P29 8	456694. 307	4834072. 576	1879. 675	26				
P29 9	456694. 911	4834072. 79	1879. 684	26				
P30 0	456700. 518	4834073. 994	1879. 658	26				
P30 1	456699. 973	4834075. 089	1879. 75	26				
P30 2	456700. 771	4834075. 135	1879. 76	26				

Table 3.4: Topographic data of INES4 and INES1

Point s	X	Y	Z	Code	X	Y	Z
INES 1	456585.58 1	4833811.67 2	1878.189 8		456722.76 7	4834071.32 5	1879.457 6
MES 1	456708.36 6	4833984.54 6	1878.189 6		456723.78 8	4834073.82 5	1879.519 3

MES		4833855.73	1876.644		456725.15		1879.638
2	456669.54	6	7	P230	1	4834076.96	8
P1	456651.88	4833871.42	1879.019		456735.69	4834045.52	1878.353
	3	4	6	P231	5	5	1
P2	456672.52	4833880.39	1875.658		456736.82		1878.318
	456686.43	4833885.76	1875.246		456735.39	4834040.14	1877.976
P3	9	4	3	P233	9	7	3
P4	456694.09	4833865.80	1875.396		456725.81	4834036.31	1878.085
	6	7	2	P234	7	8	2
P5	456670.44	4833854.89	1876.556			4834030.46	1877.804
	8	7	4	P235	456735.28	8	3
P6	456689.22	4833839.28	1877.737		456727.03	4834031.57	1877.946
	1	4	2	P236	3	1	3
P7	456701.82	4833845.54	1875.887		456733.88		
	9	7	6	P237	2	4834033.23	1877.945
P8		4833846.05	1875.841		456727.69	4834033.83	1878.002
	456703.12	7	5	P238	8	4	7
P9	456695.87	4833864.75	1875.372		456737.93	4834033.55	1877.758
	6	6	2	P239	8	6	6
P10	456695.34	4833866.25	1875.395		456738.47	4834038.94	1877.895
	5	2	5	P240	1	2	2
P11	456734.83	4833880.85	1874.778		456745.61	4834035.55	1877.779
	9	2	9	P241	7	6	4
P12	456735.83	4833881.26			456741.50	4834040.84	1877.819
	7	9	1874.74	P242	1	2	1
P13		4833894.94	1874.671		456748.52	4834033.39	1877.705
	456742.26	7	4	P243	2	2	2

P14	456741.25 3	4833895.79 8	1874.659 9	P244	456753.22 5	4834043.72 8	1878.010 8
P15	456757.22 4	4833889.73 9	1874.632 1	P245	456747.20 6	4834026.69 8	1877.649 3
P16	456758.06 2	4833890.01 2	1874.658 1	P246	456752.03 5	4834037.44 4	1877.771
P17	456758.50 9	4833888.56 4	1874.640 1	P247	456748.60 8	4834026.41 6	1877.529 9
P18	456766.35 8	4833893.25 4	1874.908 6	P248	456755.93 4	4834032.44 4	1877.622 4
P19	456763.98 9	4833896.08 4	1875.038 3	P249	456750.38 5	4834023.43 1	1877.473 3
P20	456761.98 5	4833900.64 8	1875.200 7	P250	456758.79 3	4834026.94 4	1877.385 9
P21	456748.07 2	4833911.56 7	1875.631 3	P251	456764.60 4	4834035.98 3	1877.761 5
P22	456732.32 8	4833905.24 1	1874.983 9	P252	456768.74 6	4834026.58 5	1877.547 5
P23	456730.03 4	4833904.13 8	1874.909 4	P253	456761.95 6	4834043.53 3	1877.948 3
P24	456734.05 1	4833901.98 6	1874.947 1	P254	456769.41 5	4834020.71 1	1877.289 1
P25	456688.06 2	4833886.40 8	1875.136 5	P255	456771.37 3	4834021.71 8	1877.314 8
P26	456670.50 9	4833875.87 1	1876.516 5	P256	456771.41 1	4834022.40 6	1877.339 6
P27	456673.98 1	4833871.24	1876.569 4	P257	456772.46 2	4834023.01 3	1877.412 6

P28	456672.00 9	4833871.01 3	1876.547	P258	456757.88 3	4834043.19 7	1877.844 5
P29	456666.96 8	4833873.54 5	1876.517	P259	456766.12	4834027.25 2	1877.492 6
P30	456662.99 3	4833874.21 6	1876.834 3	P260	456762.86 2	4834045.19 9	1877.906 5
P31	456678.36 9	4833862.82 2	1875.962 2	P261	456751.10 9	4834020.89 4	1877.359 7
P32	456679.75 3	4833865.67 4	1875.876 5	P262	456755.37 2	4834049.63 8	1878.384 5
P33	456688.1	4833859.00 2	1875.604 6	P263	456735.57 5	4834030.44 9	1877.883 1
P34	456692.21 3	4833859.43 1	1875.613 4	P264	456737.17 8	4834042.15 8	1877.986 1
P35	456695.85 4	4833854.36 9	1875.802 7	P265	456742.76 4	4834032.52 9	1877.710 9
P36	456697.74 3	4833861.37 6	1875.638 5	P266	456741.28 4	4834030.15 8	1877.671 9
P37	456701.42 4	4833862.52	1875.570 3	P267	456743.84 2	4834030.25 1	1877.703 3
P38	456707.08 8	4833858.59 3	1875.651 7	P268	456745.52 3	4834029.17 8	1877.670 7
P39	456715.04 2	4833857.01 2	1875.459	P269	456743.81 3	4834026.7	1877.637 7
P40	456726.36 8	4833859.57 3	1875.287 8	P270	456743.08 1	4834030.09	1877.570 6
P41	456723.81 5	4833874.42 6	1874.971 8	P271	456742.10 1	4834032.49	1877.592 3

P42	456703.08 5	4833870.41 3	1875.230 4	P272	456743.37 9	4834027.95 5	1877.555 6
P43	456702.78 5	4833845.50 8	1876.374	P273	456742.89 8	4834030.94 5	1877.663 4
P44	456688.49	4833838.20 9	1878.028 5	P274	456755.78 6	4834050.59 1	1878.761
P45	456638.61 2	4833884.08 5	1878.118 3	P275	456758.38 4	4834044.14 6	1878.187 3
P46	456630.22 1	4833892.97 1	1879.968 5	P276	456763.75 1	4834046.36 1	1878.729 2
P47	456644.70 7	4833878.56 2	1877.611 8	P277	456772.42 4	4834012.60 7	1877.153 3
P48	456667.78 2	4833883.36 9	1876.147 6	P278	456776.51 7	4834015.96 5	1878.068 8
P49	456685.36 7	4833912.90 3	1876.264 5	P279	456777.27 7	4834012.03 8	1877.170 6
P50	456686.54 9	4833946.92	1877.984 3	P280	456761.29 4	4833985.78 4	1877.097 8
P51	456679.99 5	4833942.49 7	1878.063 6	P251	456764.60 4	4834035.98 3	1877.761 5
P52	456665.39 2	4833965.09 9	1878.771 1	P252	456768.74 6	4834026.58 5	1877.547 5
P53	456612.87 1	4833937.53 9	1880.723 4	P253	456761.95 6	4834043.53 3	1877.948 3
P54	456611.73 9	4833938.17 1	1880.590 9	P254	456769.41 5	4834020.71 1	1877.289 1
P55	456609.68 3	4833933.13 6	1880.788 8	P255	456771.37 3	4834021.71	1877.314 8

