

Shaping South Africa's Future with GIS – The 1999 General Election Experience

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*'Some see things that are and ask "why?";
Others dream things that never were and ask "why not?"'*

George Bernard Shaw

Summary

The first South African democratic election held in 1994, in spite of being declared to be free and fair by international monitors and the Independent Electoral Commission (IEC), was marred by accusations of irregularities. The main cause for concern was that there had been no voters roll and any person over the age of eighteen who could by some means of identity prove that he or she was a South African citizen was eligible to vote.

The IEC mindful that for the 1999 General Election such a procedure would not have been acceptable to either the electorate or the international community convened a meeting in October 1996 with major role players who they had identified as collectors and suppliers of essential base information. The purpose of the meeting was to examine the viability of completing the capture and conversion to digital form of the country's cadastre, various layers of topographic data of the 1:50 000 national map series and the enumerator areas (EA's) which had been used in the 1996 Census and using these data sets as the building blocks on which the 1999 General Election could be based.

The enormity of their request can best be judged when considering that at that stage less than 4 per cent of the approximate eight million land parcels and 75 per cent of selected topographical data had been captured while serious doubt existed as to how accurately the 87 000 EA's of Census '96 had been demarcated.

The paper describes the requirements of the IEC, the availability of the essential data sets, the time scales set for various phases of the project by the IEC and how the task of capturing the eight million land parcels and the boundaries of the 87 000 EA's in less than 15 months and combining these data sets prior to adding the 1996 Census data was achieved. The delimitation of the voting districts and the adding of various layers of the 1:50 000 topographical data set as a backdrop for the maps produced is also briefly addressed.

Finally the paper examines the challenges now facing the major role players in maintaining the data and the opportunities for marketing the information.

Introduction

In 1994 South Africa held its first non-racial, democratic election with close to 20 million votes being cast to give an estimated poll turnout of around 85 per cent. The election, however, highlighted the lack of an effective, coordinated, and integrated land information system within the public sector as a tool for meaningful decision-making. Although a census had been held in 1991 assumptions regarding population distribution had been made which proved to be completely wrong when compared to the reality on the ground. There had been no voters roll and in some areas there was a huge surplus of ballot papers while in other areas these had to be airlifted by helicopter to satisfy first time voters clamouring to exercise their vote. It was obvious that such a situation would not be tolerated for future elections.

The Chief Directorate of Surveys and Land Information of the Department of Land Affairs had as early as 1988 taken steps to initiate an information system. Although a wealth of land-based information existed little progress had been made since there was no approved policy within Government for the management of such data. Fragmented infrastructures existed and most organisations within the public sector continued 'to do their own thing'. In the final analysis the IEC with its political clout and financial resources proved to be the catalyst in the successful implementation of the system.

Requirements of the Independent Electoral Commission (IEC)

The three major role players, namely the Chief Surveyor-General, the Chief Directorate of Surveys and Mapping and Central Statistics in accepting the challenge in October 1996 to establish and complete the required information system by April 1998 recognised that a number of almost insurmountable problems would have to be resolved especially in view of the fact that most of the required data sets had not been captured let alone converted to digital format or where available were in a form not usable for integration with other data sets. Together with the IEC they identified the following data sets as essential components for the corporate database:-

1:50 000 Topographical Map Series:

- communications (roads, railways and bridges);
- hydrography (rivers, pans, lakes and dams); and
- built-up areas.

Census '96

- demography (age, population distribution, gender and enumerator boundaries).

Cadastral

- cadastral land parcels (erven, farms, open spaces, parks, streets and names);
- local authority, regional council and provincial boundaries; and
- magisterial districts.

To meet the requirements of the IEC the following objectives had to be met:

- Enhance the Topographical database by completing the capture of identified features of the 1916 sheets comprising the 1:50 000 Map series.
- Enhance the Cadastral database by verifying and updating the captured rural data and capture the urban data.

- Establish an Enumerator Area(EA) database and capture the boundaries and data;
- Establish a Corporate database by integrating the EA's and the Cadastral data and adding the selected topographical features and the 1996 Census data ;
- Use the Corporate database to establish and demarcate Voting Districts.

Availability of essential data sets

The topographical database

South Africa is fortunate to have complete topographical map coverage at a scale of 1:50 000 – the largest scale series covering the country and comprising 1916 sheets. The series was initially completed in 1971 and metricated by 1991.

In 1986 approval had been given to the Chief Directorate of Surveys and Mapping to carry out a pilot project to set up an information system based on the 23 sheets of the 1:500 000 national map series with the purpose of establishing procedures to convert the existing 1:50 000 mapping data into digital data and the subsequent processing and manipulation of this data as input into a topographical information system.

Since 1992 a concerted effort had been made to capture the communications, hydrography, built up areas and hypsometric data of the 1:50 000 series. By October 1996 more than 75 per cent of this data had been captured while for the remaining sheets the selected features, communications, built up areas and hydrography, were available.

