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Determination Of National Transformation Parameters Using Wgs84 Coordinates Obtained From Direct Observations At Trigonometrical Beacons

NEWSLETTER Vol 1 of 2015

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FIG International Federation of Surveyors
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Editorial Comment

One of the objectives of the outgoing council was to increase visibility of the surveying profession to the public and communication between the surveying professionals. Increase in visibility will enable the profession to be known to the greater generally of the public.

As a profession we need to exchange ideas and give each other advice. Having articles in our newsletter will do a lot to increase communication between us. The article by Mr. K. Mukombe is calling us to become business minded people who are able to swim with the current in the business world. The article on Land Delivery by our former SIZ President Mr. Michael Kagweya gives a detailed way to be followed when carrying out land development. This article entails a wholesome approach which involves all the relevant professionals in land delivery system. Mr. C. Tarerwa carried out a project to calculate transformation parameters for Zimbabwe. The transformation parameters will do away with the need for site calibration whenever carrying out GPS surveys. He made some interesting findings which the country should solve so that using GPS becomes faster for surveyors.

Enjoy the reading!

Regards

Admire Nyirenda

Publication Chairman

M.S.I.Z, L.S.(ZIM)

FROM THE PRESIDENT'S DESK

Hello dear colleagues and stakeholders. Finally we have our very first SIZ publication in a very long time. Thanks to the efforts of the publications office whose energy and persuasive language resulted in these articles you are about to enjoy reading.

I call upon all our members to contribute to this noble and highly informative news letter by sharing our experiences, views and opinions. Everyday in the life of a surveyor, the good and the ugly happens. Be it in operational, tactical or strategic spheres. In the offices or during rigorous field trips, some encounters are worth sharing with others no matter how immaterial you may think they are. A lot is happening in our industry. ***Take note of FIG 2015-2018 theme, "***Responding to rapid change, ensuring the Surveyor of Tomorrow".

So colleagues there you are. I personally do not believe you have to gather any courage to sit and write something that your colleagues will laugh with you, empathise with you or critic. That's how life should be. As they say "variety is the spice of life", so be it. Even if you believe or feel that the institution's relevance or credibility is becoming questionable, here is the forum.

Thank you once again to those who contributed to this publication and we hope to receive many articles in time for our December issue of the publication. Our intention is to have a publication every half year increasing them to one every quarter as the writers develop to be prolific.

Say very well blessed.

TT Mapengo

SIZ President -2014/15

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Determination of national transformation parameters using wgs84 coordinates obtained from direct observations at trigonometrical beacons

***By Clifford Tarerwa, T. P. Masarira,* F. O. Chikomo**

ABSTRACT

The land administration systems and Cadastral surveys in Zimbabwe are required to be referenced in the Gauss Lo. Projection based on the Modified Clarke 1880 ellipsoid while the satellite surveying equipment uses the WGS84 global geocentric reference coordinate system. The main objective of the research was to determine transformation parameters between the Modified Clarke 1880 and World Geodetic System of 1984 (WGS84) coordinate systems. The WGS84 coordinates were calculated from collected from raw Global Navigation Satellite System (GNSS) data for suitably located points. A selected set of trigonometrical beacons with coordinates in WGS84 and Modified Clarke 1880 were then used to calculate sets of transformation parameters by the Molodensky – Badekas and Bursa – Wolf seven parameter models. Owing to an insufficient distribution of suitably located points and the distortions and non – homogeneity of the geodetic network of Zimbabwe, the calculated transformation parameters give varying accuracies in different areas around the country. A GNSS campaign should be carried out with to achieve a sufficient representation of the whole country to determine a robust set of transformation parameters.

Introduction

Land is a limited non-renewable resource that plays a vital role in a countries economy as such land management and geospatial data are of fundamental importance for sustainable socio-economic development .

There is a shift from the traditional surveying methods to satellite based surveying technologies which are fast, economic, reliable and efficient. However the satellite based equipment should be calibrated for a site to be surveyed through determination of coordinates in the local (area or site) coordinate system (Modified Clarke 1880) and the coordinate system of the equipment for example World Geodetic System of 1984 (WGS84) for Global Positioning Service (GPS) to calculate transformation parameters. WGS84 coordinates common to local coordinates can be used by appropriate transformation models to calculate transformation parameters .

There are no regulations or guidelines currently that govern the use of Global Navigation satellite Systems (GNSS) in Zimbabwe. The Surveyor currently uses his/her discretion in deciding the quality of coordinates to use in calibrating a given site. This results in a non homogeneous system of surveyed points.

The local geodetic network cannot be used as a basis for global activities therefore there is need for a link to the world is required through the use of a global datum. It is recommended that instead of using a Digital Terrain Model (DTM) or Earth Gravity Model (EGM2008) model calculators to estimate ellipsoidal heights, it is ideal that measurements of ellipsoidal heights be made and to be used for the calibration of a gravity model (Rumeu, 2013). There is therefore the need for measurement of WGS84 coordinates to necessitate calculation of transformation parameters between the local datum and the geocentric global datum.

GNSS has not only had a profound influence on the practice of surveying but it is also having a significant impact on a great many other areas of application . GNSS can now be used to obtain precise timing and positioning information anywhere on earth with high reliability and at a low cost . Thus there is need for Zimbabwe to adapt to the new technology through determination of national transformation parameters.

The project aims to determine transformation that can be used to migrate between the local Gaus Lo. System based on the Modified Clarke 1880 system and the WGS84 coordinate system. The available raw GNSS data is to be used to calculate the parameters and a campaign is to be designed to make observations that well represent the whole country.