P56	456701.42 7	4833906.50 5	1876.484 2	P256	456771.41 1	4834022.40 6	1877.339 6
P57	456703.65 7	4833900.32	1876.448	P257	456772.46 2	4834023.01 3	1877.412 6
P58	456731.59 1	4833912.03 3	1876.318 5	P258	456757.88 3	4834043.19 7	1877.844 5
P59	456735.45 4	4833913.54 9	1876.796 5	P259	456766.12 456766.12	4834027.25 2	1877.492 6
P60	456732.02 3	4833910.12 5	1875.607 3	P260	456762.86 2	4834045.19 9	1877.906 5
P61	456732.30 6	4833902.95 3	1874.319 5	P261	456751.10 9	4834020.89 4	1877.359 7
P62	456764.23	4833896.79 6	1875.615 1	P262	456755.37 2	4834049.63 8	1878.384 5
P63	456762.53 1	4833900.74 3	1875.622 9	P263	456735.57 5	4834030.44 9	1877.883 1
P64	456764.41 9	4833902.24 9	1875.398 9	P264	456737.17 8	4834042.15 8	1877.986 1
P65	456762.07 5	4833901.09 2	1875.309	P265	456742.76 4	4834032.52 9	1877.710 9
P66	456748.51 3	4833911.66 8	1875.661 1	P266	456741.28 4	4834030.15 8	1877.671 9
P67	456764.95 5	4833916.66 2	1875.301 5	P267	456743.84 2	4834030.25 1	1877.703 3
P68	456768.10 6	4833903.94 9	1875.506 4	P268	456745.52 3	4834029.17 8	1877.670 7
P69	456774.20 8	4833907.08 5	1875.597 8	P269	456743.81 3	4834026.7	1877.637 7



P70	456768.11 1	4833917.15 7	1875.900 8	P270	456743.08 1	4834030.09 6	1877.570
P71	456773.36 7	4833919.48 7	1875.811 5	P271	456742.10 1	4834032.49 3	1877.592
P72	456777.66 2	4833908.85 5	1875.575 6	P272	456743.37 9	4834027.95 5	1877.555
ST1	456756.99 8	4833920.79 5	1876.181 7	P273	456742.89 8	4834030.94 5	1877.663
INES 4	456690.67 8	4833972.56 9	1875.521 9	P274	456755.78 6	4834050.59 1	1878.761
P73	456736.57 3	4833912.05 7	1875.690 1	P275	456758.38 4	4834044.14 6	1878.187
P74	456737.61 2	4833910.12 2	1875.572 2	P276	456763.75 1	4834046.36 1	1878.729
P75	456742.64 3	4833912.15 3	1875.499	P277	456772.42 4	4834012.60 7	1877.153
P76	456746.07 2	4833915.44 2	1875.770 7	P278	456776.51 7	4834015.96 5	1878.068
P77	456739.68 5	4833918.13 3	1876.094 9	P279	456777.27 7	4834012.03 8	1877.170
P78	456749.32 8	4833927.63 2	1876.414 9	P280	456761.29 4	4833985.78 4	1877.097
P79	456759.69 5	4833922.56 7	1876.174 7	P281	456777.28 5	4834012.02 5	1877.168
P80	456768.38 8	4833925.78 3	1876.139	P282	456777.14 3	4834012.38 1	1877.272
P81	456770.3 3	4833926.62 3	1876.192 6	P283	456777.78 2	4834012.65 1	1877.195

P82	456781.23 1	4833930.54 2	1875.825 5	P284	456776.68 9	4834015.17 2	1877.106 4
P83	456765.47 1	4833936.88 4	1876.540 2	P285	456775.31 1	4834014.53 9	1877.166 1
P84	456763.55 5	4833937.21 1	1876.619 5	P286	456772.61 4	4834020.93 4	1877.264 9
P85	456763.18	4833939.74 7	1876.837 4	P287	456773.99 3	4834017.71 6	1877.200 7
P86	456760.79 4	4833933.91 8	1876.875 9	P288	456772.28	4834021.86	1877.336 6
P87	456761.68 3	4833932.95	1876.549 7	P289	456769.42 6	4834019.96 3	1877.122 4
P88	456749.01 4	4833928.97 1	1876.872 2	P290	456773.76 6	4834017.56 4	1877.165 4
P89	456742.75 4	4833931.59 9	1876.995 6	P291	456772.45 2	4834014.27 7	1877.129 9
P90	456742.22 5	4833926.35 2	1876.480 2	P292	456771.45 3	4834016.52 8	1877.146 6
P91	456743.63 1	4833929.97 8	1876.641	P293	456776.85	4834012.23 3	1877.122 7
P92	456741.20 1	4833924.03	1876.352 9	P294	456775.61 8	4834012.63 1	1877.702 4
P93	456740.22	4833921.64	1876.253 8	P295	456776.16 1	4834014.08 7	1877.350 6
P94	456739.10 8	4833918.96 6	1876.286 9	P296	456771.72 9	4834013.67 1	1877.119 6
P95	456744.69 8	4833916.74 5	1875.853 7	P297	456770.64 8	4834010.10 6	1877.885 7

P96	456745.53 5	4833919.17 8	1875.982 3	P298	456766.55 7	4834011.65 5	1878.216
P97	456746.35 4	4833921.63	1876.113 9	P299	456764.04 8	4834010.40 6	1877.153 5
P98	456747.54 3	4833923.9	1876.128 6	P300	456758.13 5	4834008.13 5	1877.037 6
P99	456741.97 7	4833928.31 7	1877.377 5	P301	456769.68 6	4834008.25 1	1878.254 9
P100	456756.61 2	4833924.49 8	1876.245 1	P302	456758.39 5	4833979.37 1	1876.578 9
P101	456761.55 6	4833925.98 8	1876.227 6	P303	456755.66 1	4833981.75 9	1876.705 4
P102	456764.33 5	4833927.94 4	1876.416	P304	456763.06 3	4833972.49 6	1877.985 7
P103	456781.35 2	4833932.75 1	1876.829 9	P305	456764.39 4	4833969.71 2	1877.853 2
P104	456814.44 9	4833946.43 1	1875.563 2	P306	456757.16 8	4833970.02 4	1876.857 7
P105	456821.20 5	4833943.90 2	1875.156 1	P307	456754.25 7	4833969.06 5	1876.840 3
P106	456783.85 8	4833925.40 9	1875.406 9	P106	456783.85 8	4833925.40 8	1875.407
P107	456785.52 7	4833911.20 4	1875.278 4	P107	456785.52 7	4833911.20 4	1875.278
P108	456782.13 6	4833909.46 7	1875.392 1	P108	456782.13 5	4833909.46 7	1875.392
P109	456781.13 7	4833908.72 2	1875.692 8	P311	456757.91 5	4833986.94 8	1876.721 2