The enumerator area database

Another significant event in South Africa's post-apartheid era was Census '96. In October 1996 all the people of the country were counted as members of a unified nation for the first time. For the purpose of the census the whole country had been divided into approximately 87 000 small geographic areas with distinguishable boundaries called enumerator areas (EA's). Each EA consisted of from 100 to 250 households, the size being determined by whether it was located in a densely or sparsely populated area. Because of the large number of squatter settlements within urban areas a household was defined as a person or group of people living together for at least four days a week.

There were 34 500 EA's situated within formal urban areas under the control of either a municipality or local authority and 6 500 formal rural EA's under the control of regional bodies while the remaining 46 000 so called informal EA's covering less than 20 per cent of the area of South Africa included the informal (squatter) settlements as well as some 13 000 communities and villages. The serious doubt that existed as to how accurately these EA's had been demarcated soon became apparent. In the rural and informal areas existing maps were out-of-date and the proposed aerial photography programme on which it was intended to base the demarcation was severely hampered by continuous heavy rain and cloud cover.

In many areas reliance had to be placed on descriptions with the result that many boundaries were frequently found to be unreliable. Additionally the EA numbering system had been inadequately controlled with the result that EA's within a particular magisterial district had often been given the same number. Furthermore in many areas there were no street addresses and numbers had been painted onto the walls of dwellings so that these could be listed within an EA. This led to very serious problems during the demarcation and surveying of the EA boundaries.

Cadastral data

Mindful that the cadastre of a country, together with the topographic mapping, supplies the base on which modern society operates, the need for an integrated, distributed land information system made up of these data sets had been timeously recognised by the Chief Surveyor-General and the capture of the cadastral data in the offices of the Surveyors General had started in 1990.

Fortunately the South African coordinate based system of defining cadastral land parcels was ideally suited to the establishment of a computerised database.

The advantage of the system is that:

- every piece of surveyed or registered land can be accounted for;
- demarcation of land has been carried out since 1685 when the first grants were issued and the Surveyor-General as the custodian of survey records is in possession of the data for the beacons and boundaries of all land parcels;
- since 1927 all surveys for registration had, where possible, been based on the national control survey network; and
- each land parcel has a unique designation.

During 1994, much effort had been expended on the establishment of a State Land Information System. This structured spatial database contained all the rural land parcels in the country, some 380 000 in number, and added to this was the 1:500 000 topographic information giving the infrastructure and hydrography of the area. This project greatly facilitated setting up the procedures which were used to capture the urban land parcels.

A number of the larger local authorities and other parastatal bodies had captured cadastral data and this was available in digital format. This data after having been verified was incorporated into the existing spatial database.

However, in spite of all the work that had been done since 1990 less than 4 per cent of the more than seven million land parcels in the country had been captured at the commencement of *Project Miracle* in February 1997.

Time scales set by the IEC

In terms of the South African constitution the General Election had to take place no later than June 1999. To accomplish this, the registration of voters should have ideally commenced in June 1998. This would have required the delimitation of the voting districts to have started in January 1998. Based on these timescales the capturing of the cadastral and EA data as well as the establishment of the Corporate Database needed to be completed by December 1997.

The cadastral spatial database was completed in November 1997, the enumerator area database in April 1998 and the corporate database was in place by the end of May 1998. Although the delimitation of the voting districts had started prior to this date the main thrust occurred from June to September 1998. Registration finally commenced in November 1998 and the General Election is scheduled to take place on 2 June 1999.

The methodology

Enhancing the topographical database (*Project Merge*)

The major task entrusted to Surveys and Mapping was to ensure, where possible, that features appearing in the Topographical Database which were also boundaries of either an EA or a land parcel would coincide with the data from the other relevant data set. Anomalies between topographical features such as roads, railway lines or rivers which formed a cadastral or an EA boundary were minimised by merging the topographical feature and the cadastral or EA boundary.

Enhancing the Cadastral database (*Project Miracle*)

Project Miracle completed the capture and topological structuring of the 7.2 million urban and the verifying of the 380 000 rural land parcels during the period February to November 1997 using the available resources in the offices of the Surveyors-General and employing 270, initially untrained, contractors who worked double shift and later a third and fourth shift, in-house, under supervision. The process consisted of capturing coordinates, where these existed, from diagrams or general plans, digitising the data where no coordinates existed and scanning and vectorising as a last resort especially in those cases where digitising was not suitable. This latter process reduced the capturing time for a specific number of land parcels from seven days to two days. The featurising process which followed data capturing was mainly concerned with the checking of the drawings prior to the featurising of all the information contained in the drawing. The final process involved substantial quality checking. During the entire process the major emphasis was placed on completeness and content rather than a high degree of accuracy. Street names, a vital component of the published maps were added where available and an update routine was developed for improving accuracy as better data became available. It is estimated that under normal circumstances it would have taken from five to seven years to complete the project.