Motivation

The surveying sector in Zimbabwe is changing from the use of traditional surveying instruments to the use of GNSS instruments, the country does not have a unified set of national transformation parameters between the WGS84 and Modified Clarke 1880 ellipsoid and an official list of WGS84 coordinates of trigonometrical beacons. There is repetition of the site calibration of the same areas by different Land Surveyors.

Scope of the project

The research aims at determining national datum transformation parameters for the republic of Zimbabwe. Zimbabwe occupies approximately 390 757 km^2 of land in south central Africa between the Limpopo and the Zambezi rivers. It has an economy largely dependent on agricultural products including tobacco, cotton and sugar cane..

GNSS

Satellite based navigation systems have been developed by countries such as America, Russia, Japan, China and also the European countries' collective effort. They are collectively called Global Navigation Satellite Systems (GNSS) and include the American Global Positioning System (GPS), the Russian

Continued on Page 3

Global'naya Navigatsionnaya Sputnikowaya Sistema (Glonass), the Japanese Quasi Zenith Satellite System (QZSS), the Chinese Beidou and the European Galileo systems. Collective use of these systems would guarantee integrity, accuracy, continuity of service, interoperability and availability. GPS and Glonass are the main systems and have a wide range of global applications. (Mattos & Pisoni, 2014).

GNSS surveys

A particular survey procedure is dependent on the survey objectives, the available equipment, the desired accuracy and precision, the geographic environment, the distance between points to be positioned, duration of observations and most importantly the overall cost of the project. The types of GNSS surveys include kinematic, static, fast/rapid static, semi kinematic, differential GNSS and single point positioning. High accuracy surveys require rigorous field methodology and long occupation times .

The static surveys are reliable and accurate but have the disadvantage that they take longer thus more expensive. The kinematic method is fast, cheaper and is limited to areas between 10 km^2 and 20km^2. It's the old trade off; speed and efficiency versus accuracy and confidence, we would want to use static when establishing new control or calibrating a site .

Datum Transformation

A transformation is applied when expressing coordinates of one datum in another datum for instance expressing points measured using GPS equipment (WGS84 datum) in the accepted local datum in Zimbabwe (Cape datum). The accuracy of datum transformations depends on the method chosen as well as the number, distribution and accuracy of the common points used to determine the transformation parameters .

According to studies done across the world, the similarity seven parameter models are the most commonly used transformation models. The conformal similarity seven parameter transformation models include the Helmet, Molodensky-Badekas, Veis and the Bursa-wolf models. The Bursa-Wolf model apply a scale factor to all position vectors while the Molodensky-Badekas apply the scale factor only to coordinate differences . The Bursa-Wolf and the Molodensky-Badekas models yield identical scale factors and rotation parameters and differ in the translation parameters. The Bursa-Wolf method give higher RMS (Root Mean Square) values than the Veis and the Molodensky models .

2.1 GNSS campaign

A campaign is an approach in which a small number of receivers are used to occupy a large number of survey makers on a temporal basis usually over several weeks. Campaigns offer better coverage than continuous networks. A multimodal occupational strategy (MOST) can be used by blending continuous and campaign models . The International Terrestrial Reference Frame (ITRF) is composed of continuously operating reference stations (CORS) operating 24 hours every day spread across the world. The observations made in static mode can adjusted constrained to these CORS thus making a MOST strategy.

The MOST strategy is flexible and logistically robust and incorporates a continuous time series making it possible for different participants or groups of a campaign to contribute at their own convenience. It allows for participation of diverse institutions allowing costs to be shared .

The following table shows parameters to be considered when planning a field campaign.

Table 2.6.1 GNSS survey design parameters

Parameter group	Parameters
Station geometry	• Number of stations to be observed • Configuration of stations • Length of baselines
Satellite geometry	• Mask angle • Best observation window • PDOP and GDOP
Receivers	• Type(s) of receiver(s) to be used • Number of receivers available • Configuration for each session
Time considerations	• Time of the day • Duration of the observations • Sampling rate
Ranging mode	• Code (C/A or P) or carrier or both • L1 or L2 or both
Processing software mode	• Network or by baselines • Orbit and clock products or differential method • Bias modelling • Broadcast or precise ephemerides
Processing Method	• Constrained or unconstrained adjustment • Precise or single point positioning
Auxiliary or logistical issues	• Number of personnel • Transportation method • Leased or owned equipment • Project budget

Sourced from, Guide to GPS positioning .

Methodology

The transformation of involves a series of methods, tools and complicated software. The methods, tools and procedure followed in the calculation of transformations parameters is all explained in this chapter.

GNSS raw static observation data was collected from the Department of the Surveyor General and from private Surveyors. The data was collected in receiver native formats e.g. T02 for a Trimble receiver and in Receiver Independent Exchange (RINEX) format. The data collected in the native receiver formats was converted to RINEX format.

The collected static observation data was analyzed for suitability and to extract information required for postprocessing. The suitable observation data was that which had a minimum duration (the time spent logging observations at a given point) of 1hour. Information required for postprocessing was the duration, date of survey, antenna type and antenna height.

The acquired data was processed using online commercial post processing services, specifically the Australian AUSPOS, Trimble Center Point RTX technology and Canadian Spatial Reference System – Precise Point Positioning (CSRS – PPP). The coordinates were referenced to the ITRF08 frame and the WGS84 reference ellipsoid.

The data from the 1994 GPS campaign and the Civil Aviation Authority of Zimbabwe (CAAZ) GPS campaign of 1998 referenced to the ITRF94.0 epoch was transformed to the ITRF08 epoch using parameters obtained from the ITRF website.

