Geomatics in mining: The need for consolidated geodatabases for improved planning and decision making

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Abstract

With $2,5-trillion in mineral reserves and an estimated 184 years of production, South Africa holds the world’s largest mineral reserves. There are over 600 operational mines in South Africa and the industry accounts for 8,8% of South Africa’s nominal gross domestic product (GDP), and closer to 18% of GDP if all of its induced effects are considered. The statistics above illustrate the massive role that mining currently adds and has to offer in the future of the South African economy; yet staggering figures of unemployment and underutilisation of the countries resources are evident.

This paper will illustrate the value that geomatics, geographical information systems (GIS), surveyors and related geospatial professionals can add to the South African mining industry by identifying and populating gaps in available information. It will illustrate ways in which national geospatial systems need to develop in order to achieve growth and development that contribute towards national development planning.

This paper will act as a proposal for the development of national geodatabases that will allow the numerous sources of information (environmental, social, geological, topographical, economical, etc.) to share and access spatial information through a central custodian and centralised web-based geodatabases. It will also illustrate how the conglomeration of skills (surveyors, engineers, data administrators, GIS professionals and programmers) will assist in developing the industry in a sustainable and transparent way.

This paper will incorporate various important aspects such as data integrity, metadata capture, temporal and spatial accuracy, professional accreditation; and industry and professional standards required for the development of a centralised geospatial framework that will be viable and effective.

Whilst mining will be used as an industry case study, this paper will serve to act as a guideline to various industries in need of information that is stored centrally and accessible through various web-based platforms for decision makers.

South Africa’s long-term plan is based on the National Development Plan (NDP): 2030 which states the country needs focused leadership, a plan for all, institutional capacity, resource mobilisation and clarity on responsibility. A solution for the dissemination of geospatial data through a central/national custodian, in conjunction with relevant national agencies and regulatory bodies will assist in meeting some of these critical success factors.

Keywords

National Development Plan (NDP), geographic information systems (GIS), National Geospatial Information (NGI), Chief Surveyor General (CSG), Web Map Service/Web Feature Service (WMS/WFS)

Introduction

The South African government, through the National Planning Commission, published the National Development Plan (NDP): 2030. The plan outlines various strategic objectives, critical performance areas, and long-term policy frameworks to ensure that South Africa is more sustainable, better governed and has a holistic vision moving towards 2030.

"Critical Success Factors of the NDP include:

- Focused leadership
- A plan for all
- Institutional capability
- Resource mobilisation and agreement on trade-offs
- Sequencing and willingness to prioritise
- Clarity on responsibility” [1]

Numerous strategies, long-term plans, policy frameworks, public-private partnerships are suggested within the NDP and as a whole it can be summarised as a plan that looks at holistic solutions from various spheres of society including government, private firms, and the civilian population.
This paper will use the South African mining industry as a case study to argue for the consolidation of the many geospatial databases currently available through government, parastatal and private agencies. It will use the NDP as a guideline from which to promote the ideology of shared resources through web-based applications such as web-map/web-feature services to work towards the advancement of the geospatial industry in South Africa.

To quote the NDP, “Business, labour and civil society are diverse groupings and rarely speak with a common voice” [2]. This statement although generic, is very apt in the context of the relationship between government and the private sector in the mining industry. Furthermore, inter-governmental communication and information sharing; and the relationship between private companies remains segregated. How will the economy develop if critical information is not adequately shared? The sharing of data, ideas, information, and resources is limited within the current model and this hampers the development of the Department of Mineral Resources (DMR), mining companies, contractors and consultants who in theory should be working together to build a sustainable and transparent knowledge economy.

The way it stands: South African mining industry

South Africa by all accounts is a mining giant. "It hold the world's largest mineral reserves with US$ 2,5-trillion and the centrality of mining is illustrated by the fact that nearly 60% of the country’s export revenue is attributable to mining, mineral and secondary beneficiated products. In country league tables, South Africa’s mining industry in 2008 ranked fifth in the world in terms of the contribution of mining to GDP” [3].

