Prospects, Challenges and Strategies in the Implementation of the Nigerian Computerized Mining Information System

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ABSTRACT

The mining sector of mineral-producing countries serves as a veritable foreign exchange earner and a provider of job opportunities for their citizens and other stakeholders. Computerization of mining cadastre procedures and operations has significant multiplier effects on the earnings from the sector in particular and on the national economy in general. A Computerized Mining Information System (CMIS) or Computerized Mining Cadastre (CMC) is a computer-based system that maintains a database of mining licenses with their ownership status, time validity, geographic location of their mineral concession areas, fees and dues paid, and other relevant information. An operational CMC should cover all the transactions that occur during the entire life cycle of a mining title from the initial application, through the granting of the license, payment of annual fees, tracking of the necessary annual reports, re-assignment or lapsing, and final relinquishment of the title. The system must, as a rule, support tools and functionalities for the execution of a number basic tasks, including applicants and holders management, data encoding, data conversion and transfer, priorities and encumbrances checking, geometric validation of concession areas, management of digital registers, titles monitoring, spatial queries and map visualization, management of system parameters, generation of statistical reports and management of user roles, privileges and rights. The goals of such a system are to strengthen investors' property rights and security of tenure within the mining sector, enhance the transparency of the mineral licensing process and support government's regulatory capacity through improved efficiency, information availability and management. In this paper, we present the prospects, challenges, and strategies in the implementation of a computerized mining information system for the Federal Republic of Nigeria within the framework of an on-going project named "Sustainable Management of Mineral Resources Project (SMMRP)".

1. INTRODUCTION

For many years, the mining sector has remained a positive core contributor to the sustainable socio-economic development of mineral-producing countries. Recent economic research findings indicate that earnings from solid minerals contribute a handsome share of the Gross Domestic Product (GDP) of such countries as Ghana, South Africa, Australia, Canada, the USA, among others. In 2007, for instance, the mining sector contributed 5% to Ghana's GDP, accounted for 12% of its government's revenue, comprised 41% of total export earnings and employed over 500,000 people; contributed 7% to South Africa's GDP, accounted for 12.4% of its total company tax, provided 25.2% of the country's total foreign exchange earnings and employed slightly under a million workers; contributed $42 billion or 3% to Canada's GDP, with mining industry payments of $8 billion to its government, constituted 19% of total exports, and provided direct employment of 363,000 people(Alison-Madueke, D., 2009). In Nigeria however, the situation is pathetically paradoxical: the country is extraordinarily endowed with a vast range of solid minerals and yet the mining sector contributes only a paltry 1% to the nation's GDP (Alison-Madueke, D., 2009). To redress this moribund situation, the government of Nigeria has over the past few years, made aggressive efforts towards the institutionalization of the necessary strategic frameworks for the mining sector to thrive. Principal amongst these recent initiatives has been the enactment of the Minerals and Mining Act of 2007 which marked a watershed moment in the solid minerals development in Nigeria. This Act establishes the foundation to revamp and revitalize the mining sector through the establishment of:

- conducive macro-economic environments for mining investment;
- clear, stable legal and regulatory frameworks;
- well-defined institutional responsibilities;
- transparent and non-discretionary procedures;
- stable, competitive and fair fiscal regimes.

A key component of the plan to revitalize and resuscitate the Nigerian mining sector is the computerisation of the procedures of the Mining Cadastre Office (MCO), the principal public institution that manages mining titles in the country. The goals of such a system are to strengthen investors' property rights and security of tenure within the mining sector, enhance the transparency of the mineral licensing process and support government's regulatory capacity through improved efficiency, information availability and management. In 2007, the setting up of a new computerized cadastral system took off within the framework of an on-going World Bank-funded project named "Sustainable Management of Mineral Resources Project (SMMRP)" coordinated by the Project Management Unit (PMU) under the Ministry of Mines and Steel Development (MMSD) of the Federal Republic of Nigeria. The new Computerized Mining Cadastre (CMC) was handled by GAF AG, a German-based company with tremendous international reputation for excellence in geo-informatics software design and implementation. The activities and services in Nigeria follow those offered in countries like the Democratic Republic of Congo, Madagascar and Namibia, where the company has successfully set-up and operationalized nation-wide computerized mining titling systems since several years. The principal objective of the services to be offered under the Nigerian Mining Cadastre computerization project was the setting up of a new cadastral organization for the management of mining titles, guaranteeing their transparency and performance, as well as the security of the mining property in an economically and environmentally sustainable manner (Wever, T. et al, 2007). The new organization would be integrated by a central office in the capital city of Abuja and six decentralized regional cadastre offices.