The spatial distribution of the acquired and processed data was checked by mapping the points using ArcMap. The raw data was mapped using approximate coordinates extracted on the analysis stage. After processing the processed data was mapped using the actual coordinates of the points.

Calculation of transformation parameters

The calculation of transformation parameters was done using Leica Geo Office Combined ver. 7.01 software. First the seven parameters are calculated by the Molodensky Badekas model, and then by the Bursa – Wolf transformation model. The points with large Root Mean Square Errors (RMSE) that is above 1.5 were eliminated and different combinations of points were tested to determine the best combination of trigonometrical beacons.

Validation

The validation of calculated parameters was done using the common points that were not used in the calculation of transformation parameters. The calculated transformation parameters were compared with the transformation parameters calculated by Rumeu (2013) using the coordinates from the 1994 and 1998 campaign coordinates. The WGS84 coordinates of the common points were transformed using the calculated sets of the transformation parameters and those by Rumeu (2013). The coordinates were then transformed to the Universal Transverse Mercator (UTM) projection for comparison in metric units.

Receivers

Geodetic quality receivers shall be required for the campaign. The number of receivers to be used shall be determined by availability but a minimum of three receivers for each session shall be recommended. One station to be used in calculation of transformation parameters will remain fixed as the base and the surrounding stations can be observed for shorter durations.

Time Considerations

A minimum duration of 6 hours shall be recommended for the base station and a minimum of 30 minutes for the surrounding stations. The observations shall be made at a sampling rate of 15 seconds. Using precise ephemerides not more than a week old, the best observation time of the day on a selected date and for particular stations shall be predicted using mission planning software.

Ranging Mode

The observations shall be carried out using the carrier phase observable. The receiver shall be configured to track both L1 and L2 frequencies in the case of GPS and Glonass.

Satellite Geometry

The observations shall be made with a 15 degree mask angle setting to minimize errors due to low elevation satellite and also maximize the number of observations logged by the receiver. The PDOP and GDOP shall not be more than 5 for the selected window.

Processing Software

The observations shall be processed using commercial software such as Bernese. This will be done using online post processing services e.g. AUSPOS. Proprietary softwares provided by equipment manufacturers shall also be used to process the observations.

Processing Method

The observations shall be adjusted by unconstrained adjustment method for each session and then by constrained adjustment method using precise ephemeris of IGS CORS stations. This can be achieved using proprietary softwares. The observations should also be uploaded to online commercial software processing services for processing by the constrained adjustment method or precise point positioning.

Logistical Planning

Based on the reecent report of each station, the corresponding budget shall be adjusted depending on the location, accessibility and the number of personnel involved. At the end of every session a backup of the observation data shall be made by the project coordinator.

Distribution of Points

The accuracy of the transformation parameters is dependent upon the distribution of points used in the transformation. Therefore at least one trigonometrical beacon should be occupied in each degree square to define a well distributed set of trigonometrical beacons. To improve the accuracy of the parameters in the development areas such as farms, towns and cities, the trigonometrical beacons should be preferably in the development area within a particular degree square.

The distribution in the campaign is to be as shown in fig 3.5.8.

Materials

Fig 3.5.8 The ideal distribution for the campaign.

The different tools used in the research for acquisition, analysis, processing, transformation and comparison of the data used in the research are listed subsections to follow.

Software

The softwares used are Translate Edit Quality and Control (TEQC), Leica Geo Office combined 7.01, ArcMap 9.3, Trimble Geomatics Office 1.63 and SURPAC98.

Online post processing services

Canadian Spatial Reference System

Table 4.1 The sample raw data collection sheet.

Point name	Antenna type	Antenna height	Duration	Date	lat	
1. 21/P	AT503	0.229	0h 45' 10"	12/06/13	-17.73384	31.44148
2. 165/S	AT502	0.590	0h 45' 00"	12/06/13	-17.61080	31.42138
3. 223/S	AT502	0.587	0h 32' 50"	12/06/13	-17.74135	31.57209
4. 617/S	AT502	0.232	0h 57' 00"	15/04/13	-17.34994	30.86525
5. 346/T	AT502	0.230	0h 37' 30"	15/04/13	-17.39593	30.93389

Online post processing services

Canadian Spatial Reference System (CSRS – PPP)

Geospatial Australia: Geodesy (AUSPOS)

Trimble Centerpoint RTX technology (RTX)

Results and Analysis

The results of all the processes in the research from the acquisition to the final transformation parameters are presented in this chapter.

The collected raw observation data was recorded on a raw data collection sheet showing the point name, antenna type, duration, antenna height, date of observation and estimated latitude and longitude of the point. The raw data collection sheet sample is shown in table 4.1.

Processed Coordinates

Post processing was done using three online post processing services which are RTX, AUSPOS and CSRS – PPP. The positional accuracy for the processed WGS84 coordinates was at 95% confidence interval. The processing services reference the calculated coordinates to the ITRF08 frame.

The 1998 campaign coordinates obtained from the Surveyor General's Geodesy department were used in the research to supplement the distribution of the common points. The coordinates were referenced on the ITRF94 reference frame, epoch 1997.00. The coordinates were transformed from the ITRF94 frame to the ITRF08 frame using the parameters obtained from the ITRF website.

The Root Mean Square Errors (RMSE) of the points used in the transformation was below 1.5 units for the first set of parameters. Also in every cluster of points, a single point with the best RMSE was selected for the datum transformation. An extra five points with values greater than 1.5 of RMSE were added to the selected points to define a better distribution for the whole country in calculating a second set of parameters.

The National Datum Transformation Parameters

The national transformation parameters according to Rumeu (2013) determined using coordinates from the 1994 and 1998 GPS campaigns using the Molodensky – Badekas and Bursa – Wolf models are given in the tables 4.3.1 and 4.3.2.

