PRESENTATION OF THE NAMIBIA ZERO ORDER STATIONS AND INFORMATION SITE FOR DIRECTORATE OF SURVEY AND MAPPING

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Abstract

This project is focused on the presentation of the Namibia Zero Order Stations, including the descriptions of the 21 stations across the country and to create information site for Directorate of Survey and Mapping in Namibia. The main reason for the implementation of web site is for the distribution of information and data to domestic and international clients. Most of the materials and information used in this project were available in digital format. Some information was collected from Directorate of Survey and Mapping of Namibia, Swedesurvey of Sweden, and Asci of Sweden as well as from the internet and library facilities. As such it was very important to analyse and display geo-spatial data before creating web site. The computer makes it possible to create a link between filed documents, maps, graphic documents and other related information using hyperlinking. Therefore the computer made the world easier to communicate and mapping via internet.

Keywords: DSM, Swedesurvey, Asci, Zero Order Stations, Hyperlink.
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1. INTRODUCTION

The Directorate of Survey and Mapping (DSM) is a national agency at the Ministry of Lands and Resettlement, responsible for providing services related to surveying and mapping. The DSM established a new project, named National Integrated Geodesy, which is responsible for integrating the geodetic control network with the International Terrestrial Reference Frame (ITRF). The technical aspect of the project was undertaken by the DSM in collaboration with the Swedesurvey agency in 2004. The project was initiated with the purpose of observing the Namibian Zero Order Stations (Nam-Zero) across the country and process northern Nam-Zero as well as to re-process the stations at the southern part of Namibia. The new geodetic network is the main framework on which all kinds of surveying such as cadastral, topographic, construction, control surveys and mapping activities are based.

The purposes of this project is to present Nam-Zero including descriptions of the 21 stations, explains the reasons for establishing the new Nam-Zero, how the use of it would improve accurate positioning in Namibia and to create an information site about the new geodetic network for distribution of information and data world wide.

1.1 Geographical description of Namibia

Namibia is a country located at the south western part of Africa, with an area of 824,268 square kilometres. The country has an estimated population of 2 million inhabitants. It borders, Angola, Zambia, Zimbabwe, Botswana, South Africa and the Atlantic Ocean.

The country is divided into thirteen administrative regions, namely: Kunene, Omusati, Oshana, Ohangwena, Oshikoto, Kavango, Caprivi, Otjozondjupa, Omaheke, Khomas, Hardap and Karas. These regions were created to enable and facilitate a more adequate administration of the country.

1.2.1 A short overview of land surveying profession in Namibia

The history of surveying in Namibia has developed significantly over the past few years; from traditional to modern systems. The profession of land surveying in Namibia is controlled by the Namibian council for professional land surveyors, technical surveyors and survey technicians (SURCON). Before any person can practice any surveying activity in Namibia, he/she must be registered as professional land surveyor by SURCON. The requirements to be registered as professional land surveyor are the following:

- To have a university degree in surveying at least bachelor’s degree
- To go through a written test in surveying laws
- To go through a practical experience: 270 working days in various field works
- To go through a practical test.

So far, the country has a small number of professional land surveyors and many of them are employed in private institutions.

In the early 1980’s, the beacons for the old geodetic network were built on top of the mountains as shown in Figure 1a, and on roofs of some public buildings and some church
towers as shown in Figure 1b, were used as trig-beacons because they are fixed points and visible from far.

Due to difficulties to reach the top of mountains, the DSM, during the design of the new Nam-Zero, decided to build the pillars for the new Nam-Zero closer to roads and closer to public buildings such as police stations in order to avoid their possible destruction in future.

1.2.2 Presentation of the Nam-Zero

The DSM staff constructed the Nam-Zero, which currently covers the whole country. The constructions started in 2002 and were completed in 2003. The network comprises of 21 points and they are all concrete pillars, some with the GPS antenna attached. Figure 2a, distribution of Nam-Zero and Figure 2b, antenna set up at the roof of DSM, based on the ITRF epoch 2005.0.