P110	456788.11 9	4833911.97 2	1875.207 3	P312	456759.36 3	4833995.81 5	1876.930 8
P111	456796.19 2	4833907.67 6	1875.623 1875.623	P313	456759.09 4	4834002.71 4834002.71	1876.982 3
ST2	456837.88 7	4833932.69 7	1875.028 6	P314	456753.84 3	4834017.15 7	1877.194 4
ST1	456756.36 3	4833926.42 5	1876.178 4	P315	456743.90 6	4834026.03 2	1877.745 1877.745
MES 3	456757.00 9	4833920.79 6	1876.18 1876.18	P316	456734.91 4	4834025.28 4	1877.767 9
MES 4	456757.00 5	4833920.79 3	1876.179 8	P317	456733.21 6	4834025.79 4	1877.776 1877.776
P112	456782.86 8	4833904.81 4	1876.182 8	P318	456727.09 7	4834026.24 8	1877.765 6
P113	456800.06 8	4833898.17 2	1876.737 5	P319	456721.52 8	4834025.82 5	1877.931 4
P114	456793.93 1	4833902.72 3	1876.638 8	P320	456717.15 2	4834024.41 4834024.41	1878.185 2
P115	456790.23 3	4833911.30 5	1875.098 5	P321	456714.88 5	4834023.67 4	1878.168 6
P116	456826.29 5	4833926.76 8	1874.04 1874.04	P322	456709.09 2	4834020.06 7	1878.489 2
P117	456825.89 7	4833928.19 8	1874.064 7	P323	456704.80 2	4834015.39 4834015.39	1879.094 6
P118	456827.25 1	4833928.86 8	1874.034 4	P324	456702.24 8	4834011.70 3	1879.359 1
P119	456827.73 8	4833927.48 7	1873.951 9	P325	456701.60 5	4834010.47 1	1879.399 3

P120	456828.76 1	4833918.24 5	1873.999 1	P326	456699.12 3	4834002.04 3	1878.542 3
P121	456830.34 9	4833918.71 9	1874.194 3	P327	456699.46 4	4833992.41 4	1878.452 5
P122	456845.14 9	4833923.59 7	1875.426 3	P328	456703.92 9	4833981.37 9	1878.209 2
P123	456840.85 7	4833933.10 9	1874.891 7	P329	456711.58 4	4833974.12 4	1877.849 8
P124	456840.43 8	4833934.39 4	1874.881 3	P330	456717.90 7	4833971.23 4	1877.534 4
P125	456823.00 8	4833944.16 4	1875.126 4	P331	456719.65 2	4833970.75 2	1878.818 1
P126	456834.76 5	4833950.03 5	1875.753 7	P332	456724.99 7	4833969.74 2	1877.237 5
P127	456833.40 2	4833954.11 5	1876.057 2	P333	456731.23 7	4833970.3 4	1877.163 9
P128	456833.42 7	4833942.81 3	1875.631 6	P334	456736.48 4	4833971.62 9	1877.150 4
P129	456831.55 8	4833941.89 6	1875.629 6	P335	456738.77 3	4833972.36 4	1877.438 7
P130	456832.36 1	4833940.13 6	1875.630 2	P336	456744.08 8	4833975.85 3	1876.947 6
P131	456834.22 6	4833941.00 7	1875.622 7	P337	456749.26 9	4833980.9 4	1876.856 5
P132	456833.11 1	4833946.31 4	1876.265 5	P338	456751.42 9	4833984.48 4	1876.879 6
P133	456836.96 4	4833938.73 6	1875.458 8	P339	456752.61 8	4833986.35 1	1876.873 7

P134	456830.90 8	4833936.87 6	1875.369 4	P340	456754.62 7	4833994.21 2	1876.826 4
P135	456838.46 5	4833931.40 8	1874.940 2	P341	456754.77 4	4834001.08 9	1876.926 3
P136	456833.00 6	4833926.28 2	1874.655 9	P342	456752.75 6	4834009.45 2	1877.166 1
P137	456829.00 9	4833926.89 9	1873.881 5	P343	456747.68 3	4834017.19 8	1877.354 7
P138	456814.12 5	4833937.03 8	1874.767 1874.767	P344	456740.62 6	4834022.53 3	1877.655 7
P139	456829.96 3	4833930.79 4	1874.570 6	P345	456726.76 8	4834001.75 8	1877.697 9
P140	456830.90 8	4833931.39 9	1874.571 2	P346	456727.81 8	4833998.70 9	1877.562 8
P141	456830.30 9	4833932.42 8	1874.582 3	P347	456728.65 8	4833996.46 8	1877.473 7
P142	456829.3 456829.3	4833931.84 5	1874.662 4	P348	456726.60 2	4833995.21 4	1877.431 7
P143	456820.68 456820.68	4833945.54 4833945.54	1875.235 7	P349	456725.35 4	4833997.83 4	1877.531 6
P144	456829.42 456829.42	4833954.07 9	1875.297 5	P350	456724.43 6	4834000.33 4	1877.673 7
P145	456833.56 1	4833953.62 9	1875.940 4	P351	456715.68 4	4833993.44 4833993.44	1878.003 8
P146	456785.87 8	4833932.85 5	1876.109 4	P352	456716.28 5	4833974.31 2	1877.563 6
ST3	456774.73 8	4833980.70 4	1876.488 7	P353	456712.21 6	4833979.71 4	1878.15 1878.15

ST2	456833.09 1	4834034.44 2	1875.023 3	P354	456704.83 1	4833988.17 1	1878.302 3
P147	456770.59 1	4833980.75 5	1876.504 6	P355	456701.52 9	4833997.45 3	1878.500 3
P148	456762.82 3	4833983.80 4	1876.715 2	P356	456711.98 456711.98	4834000.13 7	1878.030 9
P149	456760.77 7	4833978.69 3	1876.585 7	P357	456703.22 456703.22	4834007.28 5	1878.772 6
P150	456780.98 8	4833970.13 6	1876.1 1876.1	P358	456706.81 2	4834012.87 2	1878.394 3
P151	456781.27 4	4833973.31 1	1876.300 8	P359	456709.48 456709.48	4834016.48 4	1878.242 1
P152	456777.42 3	4833982.83 8	1876.442 6	P360	456714.31 456714.31	4834020.46 6	1878.338 9
P153	456782.45 456782.45	4833985.11 7	1876.541 1	P361	456718.28 2	4834007.96 7	1877.942 7
P154	456779.93 2	4833991.47 5	1876.715 7	P362	456713.26 1	4834013.33 6	1878.084 2
P155	456784.98 4	4833993.82 3	1876.776 6	P363	456720.12 456720.12	4834023.34 4	1878.129 3
P156	456782.53 7	4834000.18 8	1876.876 2	P364	456724.91 456724.91	4834024.16 6	1877.719 1877.719
P157	456787.93 4	4834002.54 6	1876.901 5	P365	456730.36 2	4834023.66 6	1878.107 8
P158	456786.61 2	4834005.69 3	1876.959 3	P366	456725.91 2	4834018.61 8	1877.809 5
P159	456780.13 1	4834002.98 9	1876.920 2	P367	456726.03 8	4834011.46 1	1877.766 6

P160	456771.11 3	4833981.31 9	1876.549 2	P368	456735.67 5	4834002.81 1	1877.955 2
P161	456771.43	4833979.69 3	1876.458 2	P369	456742.02 3	4833993.98 3	1876.921 7
P162	456771.00 3	4833979.56 1	1876.435 6	P370	456750.98 3	4833989.36 1	1876.787 3
P163	456766.09 9	4833979.51 3	1876.528	P371	456752.60 6	4833999.20 4	1876.825 5
P164	456776.87 1	4833972.67 3	1876.226 9	P372	456747.77	4834009.01 6	1877.135
P165	456776.58 3	4833979.06	1876.400 6	P373	456743.83	4834018.43 7	1877.407 7
P166	456773.07	4833980.69 2	1876.489 7	P374	456735.99 1	4834022.45 1	1877.694
P167	456774.77 5	4833985.61 5	1876.639 4	P375	456735.87 6	4833989.04 9	1876.988 2
P168	456780.76 8	4833985.57 4	1876.551	P376	456741.06 7	4833983.53 2	1876.676 8
P169	456777.02 2	4833991.28 2	1876.749	P377	456740.18 9	4833976.14 1	1877.753 3
P170	456780.24 2	4833996.44 9	1876.893 2	P378	456744.25 7	4833979.26 5	1877.622 7
P171	456785.30 9	4834003.40 8	1876.993 8	P379	456758.74 7	4833981.92 3	1876.680 9
P172	456782.49 9	4834001.99 9	1876.957 2	P380	456760.85 2	4833994.57 8	1876.964 3
P173	456783.7	4834014.55 1	1877.897 2	P381	456763.08 8	4834003.54 9	1877.035