Table 4.3.1 Bursa – Wolf 7 parameters

Table 4.3.1 Bursa – Wolf 7 parameters

Translation in X	140.1086	m
Translation in Y	117.1888	m
Translation in Z	351.3009	m
Rotation in X	-3.98174	"
Rotation in Y	-4.45475	"
Rotation in Z	2.60527	"
Scale	2.0026	ppm

Table 4.3.2 Molodensky Badekas 7-Parameters

Translation in X	144.2392	m
Translation in Y	96.7180	m
Translation in Z	292.1988	m
Rotation in X	-3.98174	"
Rotation in Y	-4.45475	"
Rotation in Z	2.60527	"
Scale	2.0026	ppm

Source

The calculated transformation parameters for the selected first set of points and the second set of points are shown in tables 4.3.1-2. The first set represent points that were used to calculate transformation parameters which had RMSE (position + height) below 1.5m and the second set after addition of five points which had RMSE (position + height) above 1.5m shown in tables 4.3.3 and 4.3.4.

Table 4.3.1 Molodensky – Badekas transformation parameters of set 1

Translation in X	147.325	m
Translation in Y	96.831	m
Translation in Z	294.707	m
Rotation X	-5.63043	"
Rotation Y	0.43106	"
Rotation in Z	3.393	"
Scale	5.6646	ppm

Table 4.3.2 Bursa – Wolf transformation parameters of set 1

Translation in X	65.208	m
Translation in Y	106.157	m
Translation in Z	210.251	m
Rotation in X	-5.6536	"
Rotation in Y	0.39881	"
Rotation in Z	3.27801	"
Scale	5.513	ppm

Table 4.3.3 Molodensky – Badekas transformation parameters of set 2

Translation in X	146.943	m
Translation in Y	97.004	m
Translation in Z	294.323	m
Rotation in X	-5.11811	"
Rotation in Y	0.3155	"
Rotation in Z	4.77735	"
Scale	3.3423	ppm

Table 4.3.4 Bursa – Wolf transformation parameters of set 2

Translation in X	56.212	m
Translation in Y	147.087	m
Translation in Z	221.031	m
Rotation in X	-5.1191	"
Rotation in Y	0.17458	"
Rotation in Z	4.51381	"
Scale	4.0661	ppm

Validation

The validation of the calculated parameters was done using the coordinates that were not used in the calculation of the transformation parameters. The WGS84 coordinates of the points were transformed to Modified Clarke 1880 coordinates for comparison with those obtained from the Surveyor General's department. In order to determine the distance separations of the common points, the coordinates were projected using the Universal Transverse Mercator projection.

A comparison was done with the national transformation parameters determined by Rumeu, (2013) and the differences are shown in tables 4.4.1 – 4.4.3 below for 11 randomly selected points. The coordinates were compared for the different axis separately. Note that all values are expressed in meters. The column headings for tables 4.4.1, 4.4.2 and 4.4.3 are abbreviated as follows:

BDK1 – Molodensky Badekas transformation parameter set 1
BDK2 – Molodensky Badekas transformation parameter set 1
BWF1 – Bursa Wolf transformation parameter set 1
BWF2 – Bursa Wolf transformation parameter set 2
BDKD – Molodensky Badekas transformation parameter set by Rumeu (2013)
BWFD – Bursa Wolf transformation parameter set by Rumeu (2013)

Translation in Z	294.323	m
Rotation in X	-5.11811	"
Rotation in Y	0.3155	"
Rotation in Z	4.77735	"
Scale	3.3423	ppm

Table 4.3.4 Bursa – Wolf transformation parameters of set 2

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BWF1 – Bursa Wolf transformation parameter set 1
BWF2 – Bursa Wolf transformation parameter set 2
BDKD – Molodensky Badekas transformation parameter set by Rumeu (2013)
BWFD – Bursa Wolf transformation parameter set by Rumeu (2013)

Table 4.4.2 Y – Coordinate differences expressed in meters

Point	BDK1	BDK2	BWF1	BWF2	BDKD	BWFD
17/T	0.37978	0.72340	0.40120	0.59660	0.11700	0.11690
91/P	1.38298	1.11370	1.38980	1.21060	0.97760	0.97750
170/S	0.19359	0.42210	0.20700	0.33099	-0.12810	-0.12820
259/S	-0.02689	0.17170	-0.01600	0.09140	-0.23360	-0.23380
346/P	-2.30332	-2.17570	-2.31280	-2.23090	-1.77380	-1.77390
469/S	-2.05627	-1.52010	-2.02310	-1.70099	-1.33520	-1.33530
531/T	-13.09909	-12.74980	-13.07710	-12.87840	-13.36020	-13.36030
558/T	-0.16024	-0.24100	-0.16760	-0.23770	-0.95660	-0.95670
651/T	1.18864	0.89569	1.14340	0.98340	0.81000	0.80990
835/S	0.94930	1.48170	0.98280	1.29870	0.86450	0.86440
TSM11044	-0.05047	0.16160	-0.03790	0.07510	-0.43420	-0.43420