Nam-Zero are designed in such a way that the GPS receiver and related hardware are stored inside a lockable box attached to it as shown in Figure 3.
The construction of the Nam-Zero was followed by the GPS campaign in May 2004 at the southern part of the country. Private surveyors from Swedesurvey of Sweden carried out the GPS campaign. In March 2005 the GPS campaign continued at the northern part of Namibia, joined by surveyors from DSM and a local private company Strydom and Associate. The Nam-Zero becomes an official system on 01 January 2005.

1.2.3 The southern Namibia GPS campaign

Swedesurvey conducted GPS Observation activities for the Nam-Zero in southern Namibia (south of Latitude 25°00’00’’) from the 8 May to 15 May 2004. These points were also used as ground photo control points during the aerial photography campaign in the same area. After the observation activities in southern part of the country, Swedesurvey, using scientific software called" Bernese version 4.2", started the first processing of data concerning only the southern observations.

1.2.4 The northern Namibia GPS campaign

Between 10 March and 17 March 2005, Swedesurvey conducted a new GPS campaign in the northern part of Namibia (North of Latitude 25°00’00’’) in order to survey the 14 Nam-Zero situated there. Among those points, three of them were also observed during the first campaign in the southern part of the country in 2004. After the observation of 14 Nam-Zero, the next mission was to observe the 31 old geodetic points (first order points) plus 10 benchmarks. These points were also located in the same area covered by Nam-Zero.

Swedesurvey used the appropriate Bernese software version 5.0 (not available at DSM) and did the computation of all observations at the northern part. The coordinates of the Nam-Zero at the north-central part of the country were calculated from the combination of data from different stations namely: 13 Nam-Zero points, reference station of DSM Botswana, two
permanent stations in South Africa and 10 International GNSS Services (IGS) stations were also added in the final processing. All stations tied together with the Nam-zero covering the whole of Namibia.

1.2.5 The southern and northern data processing

It is obvious that the Nam-Zero is tied to the IGS, especially with the Windhoek permanent station, located on the roof of DSM in Namibia, which is now fully integrated into IGS services.

Same purposes, the southern part were reprocessed in order to comply with the processing of the northern part; then the reprocessed southern data and the northern data were combined into one final and homogeneous data as shown in Figure 4. The processing of the above mentioned final and homogeneous data was carried out using the Bernese Software version 5.0.

![Figure 4. Namibia Zero Order Stations including AFREF reference stations (Source: NA-1506-ZO-02)](image)

According to Swedesurvey is report, southern and northern coordinates were fitted to the IGS solution and International Earth Rotation and Reference Systems Service – International Terrestrial Reference Frame (IERS-ITRF). The results after the fits of the IGS solution were used as a final coordinates of the Nam-Zero network.
1.2.6 The reasons of establishing the new Nam-Zero

The project was performed to enhance the establishment of a common Geodetic Reference Frame for entire Africa and also as a fundamental basis for the national and regional three-dimensional reference works fully consistent with the ITRF (Jival and Lilje, 2005). The Nam-Zero is a new geodetic network based on the ITRF as was approved by the International Association of Geodesy (IAG).

According to Wonnacott (1997) most development projects for any application, for any product or service requiring geo-referenced data needs an identical coordinate reference system. In Namibia, the old geodetic network was based on a locally fitted reference ellipsoid namely, Bessel 1841. The local reference restricted use of coordinates to Namibia only, something that made difficult to exchange data with others countries.

Today, most countries in the world are using Global Navigation Satellite System (GNSS) technology, particularly the GPS (Jival and Lilje, 2005). The new Nam-Zero will connect to the existing trig-beacons network (the old geodetic network) to the new system, making it possible to convert old geodetic coordinates to the new system based on ITRF epoch 2005.0. This conversion is needed especially for the property boundaries, which were computed in the old geodetic system.

