

DIFFERENT METHODS OF SURVEYING

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Introduction

Most people have an understanding that surveying is only restricted to field work on construction sites. The truth of the matter is that there are six different types of surveying that a surveyor can choose from in order to undertake a particular job, namely:

Geodetic Surveys

Cadastral Surveys

Engineering Surveys

Aerial Surveys

Mining Surveys

Hydrographic Surveys

In this article we will discuss these different types. To a large degree, the extent of urbanization and relative worth of the land determine the method of surveying most appropriate. The equipment used varies with the need and nature of survey.

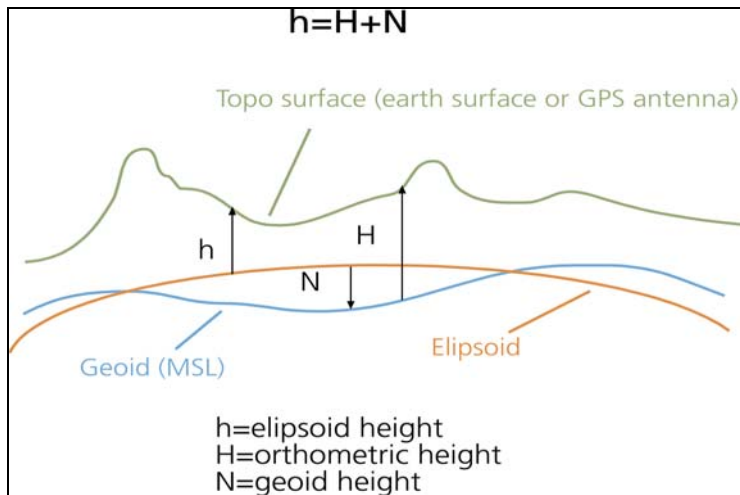
Geodetic Surveys

Geodetic Surveying is basically control surveying on a large scale, this means that it is control survey over long distances where measurements are taken and the earth's curvature and atmospheric pressures deductions are considered and applied. The word geodesy is from a Greek word **geodasia** meaning dividing and the study of the earth's shape and size.

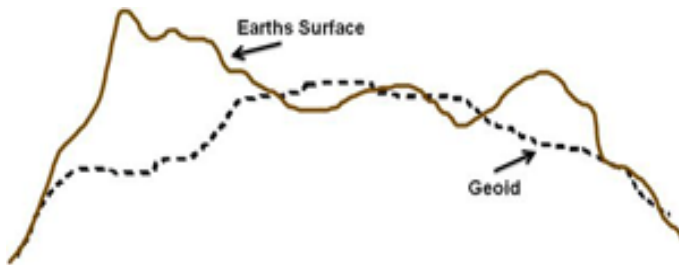
In most cases this type of survey is carried out when establishing control network of large magnitude, i.e. the network of trigonometrical survey beacons of the country. If you can imagine the daunting task of measuring these in South Africa, with all the mountains, valleys and rivers, this is why the curvature of earth calculations are of vast importance in geodetic surveying.

As we all know, the earth's surface is round, however highly irregular and not suitable as a computational surface because of the mountains, valleys, rivers and the surface of the sea, it is because of this reason that the more suitable surfaces were assumed for computational purposes, namely the **Geoid** and an **Ellipsoid**.

Below are the illustrations that show the relationship between the earth's surface, the geoid and an ellipsoid.



The **geoid** is defined as the more smoothed representation of the earth and is described as the surface that would be assumed by the undisturbed surface of the sea, continued underneath the continents by means of small frictionless channels while the **ellipsoid** is a smooth mathematical surface that best fits the shape of the geoid and is the next level of approximation of the actual shape of the earth.



It is of utmost importance to take note of these issues when undertaking geodetic survey as it involves the curvature of the earth and the atmospheric conditions and to produce the 3 dimensional control points of good quality, i.e. horizontal values of Y & X and height at MSL.

Cadastral Surveys

The name Cadastre is a Latin base term which refers to a registry of lands. Cadastral Surveying is surveying of land so as to determine and define land ownership and boundaries.

