

# Land Information Management in Southern Africa

## Focus on technology management training in Surveying and Mapping in Namibia

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### ABSTRACT

The overall objective of the Dutch funded project, Land Information Management in Southern Africa (IT-2), is to strengthen the capacity of the Ministry of Lands, Resettlement and Rehabilitation (MLRR) in Namibia, Department of Lands Affairs (DLA) in South Africa, equivalent and/or related Ministries, Non Governmental Organizations (NGOs) and private sector in southern Africa, to achieve their strategic objectives related to the effective implementation of land reform programmes, through the development of a comprehensive educational programme in Land (Information) Management. In particular, a series of one or two-weeks organisation and technology management workshops for MLRR managers has been designed and implemented. Following and in relation to these workshops the MLRR managers have received professional coaching to support the elaboration of action plans to enhance MLRR operations. The paper elaborates on the guiding principles, modus operandi and results of this organisation development programme and in particular on one of its components related to technology management training on modern data acquisition methods, focussing on the particular needs of the Directorate of Survey and Mapping. The Existing situation in Namibia, namely, the reference ellipsoid, map Projection, GPS Network Coordinate system is reviewed. The triangulation Network in S. Africa is discussed. Further, the Namibian Cadastral Data Base, and the practice of surveying in Namibian cadastre department are presented. Moreover, some comments on existing Namibian systems/procedures, namely, the ground control point network, and the transformation parameters, cadastral surveying are presented. Finally, problems in surveying and mapping in Namibia are discussed.

### INTRODUCTION

For decades the central social and political issue in southern Africa has been access to land. The recent democratisation in Namibia and RSA and in other southern African countries has resulted in new constitutional provisions, new laws and new policies on land. Consequently land managing institutions face an immense task to implement land reform. At the same time the new democracies in southern Africa lack a good cadre in all segments of society. One of the prime reasons for the slow delivery of land in the reform programme in Southern Africa is the lack of suitably trained and educated land managers to deliver land at the required rates. The Dutch government has very early recognized the need to strengthen the capacity of land managing institutions (governmental, NGO, private sector) in southern Africa, to achieve their strategic objectives related to the effective implementation of land reform programmes, through the development of a comprehensive educational programme in Land (Information) Management. This has led to setting up a series of Dutch funded development programmes in Namibia and South Africa between 1996 and 2004 that are shortly reported below. But the emphasis of the paper is on organisation and technology management training, to enhance the effectiveness and efficiency of service delivery of land managing institutions, focussing on the particular needs of the Directorate of Survey and Mapping in Namibia.

### 1. INTERNATIONAL COOPERATION PROJECTS IN LAND INFORMATION MANAGEMENT IN SOUTHERN AFRICA

First contacts were established between THE Ministry of Lands, Resettlement and Rehabilitation (MLRR) of Namibia and the International Institute for Geo-Information Science and Earth Observation (ITC) in May 1993. As a result an ITC certificate course in land use planning was implemented in Namibia on a block release basis in the period 1995-96 with funds from the Danish NGO Ibis. Thereafter the concept was further developed and with funding initially from Directoraat Generaal Internationale Samenwerking (DGIS) International Education Programme (DPO/IO) (later from the SAIL project programme), the Institutional Support and Human Resource Development (INSHURD) project provided institutional support and human resource development for MLRR in the period 1996-2001. Two one-year National Certificate (NC) courses in Land Use Planning and Land Measuring have been designed, developed and implemented at the Polytechnic of Namibia. The target group for the course participants was primarily MLRR. The INSHURD courses have been fully institutionalised at the Polytechnic in 1999.