State custodianship of resources

“The mining industry in South Africa is governed by the Mineral and Petroleum Resources Development Act (MRPDA) of 2002. The act overhauled the Minerals Act of 1991 and with it came the abolishment of the property-law based system whereby landowners no longer owned the mineral resources on their property. This was replaced by the public trust doctrine of state custodianship under which the state, acting through the minister, holds mineral rights and is empowered to ‘grant, issue, refuse, control, administer and manage’ rights to minerals” [4].

This is important for discussion since the custodian of the nation’s mineral resources should technically be the custodian of all information pertaining to those resources. This includes the spatial location of the resource, the entities that have been assigned the rights to the resource, technical information about the resource (quantity/geological models of the resource), the social environment surrounding the resource, the state of the biophysical environment surrounding the resource, and the logistical and infrastructural systems that determine transportation and export of the resource.

Cognisance of the regulatory framework forms the basis from which any system or framework needs to be planned from as an holistic system that looks to address data/information storage, access, rights, standards, accessibility and dissemination should incorporate a model that is line with all existing regulatory and legal frameworks that in theory are determined from national through to local government structures.

A system that works, whether economical, political, information technology (IT) or geographic information systems (GIS) should be designed around a framework that is in place, is governed through legal systems, such as legislation, and is therefore aligned to a framework that has an existing structure.

The way it stands: Geospatial professionals in the South African mining industry

The South African geospatial industry is large and diverse. The list of professional categories amongst the South African Geomatics Institute (SAGI) and the Geo-information Society of South Africa (GISSA), and the regulatory body PLATO include land surveyors, engineering surveyors, mining surveyors, photogrammetric surveyors, GISc practitioners and hydrographic surveyors [5].

Many of these professionals work in the mining industry, either directly for mining companies, as sub-contractors to the mining industry or the plethora of consulting companies providing services to the mining industry. The mining industry has a large spatial and geospatial component that requires professionals from the application for prospecting/mining right phase, to the pre-feasibility and feasibility phase where geologists spatially depict 3D resource models based off exploration results, to the environmental impact assessment phase where specialists map the impacts on the environment for their various disciplines, to the ground/aerial survey that allows engineers to start designing the mines, to the operational phase of mining where mine surveyors perpetually map the operations and design new expansion facilities. The relationships between mines, social systems (communities), the bio-physical environment, and infrastructure that link private entities to the national transportation an electricity networks all have a spatial component.

The diversity of professionals with various skills creates a data management challenge itself as each of these professionals will operate within different business units i.e. exploration geology, mine geology, survey, engineering, drafting, GIS, etc. This creates a situation whereby a private mine may not have a central database of all its information
as each sub-unit will have its own standard operating procedure, along with its own server, and hence segregation of data and information becomes a challenge at a very early stage of operation.

This is where professional bodies and regulatory institutions need to become involved in the process. Do regulatory bodies require members to submit all their plans and spatial data for technical review, authorisation, and storage? If they do, what happens to that data or information? In all likelihood, this information will be briefly screened and archived into a data repository that will only ever be re-accessed should it be required in a legal battle or arbitration procedure, whereby all such information is forcibly obtained via summons. The above would assume that the afore-mentioned process would only occur provided the professional responsible for the data is registered with their respective professional body, a scenario that is not always the case.

Current institutions: Diversity of geospatial datasets

National government and parastatal institutions

The current system is not entirely derelict and uncensored. There are numerous government and semi-government agencies that have well maintained, up-to-date, verified and usable datasets, along with associated metadata, that are disseminated through open, web-based platforms that require little more than a username and password.

An example of such geodatabases include:

- **South African National Biodiversity Institute (SANBI)**

The South African National Biodiversity Institute (SANBI) Biodiversity GIS: National databases include the National Biodiversity Assessment 2011 illustrated, the National Freshwater Ecosystem Priority Areas (NFEPA), the National Landcover 2009 dataset, the National Vegetation Map 2006 to name a few. Figs. 1 and 2 illustrate the system interface and available data.

![Fig. 1: SANBI Biodiversity GIS interface snapshot.](image-url)
The CSG, in conjunction with the NGI, is the custodian of the national survey in South Africa. They are responsible for the national cadastral dataset and topographic map sheets for the whole country. Data in hardcopy and raw format is available to the public free of charge.