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In this paper, we present the prospects, challenges, and strategies in the implementation of the new computerized mining information system for the Federal Republic of Nigeria. The rest of the paper is structured as follows. Section 2 describes the institutional context of the Nigerian Mining Cadastre while Section 3 presents the operational status of the Mining Cadastre Office prior to the establishment of the New Mining Cadastre. The prospects of the new computerized cadastre are presented in Section 4 while the constraints and challenges encountered during the project implementation are outlined in Section 5. The strategies adopted in the project implementation are detailed in Section 6. The paper concludes in Section 7 with a description of the level of success hitherto achieved and some recommendations for future expansion of the project.

2. INSTITUTIONAL CONTEXT OF THE NIGERIAN MINING CADASTRE

From an institutional standpoint, the Mining Cadastre is a key management system for accessing mineral resources and monitoring sector performance. The establishment of a public register and the application of non-discretionary, consistent procedures as part of the Mining Cadastre are critical to ensure transparency in the granting of mineral rights, to guarantee the security of tenure, and to facilitate the management of competing land uses (Ortega, E. G. et al, 2009). The Nigerian Minerals and Mining Act (2007) clearly defines the structure, responsibilities and functions of all the public mineral institutions (PMIs) in Nigeria as departments and agencies under the Ministry of Mines and Steel Development. Figure 1 depicts the administrative hierarchy of the various Nigerian PMIs, including the Mining Cadastre Office.

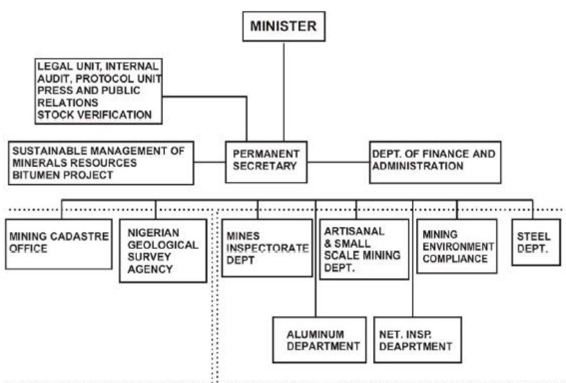

Figure 1. Administrative hierarchy of Nigerian PMIs under the MMSD

As an agency responsible for the administration of mineral titles in Nigeria, the Mining Cadastre Office is charged with the following responsibilities:

- acting as a liaison between the MMSD and the holders or applicants on any question related to mineral rights;
- receiving and considering applications for mineral titles and permits, issue, suspend and revoke any mineral title;
- receiving and disposing of applications for the transfer, renewal, modification, relinquishment of mineral titles or extension of areas;
- maintaining a chronological record of all applications for mineral titles in a priority register and a general register and undertake such other activities necessary for the carrying out of its duties and responsibilities under the provisions of under Act;
- producing updated cadastral maps on which existing minerals rights, pending applications, and areas restricted for mining activities are correctly plotted;
- verifying that licenses do not overlap (especially in the case of new applications), checking the eligibility of applicants, and making decisions to grant or refuse applications;
- keeping cadastral maps and registers open and accessible for public consultation;
- acting as a technical referee in the event of dissension between holders about the location of areas granted and resolving any disputes resulting from the definition; and
- collecting administrative fees required for the submission of mineral rights applications, as well as annual rental fees for valid licenses.

Administratively, the Nigerian Mining Cadastre Office comprises of a central office located in the federal capital city of Abuja and six zonal offices located at the zonal headquarters of the six geo-political zones in the country. Figure 2 depicts the administrative structure of the Nigerian MCO showing the hierarchical relationships between its various sections (Directorate, Legal unit, Accounting unit, Concession unit, Registry and the zonal offices).