Most people do not take seriously the issue of surveying their properties before they develop or erect a fence/wall, until they have found-out that they have spent so much money on those developments etc. on someone else's property or land.

Cadastral survey deals with measurements of land, subdivisions and sectional titles. This kind of survey can only be carried-out by a Professional Land Surveyor registered with the South African Council for Professional and Technical Surveyors (**PLATO**) as it is stated on the Land Survey Act (No.8 of 1997).

CADASTRAL SURVEYS IN SOUTH AFRICAN CONTEXT

There are currently nine Surveyor General offices, each of which regulates Cadastral Surveys in the Provinces for which it responsible. These offices are dealing with the safe keeping of survey records, examinations and approval of cadastral surveys, general plans and draft sectional plans for registration purpose.

Nearby all these Surveyors General offices there are Deeds Offices which deal with the registration of properties or land.

Surveyor General's office have a plan safe where they keep all cadastral surveys that have been submitted to them by different Land Surveyors. These records are used for beacon relocations and all other cadastral surveys to ensure that there is no possibility of properties overlapping as to avoid conflicting claims to ownership.

In South Africa, only Professional Land Surveyors registered with the South African Council for Professional and Technical Surveyors (PLATO) are legally entitled to undertake this work.

How Cadastral Surveys are performed

Survey methods

There are no prescribed methods that are used in cadastral survey, each survey is different from the other and it all depends on the area and information that land surveyors have. The only requirement is that all cadastral survey must be adequately and carefully checked. The control must be based on the National Control Network.

All survey instruments can be used for cadastral survey as long as they are accurate. When using the GPS or photogrammetric techniques, a land surveyor needs to follow special requirements that are laid down.

The accuracies to which surveys must be carried-out are prescribed and there are three classes of surveys:

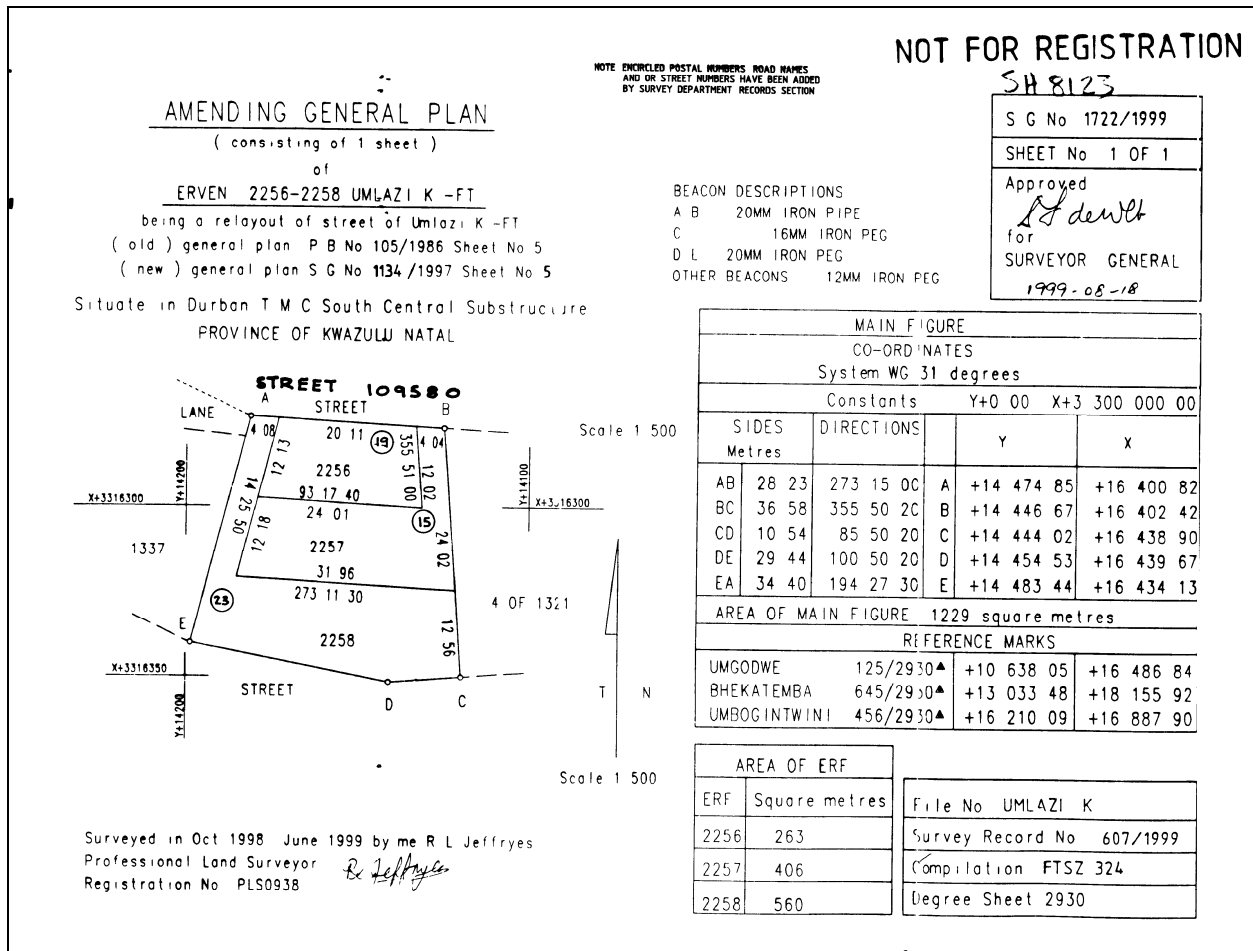
- Class A – surveys for the determination of the position of reference marks in urban surveys
- Class B – surveys in urban and mining titles in respect of precious stones
- Class C – other surveys, including farm surveys and surveys for mining titles in respect of base minerals.