Table 4.4.3 Height (H) Coordinate differences in meters

Point	BDK1	BDK2	BWF1	BWF2	BDKD	BWFD
17/T	1.80270	1.40400	1.80490	1.25700	-0.70220	-0.70180
91/P	-9.25010	-6.59800	-9.41650	-6.99000	-4.44830	-4.44800
170/S	-0.57700	-0.62280	-0.59270	-0.78800	-1.97920	-1.97890
259/S	0.47540	0.82630	0.43090	0.60340	-0.71910	-0.71880
346/P	0.75540	3.83090	0.50710	3.16080	-0.25210	-0.25170
469/S	3.18270	3.93880	3.07440	3.50530	-1.98310	-1.98280
531/T	1.94470	1.53140	1.94750	1.38500	-0.61400	-0.61360
558/T	-2.23370	-2.00490	-2.24260	-2.09830	-0.37020	-0.36990
651/T	-3.35520	-0.56290	-3.53500	-0.99030	1.10810	1.10840
835/S	6.65500	5.84820	6.67400	5.70360	2.37130	2.37160
TSM11044	-0.87280	-0.97570	-0.88250	-1.12460	-2.08270	-2.08270

The trigonometrical beacons; 25/T, 331/T and 674/T showed residuals above 100m and therefore need investigation. The other clusters of points in different areas exhibited deviations peculiar to a given area for example trigonometrical beacons 639/S, 644/S, 672/T and 673/T had large deviations in the y – axis and

Fig 4.5.1 The first set of points used in the calculation of transformation parameters

in height, also the cluster with 651/T, 652/T, 653/T, 266/, 91/P, 117/P and BPT56 showed a unique behavior with large deviations in the x – axis and height and 358/P and 346/P showed large deviations in x and y axes.

Distribution of points used for the transformation

The distribution of points shown in figures 4.5.1 and 4.5.2 shows that the points used for the calculation of the national transformation parameters are not a well defined set of trigonometrical beacons for the determination of national transformation parameters. This resulted in the resulting coordinates transformed from calculated national transformation parameters giving residuals greater than

Conclusion

The determination of national transformation parameters required a well defined distribution of accurately calculated coordinates of common points in two systems.

The available suitable data does not well represent the whole country and had to be complimented with the 1998 campaign coordinates. The challenge faced was that the majority of Land Surveyors in Zimbabwe do not use the static surveying technique.

The WGS84 coordinates were referenced onto the ITRF08 frame at the epoch the observation was made was done using commercial post processing services. The WGS84 coordinates only covered 13 out of 35 degree squares covering the whole country which show that the coverage is insufficient for the determination of national parameters. The national datum transformation parameters were then calculated using 44 processed WGS84 and local Modified Clarke 1880 common coordinates. A validation of the transformation parameters was performed using 30 common points not used in the transformation. A comparison of the calculated transformation parameters and those

Fig 4.5.2 The second set of points in the calculation of transformation parameters.

calculated by Rumeu (2013) showed that the residuals of the different sets apply variably in different areas around the country. This could be attributed to by the inhomogeneity of the geodetic network of Zimbabwe, inconsistent durations of the observations, and the different distributions of the common points used in the calculation of the transformation parameters. The calculated parameters can deliver transformation results accurate to

A GNSS campaign is therefore recommended due to the inconsistent accuracies of the calculated transformation parameters to achieve a complete coverage of Zimbabwe. A total of 22 trigonometrical beacons, one in each degree square not covered by the coordinates used in the calculation of transformation parameters should be occupied. The trigonometrical beacons should be the nearest to the center of the degree square or within a growth point, town, city or any other development area within that degree square.

Recommendations

Although the calculation of an accurate and uniform set of national transformation parameters was not successful the following recommendations should be considered. There is the need to solve the height issue in the determination of national transformation parameters by determining and calibrating a gravity model to get geoid model for Zimbabwe.

There is need for the readjustment of the geodetic network of Zimbabwe to reduce the distortions and swing and scale errors.

There is need to run a national GNSS campaign to determine accurate national parameters which can be applied anywhere in the country delivering the best accuracies.

There is need for guidelines or regulations for the use of GNSS technology in Zimbabwe. There is need for the emancipation of the Land Surveyors in Zimbabwe on the acquisition and use of GNSS technology. There must be a zero order network of trigonometrical beacons from which WGS84 coordinates of other trigonometrical beacons and Town survey marks will be based.

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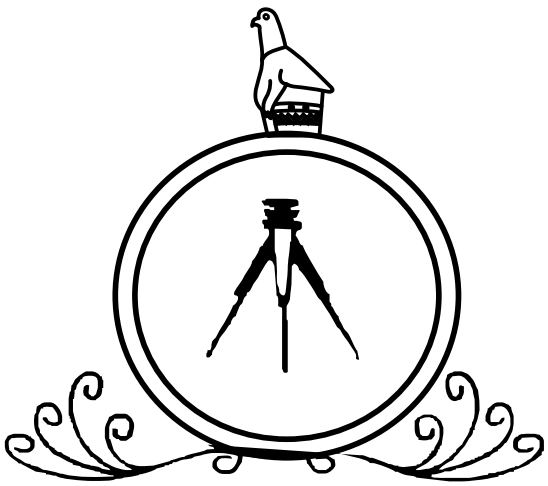

BEYOND THE TRIPOD – A BUSINESS PERSPERCTIVE BY K.MUKOMBE

I have to be unapologetically blunt here! Throughout my sojourn in this region of Africa, I have come to realise that most surveyors have one thing in common: we are financially illiterate. It is pitiful and very sad that you often meet a very good and accomplished surveyor who, not only does not know about business and financial matters, but also does not care about what happens in the world of business and finance. We seem not to mind. It belongs to other people, we feel! I strongly feel that an entrepreneurial behaviour is just a must in the world today. In the world today, it is compulsory to know what happens in the business world. It is very unfortunate that our school system does not teach us about business. We live business, we work business and our lives revolve around business. This failure to understand the world of business puts our lives and operations at great danger. We often become vulnerable and sometimes fail to swim in the often challenging tides of the business waters. Simply put, we just need to be business minded. I know most of us will challenge me and say, 'I am already business minded as I am running a practice'. Yes, that is what we all think but being business minded does not entail opening an office by Julius Nyerere Street. If so, then all those vendors in the pavements are business minded. Surely it goes beyond that.