The Training and Education in Land Management in Southern Africa (TELMSA) project, 1999-2001, which was funded under the Dutch SAIL project programme, regionalizes the INSHURD concept and training and education was also developed at the Centre for Environment and Development, University of Natal (CEAD/NU) in South Africa. TELMSA adds two additional one year NCs in Land Valuation and Urban Land Use Management and develops a three year National Diploma (ND) in Land Management at the Polytechnic of

Namibia. At CEAD/NU the original thinking was to transfer the Namibian para- professional courses to RSA, however, after a series of workshops with the Department of Land Affairs (DLA), the main client in RSA, a flexible Masters programme in Land Information Management (LIM) was designed to more optimally meet the needs of DLA.

The INSHURD-TELSA 2 (IT-2) project on Land Information Management in Southern Africa, 2001-2004, also funded under the Dutch SAIL project programme, has complemented the achievements of the INSHURD and TELSMA projects in terms of:

- Further development of the education and training capacity in Land Management at the Polytechnic of Namibia to ensure the sustainable provision of staff required by land managing organisations at managerial, professional and para-professional levels.
- Further developing the education, training and research capacity in Land Information Management at CEAD/NU to ensure sustainable provision of professional and academic staff required by land managing organisations and their supporting training suppliers.
- Institutional strengthening of the MLRR to improve organisation's performance in terms of efficiency and professionalism, through managerial capacity (general and technology management) development of the MLRR managerial staff.
- Polytechnic of Namibia and CEAD/NU teaching staff development abroad, enhancement of teaching/learning facilities and South to South fellowships to support the regional perspective of the project.

At the Polytechnic of Namibia, a Managers development programme, a Bachelor of Technology (B. Tech.) degree course programme in Land Management, a National Certificate course in Land Registration, a National Diploma in Land Use Planning and a National Diploma in Cadastral Surveying have been developed, institutionalised and operationalised during the project period. In 2004, 165 students were attending the courses in Land Management at the Polytechnic of Namibia.

At CEAD/NU, the Land Information Management stream of the Masters programme in Environment and Development has been developed and implemented.

At MLRR, a series of one or two-weeks organisation and technology management workshops for MLRR managers have been designed and implemented. Following and in relation to these workshops the MLRR managers have received professional coaching to support the elaboration of action plans to enhance MLRR operations. Seventy (70) MLRR managers have been trained in organisation and technology management during the IT-2 project period.

## **2. ORGANISATION AND TECHNOLOGY MANAGEMENT TRAINING PROGRAMME FOR MLRR MANAGERS**

A series of 14 organisation and technology management workshops of a duration of one or two weeks each have been designed and delivered to MLRR managerial staff over the period 2002 – 2004, with the aim to enhance management

capabilities (knowledge and skills), within the particular setting of the MLRR, for the effective planning, organising and controlling of activities, in line with the requirements for effective and efficient Land Reform and Management operations in Namibia.

Through interactive, problem and action-oriented workshops and consequent professional coaching, facilitated by a team of international and local experts, the following objectives were achieved:

- Definition of a common basis of operations and management, within a uniform MLRR policy framework, based on agreed management and administrative procedures
- Enhancement of MLRR manager's knowledge and skills in areas related to policy making and strategic issues, including decentralisation policies aspects, organisational effectiveness and the supporting role of information systems, managerial effectiveness and optimisation of services and production processes
- Definition of parameters for organisational performance enhancement, analysis of operational performance through benchmarking and identification and analysis of bottlenecks in operations and areas for improvement
- Updating of the knowledge of MLRR managers on technology developments and trends in their particular fields of operation
- Definition and work-out of action plans for improved organisational performance, including detailed proposals for implementation
- Identification of further training needs for action plans implementation

The following workshops were delivered between March 2002 and May 2004:

- Organisation-wide workshops on common and/or inter-related problems
  - Workshop 1: Policy making and strategic issues
  - Workshop 2: Organisational effectiveness
  - Workshop 3: Managerial effectiveness
  - Workshop 4: Financial management, budgeting and control
  - Workshop 13: Optimisation of production processes
  - Workshop 14: General and technology management consolidation
- Directorate/Division-wide workshops on specific/disciplinary problems:
  - Workshop 5: General management for the Directorates of Land Reform and Resettlement and Rehabilitation
  - Workshop 6: Technology update for the Directorate of Land Reform and Regional Officers
  - Workshop 7: General management for the Directorates of Surveying & Mapping and Deed Registration
  - Workshop 8: Technology update for the Directorate of Resettlement and Rehabilitation and Regional Officers
  - Workshop 9: General management for the Divisions of General Services and Research & Planning