Beacons and Boundaries

A property beacon is a natural or artificial feature which marks the boundary corner of a piece of land/property. A boundary is an imaginary line between the beacons.

The types of beacons that can be used are prescribed by the regulations, but it is usually an iron peg of specified dimension, corner of a permanent building, well constructed corner post or a drilled hole in rock/concrete. All beacons used need to be described on the general plan or diagram.

A typical general plan



Consolidation and Sub divisional surveys

A consolidation is where an owner of adjacent properties/land wants to combine it to form one big property/land. A subdivision is the opposite of a consolidation; here an owner of adjacent properties/land wants to cut his/her property/land into small pieces of parcels.

This kind of survey can only be done by a registered Professional Land Surveyor and the Land Surveyor need to send all the necessary information to the Surveyor General Office for registration and approval.

Engineering Surveys

This type of survey is associated with the engineering design (topographic, layout and as built) often requiring geodetic computations beyond normal civil engineering practice. It is required in planning and execution of nearly every form of construction. The equipment commonly used for this are theodolites, GNSS(GPS) and levelling instruments.

Topographic or Detail Surveys

The purpose of topographic survey is to gather survey data about the natural and manmade features of the land as well as its elevations. Maps are then prepared from this information. The work usually consists of the following:

- Establishing horizontal and vertical control that will serve as reference points for the survey. The most accurate method of establishing the vertical control is by levelling.
- Collecting enough horizontal and elevation of ground points to provide enough data for plotting when the map is prepared. For example, when surveying for upgrading a taxi rank, the features to be located will be: existing sidewalks, curbs, trees, island, etc. And also for a road intersection features like: kerbs, road marking (white/yellow lines), islands will be located.
- the Position and shape of natural and manmade features that may be required for the survey.
- Calculating distances, angles and elevations.



Setting Out

This is done to construct a structure accurately according to a design. The most common procedure is to establish a grid in relation to the design. Then, particular points are correctly staked out physically on site either on exact position or at a particular offset as agreed amongst parties involved

As Built Surveys

This type of survey is carried out during or immediately after a construction project for record, completion evaluation and payment purposes. An as built survey shows the location or position of features that have been constructed and that are subject to completion evaluation. As built surveys are usually compared to the design information. They show the difference between the constructed or built information and the design.