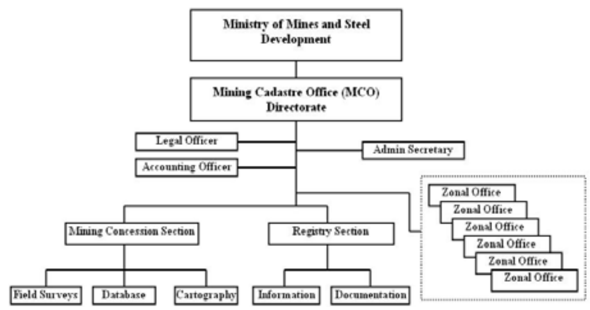

Figure 2. Institutional structure of the Nigerian Mining Cadastre

3. OPERATIONAL STATUS OF THE NIGERIAN MINING CADASTRE PRIOR TO THE NEW SYSTEM

A common feature of the process of implementation of a Computerized Mining Cadastre is the transition from a system characterized by standard paper files and analog-based methodology to digital methodology. In the process of computerization of the Nigerian Mining Cadastre, the migration from the old paper system to the new system of computerized mining procedures was a gradual process that spanned three broad evolutionary phases: the pre-cadastral phase, the interim cadastral phase and the new computerized cadastral phase.

The Nigerian Mining Cadastre Office was established in October, 2005 and opened to the public in May, 2006. The period before this epoch can be regarded as the pre-cadastral phase while the period between the inception of the MCO and the commencement of the new computerized mining cadastral project can be regarded as the interim cadastral phase. The two phases preceding the full computerization phase were characterized by a number of features, developmental milestones and events. During the pre-cadastral phase, all mining cadastre activities were undertaken manually by the Mines Department in the Ministry of Mines and Steel Development (MSMD). The activities were centrally controlled with the initial steps in the application procedures decentralized to the thirty-six existing State Mines Offices and the Federal Capital Mines Office in Abuja (Kahra, A., 2007). The structure of the mining property during this phase was characterized by four basic types of licenses: the Exclusive Prospecting Licenses (EPL), the Mining Leases (ML), the Quarry

Leases and the Quarry Licenses. Moreover, there were "Prospecting Rights" (not giving exclusive rights) and "Special Prospecting Licenses" where the granting conditions were variable and discretionary (Wever, T, 2007).

Usually, modern cadastral systems are based on a pre-established regular grid system (specific or generic) defining the limits and spatial extents of the licenses (Ortega, E. G. et al, 2009). However, licenses captured during the pre-cadastral period were characterized by irregular orientation and geometry with no restriction on the size of a concession area. The topographic infrastructure of Nigeria for cadastral purposes is usually based on the 1:50.000 maps (1404 map sheets) covering the entire country (Wever, T, 2007). Although the granting system for pre-existing licenses was to be based on these official topographical maps, the coverage of the maps was not complete for the whole country with 163 map sheets missing. Moreover, the triangulation network which was established between the 1950's and the 1960's had an irregular accuracy. During the pre-cadastral phase, only six points belonging to the primary network had been measured with high accuracy GPS technology during the early 1990's and the transfer of the GPS coordinates to the Nigerian map coordinates (using the available transformation algorithms) was not homogeneous.

The establishment of the Nigerian Mining Cadastre Office in October, 2005 and its subsequent opening to the public in May, 2006 marked a watershed moment in the evolution of the Nigerian Mining Cadastre from the old to the new system. In preparation for transition from the old to the new (computerized) system of title administration, a revalidation exercise was undertaken to clean up the mining title registry of all irregular mineral titles and bring the geometry of applications and titles to conform with the new standard grid-based mining cadastral representation system (Kahra, A., 2007). This migration process was carried out while satisfying a fundamental requirement of guaranteeing the maintenance of existing mineral rights and status of registered applications, thus minimizing the risks for title-holders and the administration. The revalidation of all titles existing during the pre-cadastral period involved a systematic process of inventorying all transactions (applications, transfers, assignments, modifications, cancellations, etc) on licenses over time and the transformation of the geometries of all affected licenses from the irregular, non-quadrangular polygonal representation into a new quadrangular tessellation representation using a 15"x15" square as a cadastral unit (CU). This process basically entailed the discretization of the original license polygons into regular polygons with specific multiples of cadastral units and resulted in the transformation of 842 extant titles into a new cadastral system the properties of which are summarized in Table 1 below. With the opening of the Mining Cadastre Office in May, 2006, new title applications were received and processed based on the newly established standards.