- Workshop 10: Technology update for the Directorate of Surveying & Mapping and Regional Officers
- Workshop 11: General management for the Regional Offices
- Workshop 12: Technology update for the Directorate of Deed Registration and Regional Officers

### 3. TECHNOLOGY MANAGEMENT PROGRAMME FOR THE MLRR DIRECTORATE OF SURVEYING AND MAPPING

Workshop 10 of the IT-2 Organisation and Technology Management Training Programme for MLRR Managers focussed on Technology update for the MLRR Directorate of Surveying & Mapping.

In phase 1, a series of lecture the following issues were considered:

Introduction to Map projection systems, Introduction to Geodetic Datums, Reference Ellipsoids, Global Coordinate Systems, Geodetic Datums, Datum Conversions, Reference Ellipsoids, Geodetic Datums, GPS system overview, satellites, differential GPS (DGPS) techniques, Transformation of coordinates (Molodensky, Bursa Wolf) , and least squares adjustment.

In phase 2 the existing situation in Namibia were considered and number of problems were discussed.

#### 4. EXISTING SITUATION IN NAMIBIA

##### 4.1 The reference ellipsoid

The reference ellipsoid of Namibia is Bessel, (according to, surveying and mapping organization of Namibia) Namibian Bessel, and (according to Polytechnic of Namibia) the European Bessel, although they are slightly different.

##### 4.2 Map Projection

The Namibian projection system is Gauss Conformal Projection, also known as the Transverse Mercator Projection. The system consist of zones of 2° of longitude wide, the central meridians consist of every odd meridians, i.e. 15°, 17°, 22°19', ..... With the origin at latitude 22° South, (S. African origin is at Equator).

##### 4.3 Coordinate system

The Namibian Coordinate system consist of the following, the positive Y is towards the West of central meridian, and negative to the East of central meridian, X is positive south of the parallel 22°. (Therefore always positive in S. Africa). See Fig 1

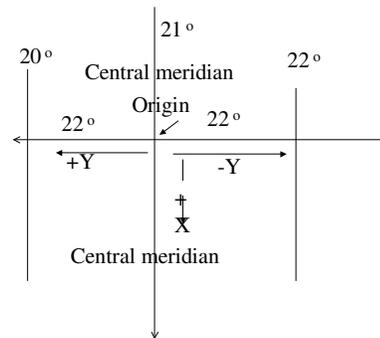


Fig 1. The Namibian Coordinate system (zone 21°)

##### 4.4 Directions

The direction is the angle measured in a clockwise sense, between the direction south, and the line in question see Fig2.

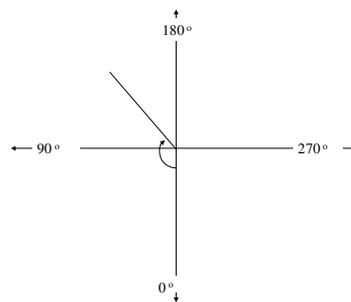


Fig2. The Namibian angle measurement

##### 4.5 Triangulation Network in S. Africa

The origin of the triangulation (in S. Africa) is the station at Schwarzeck, with the following coordinates

Latitude = 22° 45 '35.820" S

Longitude = 18° 40 '34.549" E

The azimuth Schwarzeck – Langer Forst = 36° 47 '59.35" from N to E

The following progressive steps were performed to establish the Triangulation Network in S. Africa.

**4.5.1 Selection of Circuits:** The country is divided into sections (circuits) or approximate squares of about 500 to 800 km sides, where a baseline is measured accurately near each corner, so that a geodetic chain of triangles may be extended between these base lines.