There are so many symptoms of how illiterate we are in business! Some of them are; failure to separate ourselves from the business, no distinction between the personal finances and business finances, failure to adhere to the basic principles governing human resource practice, an unqualified cousin or brother in law wields more powers than qualified people in the set up, some of us hardly generate an honest payroll for the office staff, no payslips and let alone formal contracts of employment, the dress code is shambolic, communication is ridiculous and the front office itself resembles a laboratory. Even the way we execute projects sometimes leaves a lot of things to be desired. We even do not make arrangements with suppliers for accounts, discounts and related promotions that ease our cash-flows. We often fail to even negotiate for a satisfactory contract on contract jobs; we simply sign those defective contracts which are heavily skewed against us.

This reminds me of one huge project that I had an opportunity to work on in the region. We were part of a multi-disciplinary project team. We had a running contract on the project and used to process a monthly payment certificate. One day, there happened a very important incident in my career. It was end of month and, as usual, I went to submit our monthly certificate to the site commercial manager. He looked at my certificate and said, 'how many are you in your team?' 'Three, it's me and my two assistants' I answered. He continued, 'I understand your machines are very expensive, is it so?' I comfortably answered, 'true, we have a dedicated computer workstation with expensive software, RTK GPS, a one second total station and a good spirit level, all with their accessories, they really cost a fortune'.

He then looked at my certificate again and looked at me and, in a cool voice, he said, ' the value on your certificate does not seem to confirm what you are saying, your organisation is paid less than the least paid engineer on this project. What amazes me is that we can still run the project in his absence, but, should you be absent for a day, we feel the pinch the project won't move'.

I could not say a word. I felt sorry for myself, my boss and my company. I will not forget myself taking a shameful walk out of the commercial manager's office. He actually dressed me down. It was very hard to learn that, as an organisation, with all the equipment and personnel that we had brought to site we were racking far less than an engineer who simply took himself to site with nothing, just himself! The commercial manager just ran short of saying the truth that we were not wise; just to be polite enough not to use the 'f' word. This is one instance that shows how much, at times, we fail to even tell how much we are worth. We fail to get an idea of a project we are walking into. We just walk in! Sometimes we do not even say a word when the scope of work is changed! It's a shame!

My other colleague told me that the reason why surveyors do not seem to exude business acumen in their operations is the stringent code of ethics which they have to religious follow! I strongly disagree; there is no ethical code which prohibits people from understanding business, the market forces around them and in so doing behaving as business people. Every industry has their ethical codes and laws governing their operations. Be it insurance, telecoms, medicine, banking and even sport just to name a few. These codes are just promulgated to stamp out some wayward behaviour and unfair practice as well as to protect the integrity of the profession. They are not meant to prohibit players from being business minded. Never!

Most surveyors often fail to understand and comprehend how much the macro-economic environment affects their daily operations. They simply do not care. We buy a newspaper to read the gossip and sport sections and innocently skip the business section, when the TV news anchor introduces the business section for the bulletin of the day, we retire to bed and when the finance minister spells out his annual budgetary statement we just feel it is for other people. It is often embarrassing that you meet a whole professional person who do not understand basic economic dictates like the obtaining GDP and such financial instruments as interest and exchange rates, inflation, growth rates, poverty datum lines and so forth which are key economic indicators in the environment we operate. It is prudent to have a grasp of such fundamentals; the authorities announce them for our consumption. We only ignore them at our own peril.

The world economic order is changing and changing faster than what any yesteryear scholars would have ever thought of. It is often very difficult to survive without a firm knowledge of business. This is some of the reasons why we often fail to harness new business opportunities,

BEYOND THE TRIPOD – A BUSINESS PERSPERCTIVE BY K.MUKOMBE

we are often stuck on the business line that we are traditionally confined to and letting off the new business opportunities to other more aggressive professionals. As the world evolves so are business opportunities. Being a business person is never by instinct but is something that one has to acquire. All the successful businessmen we see acquired the business skills. This serious lack of business minds is pushing most of us into oblivion. True, we are becoming extinct! Really endangered and going the dodo way! Our societal relevance is diminishing as we fail to redefine ourselves in the new business order. We are not mutating fast enough to catch up with the new world economic order. In times of recessions, we are usually in the first batch of causalities. In the event of an economic rebound, we are the last to be on our feet if, ever we manage. These are some of the painful effects of not being aware of the environment around us.

We simply wait for fate; we simply adopt a ***'post office'*** approach to business. I call this a 'post office' approach because of what, as we all know, happened to the post office. Post offices the world over adopted a bystander attitude when the information revolution was sweeping the world. They had everything it would have taken to take the leading role in the information revolution (lots of cash, the laws favouring them, extensive branch networks and the experience in the information business) and decided to confine themselves to their 'core' business as mandated by the law! By the time that they realised this their 'innings' were over. To be frank, they did not know what hit them, they were left to scramble for the crumbs from the operators of the businesses that they, themselves, were strategically poised to run at some point in time. They were relegated to being vendors. This needs no emphasis.

My other colleagues always argue that they never think of ever running any entity. They seem to suggest that they do not need to 'waste' their time on finance and economic matters since they are simply confined in the 'comfort' of their jobs. What a serious misconception!! Nothing makes these people immune from the events on the financial and economic front. They do not realise that in their current situation, they are dangerously closer to the epicentre of any economic tremors around them. Moreover, a financially literate employee adds value to the organisation that they work for and increases their chances of climbing the corporate ladder. They will also be able to negotiate proper and very lucrative contracts with the employers. Therefore, no one can claim to be insulated from dictates of the world economic order.

insulated from dictates of the world economic order.