The CSG released the spatial component that visualises all land parcels and administrative boundaries in South Africa. Fig. 3 below illustrates the interface that allows for selection of individual farm portions.

The CSG also has a web-page that allows search and download of surveyor-general (SG) diagrams through a search engine.

The CGS is the custodian the official geology data (1:50 000, 1:2 500 000 and 1:1 000 000 scale) available for South Africa. Such information is available for purchase to the public. This data is not available for view in a WMS/WFS.

Statistics South Africa collects a large amount of GIS information for South Africa and they are commissioned with
large projects such as the national census. Statistics SA released the Beta version of the Digital Census Atlas after the 2011 census. Fig. 4 illustrates this atlas:

![Digital Census Atlas](image)

Fig. 4: Statistics South Africa Digital Census Atlas – population distribution by municipality [9].

- **Other government agencies**

Other examples of spatial data available through national agencies include the Municipal Demarcation Board that is commissioned with the demarcation of South Africa's provincial, district and local municipalities, the Department of Water Affairs (DWA) which controls the National Groundwater Archive (NGA), although there are various spatial inaccuracies within this data, and the Arc Institute for Soils, which releases the national soils dataset for South Africa. Eskom also has a large GIS section that produces maps and spatial data for the country's electricity transmission and distribution lines. The Council for Science and Industrial Research (CSIR) has a geoportal [http://gsdi.geoportal.csir.co.za/](http://gsdi.geoportal.csir.co.za/) [10] that provides various hyperlinks to suppliers of GIS information at national, provincial, municipal and private level.

The examples above illustrate the diverse source of spatial data in the country. The scale, quality, spatial and temporal accuracy naturally differ based on the methodology of data collection, the source of the data, and the intended purpose of the data. Budgetary, skill and resource limitations also affect quality of the data available. Metadata is available for most of these datasets, generally in a pdf format that outlines the data description, copyright holder, the origin of the data, source of capture, scale at which data was captured, date captured, organisational details and contact information, spatial datum and projection of data, detailed notes, and the various attribute fields within the data.

- **Private companies and individuals**

Much harder to quantify, list and rate is the quantity, scale and quality of spatial data produced by private firms, freelance professionals and private individuals. Despite talk of nationalisation, the mining industry in South Africa remains heavily privatised. The nature of the mining industry, where geological bodies can have economic values of billions of rands, means that mining companies are not inclined to share information that may provide their competitors with useful insight into geological resource bodies. The culture of the mining industry can be described as “secretive” where mining company employees, contractors, sub-contractors and consultants are bound by strict confidentiality agreements.

Although this may seem regressive in thought and against many models of open source data theory, it has to be remembered that the outset capital expenditure of mining companies is large and private mining companies will not risk leaking critical information into the public domain that could potentially jeopardise the value of their investment.

Mining companies spend millions of rand on data collection, acquisition, storage and warehousing, utilising a web of skills as mentioned previously. Much of this data collection includes resource modelling, ground/aerial survey for
infrastructure planning, environmental authorisation studies, including traffic, groundwater, surface water, fauna and flora, wetlands, soils, air quality, noise, and visual, to satisfy government regulations to obtain authorisation and water use permits. These plans, along with engineering drawings, closure cost plans, and a host of other spatially based data in GIS and CAD formats result from these processes.

Whilst this data/information will be kept confidential for a period of time, regulatory procedures such as the submission of environmental impact assessments to government departments, subject to review by the public, means that this data does enter the public domain. Engineering plans need to be submitted to local authorities for approval in order to receive construction and building permits. This means that a large amount of this data is available to the public.

Fig. 5 illustrates the spatial location of projects at a specialist water and environmental company that renders 70% of its services to the mining industry and large scale industrial projects. For many of these project locations, a wealth of GIS and CAD data exists including mine plans, high-level environmental data, ground and aerial survey data, mining and prospecting leases and rights, cadastral ownership information, etc. If all the mining companies, contractors and consultancies that deal with spatial data had to submit such data to national regulators/agencies, a wealth of very-high level information could be discovered.