**4.5.2 Base line measurement:** The triangulation system is based on base line measurement, whose extremities are fixed astronomically. The lengths of the base lines are approximately 8 to 30 km.

**4.5.3 Geodetic Chain:** The Geodetic Chains are composed of well-conditioned triangles, where the sides are about 60 km (between 30 to 190 km). Chains consist of a rows of polygons, composed of a number of triangles, or a double row of triangles forming a single row of quadrilaterals. Fig 3. is a schematic representation, the real figure is not so regular)

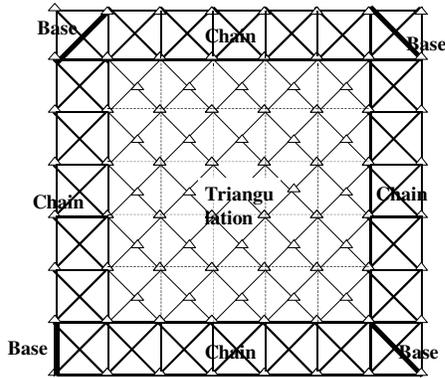


Fig 3. Geodetic control network of Namibia

**4.5.4 Primary Triangulation:** The areas inside the geodetic chains are covered with a network of triangulation. The side of a primary triangle is 30 to 60 km.

**4.5.5 Secondary Triangulation:** The Secondary Triangulation consists of densification of the Primary Triangulation with triangles of about 12 to 18 km sides see Fig 4.

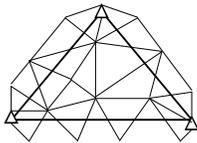


Fig 4. densification of triangulation network

**4.5.5 Tertiary Triangulation:** The Tertiary Triangulation consists of densification of the Secondary Triangulation with triangles of about 3 to 6 km sides

**4.5.6 Town Survey Marks:** This is the final densification of the control network, which consists of marked traverse stations on the road surface, in township and built up areas.

**4.5.7 GPS Network:** There are 8 GPS control points in WGS84

**4.5.8 Altimetry:** The mean sea level is determined by taking tide observations at various points along the coast. A network of precise levelling is being carried out. Heights of trig points

are connected to precise bench marks. The elevations are determined by observing vertical angles. There is no geoid model in Namibia.

#### 4.6 Unit of distance measurement

The S. African Unit of distance measurement were;

1 Cape rood = 12 Cape feet

1 Cape foot = 1.033 English feet

The Chain = 100 links = 66 English feet

#### 4.7 Conversion to international meters

1 South African Geodetic Foot = 0.304 797 265 4 international meters

1 Geodetic Cape foot = 0.314 855 575 16 international meters

1 Geodetic Cape rood = 3.788 266 902 2 international meters

The Unit of measurement in Namibia is the **Legal** meter applied in Germany

1 Legal meter = 1.000 013 596 5 International meters

### 5. PRACTICE OF SURVEYING IN NAMIBIAN CADASTRE DEPARTMENT.

The cadastre department does not carry out the cadastre surveying, the surveying is contracted out to private surveying companies. The cadastre department performs the quality control, which consist of checking the accuracy threshold, as a consequence of which sometimes companies have to repeat the measurements.

Areas of properties are computed using Geomedia software (Intergraph), within 1 m<sup>2</sup> accuracy.

#### 5.1 Cadastral Data Base.

The Namibian Cadastral Data Base. Is developed by digitizing existing cadastral map, and completed by adding digital data, resulting from the project contracted by different private companies. The method of data acquisition applied by those companies is GPS acquisition techniques.

### 6. COMMENTS ON EXISTING SYSTEMS/PROCEDURES

#### 6.1 Ground control point Network

As the density of the Ground control points is insufficient and their accuracy is not homogenous, it is proposed to carry a densification of those control points using GPS, which is a rather fast method of ground control point densification. Next carry an overall adjustment of all ground control points. It is obvious that the overall adjustment of the existing control points can be done before densification step, and repeated after densification step. Note, that the coordinates of all cadastral points also have to be changed after such an operation. Consistency is the goal, thus all old surveys must be converted to the new situation after an overall network adjustment.