	456783.19	4833999.90	1876.862			4834021.72	
P174	3	5	7	ST7	456678.37	3	1879.621
	456785.87	4833993.45	1876.829		456750.99		1877.839
P175	1	9	5	ST6	8	4833995.03	7
	456780.61	4833991.24	1876.832		456688.90	4834024.87	1879.135
P176	9	4	6	P382	5	7	4
	456783.34	4833984.72			456686.20	4834031.36	1879.159
P177	1	2	1876.842	P383	5	8	3
	456778.06	4833982.60	1876.824		456684.19	4834030.67	1879.151
P178	3	3	6	P384	1	5	3
	456781.67	4833974.01	1876.838		456681.50	4834037.37	1879.253
P179	2	6	7	P385	6	6	1
	456770.37	4833981.72	1877.081		456672.75	4834041.27	1880.081
P180	2	6	9	P386	2	1	4
	456779.62	4834004.22	1877.107		456674.94	4834039.73	1879.768
P181	6	9	6	P387	6	8	9
		4834006.32	1877.017		456666.82		1880.028
P182	456780.4	3	4	P388	9	4834036.27	6
		4834008.35	1877.107		456676.07		1879.482
ST4	456780.84	9	4	P389	5	4834015.84	7
		4834035.38	1876.485			4834021.22	1879.349
ST3	456772.03	9	4	P390	456683.83	7	3
	456788.77	4834002.25	1877.207		456685.66	4834022.45	1879.333
P183	5	3	1	P391	7	3	6
	456784.63	4834009.28	1877.086		456687.54	4834023.92	
P184	3	5	9	P392	6	2	1879.192
	456782.78	4834012.50	1877.165		456684.84	4834029.22	1879.149
P185	6	5	9	P393	7	6	4

P186	456775.69 8	4834010.19 4	1877.205 2	P394	456683.44 2	4834029.68 9	1879.232 9
P187	456780.25 2	4834010 4834010	1877.179 1877.179	P395	456680.22 1	4834038.40 2	1879.414 3
P188	456780.28 2	4834007.2 4834007.2	1877.579 2	P396	456679.21 4	4834038.54 2	1879.64 1879.64
P189	456774.41 5	4834008.98 6	1877.002 4	P397	456668.97 9	4834033.72 3	1879.843 2
P190	456775.39 4	4834011.64 2	1877.116 9	P398	456671.54 456671.54	4834028.27 2	1879.955 1
P191	456777.15 5	4834011.06 9	1877.078 9	P399	456671.41 9	4834027.31 3	1879.903 6
P192	456783.27 2	4834013.47 3	1877.160 6	P400	456671.83 456671.83	4834026.10 1	1879.925 2
P193	456785.12 5	4834008.60 4	1877.047 7	P401	456674.19 456674.19	4834031.12 7	1879.745 1
P194	456780.26 5	4834006.5 4834006.5	1877.021 2	P402	456677.83 5	4834029.01 5	1879.526 1879.526
ST5	456720.56 4	4834068.29 7	1879.143 8	P403	456678.58 8	4834028.18 4	1879.484 8
P195	456731.72 9	4834050.47 6	1878.706 2	P404	456684.70 7	4834024.72 4	1879.251 7
ST4	456782.95 9	4834125.99 7	1877.096 8	P405	456688.80 8	4834020.19 1	1879.137 1
P196	456725.09 3	4834055.91 1	1878.936 7	P406	456696.30 6	4834015.31 9	1878.913 7
P197	456722.46 4	4834062.19 6	1878.962 5	P407	456698.57 5	4834027.10 1	1879.046 1

P198	456717.87 7	4834060.36 4	1879.089 4	P408	456700.21 4	4834027.10 4	1878.986 9
P199	456714.19 9	4834069.21 2	1879.802 4	P409	456707.25 7	4834025.13 5	1878.724 3
P200	456714.88 5	4834070.92 2	1879.257 4	P410	456698.18 3	4834014.30 8	1878.878 3
P201	456720.05 3	4834068.88 1	1879.232 4	P411	456696.22 9	4834017.34 1	1878.941 7
P202	456724.34 6	4834078.86 6	1879.569 4	P412	456700.39 7	4834022.43 8	1878.757 6
P203	456732.26 9	4834075.45 8	1879.226 4	P413	456693.1 456693.1	4834022.93 4834022.93	1879.143 3
P204	456732.75 2	4834074.47 7	1879.271 1	ST8	456673.43 8	4834045.65 4834045.65	1879.869 4
P205	456731.43 5	4834073.80 4	1879.193 4	ST7	456655.08 9	4834061.70 7	1879.640 1
P206	456734.15 6	4834067.11 5	1879.170 5	P414	456671.19 7	4834056.57 2	1880.3 1880.3
P207	456733.54 456733.54	4834065.35 6	1878.762 1	P415	456681.99 2	4834052.36 4834052.36	1880.091 1
P208	456729.86 1	4834074.60 3	1879.027 5	P416	456668.36 1	4834049.07 2	1880.143 4
P209	456726.21 1	4834076.19 5	1879.222 7	P417	456669.91 5	4834047.86 4	1880.096 9
P210	456722.15 456722.15	4834067.63 5	1879.000 4	P418	456685.45 3	4834055.98 8	1879.908 1879.908
P211	456716.91 3	4834067.9 4834067.9	1879.039 2	P419	456684.36 9	4834046.11 4834046.11	1879.278 7

P212	456718.92 1	4834062.6	1878.974 1	P420	456688.84 2	4834048.18 5	1879.327 4
P213	456723.09 1	4834064.20	1878.951 1	P421	456687.06 3	4834039.72 9	1879.245 6
P214	456726.36 7	4834058.17 5	1878.837 2	P422	456684.92 8	4834040.95 9	1879.265 5
P215	456731.47 1	4834060.06	1878.670 8	P423	456683.04 4	4834046.53 7	1879.519 8
P216	456735.81 8	4834058.67	1878.567 3	P424	456687.07 6	4834049.15 6	1879.453 8
P217	456738.78 3	4834063.60 9	1878.735 9	P425	456684.69 6	4834054.05 5	1879.861 8
P218	456744.59 1	4834055.12 6	1878.384 6	P426	456681.87 9	4834049.70 7	1879.649 4
P219	456745.04 7	4834051.74 5	1878.373 6	P427	456672.11 3	4834053.17 4	1880.067 1
P220	456745.84 9	4834049.41 7	1878.331 9	P428	456678.17 7	4834046.21 1	1879.667 2
P221	456741.39 4	4834047.83 8	1878.299 6	P429	456683.46 7	4834050.09 2	1879.753 1
P222	456748.99 7	4834050.97 6	1878.424 8	P430	456677.67 8	4834052.28 6	1880.157 9
P223	456746.40 6	4834056.77 9	1878.553 5	P431	456674.75 7	4834053.40 6	1880.222 7
P224	456743.68 4	4834058.45 8	1878.528 7	P432	456672.09 7	4834054.43 8	1880.254 7
P225	456751.11 8	4834048.75 8	1878.786 7	ST9	456693.30 9	4833961.53 1	1878.328 4

P226	456747.48 1	4834057.33 6	1878.776 8	ST8	456725.44 1	4834041.74 2	1879.883 3
ST6	456753.74 9	4834039.17 4	1877.817 4	INES1 - CLOS E	456708.34 2	4833984.30 3	1878.223 7
ST5	456710.73 2	4834049.20 5	1879.145 3	INES4 - CLOS E	456694.02	4833864.24 1	1875.541 8
P227	456721.80 7	4834067.65 8	1879.177 5				

### 3.8. Data processing

The researcher quantified data and grouped them accordingly. To make the information more meaningful to the reader, data was reduced to narrative descriptions, tables, bar graphs, pie charts and pictures. Narrative descriptions were used to explain given scenarios and relationships. Tables condense numerical data and thus make it easier to understand. In addition to condensing data, graphs, charts, maps and pictures give data a pictorial appeal and make it easier to compare.