The revalidation of old mineral titles and the processing of new applications during the interim period culminated in the generation of a preliminary database of six types of licenses (see Table 2) containing administrative data (company names, addresses, phone numbers, etc) on applications and title holders, administrative data on applications and titles (application data, license type, map sheet number, local government and state, fees paid, application and license status, etc) and geometrical information (position and size) on all applications and titles.

The task of transformation and migration of existing cadastral data from the old paper-based system to the new, standardized digital model necessitated the introduction of a new codification system and the recoding of all documents in keeping with the requirements and criteria of the new digital system of data representation and processing. In preparation for the migration of the preliminary mining cadastral information to a new computerized system, two separate databases were created and populated to maintain the administrative and geometrical data on applications and titles as follows:

- a set of Microsoft Excel files containing all administrative data on applications and titles (contacts, fees, application dates, etc) with numerical application numbers used as identifiers of applications/titles;
- an AutoCAD Drawing file containing the geometries of applications and titles with numeric application numbers employed as labels to identify corresponding concession areas of applications and titles.

In addition to the two digital databases, paper-based registers (priority and general) were created, populated and maintained for the different license types.

System property	Definition
Grid Scale	1:50,000
Coordinate System	Geographic on Minna datum
CU Dimensions	15" x 15" (463m x 456m)
CU Type	Generic
CU Surface Area	Approximately 20 Ha
Total Number of CUs	Over 3 million

Table 1. Properties of the CU System adopted for Nigerian Mining Cadastre

License Type	Code
Reconnaissance Permit	RP
Exploration License	EL
Small Scale Mining Lease	SSML
Mining Lease	ML
Quarry Lease	QL
Water Use Permit	WUP

Table 2. License types maintained in the Nigerian Mining Cadastre

4. PROSPECTS OF THE COMPUTERIZED MINING CADASTRE

Over the past few decades, the huge advances in information and communication technology especially in hardware processing power, graphics libraries, distributed computing paradigms and user-friendly application software packages have revolutionized the development of applications in diverse disciplines. In particular, the computerization of mining cadastral procedures and operations has engendered a new environment of positive growth in the management of mineral rights. A Computerized Mining Cadastre (CMC) is a computer-based system that maintains a database of mining licenses with their ownership status, time validity, geographic location of their mineral concession areas, fees and dues paid, and other relevant information on applicants, holders, applications, licenses and other ancillary data. An operational CMC should cover all the transactions that occur during the entire life cycle of a mining title from the initial application, through the granting of the license, payment of annual fees, tracking of the necessary annual reports, re-assignment or lapsing, and final relinquishment of the title.

The benefits and prospects of a computerized mining cadastre for Nigeria as a solid mineral-producing nation are legion. The primary goals of such a system are to strengthen investors' property rights and security of tenure within the mining sector, enhance the transparency of the mineral licensing process and support government's regulatory capacity through improved efficiency, information availability and management. The multiplier effect of this scenario is the increase in the activity of the mining sector which translates to increased employment potentials, reduction of poverty and increase in national wealth. A CMC can therefore benefit all stakeholders in the mining sector including, administrators, mining investors, external users and the national government in diverse ways. More specifically, the following are some of the benefits accruable from mining cadastre computerization:

(1) Computerization of cadastral operations brings immense benefits of higher peak throughput capacity in the processing of mineral titles, thereby ensuring a significant decrease in the time required to assess cadastral dossiers, allowing applicants and titleholders to avoid long and potentially costly waiting periods between application and cadastral decisions and, in the case of renewals or transformations from exploration licenses into exploitation licenses, shorter waiting times mean a significant increase in the security of tenure.
(2) A CMC allows early detection and correction of errors and mistakes in the processing of cadastral documents linked to mineral rights geometry or positioning, as well as conflicts related to overlaps between adjacent licenses before titles are granted, contributing even more to the security of tenure for mineral rights.
(3) A CMS helps to prevent users from manipulating or violating cadastral procedures, thereby ensuring the strict application of legal provisions, a decrease in opportunities for discretion and corruption, and, consequently, a further enhancement of the security of tenure.
(3) A CMC ensures instantaneous access for applicants, titleholders, industry and external users to up-to-date cadastral information, including the most recent applications, thereby helping to prevent misunderstandings and conflict over which areas are vacant or occupied. This has the added advantage of increasing transparency, and minimizing possibilities for corruption.
(4) A CMC accords external users the opportunity of gaining instantaneous access to non-confidential information in the database through the dissemination of digital cadastral information over the Internet, thereby further increasing the transparency of cadastral procedures.
(5) Exploration of the historical cadastral database using supported interface tools ensures increased efficiency in the automatic generation of statistical products, thereby facilitating the analysis of the status of the mining sector, cadastral management, and the impacts of mineral resources policy on the mining sector.
(6) A decentralized CMC provides services that can be extremely useful for titleholders and applicants, enabling them to avoid lengthy and sometimes unaffordable trips to the cadastre headquarters and allowing for the normalization of many irregular mining activities.
(7) A distributed CMC can be linked with other databases and information systems within the framework of the National Geospatial Data Infrastructure (NGDI) to promote the sharing of up-to-date geospatial information, thereby increasing transparency in sector activities.