Fig. 5: GCS project locations map [11].

Once this information has entered the public sphere, there is no reason why it should not be freely accessible to the general public through a national agency that has verification procedures and a database of registered users with different levels of access. Highly sensitive data/information should only be accessible to high-level, appropriately designated officials as such data/information could be of national significance or compromise national security, for example it would not be in the best interests of the country to publish all gas pipeline data due to the potential security risk.

Possible solution: National custodianship of spatial data

The data management procedures are complex within any organisation. Various sources of data, in different formats and different versions often result in confusion. Each company and government agency will have different database and data structures suited to their needs and various information and content management systems can be used for data structure and warehousing purposes.
National custodian data centralisation framework

The solution below is not system specific. It also does not take preference of open source or proprietary software. Such guidelines are already in place within different government departments and agencies. The solution is an organisational framework that incorporates existing organisations, agencies and regulatory bodies. The model illustrated in Fig. 6 represents a theory of centralisation through a top-down model where the custodian of all national data should be an organisation equipped with the necessary capacity both financially and technically, such as the NGI/CSG.

![Fig. 6: Suggested framework for national data centralisation.](image-url)

The framework above has three main levels:

- **National custodian**

  The national custodian should be a large government agency such as the NGI in conjunction with the CSG. Their responsibilities should include:
  
  - Development of a web-based map service (WMS/WFS) to disseminate and serve information to the public.
  - Set national geospatial standards.
  - Set national metadata capture standards, such as International Organisation for Standardisation (ISO).
  - Act as a central custodian for the centralised geodatabase.
  - Provide direction and framework for the South African geospatial industry.
  - Regulate the national geospatial industry.

- **National agencies**

  National agencies include existing government institutions and agencies that prepare specialist geospatial datasets, such as SANBI, Statistics South Africa, Eskom, the CSG, etc. Their responsibilities should include:

  - Provision of specialist datasets on a national scale.
  - Develop internal spatial frameworks based on the guidelines set by the national custodian.
  - Enforce internal standards in line with the national custodian guidelines and specifications.
  - Commission necessary data collection surveys.
  - Develop national – local authority data structures and frameworks.

- **Professional registration bodies**

  Statutory professional bodies, such as the South African Council for Professional and Technical Surveyors (PLATO) and the South African Council for Natural Scientific Professions (SACNASP) should enforce their members to submit all their plans and data for review. This would assist with industry regulation and standardisation and act as a platform
for data collection. Once approved to have met regulatory standards, this information could be sent to the national custodian for centralisation and dissemination. Their responsibilities should include:

− Set data standards amongst their registered professionals in line with NGI guidelines
− Set metadata standards amongst their professionals.
− Approve and authorise geospatial data.
− Liaise with the national custodian to monitor geospatial developments.
− Regulate industry and data standards and provide directions to professionals.

Conclusion

A wealth of geospatial data is available in South Africa. This data is critical for various sectors of the economy. Mining, one of the largest industries in the country, is particularly reliant on accurate spatial data, information and databases for planning, operation and decision-making.

Access to information is a constitutional right in South Africa as section 32 of the Constitution of the Republic of South Africa, No. 108 of 1996 (“the Constitution”) provides:

(1) Everyone has the right of access to – (a) any information held by the state;" [12].

It is therefore the responsibility of professionals, their regulatory bodies, and government to ensure that South Africans have ways in which to access information that is accurate and transparent.

South Africa’s long-term plan is based on the NDP: Vision 2030 which states the country needs focused leadership, a plan for all, institutional capacity, resource mobilisation and clarity on responsibility.

A solution for the dissemination of geospatial data through a central / national custodian, in conjunction with relevant national agencies and regulatory bodies will assist in meeting some of these critical success factors.

This solution calls for integration and better communication amongst all levels of society, from national government to professionals within the mining industry. It will also aid decision-makers in all spheres of society who will have access to better quality databases and WMS/WFS. High quality data and information will result in better decision-making that will ultimately benefit the country as a whole.

References


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