The coordinates (x, y, z or northing, easting, and elevation) of surveyed points were calculated automatically by total station. To download these coordinate from total station and transform in Cartesian system, DXF format will be used.

Design was conducted using different software like Microsoft excel, notepad, and ArcGIS 10.1

## CHAPTER 4: RESULTS

### 4.1. Traversing results

Field procedure of the INES3 and INES1

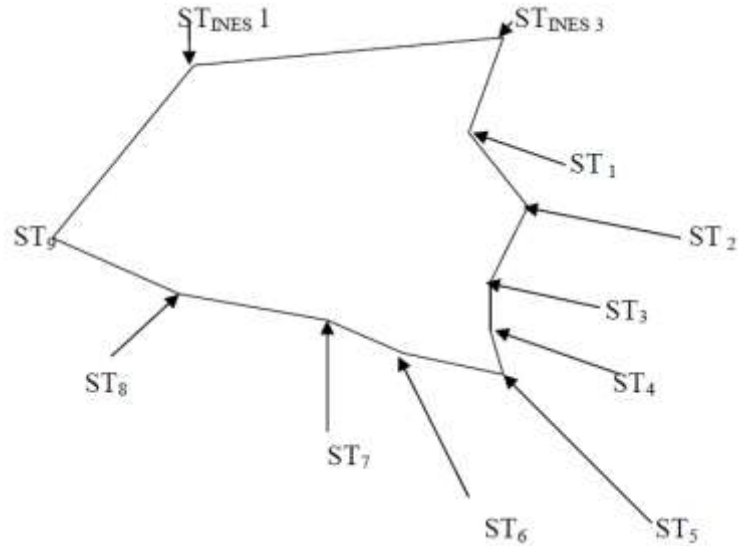


Figure 4.1 :Traversing for INES3 and INES1

Traverse of the INES4 and INES1

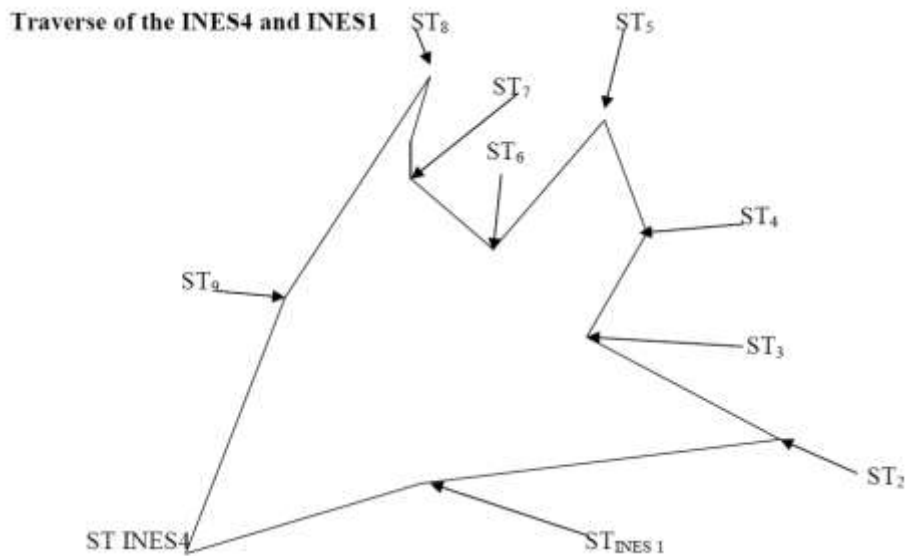


Figure 4.2 :Traversing for the group of INES4 AND INES1

### 4.2. The procedures to download data from total station

- Program, Job, Export, stick –USB: Type of data: fixes point and measure enter

Job: Job unique, select job: choose name, List (choose name), Continue, Nouveau, Write name of file-Continue, Format: ASCII, Continue, Delimiter: Space, Unity: chose <<Meter>> enter, Head of inclination: oui

Field data: N<sup>0</sup> point enter

- X enter
- Y enter
- Z enter
- Code enter

➤ Continue, Non

This table below shows data recording, processing and at each traverse Point.

Table 4.1: INES3 and INES1

Station	Northing	Easting	Elevation
st1	4834098.633	456755.714	1878.952
st2	4834083.153	456678.115	1880.625
st3	4834065.904	456648.668	1881.075
st4	4834038.115	456605.714	1880.764
st5	4833993.302	456587.213	1880.809
st6	4833945.043	456637.539	1879.634
st7	4833915.613	456684.066	1876.275
st8	4833997.028	456723.405	1877.757
st9	4833977.902	456722.608	1877.466
INES1 clause	4833984.522	456708.232	1878.294
INES3 clause	4833965.193	456826.315	1875.521

### INES4 and INES1

Table 4.2: The table above shows the collected data at each Traverse Point for the INES4 to INES1

Station	Northing	Easting	Elevation
st1	4833920.795	456756.9981	1876.182

st2	4833932.697	456837.8866	1875.029
st3	4833980.704	456774.738	1876.489
st4	48334008.36	456780.84	1877.107
st5	4834068.297	456720.5638	1879.144
st6	4834039.174	456753.7489	1877.817
st7	4834061.707	456655.0887	1879.64
st8	4834045.65	456673.4378	1879.689
st9	4833961.531	456693.3092	1878.328
INES1 Close	4833984.303	45678.3422	1878.224
INES4 Close	4833864.241	456694.0203	1875.542