Establishing the enumerator area database (*Project Eagle*)

Project Eagle involved, not only, the capturing of the 1996 Census data, but also, the capturing of some 87 000 enumerator areas which had been used in Census '96. The capture, demarcation and survey of the 34 500 formal urban EA's were outsourced to contractors in the private sector, while the 6 500 formal rural EA's were captured by Surveys and Mapping. The capturing and survey of the bulk of the 46 000 EA's situated in the informal areas was outsourced to two private contractors, while Surveys and Mapping captured the informal settlements in Gauteng and in the Cape Town metropolitan area. The work involved both the capture of the boundaries in the field using mainly GPS and aerial photography as well as the capture of the maps.

These maps in digital form together with the descriptions of the EA's were submitted to the offices of the Surveyors-General for validation, combining and finally featurisation. The combination process in particular proved to be time consuming especially where the descriptions did not match the digital map.

Furthermore in many cases urban and rural EA's either overlapped or there were gaps between the two boundaries. The process also involved the establishment of an alphanumeric database which described the EA boundaries.

Establishing the corporate database (Project Elf)

Project Elf combined the EA database with the cadastral database. The relevant merging and embedding procedures were subjected to rigorous quality assurance checks. This involved not only a location check, but also content and integrity checks. Finally the census data was added.

Establishing and demarcating the Voting Districts.

The corporate database that was assembled contains approximately 50 Gb of data distributed over a number of file servers and comprises the complete distributed Cadastral database, with a total size of 36 Gb, the 1:50 000 Topographical data set, approximately 8 Gb in size, and the EA database which is 9 Gb in size.

The pre-delimitation process involved quality assurance to ensure that there was complete coverage for the entire country. The preparation also required that all local or regional authority boundaries in the corporate database be verified and that where these boundaries are co-located, they should coincide with the EA boundaries. In many cases two adjacent local authorities were under the mistaken impression that a certain area fell under their jurisdiction or even that it fell outside their jurisdiction. Once these disputes had been resolved the boundaries were updated and captured into the corporate database. After a QA process had verified the changes the delimitation process was undertaken.

Semi-automatic demarcation of voting districts was performed by accessing the data per local authority. Certain constraints were introduced to ensure that voting stations would be within easy walking distance. To achieve this the boundaries of a voting district, where possible, do not:

- cross natural barriers such as national roads, railway lines and rivers; do not include more than 3 500 persons in an urban area and 1 200 in a rural area;
- require persons in an urban area to travel more than 7.5 kilometres and those in rural areas more than 15 kilometres to a voting station.

The building block for each voting district was an EA consisting of between 100 and 250 households and using the preliminary 1996 census data voter population as a guide. Once the delimitation process had been completed, the data was cartographically enhanced, for optimal text placement and colours, where after readable A0 maps were printed for each local authority or regional body. Some larger municipalities required up to 100 A0 maps. At the same time another project identified areas which lacked backdrop data. This was then supplemented with vector backdrops obtained from parastatal and other organisations, orthophotos obtained from various sources and the alphanumeric data which described the EA boundaries.

These maps were then sent to the local authorities or regional bodies for amendment where necessary and for evaluation by the Party Liaison Committee before being returned to the IEC. As part of the evaluation, a primary and secondary choice for a voting station per voting district had to be indicated. A further restriction is that there can only be one voting station per voting district.

The final phase of the project was to carry out the necessary amendments to the A0 maps and capture and add the voting stations. For the registration of voters and election purposes each local or regional authority will receive an A0 and A3 map of each voting district within its area of jurisdiction. In total more than 18 000 maps have been produced to meet all the requirements of the IEC. An interesting feature of the map is that the legend contains the voting district number in barcode format to facilitate the electronic scanning and tracking of the maps within the processes of the IEC.

The initial registration of voters took place in November 1998 and on 30 April 1999 the IEC achieved a historical milestone when South Africa's first ever common voter's roll was certified and presented to the Deputy President, just a mere two and a half years after the commencement of the project.

Looking to the future

As we approach the new millennium it is evident that with the advance of technology the demand for the utilisation thereof in a large variety of applications ranging from land management to spatial analysis will continue unabated. The Chief Surveyor-General and Central Statistics are indeed fortunate that the requirements of the Independent Electoral Commission has accelerated the establishment of their spatial databases by at least five years. Land Information, however, is dynamic and to ensure that decision-makers and planners are using up to date information the challenge will be to maintain these databases on an ongoing basis. There is also a need to improve the accuracy of the databases and to improve quality control. Furthermore the linkages between the data especially cadastral data, topographical data, statistical data, land use data and remotely sensed data will become increasingly important in revision and maintenance procedures.

There has already been a significant increase in requests for digital data and products. The data of Central Statistics is a vital data set in any development project and in due course is likely to be available from their web site. The Chief Surveyor-General has created a web site which enables users to view the cadastral data with the topographical data as a backdrop. There are plans afoot to include the diagrams and general plans in the database, no later than December 1999. Surveys and Mapping is presently developing a web site to be able to facilitate the supply of topographic and related information. It will, however, be necessary for these organisations to ensure that their data is readily accessible to users and that facilities for payment are enhanced to enable users to download the data directly from the web sites.

While the continued need for an integrated, distributed land information system made up of the various data sets that have been collected has been widely accepted it remains to be seen whether the major role players will place the interests of the country above their own or whether they will continue 'doing their own thing'.