Areas and Volumes

On an engineering site the measurement of areas is more often only a step in the determination of volumes although occasions do arise when areas are only required for example;

Design and Costing : - For capacity of the wall, volume of material within given limits, or volume required to fill an empty space. All of these are determined by doing a survey and certain calculations.

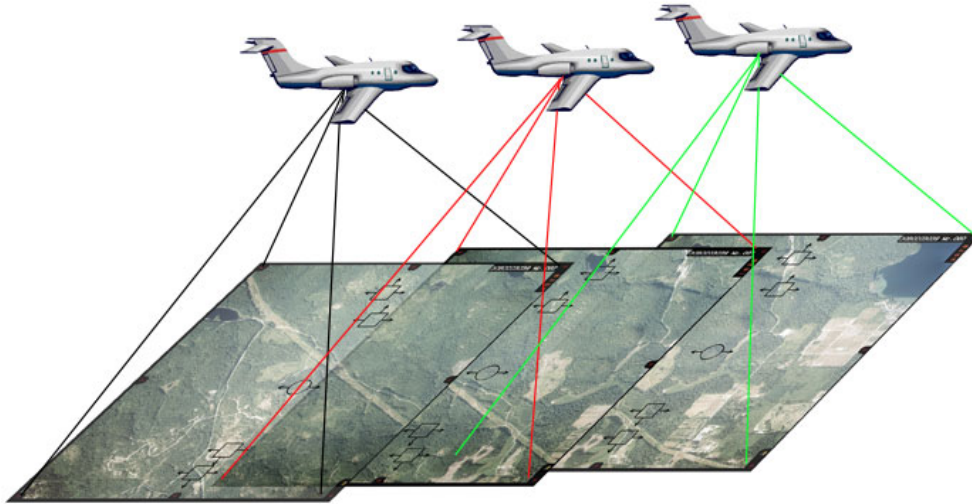


The Survey Department has undertaken some of the as built, setting out and field checks on numerous sites in the Ethekewini Municipality the largest being the construction of the Queen Nandi Drive from phase 1 to the present phase of construction. We continue to carry out detail surveys for various projects for all departments in the municipality.

Aerial Surveys

Aerial survey is a method of collecting information conducted from an airborne platform. This is collected by using aerial photography, LiDAR or laser scanning. It is often recognized similarly as aerophotogrammetry, part of photogrammetry where the camera is mounted on an aircraft. Aerial survey is different to satellite imagery because of its better resolution, quality and atmospheric conditions.

Photogrammetry is the practice of determining the geometric properties of objects from photographic images. This involves estimating the three dimensional coordinates of points on an object. These are determined by measurements made in two or more photographic images taken from different positions. Common points are identified on each image. A line of sight (or ray) can be constructed from the camera location to the point on the object. It is the intersection of these rays (triangulation) that determines the three-dimensional location of the point.