### 4.3. Computing change in easting and in northing

#### 4.3.1. Calculate of errors for INES3 and INES1

$$X_{ST1}=456755.7140+0.011=456755.725$$

$$Y_{ST1}=4834098.6330+ 0.054363636 =4834098.687$$

$$Z_{ST1} =1878.952-0.010363636 =1878.9416636$$

$$X_{ST2} =456678.1150 +(0.011)*2 =456678.137$$

$$Y_{ST2}=4834083.1530 +(0.054636363)*2=4834083.262$$

$$Z_{ST2}= 1880.625 -(0.010363636)*2 = 1880.604273$$

$$X_{ST3} =456648.6680+ (0.011)*3 =456648.701$$

$$Y_{ST3} 4834065.9040 + (0.054363636)*3 =4834066.230$$

$$Z_{ST3} = 1880.075 -(0.010363636)*3 =1881.012818$$

$$X_{ST4}=456605.7140 +(0.011)*4 =456605.758$$

$$Y_{ST4} = 4834038.1150 +(0.054363636)*4 =4834039.420$$

$$Z_{ST4} = 1880.764 -(0.010363636)*4 =1880515273$$

$$X_{ST5} = 456587.2130 +(0.011)*5 =456587.2245$$

$$Y_{ST5} = 4833993.3020 +(0.054363636)*5 =483999.8256$$

$$Z_{ST5}=1880.809 -(0.010363636)*5 =1879.565364$$

$$X_{ST6}=456637.5390 + (0.011)*6 =456637.605$$



$$Y_{ST6} = 4833945.0430 + (0.054363636)*6 = 4833984.285$$

$$Z_{ST6} = 1879.634 - (0.010363636)*6 = 1872.172182$$

$$X_{ST7} = 456684.660 + (0.011)*7 = 456684.143$$

$$Y_{ST7} = 4833915.6130 + (0.054363636)*7 = 4834189.606$$

$$Z_{ST7} = 1876.275 - (0.010363636)*7 = 1824.042273$$

$$X_{ST8} = 456723.84050 + (0.011)*8 = 456723.493$$

$$Y_{ST8} = 4833997.0280 + (0.054363636)*8 = 4836188.970$$

$$Z_{ST8} = 1877.757 - (0.010363636)*8 = 1877.674091$$

$$X_{ST9} = 456708.2320 + (0.011)*9 = 456722.707$$

$$Y_{ST9} = 4833977.9020 + (0.054363636)*9 = 4853705.378$$

$$Z_{ST9} = 1877.466 - (0.010363636)*9 = 1876.719818$$

$$X_{INES1\text{ CLOSE}} = 456708.2320 + (0.011)*10 = 456708.342$$

$$Y_{INES1\text{ CLOSE}} = 4833984.5220 + (0.054363636)*10 = 4833985.066$$

$$Z_{INES1\text{ CLOSE}} = 1878.294 - (0.010363636)*10 = 1878.190364$$

$$X_{INES3\text{ CLOSE}} = 456826.3150 + (0.011)*11 = 456826.436$$

$$Y_{INES3\text{ CLOSE}} = 4833965.1830 + (0.054363636)*11 = 4833965.791$$

$$Z_{INES3\text{ CLOSE}} = 1875.521 - (0.010363636)*11 = 1875.407$$

Table 1.3 :Shows the correction of errors of INES3 and INES1

Station	Northing	Easting	Elevation
1	4834098.687	456755.725	1878.941636
2	4834083.262	456678.137	1880.604273
3	4834066.23	456648.701	1881.012818
4	4834039.42	456605.758	1880.515273
5	483999.8256	456587.2245	1879.565364
6	4833984.185	456637.605	1872.172182
7	4834189.606	456684.143	1824.042273
8	4836188.97	456723.493	1877.674091
9	4855705.378	456722.707	1876.719818

<b>INES 1</b>			
<b>Close</b>	48333985.07	456708.342	1878.190364
<b>INES 3</b>			
<b>Close</b>	4833965.791	456826.436	1875.407

#### 4.3.2. Calculate of errors for INES 4 and INES1

$$DX = 456694.472 - 456694.0203 = 0.4517$$

$$DY = 4833864.368 - 4833864.2414 = 0.127$$

$$DZ = 1875.518 - 1875.542 = -0.024$$

$$\text{Error for X} = 0.4517 : 11 = 0.0410636363$$

$$\text{Error for Y} = 0.127 : 11 = 0.0115454$$

$$\text{Error for Z} = -0.024 : 11 = -2.1818$$

$$X_{ST1} = 456756.9981 + 0.04106363 = 456757.3916$$

$$Y_{ST1} = 4833920.7953 + 0.01115454 = 4833920.807$$

$$Z_{ST1} = 1876.182 - 2.181818 = 1878.9416636$$

$$X_{ST2} = 456837.8866 + (0.04106363) * 2 = 456678.137$$

$$Y_{ST2} = 4833932.6973 + (0.0115454) * 2 = 4834083.262$$

$$Z_{ST2} = 1875.029 - (2.181818) * 2 = 1880.604273$$

$$X_{ST3} = 456774.7380 + (0.04106363) * 3 = 456774.8612$$

$$Y_{ST3} = 4833980.7040 + (0.0115454) * 3 = 4833980.739$$

$$Z_{ST3} = 1876.489 - (2.181818) * 3 = 1876.4824$$

$$X_{ST4} = 456780.8400 + (0.011) * 4 = 456781.0043$$

$$Y_{ST4} = 4843008.3588 + (0.054363636) * 4 = 4834008.497$$

$$Z_{ST4} = 1877.107 - (2.181818) * 4 = 1878.0982$$

$$X_{ST5} = 456720.5638 + (0.4106363) * 5 = 456721.3851$$

$$Y_{ST5} = 48340682973 + (0.0115454) * 5 = 48334068.69$$

$$Z_{ST5} = 1879.144 - (2.1818) * 5 = 1879.1330$$

$$X_{ST6} = 45673.7489 + (0.0416363) * 6 = 456758.6765$$

$$Y_{ST6} = 4834039.1740 + (0.0115454) * 6 = 4834043.33$$

$$Z_{ST6} = 1877.819 - (2.1818) * 6 = 1877.7535$$

$$X_{ST7} = 456655.0887 + (0.4106363) * 7 = 456689.5822$$

$$Y_{ST7} = 48340061.7072 + (0.0115454)*7 = 4834090.802$$

$$Z_{ST7} = 1879.640 - (2.1818)*7 = 1879.1818$$

$$X_{ST8} = 456673.4378 + (0.04106363)*8 = 456949.3854$$

$$Y_{ST8} = 4834045.6495 + (0.0115454)*8 = 4834278.405$$

$$Z_{ST8} = 1879.689 - (2.1818)*8 = 1876.0236$$

$$X_{ST9} = 456693.3092 + (0.04106363)*9 = 457691.8379$$

$$Y_{ST9} = 4833961.5308 + (0.0115454)*9 = 4836056.337$$

$$Z_{ST9} = 1878.328 - (2.1818)*9 = 1845.3389$$

$$X_{INES1\ CLOSE} = 456708.3422 + (0.04106363)*10 = 456694.472$$

$$Y_{INES1\ CLOSE} = 4833984.3031 + (0.0115454)*10 = 4833984.448$$

$$Z_{INES1\ CLOSE} = 1878.224 - (2.1818)*10 = 1878.2021$$

$$X_{INES4\ CLOSE} = 456694.0203 + (0.04106363)*11 = 456694.472$$

$$Y_{INES4\ CLOSE} = 4833864.2414 + (0.0115454)*11 = 4833864.253$$

$$Z_{INES4\ CLOSE} = 1875.542 - (2.1818)*11 = 1875.51$$

Table 4.4 : Show the correction of errors of INES4 and INES1

<b>Stations</b>	<b>Northing</b>	<b>Easting</b>	<b>Elevation</b>
1	4833920.807	456757.3917	1876.1798
2	4833932.72	456837.9687	1875.0268
3	4833980.739	456774.8612	1876.4824
4	4834008.497	456781.0043	1878.0982
5	4834068.99	456721.3851	1879.133
6	4834043.33	456758.6765	1877.7535
7	4834090.802	456689.5822	1879.1818
8	4834278.405	456949.3856	1876.0236
9	4836056.337	459176.8379	1845.3389
<b>INES 1 Close</b>	4833984.448	456708.7528	1878.2021
<b>INES 4 Close</b>	4833864.253	456694.472	1875.185

## **CHAPTER 5. DISCUSSIONS**

### **5.0. Introduction**

The field study set out to provide topographic map of Ruhengeri institute of higher education. This objective was to be achieved through field survey. The data collected was both quantitative and qualitative. Through discussions, organizing, summarizing, crosschecking and explanations, the researcher thematically analyzed the quantitative and qualitative data in an attempt to clearly present the responses from the respondents with regards to the subject matter. Descriptive statistical methods were also used to analyze the qualitative data. The presentation of data resulting from the field was done in the form of a combination of graphical and statistical techniques. The graphical techniques used are maps whereas statistical techniques involved the use of frequency distribution tables.