In view of the huge prospects and the vast benefits of a CMC, it would not be conceivable today to implement a new cadastral methodology without the support of a computerized system of cadastral operations (Ortega, E. G. et al, 2009).

5. CONSTRAINTS AND CHALLENGES

Despite the existence of an efficiently operational analogue (paper-based) cadastre, the transition from analogue to computerized methodology is usually fraught with a plethora of institutional, administrative and technical constraints and challenges that tend to pose serious threats to the success of the computerization exercise. In the implementation of the new computerized Nigerian Mining Cadastre, these constraints and challenges can be linked to the status and structure of the operating environment of the cadastre prior to and during the entire period of the computerization exercise and are related to such issues as the status of the existing analogue and digital cadastral database, availability of requisite supporting data sets, existence of enabling laws and regulations relating to cadastral procedures, availability of basic supporting infrastructure, and administrative structure of the cadastre.

As stated in Section 3 of this paper, the pre-computerization digital database maintained by the NMC consisted of two disjoint data repositories, one in Microsoft Excel format maintaining administrative data and another in AutoCAD Drawing format maintaining the geometries of the applications and licenses. This digital database was to be cleaned and ridded of errors of inconsistencies preparatory to its migration to the new integrated cadastral database during the computerization process. Unfortunately, the disjoint system posed enormous challenges. Although the two disparate data sets contained numeric identifiers (application numbers) as links between the applications and their corresponding perimeters, these links were not unique in most cases. The administrative data component contained numerous errors and inconsistencies, namely, spelling errors, poor database integrity, existence of multiple copies of same database with different contents, excessive duplication of records, total absence of data for majority of the fields and many other errors. The maintenance of application and title perimeters also posed non-trivial challenges. First, the plotting of the perimeters was done in different spatial layers without data attribution (only labels were used to tag the features). This inefficient system resulted in a graphic database characterized by the following problems and anomalies: existence of overlaps between perimeters due to plotting inaccuracy, existence of multiple copies of the same concession perimeter in different locations, existence of multiple copies of the same concession perimeter in the same location, absence of attributes for easy linking with the administrative data component (only labels were used as tags), existence of multiple labels (application numbers) of the same concession perimeter, absence of labels for some polygons, existence of multiple copies (versions) of the same geometric database on different stand-alone computers. The result of this inefficient system was the maintenance of an inconsistent database that led to the erroneous granting and issuance of some licenses during the interim cadastral phase. The major challenge therefore was a long and costly process of database cleaning, consolidation, integration and migration to the new computerized system.

One other big challenge encountered in the computerization process was the paucity of requisite supporting datasets. Although the majority of the 1/50,000 topographic maps of Nigeria upon which the cadastral was to be based were available, a number of gaps still existed in the cartographic coverage. Moreover, the much needed spatial data on restricted areas (military zones, religious areas, reserved forests, tourist sites, etc) were missing during the computerization process. The dearth of the above important data sets resulted in the implementation of an incomplete database from the perspective of a standard computer-based cadastral system.

The Nigerian Minerals and Mining Act came into force in 2007 shortly before the commencement of the mining cadastre computerization project. However, the Mining Regulations facilitating the application of the Act was never ready throughout the entire period of computerization. This posed a huge challenge during the design and implementation phases of the project execution since most of the computerized procedures had to be implemented on temporary basis.