The big question then is; ***what is the way forward?*** The process of finding a solution starts with the knowledge of the problem and a deeper understanding of its roots. Our problem here is laid bare: ***we are financially illiterate***. The solution then is clear:

We need to make ourselves literate!

Someone puts it this way; maybe the curriculum is not responsive to business. There is a general feeling that the curriculum needs to be fine tuned to accommodate just a few modules on business. This transformation is currently sweeping across several sectors. This, at least, will make the survey graduate aware of the 'mine field' that they will be walking into from the day they don that graduation regalia. This, I leave to the academics to look at!

But for most of us who missed the train it would be advisable to learn about business basics. It is never too late for this. Let us grab those business books and learn about the real life issues which are: business and economics. This could be the only remedy to our situations. I bet that the financial derivatives in those books are not as difficult as; the moledensky theorem, the Fourier transforms and the Lagrange multipliers that we went through. This will not make us the Trumps or the Masiiwas of this world, but will help us and take us somewhere as individuals. Some may claim to be 'successful' in the midst of poor financial knowledge but they do not realise that their success is relative and, I bet, they could have done far much better should they have equipped themselves with financial knowledge. This is the time to think beyond the tripod!

Compiled by K. MUKOMBE

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Introduction

Land delivery or development is the process of adding value to land by the planning, surveying and servicing of land in readiness for the establishment of the superstructure (the buildings) for the facilitation of human habitation.

Various processes are involved in this preparation of land for human habitation, namely base-mapping, environmental impact assessment, layout design, title surveying, engineering design and construction of infrastructure, architectural design of superstructure and possible transfer of land parcels.

These processes have mainly been done on an ad-hoc basis and in some instances the sequence of execution has caused time lags and unnecessary bottlenecks and have lacked due regard to cost-effectiveness.

The apparent lack of communication or interaction among various professionals in the value addition chain has been a cause for concern. It is with this view in mind that this writer seeks to foster a common understanding of all land development-related disciplines in Zimbabwe towards one goal – land delivery.

This paper seeks to initiate a pro-active approach in advising local authorities, relevant government ministries, private land developers and various other stakeholders in matters relating to land delivery processes in Zimbabwe.

This has been necessitated by the experience that this land surveyor has gone through for almost two decades in the field of land delivery.

WHAT DOES LAND DELIVERY INVOLVE?

As alluded to above it is when land has undergone processes of improvement that the construction of the infrastructure can begin. The technical processes involved include land identification, base mapping, environment impact assessment, layout design, cadastral surveying, engineering designing and construction, conceptual architectural designing, real estate agency and conveyancing. We will show shortly how these process are interlinked and how the land surveyor can act as conduit in aiding all the other disciplines to achieve their objectives

(a) Land Identification:

Land delivery involves, from the on-set, identification of the project area. This implies indentifying who owns the land. Is it Government, the local authority or a private individual? If this is ascertained it is the land surveyor who marks it out on the ground by either locating existing beacons and boundaries, and/or establishing new ones without ambiguity. To unambiguously mark out the beacons and boundaries and ascertaining ownership involves making diligent searches in the deeds registry and scrutinizing cadastral maps in the Surveyor-General's Department.

At this stage, in consultation with the land owners and their town planner, the land surveyor could expose on time any ownership wrangles that may arise. For example, if there is likely to be encroachment onto abutting land this can be resolved before actual planning begins.

It is also at this stage that the land surveyor can advise on issues like the cancellation of general plans that might have been surveyed and approved earlier but which might no longer be serving any useful purpose at that stage. These might need to be revised or cancelled altogether before the new layout is designed.

Cancellation of general-plans is initiated by the Surveyor-General on the advice of the land surveyor and this usually takes months or even years to achieve, so the sooner this is done the better. The experience of this land surveyor is that approved layouts have sometimes been surveyed and lodged with the Surveyor-General for his examination and approval for title purposes and, thereafter, have taken years to be dispatched from his offices due to the need to effect cancellation or amendment of approved general plans. Meanwhile, the land developer will be held in limbo for periods of up to five years.

(a) Base –mapping:

It has also been the experience of this land surveyor that the implementation of designed layouts has been delayed by the lack of sufficient base-mapping. The tendency in some town planning quarters has been to obtain out-dated topographical maps from the Surveyor-General's department and proceeding to do their layout designing. Some of these maps are based on aerial photographs that were taken as early as the early nineteen seventies. They do not capture developments that have taken place throughout the years. This land surveyor has some cases in point where a whole residential layout was traversed by a 20-metre oil pipeline servitude and 33KV electric power lines. The result was that the layout had to be revised considerably after having been approved earlier. This wastage of time, resources and human effort could be avoided if the land surveyor had been involved from the onset by providing an up to date base-map to the town planners.

What does base-mapping do and achieve? This involves the topographical surveying of the project area by a land surveyor in order to produce a map depicting existing utilities and, other man-made and natural physical features. These features have a bearing on the usability of the land for a proposed project in as far as they enhance or hinder the creation of the built environment. In short the base map provides an aid to planning, be it a residential or industrial estate being conceived.

Environmental impact assessment

Armed with an accurate base map and coupled with a visit to the project site the environmental impact assessor carries out his studies and writes reports on the likely effect on the environment of establishing the development. This is a statutory requirement for any development to see the light of day in the offices of the Physical Planning Department.