## 6.2 Transformation Parameters

As private companies are in charge of cadastral surveying, they compute their own transformation parameters, in order to transform the coordinates of the parcels from WGS84 to local coordinate system. Those are computed based on common points in both systems (only in planimetry). This is acceptable within the project, but as the neighboring project (North, south, West or East of the current project) is executed by different companies, there are some discrepancies between different sets of parameters computed by different companies.

Example of different transformation parameters;

Transformation parameters of company A, using Leica GPS receivers;

Type of transformation: One step 2D Helmert transformation.

Ellipsoid A WGS84, Ellipsoid B: unknown

$$X_0 = -0.0371$$

$$Y_0 = -0.0422$$

$$\text{Shift } dX = 60028.7678 \text{ m}$$

$$\text{Shift } dY = -3937.0827 \text{ m}$$

$$\text{Rotation about } Z = -647939.2824''$$

$$\text{Scale diff.} = -6.9260 \text{ ppm}$$

Transformation parameters of company B, applying Trimble GPS receivers;

$$X_0 = -10336.893$$

$$Y_0 = -63263.495$$

$$\text{Translation East} = -3.016 \text{ m}$$

$$\text{Translation North} = -1.236 \text{ m}$$

$$\text{Rotation about } Z = 0^{\circ} 00' 03.674219''$$

$$\text{Scale factor} = 0.99999236$$

**6.2.1 Solution:** It is proposed that the mapping organization should take the responsibility of computing a unique set of parameters, to be published and applied by different companies, in this way, the coordinates would be homogenous after transformation to the local system.

Basically there are 2 solutions for coordinate transformation;

i- Geodetic rigorous transformation in 2 steps;

step 1- Change of ellipsoid

As stated before the reference ellipsoid of Namibia is Bessel defined by;

$$a = 6\,377\,397.155$$

$$b = 6\,356\,078.963$$

$$(1-e^2) = 0.993\,352\,627\,8$$

$$e^2 = 0.006\,674\,372\,231$$

$$1/f = 1/299.152\,8128$$

There are 3 Bessel ellipsoids, with the following characteristics;

### Bessel 1841

$$a = 6377397.155, \quad 1/f = 299.1528128$$

### Bessel 1841 (Japan By Law)

$$a = 6377397.155, \quad 1/f = 299.152815351$$

### Bessel 1841 (Namibia)

$$a = 6377483.865, \quad 1/f = 299.1528128$$

The difference is probably a matter of the units used: The flattening is the same for the European and the Namibian one, while the semi major axes have a ratio, which is identical to the ratio between the "Legal" meter and the International meter. Apparently the European Bessel is the same as Namibian Bessel, where the semi major axis is expressed in Legal meter. It should be checked and a unique ellipsoid used by everyone.

In Namibia there are only 3 shifts applied for transformation from WGS84 to Bessel 1841, namely;

$$\text{Shift } X = -616 \text{ m}$$

$$\text{Shift } Y = -97 \text{ m}$$

$$\text{Shift } Z = 251 \text{ m}$$

And for transformation from WGS84 to Bessel 1841 (Namibia);

$$\text{Shift } X = -615.64 \text{ m}$$

$$\text{Shift } Y = -102.08 \text{ m}$$

$$\text{Shift } Z = 255.81 \text{ m}$$

The Namibian mapping authorities should select the proper one to apply. Moreover they should compute also Rotation around X-axis, Rotation around Y-axis, Rotation around Z-axis, as well as scale factor, in order to have a unique set of parameters for the mapping organization, as well as all private companies.

Step 2.

The projection parameters should be defined per zone, according to the central meridian of the zone.

ii- One step 3D transformation.