It is an indisputable fact that adequate, un-interrupted electric power supply constitutes basic infrastructure supporting a successfully computerized system. However, during the course of computerization of the Nigerian mining cadastre, electric power supply in the host country was pathetically erratic. This situation resulted in long project idle times and, in most cases, painful data loss.

The goal of the Nigerian mining cadastre computerization project was the implementation of a decentralised system of computerized procedures with the main front-end and database domiciled at the Mining Cadastre headquarters and connected to the zonal offices through digital communication links. A major technical challenge encountered during the project implementation was the design of an optimal system capable of harmonizing and synchronizing application registration processes of the various zonal offices and the central office in the face of inadequate communication infrastructure.

All the identified constraints and challenges were tackled during the design and implementation stages of the computerization project by adopting well articulated strategies.

6. IMPLEMENTATION STRATEGIES

6.1 Project Objectives

The strategies adopted by the consultant in the Nigerian Mining Cadastre computerization project were in strict compliance with the specified project objectives which included:

- To elaborate the cadastre procedures for the whole legal framework (renewals, cancellations, etc.) and to set-up the complete (including the regional offices) new organization of the mining cadastre.
- To implement the new working methodology and the new cadastral procedures in agreement with the provisions of the new Mining Act and its Regulations, taking into consideration the specific characteristics of the decentralized cadastre.
- To implement a decentralized computerized system for the management of the mining titles, including the computerization of the new cadastral procedures, and the data exchange methodology between the central and the decentralized regional offices.
- To install adequate technical capacity required to check and to control (on the terrain) the boundaries of the titles, mainly in case of litigations between the titleholders.
- To train the Nigerian Cadastre team in the operation and use of the new computerized system.
- To reinforce the equipment of the Mining Cadastre, including the regional zonal offices, including hardware and software for cadastral data processing, as well as geodetic instrumentation.
- To design and to implement a specific website for the Nigerian Mining Cadastre, making available public access to cadastral information through the Internet.

6.2 Project Implementation Tasks

With a view to ensuring a smooth transition from the old, analogue system to the new computerized mining cadastre system, the tasks undertaken were completed under four project phases as follows:

- Pre-computerization phase.
- Design and implementation phase.
- Installation, testing and debugging phase.
- Project maintenance phase.

Pre-computerization phase: The major tasks executed during this phase involved data collection and organization in preparation for migration to the new system. The specific tasks executed in this regard included:

- Inventorying and verification of all existing applications and titles stored in Excel and AutoCAD formats to ensure data consistency, integrity, completeness and currency.
- Design and implementation of a new codification system for the general and priority title registers.
- Analysis of the existing legal context to determine the cadastral procedures.
- Design and allocation of physical office space in keeping with the cadastral workflow.
- Design of administrative forms and other cadastral documentation (application forms, license notification letters, license certificates).
- Acquisition of necessary hardware and software.

The screened Excel files were finally cleaned by eliminating duplicate entries, completing missing entries and correcting spelling and other errors. The license geometries in AutoCAD format were also cleaned by eliminating duplicates and overlaps, resolving positional conflicts and correcting attribution errors. The two separate databases were then linked together and validated using the new codification system.

Design and implementation phase: This phase involved a number of tasks as follows:

- Design of a new integrated, distributed database.
- Design and implementation of a user front-end.
- Design of the computer network structure.
- Design and implementation of the Mining Cadastre Website to host non-confidential documents and information for external users.

The design and implementation of the integrated computer-based system required a number of software applications and tools as summarized in Table 3.

An integrated relational database consisting of several core data tables (contacts, applications, titles, coordinates, fees, minerals, etc), ancillary data tables (LGAs, states, map sheets, etc) and configuration tables (users, title types, access rights, etc) was designed using MS Access 2003 with database keys and integrity links established between the relational tables. The major relational tables maintained in the system database include, contacts, applications, titles, application and title coordinates, fees, minerals and system parameters.

Application/Tool	Function
Microsoft Access 2003	Relational DBMS, programming
ArcGIS 9.2	Map composition and printing
MapObjects 2.4 OCX	Programmable map control for map processing and visualization
MS Office Development kit	Development and deployment tools.
FMS components	ActiveX components for programming data transfer functions
Visual Basic 6.0	Programming of external tools

Table 3. Software applications and tools used in the implementation.

