Geomatics Equipment and Methods Used in Lodged Cadastral Records

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Abstract

Almost anything that happens these days revolves around technology, which has made the life of Geomatics professional much simpler and easier and surveys quicker. For years spoiled of choice, Geomatics professionals today have equipment to select from when conducting a survey, most of which can perform the same functions at different speeds, different accuracy and different environments. However, the statutes under which Geomatics professionals, encompassing formerly learned professionals in Cadastral, Engineering, Mining, Mapping, Spatial Analysis etc, has remained unchanged with the survey records being submitted to the Surveyor-Generals in paper formats, even when the spatial data was collected digitally. This demonstrates a profession unconscious of trends, technological changes or too long a train for the hind carriages to feel the turn taken by the fore carriages in time before the next turn is reached. This paper evaluates the range of instruments used by Geomatics professionals (Professional land Surveyors) and their assistants in conducting cadastral surveys lodged with the Surveyor-General in the East London Office in the month of March 2013.The results show that two instruments were used; Total Stations and Global Navigation Satellite Systems (GNSS) with the latter being more commonly utilised.

1. Introduction

The learned occupation of Geomatics is now being reshaped under the Geomatics Professions Act 19 of 2013(Govt_of_SA). Under the Act, the South African Geomatics Council is established to coordinate human, institutional and technological transformation of the Geomatics Professions (including Land Surveying, Cadastral Surveying, Engineering Surveying, Cartography/ Digital Mapping and Photogrammetry/ Remote Sensing and Geographic Information Science and Technology (GISc&T)) in South Africa (Govt_of_SA 2013). Arguably, a traditionally divided profession in which Cadastral Surveying was coined when emphasising property boundary applications, Engineering Surveying when application environments involves construction such as buildings, working with civil engineers, power lines, water utilities and topographical mapping, Mine Surveying being all measuring activities associated with mineral prospecting, rights definition and extraction, Cartography and Digital Mapping when centred on spatial graphic representation and visualisation, Geoinformatics as perceived in the modern day multi-dimensional and multi-disciplinary views. However, this profession has origins dating back to the Biblical times, initially centred on cadastral and taxation purposes. For example, Deuteronomy 19 verse 14 reads “Thou

shall not remove thy neighbour's landmark" (King_James_Version 2011), the landmark being reference to modern day corner beacons use to indicate physical locations of property corners. However, though the profession has survived for these many centuries, it has had to adapt to the changing demands with those highly trained, skilled and competent professionals adapting to changing demands. These changes came in the form of the techniques and methods such as application of algebra, geometry and mathematics, in instruments and tools developed to solve the need for accuracy, precision, currency and reliability of record, and the measurement such as Total Stations, Global Navigation Satellite Systems (GNSS) and Photogrammetric Work Stations and in verification and error handling techniques such as double independent observations and closure of calculations. However for Africa, in the last two centuries, the reliance of the profession of Geomatics on statutory provisions, has made it unnecessary to justify the value, importance and existence of the learned profession of Geomatics, the appropriateness of the techniques applied, instruments selected and methods adopted to solve positioning solutions. This has created a static profession hardly transforming with changes in techniques, technology and times.

This paper presents results of a study to determine the type of instruments and the techniques or methods utilised by Geomatics Professionals in the month of March 2013, based on survey reports submitted as part of survey records to the office of Surveyor-General, East London. This provides documentary evidence of the extent to with practitioners in practice have adopted modern technological developments.

2. Background and Motivation

The Cape, as the first European settlement in Africa, south of the Sahara desert is considered the origin of organised spatial measurements. The first Geomatics professional (then referred to as Land Surveyor) to arrive in the Cape with Mr Jan Van Riebeeck was Peter Potter (Birkett 2003). His techniques were appropriate at the time as land was considered plentiful and uncontested. For example, Peter Potter would have a measurer travel by horse with instructions to stop, indicate the position and turn right to continue riding whenever he heard the sound of a fired gun (Birkett 2003). The assistants would then locate the markers and construct more visible beacon at the position they heard the rifle fired. As with any technique, this had its weakness including the likelihood that the brandy loving Peter would forget to fire the gun which resulted in the assistant not building a beacon at the correct position (Birkett 2003). The spatial diagram lodged in his office would at times have a more consistent North Pointer than accuracy figure of the property.

The poor accuracy, originally tolerated for first surveys conducted in the Cape is no longer possible today. The demand for land is higher with greater population densities and relatively more educated and legal right conscious public. Research to evaluate the relevance of the methods, techniques and instruments applied to the traditional Cadastral Surveying to date is lacking, with some learned professionals reliant on techniques and methods leant them at school or college, as old

as 50 years before. Though the research required is broad and covers instruments, techniques, methods, supervision, processes and data stores, this initial research will only focus of evident of instruments used and the disparity between the appropriateness of instruments to the guiding legal framework and appropriateness of community challenges and demands from the learned profession.

3. Literature review

The Surveyor-General (SG) East London is the prime government authority on surveying and the cadastre in the Eastern Cape Province. The primary role of this office is the represent the public and state in all issues involving land rights, ownership and spatial definition, sometimes referred to as Cadastre, in their jurisdiction. Amongst other things, the Surveyor-General oversees all Cadastral Surveys, includes the details of land property boundaries and tenure within the province.