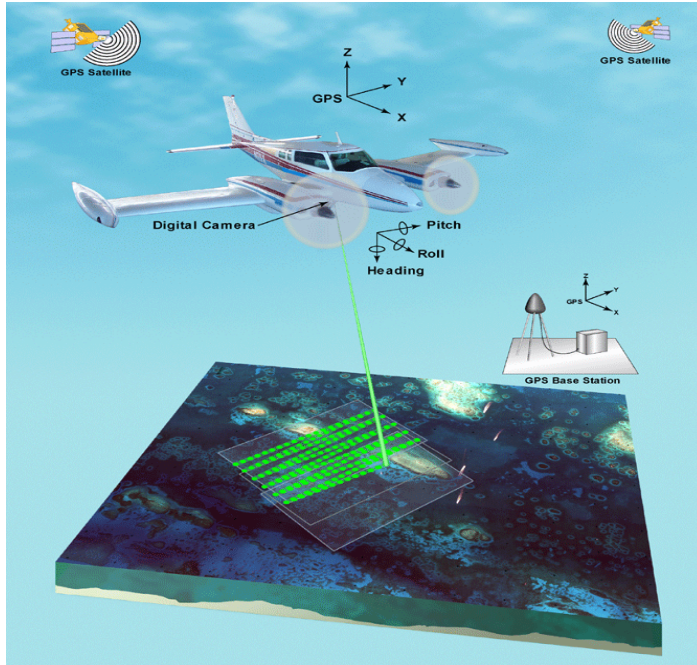


In the simplest example, the distance between two points that lie on a plane parallel to the photographic image plane can be determined by measuring their distance on the image, if the scale of the image is known. The images are obtained by mounting a camera on an aircraft which points vertically down towards the ground. Multiple overlapping photos of the ground are taken as the aircraft flies along a flight path. These photos are processed in a stereo-plotter (an instrument that lets an operator see two photos at once in stereo view). Generally the higher you fly the less points you have per square meter and your pixel resolution worsens.

Photogrammetry is more accurate in the x and y direction while range data is generally more accurate in the z direction. The range data can be supplied by techniques like LiDAR and laser scanners.

Airborne LiDAR is a highly cost effective means of collecting detailed topographic survey information, and offers significant advantages over traditional forms of topographical survey in terms of speed, access, resolution, accuracy and canopy penetration, for a variety of applications.

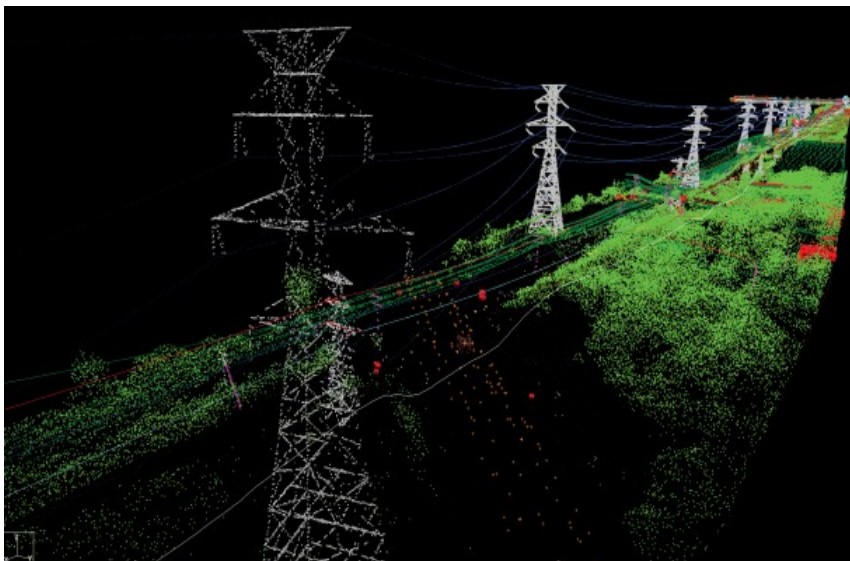
LiDAR – Light Detection and Ranging is a method of detecting distant objects and determining their position or other characteristics by analysis of pulsed laser light reflecting from their surfaces. Basically a laser pulse is reflected from a rotating mirror inside a laser scanner. By measuring the time delay between when the laser pulse is emitted, and when it returns to the scanner, the distance between the scanner and the object can be precisely determined. The scanner can also accurately measure angles. When all of the distance, angular and positional information is processed the scanner can produce highly accurate 3 dimensional data set, which is sometimes referred to a point cloud. Photos can clearly define the edges of buildings when the point cloud footprint cannot. Therefore often the orthorectified images are draped on top of the LiDAR grid thus creating a 3 dimensional visual survey.



Aerial surveys are used for:

- Archaeology
- Agriculture
- Land surveys
- Mining
- Reconnaissance
- Fishery surveys
- Monitoring vegetation and ground cover
- Large scale planning for land development

A 3D visualization can be created by geo-referencing the aerial photos and LiDAR data in the same reference frame. The laser scanners are either mounted onto airplanes or helicopters, the latter being more popular as they are more maneuverable and can be flown at lower altitudes. Typical progress rates for linear infrastructure routes, such as electricity transmission lines or highways, are 80 – 100 km per day.