The Nam-Zero is the main framework on which all surveying activities such as cadastral, topographic, construction, mining exploration, control and mapping activities will be based. The Windhoek permanent station is one of the Nam-Zero; due to the GPS technology records the data continuously 24 hours non-stop. This station will provide a continuous data to the surveyors, GIS data collectors, etc. The Nam-Zero will provide high accurate data to private surveyors, engineers and other professionals concerned by the spatial data, which they may use for controlling or establishing their project works at the centimetre level.

The establishment of a geodetic network will also promote the use of applications of IGS and it will provide high accuracy and other product related for survey and mapping within the continent. Government and non-government institutions are the main bodies that can organize or arrange all types of geographical data, where to store them, where to obtain them and how to use them so that they can contribute in decision making. The data from the Nam-Zero will also promote development in the country, particularly in planning.

1.2.7 How the use of the Nam-Zero would improve accurate positioning in Namibia

The Nam-Zero is fully integrated into the uniform continental reference coordinate system”AFREF” (Jival and Lilje, 2005). Positioning of any feature in Namibia or elsewhere in Africa, will for that reason be related to each other.

Government and private institutions, development projects, researchers and scientists from outside Namibia will no longer have problems obtaining reliable and accurate data they needed to carry out projects in Namibia. The Nam-Zero is the main frame for all engineering projects and completely in the ITRF_AFREF system. All the trig-beacons in the country for the old geodetic network will be connected to the new Nam-Zero and their coordinates will be
converted into the new system. Thereby improving accuracy. Surveyors, Engineers, Architects, GIS practitioners and other users of geo-spatial data who normally require data at centimetre level of accuracy, will be greatly happy with the Nam-Zero data, which set the accuracy of final coordinates to 20 mm in horizontal and 20-30 mm in height (Jival and Lilje, 2005).

The geodetic network will produce accurate data on centimetre level and will enable the development of digital data, which will be available to every user free of charge and will help many countries to solve infrastructure problems. Considering Galileo, the European navigation satellites system that will be operating under public control as from 2011, the possibility of determining positions will be further improved (Hanana and Shaanika, 2006).
2. METHODS AND MATERIALS

2.1 General

Maps are provided with a specific purpose of information that shows the position of objects on the earth, distances and directions separate the relationships between the features on a map. In this GIS project software such as Microsoft word, Macromedia dream viewer and Adobe Photoshop have played an important role in terms of manipulation, storage and visualization of geo-spatial data. The project has enhanced the capability of GIS to offer a consistent framework for analysing geographical data. Most of the materials and information used in this project were available in digital format such as photos for the stations, map indexes, tourist map etc.

2.2 Collected information

The information used in this project was collected in various ways:

- Some information was collected from DSM of Namibia, Swedesurvey of Sweden as well as from Asci of Sweden.
- Other information was obtained from the internet and library facilities. Figure 5 flowchart of the information collected for the DSM web site.

![Flowchart of the information collected for the DSM web site](image)

In some cases it took time to get necessary information: for instance the case of Namibia where internet connection most of the time experienced problems. It was difficult to get information on the right time.
2.3 Designed site description of each station

The site description is one of the most important aspects of this project. The recommendation was made, for the design of a very good site description for each station, before beginning the editing of the information pertaining to each particular point. An ideal sample of site description obtained from HMK: (1996). This site description is being used in Sweden for several years now. As such, the same structure was recommended as ideal for designing the Nam-Zero site description.

The site description was designed in such a way that, it could accommodate the information pertaining to each particular point such as Cartesian and geodetic coordinates etc. After designing the description of each station, rectangular hotspots were used to select each station on the base map, and then each of these stations were separately linked to their file document already existing in the dataset. The station situated on the roof of DSM in Windhoek, is only GPS permanent base station in Namibia, logging data 24 hours. It is composed of GPS receiver, GPS antenna, PC for data storage and software able of dealing with GPS data transfer for instance RINEX format (Hanana and Shaanika, 2006). The idea is to show to the clients, detailed information contained on the site description of each point. This facilitates the search for a particular station. Interested persons may view as well as print the document of the specific points of interest. These documents were saved in pdf files.