The second solution consist of computing the transformation parameters ( 10 in case of Molodensky badekas, and 7 in case of Bursa Wolf) per zone, to transform directly from WGS84 to local projected coordinate system of the zone.

ITC is able to help and assist them in performing the issues mentioned above.

Next the existing coordinate, surveyed previously, should be adjusted to new situation

## 6.3 Cadastral surveying

Cadastral surveying projects carried out by private companies are based on RTK. A copy of the report, including coordinate list is submitted to the organization. The cadastre authorities then check the coordinate of some checkpoints. If discrepancies are within the tolerance, then the project is accepted; otherwise in some cases they request repeating the surveying.

Practice of GPS measurements by surveyors of the cadastre office, is also RTK observation method, whereby they occupy simultaneously 4 stations (known), as well as 1 unknown point, called temporarily reference point for a short period of time, in order to compute the transformation parameters, to solve ambiguity integer, as well as to compute the coordinate of the temporarily reference point

Analysing reports of private companies reveals that they are applying the same procedure.

#### 6.3.1 Problems:

1. Setting up a temporarily reference point, by a few epoch of GPS observation does not provide the necessary accuracy requirements for the subsequent observation of the parcels, unless there is absolutely no reference point available in the area.
2. RTK method of observation is not advised for parcel surveying, there is no further control, to future analysis of the observation for error detection.
3. It is advised to perform baseline computation for detail cadastre surveying, followed by post processing of the observations, and archive the post processing files for further analysis.
4. In case the private companies insist on practicing RTK, they should record observations, and perform post processing, to be able to compare the results, and archiving the post processing files.

#### 6.4 Photogrammetry

There is no Photogrammetric department within the surveying and mapping organization, the authorities of the department are very interested to have one such department, and instead there is only **one** Photogrammetric analytical instrument without operator.

**6.4.1 Proposal:** It is proposed to help them to organize their Photogrammetric department (with small size, at the beginning), in acquiring instruments/digital workstations, in training the staff in different levels, in organizing special courses in Namibia or abroad.

#### 6.5 Problems in surveying and mapping

The authorities of the surveying and mapping organization expressed the followings problems;

1. For precise height computation, as well as transformation of height coordinate from ellipsoidal height to orthometric height, they do not use a geoid model. The solution would be either to have the gravimetric data, which does not exist in Namibia, and to collect those data they require an enormous time, or to have a mathematical geoid model. Another solution is to have world geoid data with 1 m accuracy. ITC is able to help them in this matter.
2. They are also in need of a DTM quality control. There are 3 different quality controls for DTM, namely; Analytical, semi analytical and experimental methods. The first two are mostly applied for research issues, for Namibia experimental method

would be applicable, which is based on checkpoints. ITC is able to help them to apply the method.

3. Moreover they are in need of a VLB processing software of the university of Bern. It is possible to look into this matter and help them acquire this software.

The aim of this report is only to point out problems in Namibia, The solutions presented are only one possible variant of many solutions, and far from being a definitive solutions to solve their problem.

In case it is decided to take the necessary measures, issues should be considered more in details, definitive solutions pointed out, and finally applied in Namibia.

## 7. CONCLUSIONS

The series of international cooperation projects on Land Information Management education and training in southern Africa, as highlighted above, have already much contributed to strengthening the capacity of land managing institutions (governmental, NGO, private sector) in southern Africa during the past 10 years.

The institutionalisation of a seamless Land Information Management education and training programme at the Polytechnic of Namibia (from the National Certificate to the B.Tech. level) and at CEAD/NU (at Master's level) offers a sustainable basis to continue providing suitably trained and educated land managers that will ensure effective and efficient Land Reform and Management operations in southern Africa for the years to come.

The original Organisation and Technology Management Training Programme for MLRR Managers, as developed in the IT-2 project framework, has proved to be effective and could easily serve as a model for training managers on a part-time basis in other regions of the world or in other professions.

## REFERENCES

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