Layout Design

From resolving issues of ownership, encroachment, cancellation of general plans and creation of accurate base maps which is mainly the domain of the land surveyor, the next stage in value addition towards final land delivery, is the town planner's layout design. The layout design indicates the residential, industrial or commercial estate as envisaged by the town planner.

Some layout designs are drawn by free hand. However, this necessitates that the land surveyor reproduce the layout by calculation or incurring the extra cost of having to digitize the hand-drawn layout. The town planner could use Computer Aided Designing (CAD) to create the actual design. If that be not the case, the land surveyor with his vast experience in CAD designing could come in handy to produce and finalise the town planner's sketched designs. This automation has the advantage that should it be required to amend the layout, this could be achieved with a few clicks of the mouse on the computer.

(a)Cadastral/title surveying

If the processes alluded to above are pursued or executed in that order, repetition and duplication of effort is always avoided with the result that time, money and effort are saved.

This means that if and when the layout is approved, the land surveyor will be at the ready to go back into the field to implement the design without further delay. It goes without saying that it is the land surveyor's main business to peg the planned stands, thereby compiling the requisite survey records for submission to the Surveyor-General office for examination and approval for title purposes.

It is clear, therefore, that if proper land survey is involved from the beginning of the project, time, money and effort will be saved considerably in undertaking the actual subdivision of the plots or stands as planned. Issues of land ownership, encroachments, possible lengthy processes of cancellation of general plans and production of up-to-date accurate base maps would have been resolved beforehand.

(b)Engineering Designs

The engineers immediately come after the approval of the general plans (and or diagrams) by the Surveyor-General for title purpose. These plans are, of course, based on the town planner's layout. It is at the engineering stage that designs for construction of roads and storm-water drains, sewer and water reticulation systems, telephone lines, road signs, electricity power lines and substations are done.

This involves the input of civil, electrical, roads and telecommunication engineers. All these engineers need not re-invent the wheel by trying to produce their own maps; they simply have to revert to the land surveyor's data base which by now has amassed vast amounts of land utility data. What is more is that the services of the land surveyor are almost always invariably required by the civil engineer in that further surveys such as cross-sections and profiles and routes designed for sewer and water-reticulation and roads are required. This goes to indicate the vital nature of the land surveyor's input in the evolution of the built environment.

(c)Architecture

When the processes outlined above have been completed up to the stage of the setting up of the infrastructure one would think that the land surveyor's case is rested. However, a careful analysis of the scenario indicates that the architect in all cases would require the land survey site plan and/or topographical map in order to start designing the superstructure.

The topographical map with appropriate contour details, gives him detailed information about the relief of the area required to come up with appropriate designs.

At this juncture, it is important to point out at the possibility of using the architect's conceptual designs for marketing purposes. The selling of stands only when serviced is an inert way of marketing the proposed residential, commercial or industrial estate.

Land owners could utilize the skills of the architect to design shopping complexes, colleges, hotels, churches, etc. for the discerning investor to visualise the concept and thus implement their investment immediately.

(a)Conveyancing and Real Estate Agency

Let us suppose that the land owner has now found some investors to purchase the serviced stands.

A cursory visit to the real estate agent's offices will reveal that the estate agent needs the land surveyor's general plans and diagrams to indicate which properties would be on sale.

It is clear that in so using the general plans and diagrams, the land surveyor's integrated data base alluded to earlier comes in handy. This data base could be put to further good use, for example, when the estate agent wants to shade off those stands in a scheme that would have been purchased. This can be achieved again by a few mouse clicks on the computer. Furthermore the lawyer (the conveyancer) needs the land surveyor's diagram and general plan (or more correctly the dispensation certificate) to effect transfer or registration of title to land.

The requirement that no portion of any piece of land shall be transferred except upon a diagram thereof, and that reference shall be made to that diagram in the deed, sometimes requires that the conveyancer approaches the land surveyor requesting him to frame a diagram in retrospect based on a general plan that has long been approved without a diagram for the particular property being contemplated for transfer.

Conclusion

A careful analysis of the development process identifies four distinct groups of stakeholders who are interested in the process to different purposes.

There is the landowner who owns the vital means of production, the land on which the infrastructure and superstructure will ultimately stand; the development professionals outlined above who are the instruments of value addition; the investors or financiers who are a vital source of funds to finance the operations and; the consumer who is the buyer or user of the finished product, which are the stands or plots on which the superstructure will be built, or the superstructure itself.

What almost invariably happens is that where central government, local authorities, and the private sector own adequate land on which construction can occur, well-trained and experienced development professionals and, willing and able consumers are always available.

It is however the experience of this writer that what seems to be always missing is the investor or financier. What is the reason for this apparent absence of the financier?

Perhaps this is the crunch. Perhaps we as a nation we have not been pro-active in providing a conducive environment for the investor. Herein lies a greater part of the solution. Landowners must always be ahead of the financier by pro-actively planning, surveying and servicing stands for immediate occupation and development.

Finally, having the architect's conceptual designs to sell together with the serviced stands can go a long way in luring investors who could implement those designs immediately.

To conclude this discussion, I draw your attention to the old adage that says, 'the pebble dropped in a pool, can make ripples to the farthest shore'.

In this instance the land surveyor is the pebble in the pool of land delivery. His input in the value addition chain towards the creation of the built environment impacts on the work of the town planner, the environment impact assessor, the various development engineers, the estate agent, the architect and the conveyancer and without his maps and diagrams all would be like ship sailing in uncharted waters without a compass.

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EVENTS HELD DURING THE YEAR

Socials was hosted by
Engineering & Topo discipline

Breakfast meeting with fellows

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