![Image of site description of the Windhoek station]

Figure 6. Site description of the Windhoek station
2.4 Design of a web site for DSM

In the past, world wide web (www) has been the medium from which geo-spatial data is obtained and published (Kraak and Ormeling, 2003). Since the Nam-Zero based on the ITRF and AFREF, the Directorate of Survey and Mapping recognized the benefits of bringing the GIS data online in order to distribute and visualize information world wide. The geo-spatial data is one of the most important and fundamental part of this project. The data were collected, processed, manipulated and published to the public through internet. Figure 7 spatial information that been used in this project.

The geographical data were produced from different sources. As such it was very important to analyse them before creating the web site. To make the interface accessible and easier to the users, the layers were created based on the structure of the web site. The users will be able to select appropriate information by clicking different headlines or buttons and download it, viewing maps and other available information. Macromedia dream weaver, Microsoft word, Adobe Photoshop is the software used in this project. The designing and implementation of the DSM website is aimed at providing detailed and accurate data to clients.

2.4.1 Compilation and hyperlinking

Hyperlinking has played a big role in this project. The computer makes it possible to create a link between filed documents, maps, graphic documents and other kinds of spatial information using hyperlinking. During the practical work of this project, all the filed documents were linked to each other by selecting the headings and then linking them to the existing one with the same functionality and then saved as a Hypertext Markup Language (HTML) file. For the Nam-Zero, rectangular hotspot was used to select the stations to be linked to the existing site description from the data set in order to view the information, belongs to that particular station. The user will be able to manipulate and display geographic information by clicking different headlines in the web site.
3. RESULTS

3.1 Results of the web site

The DSM of Namibia, like any other institutions is producing many products. Both the national and international publics would like to know about the contents, quality, format, availability and eventual costs of these products. One way to inform the public is through the internet. This explains the creation of a specific web site for DSM. The website also provides contact address where the detailed information about its products is given. Using the internet, the public will be able to browse and check the DSM products displayed and could order via email any maps of interest. They could also send a query to DSM to discuss any points of interest.

3.2 Products available in the DSM web site

The website contains a lot of information linked to each other and indicates more details about the product and services available at the DSM. Figure 8 Nam-Zero covering the whole country. On the website each station has site description and contains information for that particular point saved in a pdf file. The descriptions can be either viewed on the screen or printed as a paper document.

![Zero Order Points in Namibia](image)

The Namibian Zero Order Geodetic Network coordinates, based on the ITSEF and APRSF are published to the public, national and international. It is now connected to the neighbouring countries without any transformation of data.

Figure 8. Web site of the Zero Order Stations in Namibia

The stations are listed beside the location of the map in order to facilitate search for a specific station. It is also possible to click on the station in the map to reach the description of the station. Currently, the Nam-Zero coordinates are published and distributed to the users as well as to the national and international level. It is now easy to connect neighbouring countries without any transformation of data.
3.2.1 Map sheet index (scale 1: 250 000)

The whole territory of Namibia has been divided into grids of 200x125 kilometres squares, except some map sheets situated on the edges or boundaries of the Namibian territory, which were extended to a larger size. Figure 9 map index of 1: 250 000 scale comprises of 41 map sheets.

![Map Index](image)

Figure 9. Map index at the scale of 1:250 000 covers the whole country (source: DSM-Namibia)

The map index for the 1:250 000 was designed in such a way that it does not cut the 1:100 000 scale map sheet through. Each map sheet on the 250K is designated by name only. The name of a major town or village was chosen as sheet name. All these maps are printed and available in digital format.
3.2.2 Orthophotos covering the whole country

Orthophotos are available at the scale of 1: 50 000 covering the whole country. These orthophotos were taken from the aerial photographs of different scales and they cover an area of 15’ longitude by 15’ latitude. All these orthophotos maps were printed in black and white colours and available in digital format.