### **5.1. Findings from the study**

#### **5.1.1. Digital topographic mapping**

##### **1. Digital topographic map specifications**

A digital topographic map specification discussion was held mainly on the symbols (definitions, applicable specifications) to be used.

##### **Survey of inventory for large scale topographic mapping**

An inventory survey of geographic information in INES's possession was conducted before the abovementioned specification discussion was held.

As a result, it was found that INES did not have experience making large scale topographic maps specification, however, the editing of temporal change on existing maps was underway, based on analogue map specifications.

These analogue map specifications define, depending on scale (1:500 to 1:1000; and 1:2000 to 1:5000), a total of 127 map symbols classified into ten types of features that should be represented on the maps.

##### **2. Specification discussion on map symbols**

The specification discussion was held with explanations of the four main points below and based on the prepared map feature codes (MFC), symbol specifications (draft) and the abovementioned analogue map specifications.

- Difference between the analogue and digital methods regarding the process of digital plotting, editing and symbolization
- Structure of digital data (points, lines, polygon)
- Items to acquire (feature data) and representation for 1:5000 scale maps
- Specifications for map symbols and annotations

By October 2020 the specification discussions had produced the Map style and symbols for 1:5,000 scale digital topographic maps for the study on the topographic mapping for Ruhengeri institute of higher education.

However, because no sample topographic maps to use these map symbol specifications on had been made at the time, there was no way of getting an accurate idea of the actual size and color of these symbols or how they would look on the map and so on. Therefore, a sample topographic map was made based on these symbol specifications (Version 1.0), and any problems or areas of improvement found in the process were included in Version 1.2 of the symbol specifications.

### 3) Specification discussion on map size, marginal information and colors

Before the discussion, a survey was undertaken on whether INES responsible for printing the digital topographic data—possessed a plotter, whether it would be possible to procure plotting paper in Afghanistan, and on the size of existing INES maps.

Thereafter, a discussion was held based on the above survey results. Consequently, it was decided—by weighing up factors such as a map size easy to use in various applications and printing efficiency, against the type of paper procurable—that the paper size of the digital topographic maps would be A0. Besides map size, the specification of language and text, colors, map numbering and spacing between gridlines, as in Table 5.2, were also decided.

Table 5.1: Specification of maps, marginal information and colors

	1:5,000 scale topographic map
Inner neatline	60 cm×80 cm (3 km×4 km)
Language and text	English, alphabet
Color	Six (black, red, blue, green, brown, yellow)

Map numbering	Sheet numbering to be decided based on "Methodology of Numbering System for Afghanistan National Base Maps"
Grid spacing	20 cm×20 cm (1 km×1 km)

During this work in Ruhengeri institute of higher education, colors were discussed based on the sample map that was made to the above specifications, and a final agreement on this was reached.

#### 4) Specification discussion on surveying standards

With one of this project's basic policies—preparation of digital topographic and orthophoto maps based on global standards.

Based on the agreement, the specification of survey standards is as followings:

##### Outline of Survey Standards Adopted for this Work

- ❖ Reference ellipsoid: WGS84
- ❖ Projection system: UTM (42 zones – zone width 6°)
- ❖ The origin is the point of intersection of the equator and the central meridian (east longitude 69° )
- ❖ Coordinate of the origin (XO, YO) = (0 m, 500,000 m)
- ❖ Scale factor in the central meridian: 0.9996
- ❖ Unit: meters
- ❖ Elevation standard: Average sea level in the Baltic Sea

#### (2) Aerial photography

The aerial photography was locally recommissioned.

##### 1. Decision on specifications for aerial photography

It was decided upon discussions with AGCHO to implement the aerial photography over an area including that of the 1:5,000 topographic mapping bound by the following four points:

- 1: E= 504,000 m N= 3,845,000 m
- 2: E= 537,000 m N= 3,845,000 m
- 3: E= 537,000 m N= 3,814,000 m
- 4: E= 504,000 m N= 3,814,000 m

### **(3) Photo control point survey**

#### **1. GPS survey**

The photo control point survey for horizontal position was implemented using GPS surveying methods.

##### **a. Plan of point distribution**

A plan of point distribution, taking into consideration the aforementioned necessary number of photo control points, was formulated in the office. This distribution plan put the number of photo control points for horizontal position at 26.

##### **b. Reconnaissance of control points and selection of photo control points**

Many of the control points in the northern part of the mapping area are on mountain summits, where there are still many mine fields. Therefore, these had to be removed from the reconnaissance work, although it was found that two points were able to be used. On the other hand, the southern part of the mapping area is in the area of Musanze-Rubavu, Musanze secondary school, small forest. New photo control points were first selected in the office using satellite imagery to find points that would probably be distinct on aerial photos and it were selected on the actual aerial photographs in the field. And where necessary, selected new photo control points were set into the ground. The total of new photo control points was 21.

##### **c. Observation plan and observation**

###### **Observation plan**

As decided upon in the surveying standard discussions, the reference ellipsoid adopted was WGS84 and the method of projection was UTM.

Therefore, the first order network included reconnoitered and selected control (given) points/ 6 photo control points; and a second order network with given points.

The coordinates of which had been decided through the observation and analysis calculations of the first network was planned.

###### **Observation**

The GPS survey was implemented by six teams of three. Six GPS receivers (four Leica GX1230 and two Trimble 4000SSI) were used in the survey.

Observation for the first order network was carried out for six hours by the static method, at intervals of 30 seconds. Further, this was done in one session.

Observation for the second order network was carried out for one hour by the static method, at intervals of 15 seconds. Moreover, this was done over seven sessions.

The accuracy of the GPS observation was controlled by checking the results, on the same or the next day. The decision to resurvey or not was made promptly. And, as a result, there were no resurveys.

#### **d. Baseline analysis/calculation of network adjustment; and results**

##### **Baseline analysis**

Baseline analysis using the automatic analysis functions of the survey equipment's analysis software.

Next, using these results the closure error of the observation side in triangulation and the error on double-run sides were checked.

As a result, the closure error of the observation sides in triangulation:

- ❖ For the first order network: maximum DX = -0.005 m (limit value 0.077 m);
- ❖ DY = 0.026 m (limit value 0.077 m); DZ = 0.000 m (limit value 0.077 m);
- ❖ For the second order network: maximum DX = 0.056 m (limit value 0.077m);
- ❖ DY = 0.051 m (limit value 0.077 m); DZ = -0.052 m (limit value 0.077m);

Also, there were a total of seven double-baselines; the maximum values of DX, DY, and DZ difference were: 0.014 m, 0.034 m, and 0.031 m respectively (limit value of each: 0.045 m).

##### **Calculation of network adjustment**

The network adjustment was undertaken using the network adjustment function of the analysis software, and based on the results of the baseline analysis, as follows:

- ❖ Using the WGS84 coordinates of the given point for the six primary control points of the first order network for which six hours of GPS observation was carried out were calculated using network adjustment calculation with a single fixed point.

The results of the network adjustment calculations were:

The accuracy of X, Y, H (standard deviation) for the first order network was: 0.038 m, 0.029 m, and 0.079 m respectively (limit value of each: 0.200m); and for the second order network: 0.063 m, 0.043 m, and 0.125 m respectively (limit value of each: 0.200 m).

The results of the network adjustment calculations of the GPS survey are shown in Table 5.2.