Learned Geomatics is an age old, critical profession for organised settlements that depend of defining the property boundaries of land for public and private registration, ownership and management (Jen 2012). The significance of the techniques and methods employed in Geomatics is to minimise or eliminate errors in observations, computation and visualisation for measurements which commonly always vary in value (consistence). Traditional Cadastral Geomatics was performed and calculated manually, which resulted in systematic and random errors. However, as understanding of techniques and methods and development of better improved instruments occurred, coupled with increased knowledge, accurate instruments, techniques and methods became standard for cadastral representations came (Jen 2012). Even though the basics of land surveying remained unchanged, some equipments, techniques and methods have evolved significantly since the beginning of the history of land surveying.

There are two kinds of survey equipments used mainly in cadastral works nowadays: the total station and the Global Navigation Satellite Systems (GNSS). The total station integrated the advantaged of an electronic Theodolite with the traditional Electronic Distance Measurer (EDM) in a computer based processor. Technology vary from those instruments emitting the laser beams to a target and detecting light reflected on it to those in the visible and infra-red part of the electromagnetic spectrum. GNSS, encompassing the US Global Positioning Systems, GLObal NAvigation Satellite System (GLONASS) and modern developments in Chinese Beidou, European Unions' Galileo and other, depends on accurately monitored orbiting satellites to measure and obtain distances by calculating range from at least four satellites. The GNSS technique is seeing more research and investment in the development, however, does this translate to the replacement of the *de facto* African standard based on the Total Station?

The assumption as envisaged from a learned profession such as Geomatics is that the use of a particular survey instruments is according to appropriateness of application, as calculated from advantages and disadvantages. Equipment used in surveys has advantages and disadvantages. For

instance, satellite based measurement equipment, in particular GNSS, does not require inter-visibility of trigonometric control stations while Total Stations require inter-visibility of stations from occupied point(s). GNSS is less labour intensive with some projects conducted without the help of assistants. Further, GNSS equipment offers automated acquisition, storage and processing usually in the same "black box", making faultless, accurate and speedy land surveying possible (Jen, 2012). However, Total Stations are more appropriate when conducting undercover surveys such as tunnels, mine shafts and under canopy.

4. Results

A total of 24 records were selected from records submitted to the Surveyor-General's office, East London in the month of March 2013. Of these, 18 clearly identified the choice of instrument as being GNSS abet stated as the American GPS. This implies that the GNSS surveys were recorded as Global Positioning System (GPS) portraying a traditional satellite based system utilising only the American satellite constellation for its measurements only. There is no evidence of the Russian GLObal NAVigation Satellite System (GLONASS) signal being integrated in the measurements.

GNSS based surveys utilised Real Time Kinematic (RTK) with the base and rover configuration and/or Trignet base link. At least one survey was conducted with connection to higher order trigonometric control was largely through one, two or more official beacons. All surveys using GNSS did not have any long and detailed incident reports as the surveys were reported as *simple and straight forward*. This indicates to the maturing of GNSS technologies, particularly American GPS, for point positioning and its ability to attain required accuracies reliably and consistently.

From a needs and research perspectives, a further review of cadastral survey constraints such as accuracies and precisions demands and recommended techniques and methods need to be explored for the next century solutions.

5. Recommendations

In view of the added advantages GNSS provides to Geomatics positioning, this research tends to support the notion that GNSS is the de facto instrumentation for open air surveys in South Africa. GNSS being based on range measurements to accurately located orbiting satellite, the primary measure is distance, a technique traditionally referred to as trilateration. However, the rules and regulations seem to have remained crafted around angle based measurement techniques employed in Total Stations, as the most accurately measurable. This, as evident in the requirements recommended and adopted by Council.

The paper recommends that further, and additional broader research be conducted to explored to what extend rules and regulations as stipulated by Council have become outdated, propose updated rules and regulations in line the technological developments, de facto and modern research

directions and review plan to ensure continued appropriateness of laws, rules and regulations and direction of training, development and modernisation.

GNSS as the obvious choice instrument in cadastral surveying, a maintenance and verification plan is required to ensure the continued correct functioning of the instruments. These may include mandatory verification with TrigNET stations, mandatory maintenance and service plans and Continuous Professional Development (CPD) courses that emphasise appropriate terminology. This, as although survey reports indicated GPS as the instrument used, some of the receiver were actually utilising both GPS and GLONASS signals, thus were GNSS receivers.

Although the paper recommends re-drafting of the survey rules and regulations in favour of GNSS instrumentation, there is need to retain vital Total Station guidelines. However, demands and reference to higher order/ accurate angular measurement techniques such as triangulation, resection, and intersection should be shifted from prime focus and maintained as historical techniques. Because GNSS may not be available in certain cases, Total Stations will remain an essential but secondary instrumentation appropriate for under canopy, urban areas where GNSS would otherwise have multipath and shaft/ tunnel/ under bridge surveys.

6. Conclusion

Even though GPS seems to have taken over, total stations are still widely used because GPS do not work well in other areas and that's where total stations come in handy. Surveying works hand-in-hand with technology because a new development of equipment somehow affects the other equipments already in the market. Technology is the cause of surveyors having a range of equipment to choose from when conducting a survey.

7. Bibliography

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