Table 1, parameters characteristics of the Namibian orthophotos coverage:

<table>
<thead>
<tr>
<th>Production Year</th>
<th>Aerial photo year</th>
<th>Resolution</th>
<th>Type</th>
<th>Ref. System</th>
<th>Projection</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 (North)</td>
<td>1996</td>
<td>5 meters</td>
<td>Black &amp; white</td>
<td>Bessel (1841)</td>
<td>Lo (Local syst.) Swede Survey AB</td>
<td></td>
</tr>
<tr>
<td>2002 (Central)</td>
<td>1996</td>
<td>2 meters</td>
<td>Black &amp; white</td>
<td>Bessel (1841)</td>
<td>Lo (Local Syst.) Geo Business Solution Pty Swede Survey AB</td>
<td></td>
</tr>
<tr>
<td>2004 (South)</td>
<td>1996</td>
<td>1 meter</td>
<td>Black &amp; white</td>
<td>WGS 84 UTM (modified)</td>
<td>Swede Survey AB</td>
<td></td>
</tr>
</tbody>
</table>
3.2.3 Orthophotos index (scale: 1:50,000)

The orthophotos index was based on the 1:50,000 quadrants of 25x25 kilometres square grids. The quadrant of 25x25 kilometres squares was divided into four quadrants of 12.5x12.5 kilometres squares each. Figure 11 orthophotos indexes

![Orthophotos Index Diagram]

Figure 11. Orthophotos covers south western part of Namibia (Source: DSM-Namibia)

An alphabetical letter and numbers taken from the 1:100,000 scales and a quadrant name location taken from the 50K square grids were placed in the middle, and the quadrants of 12.5x12.5 kilometres squares were designated by numbers 1, 2, 3 and 4. Each quadrant of 12.5x12.5 square grid represents one orthophoto. Example: H10 NW 1, H10 NW 2, H10 NW 3, H10 NW 4. H10: is a unique number of the square grid of 1:100,000 Scale NW: North West (location in the quadrant of 25x25 square grid of the 50K Scale).
3.2.4 Namibia tourist map

Since Namibia has become a very common tourist place, with thousands of people visiting the country from different places of the world, it is also important to present the Namibia tourist maps on the web for the purpose of attracting travellers and tourist’s worldwide. Figure 12 tourist map of Namibia. In this project the same method was used in creating links between the maps displayed on the screen the one existing with the same functionality. So in this case the users will be able to download and display the map to check what kind of information is available on the individual maps.

Namibia is a land of mountains, rivers, beaches, dunes, and deserts, commercial farming and has much more to offer to its tourists such as luxurious lodgings, hotels, houses and cars. Almost all the towns in Namibia have some attractions to the tourist’s especially major towns like, Windhoek, Swakopmund and Luderitz. Other attractive areas include etosha national park, fish River canyon, skeleton coast, spitskoppe as well as the Kavango region. The thematic map were created for travellers and tourism purposes; in order to show the location of places of interest, to find ways to get there, and possible places for overnight stay.
3.2.5 Topographic map (scale 1:50 000)

The 1:50 000 topographic maps are only made for towns and villages. The map sheet names was chosen as the major town name shown. The relief of the topographic maps is shown by contours of 10 meters interval and also spot height. The grid lines in grey colour indicate the 1000 meters Universal Transverse Mercator (UTM), and the red grid lines indicate Geographical coordinates (Longitude, Latitude). Figure 13 topographic map cover an area of Oranjemund.

These maps contain important information for planning and decision making. All maps are printed in colours and available in digital format.
3.2.6 **Topographic map (scale 1:250 000)**

The 1:250 000 topographic maps show topographical features by means of names, contours, intervals, spot height, boundaries, grid lines in grey colour and red grid lines indicate geographical coordinates (Longitude and Latitude). Figure 14 topographic map at the scale of 1:250 000.