In order to query the database and perform various user operations, a dedicated user front-end incorporating a GIS component and several reporting tools, named **SIGTIM** ("**S**ystème **I**nformatisé de **G**estion de **Ti**tres **M**iniers" - **Computerized System for Mining Titles Management)** was designed and implemented by a GAF AG's crew of expert programmers specialized in database management systems, GIS, cartography, geography and geodesy. The software was specifically designed and implemented to be fully compatible with the law and regulations in force in Nigeria and to cater for the complete title application process in place at the Mining Cadastre Office.

The structure of the decentralized (distributed) information system was designed considering availability of network infrastructure and other prevailing local conditions.

A Website dedicated to the new computerized mining cadastre project was also designed, registered and activated in close collaboration with the clients. The Website was designed (for the benefit of all Internet users) to maintain cadastral documents and other data items deemed to be non-confidential within the context of the cadastre.

Installation, testing and debugging phase: The acquired supporting computing facilities (workstations, input/output devices, network infrastructure, etc) were installed, followed by the capture, transfer, conversion and integration of input data/information into the system. During this process, the administrative and geometric databases were migrated into the system and subsequently subjected to further cleaning and validation. Other required supporting spatial data sets in ESRI Shapefile format (administrative maps of Nigeria showing the states and local governments, bitumen blocks as restricted areas, 15-second cadastral grid map covering Nigeria, 1:50,000 index map of Nigeria, 1:100,000 index map of Nigeria, road network map of Nigeria, hydrographic map of Nigeria and a complete Landsat TM mosaick coverage) were loaded into the system.

The installed system was presented as a basic system after which several tests of functionality were conducted using the following methods: multi-criteria data retrieval (alpha-numeric and graphic), geometric checks for overlaps and irregularities, editing and printing of cadastral documents, automatic calculation of surface rental fees, generation of statistical data and standard reports, control and accounting of payment of surface rental fees, etc. Bug reports were made available to the consultants through bug reporting forms. Based on the bug reports and independent program testing sessions, bug and error fixes were made on the SIGTIM software to bring the software to a more stable build level.

A number of focused, on-the-job training sessions were also conducted for the staff MCO to allow for an effective and efficient transition of staff to their new functions. Some of the themes of the training sessions were: general overview of the Law and Regulations as well as relevant aspects of the Land Law and its Regulations, cadastral procedures as derived from the interpretation and application of the Law and Regulations, basic informatics focusing on the use and operation of PCs, the operating system and basic office automation tools, system administration in preparation for the future system, database and network administrators, operation and use of SIGTIM, Geographical Information System (GIS) to acquaint the staff with the basic principles of a Geographic Information System in order to perform geographic analysis, cartographic representations and maps and to manage and update the cadastral database within SIGTIM, hardware/software training focusing on system maintenance, limitations, troubleshooting, and appropriate backup procedures, data conversion training, system and database design training, system application training, Global Positioning System (GPS) focusing on the theoretical principles of GPS, its capabilities and limitations as well as practical operation and applications in the context of the mining cadastre.

6.3 Presentation of SIGTIM

SIGTIM is an interactive, Windows-based application for mining title administration. It is a flexible, user-friendly interface that integrates GIS technologies for spatial data handling and efficient object-oriented paradigms using rules and workflow-centric approach to facilitate the efficient administration of mineral titles.

6.4 System Architecture of SIGTIM

The logical design of SIGTIM is based on a three-tier architecture comprising of the data access tier, the workflow management tier and the information presentation tier. The data access tier is the software component that manages data/information flow to and from the database. The workflow management tier consists of a set of business rules that manage the entire workflow of the application. The presentation tier consists of a set of tools and functionalities responsible for the capture and display of information managed by the data access tier under the control of the business rules defined in the workflow tier.

Based on a client-server architecture, the SIGTIM network consists of seven local area networks (one at the Cadastre headquarters and six others corresponding to the six zonal offices). All seven LANs are linked together through a domain controller installed at the central office. Each SIGTIM LAN consists of a database and the SIGTIM front-end running on a number of clients. The primary database hosting the entire cadastral information is domiciled at the Cadastre headquarters in Abuja with Internet communication links established with the zonal offices. The primary SIGTIM back-end consists of a centralized database of core data (data on applications and titles), spatial data (positional information on applications and titles), system configuration data (parameters for system configuration) and historical data (inactive data on applications and titles). Figure 3 describes the functional architecture of SIGTIM.