This image shows a typical scan of a pylon survey (note the cables between pylons are scanned as well)

The cost of aerial surveying has reduced dramatically over the past decade and will continue to do so.

Mining Surveys

Mining survey is a specialist area of surveying involving the measurement, representation and management of data associated with mining operations which could be the underground and open-cut mine workings. These measurements enable new mine works to avoid older and possibly flooded ones, allow connections to be made between different underground passages and also to establish the boundaries of mining claims and territories.



Mine surveyors are responsible for preparing and updating the entire surface and underground plans of a mine to account for new buildings and other structures and to keep records of mining operations. They plan the direction and extent of all underground workings and used advanced surveying techniques and instruments to give these directions underground.

Mine surveyor's work underground most mornings of the week giving direction lines for the miners to follow or taking samples of the reef and during the afternoons they do calculations in their offices.



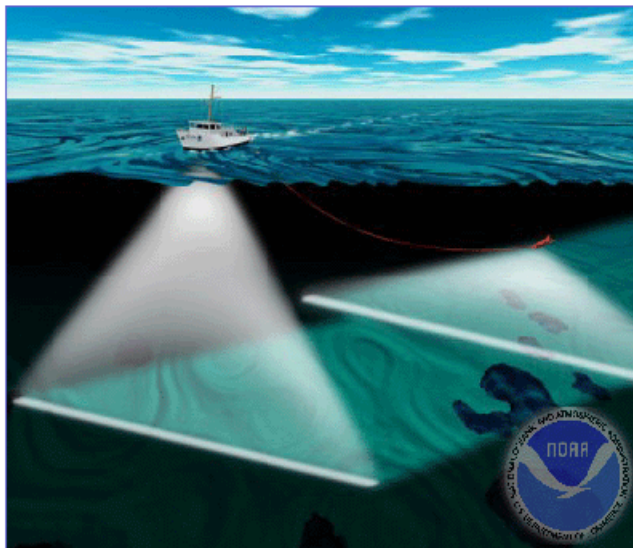
The methods and the instruments used for open cast and underground mine surveying are similar to those used for normal surveys the difference is only where the working points are fixed on the underground mine, which is on the ceiling of the rocks in the tunnels.

Hydrographic Surveys

Hydrographic survey is the science of measurement and description of the physical features of the navigable portion of the earth's surface (seas) and adjoining coastal areas, with special reference to their use for the purpose of navigation. Hydrographic surveys support a variety of activities: nautical charting, port and harbour maintenance (dredging), coastal engineering (beach erosion and replenishment studies), coastal zone management and offshore resource development.

In suitable shallow water areas LIDAR (Light Detection and Ranging) may be used which is an optical remote sensing technology that can measure the distance to and other properties of a target by illuminating the target with light often using pulses from a laser. This equipment can be installed on inflatable craft, small craft, AUVs (Autonomous Underwater Vehicles), UUVs (Unmanned Underwater Vehicles) or large ships and can include side scan, single beam and multi beam equipment.

The data that is collected during the hydrographic survey is massive and it has to undergo post-processing, thinned out and corrected for errors. These errors that need to be corrected are the errors due to bad sounding, the effects of tides, waves, water levels and temperature differences. Usually when undertaking this survey, the surveyor would have additional data collection equipment to record the data for correcting the soundings. The final product is usually charts which are created by a combination of specialty charting software or CAD packages usually AutoCAD.



Ship scanning the ocean floor



Sonar image of a wreck on the ocean floor

Conclusion

The **Survey and Land Information Department** in the Ethekewini Municipality utilizes all these survey methods with the exception of aerial, mining and hydrology surveying. These if required are outsourced to companies that specialize and have the equipment (airplanes, boats etc.) to undertake such surveys. However we do assist in establishing ground control points and air marks for the Photogrammetry Department and our department has also only recently begun using laser scanning however this is on a limited and small scale (embankments and small structures).

After having discussed the different types of surveying available and their applications one can decide which method is the most suitable to meet our client's needs. We hope that this article has enlightened and cleared up the minds of those that were not aware that there are other methods of surveying and their applications.