Table 5.2 : Show the correction of errors of INES4 and INES1

<b>Stations</b>	<b>Northing</b>	<b>Easting</b>	<b>Elevation</b>
1	4833920.807	456757.3917	1876.1798
2	4833932.72	456837.9687	1875.0268
3	4833980.739	456774.8612	1876.4824
4	4834008.497	456781.0043	1878.0982
5	4834068.99	456721.3851	1879.133
6	4834043.33	456758.6765	1877.7535
7	4834090.802	456689.5822	1879.1818
8	4834278.405	456949.3856	1876.0236
9	4836056.337	459176.8379	1845.3389
<b>INES 1 Close</b>	4833984.448	456708.7528	1878.2021
<b>INES 4 Close</b>	4833864.253	456694.472	1875185

#### (4) Photo interpretation and field identification

The photo interpretation and field identification were implemented as follows:

- ❖ Preparation of photo interpretation and field identification
- ❖ Collection and arrangement of related materials
- ❖ Collection and arrangement of annotation materials
- ❖ Implementation of photo interpretation and field identification
- ❖ Arrangement of photo interpretation and field identification results

The flowchart of the photo interpretation and field identification is shown in Fig 3-8.

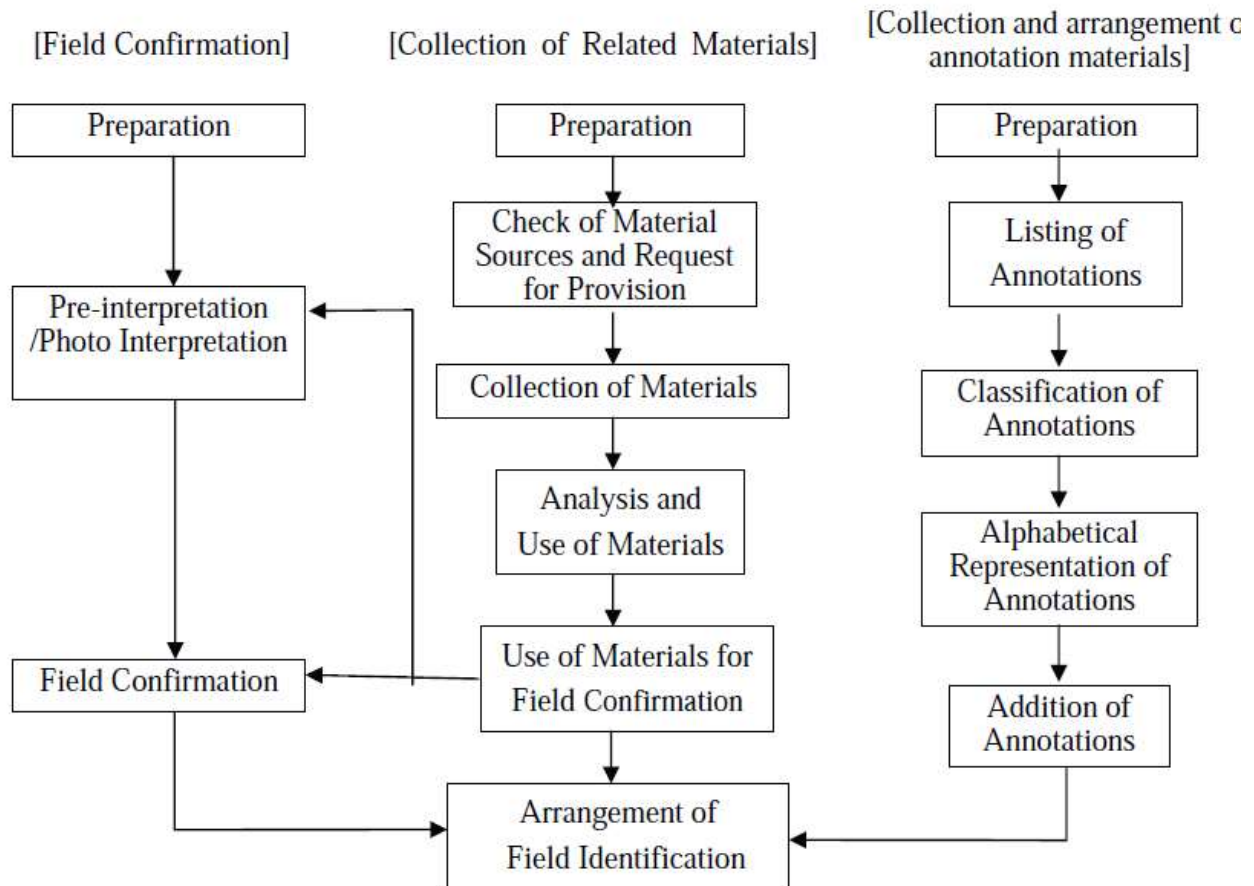


Figure 5.1: Flowchart of field identification

### 1. Preparation

Digital mosaic photos of the study area were made from the aerial photographs. These digital mosaic photos data were made into a data by unit sheet and printed out for use in photo interpretation and field identification.

### 2. Collection and arrangement of annotation information

Annotations for the area of this study from the old maps obtained were listed in an Excel file.

### 3. Photo interpretation/field identification

Before starting the photo interpretation and field identification, discussions were held with Ruhengeri institute of higher education engineers in charge about how these tasks would be implemented. The following points were explained:

- ❖ Symbol specifications (topographic features to be acquired in the photo interpretation and field identification, and standards for their application)



data were collected by using GPS and theodolite. The coordinates (x, y, z or northing, easting, and elevation) of surveyed points were calculated automatically by total station. To download these coordinate from total station and transform in Cartesian system, DXF format will be used.

The elaboration of this each mapped unit (polygon), soil type and erosion features were linked as attributes into the GIS system. This created a comprehensive database, which is unique in Rwanda. The database provides very useful information for agriculture, forestry and urban development planning, for environment protection and for many other applications. The data collected in the database provide the possibility for different kinds of spatial analysis, which is necessary in land management. Topographical survey helped too much in identifying and maps the Contours and existing features on the surface. It is also show the perimeter boundary lines, identifying or naming features and recognizing typical landform patterns.

This research was done with some methods such as **closed loop traverse**. This type of closed traverse begins at a point of known control, moves through the various required unknown points, and returns to the same point.

The results show the topographic map of Ruhengeri institute of higher education with their contours, features (streets, manholes, trees, buildings...), this map is at scale of 1/40 on the paper. It has 1<sup>st</sup> order contours in blue color and 2<sup>nd</sup> order contours in red color. The interval of 1<sup>st</sup> order contours is one and 2<sup>nd</sup> order contours is 0.5 but is shown in the legend.

The Ruhengeri institute of higher education is on low altitude where there are contours apart each others, and it is on high altitude where there are the contours close each others.

### **5.3. Limitations**

The study was limited in Ruhengeri institute of higher education and the study is concerning topographic map no physical plan was provided.

### **5.4. Recommendations**

#### **5.4.1. For the Ruhengeri institute of higher education**

The recommendations are addressed as follows:

- ❖ To follow all tasks in topographic survey carefully because every activity is very important for everyone
- ❖ Every student should show his contribution in order to understand together the practical related to the theory studied in class.

- ❖ To try to finish the courses and prepare topics on time to let enough time to students for their finish year projects.

#### **5.4.2. For the Land Bureau**

- ❖ To use the Total stations or DGPS for Land Parcels surveying
- ❖ To keep better the coordinates and documents

#### **5.4.3. For the Tourists**

- ❖ To use the Topographic map for showing the area where they don't know.
- ❖ To read better the legend on the Topographic map.

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