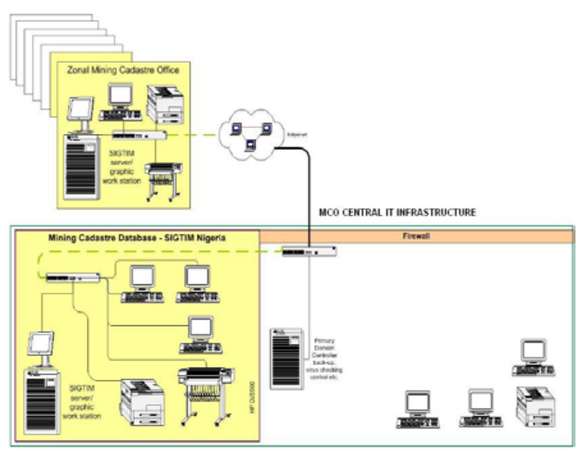

Figure 3. Functional architecture of SIGTIM

6.5 Modules, Tools and Functionalities

The SIGTIM software consists of several program modules performing several functions, including the following:

- Applicants and holders management.
- Digital encoding of applications data.
- Data conversion and transfer.
- Distributed processing of data.
- Priorities and encumbrances checking.
- Administration and geometric checks.
- Maintenance of digital registers.
- Lifetime titles monitoring.
- Multi-criteria spatial queries and maps visualization.

- System parameter configuration.
- Statistics on holders, applications and titles.
- Management of user privileges, roles and permissions.

Table 4 summarizes some of these modules and their functions.

CONTACTS	Applicants, holders, companies, individual, cadastral officers - Selections, sorts, searches
APPLICATIONS - REGISTERS	Encoding of all types of applications for new titles or titles modifications (renewal, enlargement, relinquishment, etc) - Automatic import of coordinates (Centres or corners) - Preliminary geometry check - Record keeping of digital cadastral registers
APPLICATIONS - LEGAL CHECKING	Analysis and appreciation of all requested administrative documents and recording of results
APPLICATIONS - MAPS CHECKING	Analysis of the area requested - Automatic encumbrances and overlap checking - Editing of the final perimeter
APPLICATIONS - FINAL CHECKING	Final recommendations analysis - Automatic production of notifications and certificates.
TITLES	Editing of all attributes : coordinates, fees, minerals, etc. Management of the whole life time - Recording of all actions and history.
FEES	Automatic calculation of the annual service fees for all titles - Payments management - Automatic receipt printouts.
IMPORT / EXPORT	Data export/import from zonal offices to the headquarter and vice – versa.
MAPS	Automatic display of any spatial or textual query - Production of official sketch map to be annexed to official title certificate - Printouts of large scale maps (Country, state, cadastral, topo sheet) - Automatic generation of shapefiles for the cadastral web site.
RESTRICTED AREAS	Editing of perimeters - Management of restricted areas.
STATISTICS	Various statistics on the main SIGTIM's objects: :Contacts, Applications, Titles, Cadastral units, Fees, Restricted areas, etc.
SETTINGS	Customizable secondary tables, System settings accessible from SIGTIM.
USERS	Access rights and security management.

Table 4. SIGTIM main modules and functions

7. CONCLUSION

This paper has discussed the prospects, challenges and strategies in the implementation of the new computerized Nigerian Mining Cadastre. Although the principles enunciated in the Nigerian Minerals and Mining Act of 2007 formed the legal basis for the implementation of the computerized cadastral procedures and operations, the absence of Mining Regulations throughout the main phase of project execution may have far-reaching implications on the future operations of the system. This is to be expected in a scenario where significant differences exist between the Act and the Regulations whenever the latter is produced and made available for public consumption. This may necessitate further lengthy and costly negotiations for project extension to redress the disparities.

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GAF AG (www.gaf.de) is an international company with leading competence and expertise in applied remote sensing and spatial information systems. The company offers a comprehensive portfolio of services ranging from the supply of geo-data (e.g. satellite and aerial imagery, digital elevation models), and geo-services (e.g. image processing, thematic mapping, GIS/DBMS applications and software development). It has a proven track-record in performing technical assistance projects in the overall natural resources sector and delivering customized geological and land information systems.

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