**TOPOGRAPHIC MAPS (SCALE 1:250 000)**

![Topographic map at the scale of 1:250 000 (Source: DSM-Namibia)](image)

Figure 14. Topographic map at the scale of 1:250 000 (Source: DSM-Namibia)

Projection: Transverse Mercator
Geodetic Datum: WGS 84
Central Meridian: 17°

The height depicted by means of contours at 100 m intervals. The topographic maps contain important information for sustainable development, planning and management processes. The edition year (2006), scale of the Map, publishing authority (DSM) is given and also the map index is shown in the upper right corner with a square grid around the map sheet being shown.
4. DISCUSSION

Currently, the Namibian network has been designed and established by the DSM in cooperation with Swedesurvey of Sweden. Swedesurvey using Bernese Software version 5.0 did the computation of all observations.

The main concern is that, the Namibian government should try by all means to find donors to establish more GPS permanent stations at some of the Nam-Zero stations, so that they will be equipped as permanent stations in the future and could also be a part of AFREF. If permanent stations would be established on other stations than the Nam-Zero in Namibia it is important that the relation between the permanent stations and the zero-order stations are measured properly. So in this case, the accurate will be produced. Also the Ministry should inform the public to avoid damage or destruction of the stations, which are very important for entire Namibia.

Given the fact that it is a developing country and technology with the help of internet is growing rapidly, the government of Namibia has been focusing on its attention of establishing a transparent and open door policy to all users, at the national and international levels by distributing information via internet, where all the information related to survey and mapping can be found.
5. CONCLUSION AND RECOMMENDATIONS

The development of the computer and use of the internet plays a major role in modern technological changes in the world and have also influenced the way we handle geographic data. Since the DSM decided to serve the geo-spatial data through world wide web, the first thing is that the department must try by all means to solve the problem of the internet connection, which it is often off. Poor internet connections may delay communication between the staff and clients who may wish to obtain or deliver information on time. At the present, the Nam-Zero has been converted to ITRF 2000 (epoch 2005.0). The established and maintaining Nam-Zero need a support to satisfy many of the goals and objectives of AFREF at national and regional levels. To achieve this, it might require the installation of a fully operational GPS permanent station, which would provide high accuracy down to the centimetre level. When establishing GPS permanent stations, the DSM of Namibia must take into account, the fact that these permanent stations must be located to some of the Nam-Zero. Again, the same department should build up manpower capacity to train more staff in order to gain skills and knowledge in the specialization areas like IT specialists and other related skills for future success. Last but not least, the creation and use of web site for the distribution of geographic data to domestic and international clients will promote planning and management processes for sustainable development in Namibia.
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### Site Description

**Date** – 00, 2007

**Station Name:** WINDHOEK (WIND)

**Description of Station:** Concrete Pillar

**Cartesian Coordinates**

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
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</thead>
<tbody>
<tr>
<td>5633708.7701</td>
<td>1732017.7103</td>
<td>-2433985.7960</td>
</tr>
</tbody>
</table>

**Geodetic Coordinates**

<table>
<thead>
<tr>
<th>Lat</th>
<th>Lo</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>-22 34</td>
<td>29.713464</td>
<td>17 5 21.954726</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1734.6677</td>
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</tbody>
</table>

**Reference ellipsoid:** GRS 80

**Position**

The GPS permanent station situated on top of DSM

**Markings**

Situated in the Municipal area of Windhoek

**Registration Division:** K

**Region Name:** Khomas

**Republic of Namibia**

Surveyed in March 2005 by:

DSM, Swedesurvey & Strydom Associate staff

Description is written by

Rachel N. Munyakazi
### Appendix 2

### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AFREF</td>
<td>African Geodetic Reference Frame</td>
</tr>
<tr>
<td>DSM</td>
<td>Directorate of Survey and Mapping</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>IERS</td>
<td>International Earth Rotation and Reference Systems Service</td>
</tr>
<tr>
<td>IGS</td>
<td>International GNSS Service. International network of permanent</td>
</tr>
<tr>
<td>ITRF</td>
<td>International Terrestrial Reference Frame</td>
</tr>
<tr>
<td>Nam-zero</td>
<td>Namibian Zero Order Stations</td>
</tr>
<tr>
<td>SURCON</td>
<td>Namibia council for profession land Surveyor, technical surveyors and survey technicians</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
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</table>