GUIDELINES FOR DEVELOPING AN IMPROVED INFORMATION PROVISION SYSTEM IN THE GEOLOGICAL SURVEY OF ZAMBIA

by

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Disclaimer

DEDICATION

This report is dedicated to my wife Wendy, for her patience and endurance during the period of my absence from home.

I love you very much.

.... and to our sons, Davies Munyama (Jr) and Nchimunya,

I treasure you so dearly.

ABSTRACT

Geological Information has become very essential today in Zambia than ever before. This is in the wake of the new mining policy that is intended to woo investors in the mining industry. The Zambian government has since 1990 embarked on privatisation exercise of all state owned mining conglomerates. This has brought about the need for vital background information for the new would-be investors. The information is used to decide whether to invest in a certain mining activities or whether it is worth exploring for certain minerals in different areas of the country. Information held by the geological Survey Department contains historical facts about the trend of activities that may have been occurring in those areas – borehole data, traverses, geophysical data, geological data, etc.

The Information Section has however, not lived to the expected standards. The storage, retrieval and method of dissemination of geological information in the department require complete change and improvement. There has been massive improvements in the GIS community which the storage, retrieval and dissemination of this information must be compatible with. For instance, investors would ask for digital data and accessing such metadata without having to come GSD.

The objectives of this study are twofold. The first objective is to give a summary description of the current situation of storage, retrieval and dissemination of geological information in the department. This will also help us to suggest possible changes to the information section and provide possible scenarios for change. Then we identify the requirements that the department would require to implement the changes. The second objective suggests the possibility of establishing an Electronic Front Door as a possible way to improve accessibility to the information in the department. Requirements for its development are thus discussed.

A number of recommendations to the department for the successful implementation are enumerated. A questionnaire to assist in identifying the main areas during implementation has been given in the Appendixes.

ACKNOWLEDGEMENT

I wish to acknowledge the people that made this study complete and a success. Many people contributed through their criticisms, advice and suggestions, I hereby express my sincere appreciation to them all.

I am greatly indebted to my main supervisor, Dr. M.M. Radwan, for his constant review of the initial write-ups that were very important at that stage of conception of the topic. His feedback and advice helped me make a concrete topic for the study.

I am also indebted to Mr. C.M Paresi for his initial advice on choice of an IFA topic. As my second supervisor, his timely suggestions on how to handle final assignments were very much appreciated and helped me to prepare for this study.

I owe special thanks to Mr A.M Tuladhar, who was so helpful during the absence of my supervisors. His valuable time, comments, suggestions and constructive criticism contributed greatly to the outcome of this report.

My sincere thanks to the Netherlands Government's Fellow Program (NFP) for granting me a scholarship to study in the Netherlands, without which, it would have been impossible to attain this level and knowledge.

Many thanks go to my Director of Studies, Mr A Brown and Mr Van den Worm GFM3 student advisor, for their candid support and guidance during this period of my study at ITC. My sincere thanks also to all GFM staff for their much-valued expert knowledge they imparted to me. I will also send my hearty felt appreciation to all my fellow students in the Division of Geo-Informatics and especially so the Optimisation of Geo-Information Processes (OGP) group, for the time we had to share ideas and knowledge during the course of study.

Finally, I acknowledge with great admiration the support and encouragement given to me by my wife Wendy, and *Uncle Juda.* Their endurance and perseverance during this one-year period of my absence from home is appreciated greatly. I know it was hard for all of us, but at the same time good for the best of our children.

It is not my intention not mention all those who contributed greatly to the fulfilment of this study, too numerous to mention here but I can rest assure you that your assistance and comfort extended to my immediate family and myself, during this study period is greatly appreciated.

Davies Muunga (Snr)
ITC
September 2001

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ABBREVIATIONS USED

AS-IS	= As it Is
BGS	= British Geological Survey
BSA	= British South African
DFD	= Data Flow Diagrams
DTM	= Digital Terrain Model
EFD	= Electronic Front Door
FGDC	= Federated Geologic Database Committee
GII	= Geo-Information Infrastructure
GIS	= Geographic Information System
GSD	= Geological Survey Department
HTTP	= Hyper Text Transfer Protocol
ICT	= Information Communication Technology
MHz	= Mega Hertz
MINEX	= Mineral Exploration
MMM-GSD	= Ministry of Mines and Minerals Development
MSOffice	= Micro Soft Office
NGO	= Non Governmental Organisations
PANGIS	= Pan-African Geological Information System
PC	= Personal Computer
QC	= Quality Check/Control
RAM	= Random Access Memory
SADC	= Southern African Development Community
SDW	= System Development Workbench
SWOT	= Strategies Strengths Opportunities and Threats
TO-BE	= As It Should Be
USGS	= United States Geological Survey
WF	= Workflow
WFMS	= Workflow Management System
ZCCM	= Zambia Consolidated Copper Mines
ZIMCO	= Zambia Industrial Mineral Company

1. INTRODUCTION

1.1. BACKGROUND

1.1.1. THE ROLE OF GOVERNMENT

The Zambian government has adopted a pragmatic mineral policy that is designed to enhance investment in the mining industry and to ensure the development of a self-sustaining minerals-based industry. The privatisation of many state-owned companies and especially the copper mining industry, formerly managed under the umbrella of Zambia Consolidated Copper mines Ltd (ZCCM), is a clear demonstration of this intent. The Ministry of Mines and Minerals Development is promoting enactment of this policy through the technical support available from its three constituent departments – Geological Survey Department, Mines Development and Mines Safety.

The Government of Zambia has enacted new legislation that will greatly simplify licensing procedures, places minimum reasonable constraint on prospecting and mining activities, and creates a very favourable investment environment, whilst allowing for international arbitration to be written into development agreements, should this be deemed necessary, The Mines and Minerals Act (1995). A framework for responsible development has also been created through publication of the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997.

1.1.2. SCOPE OF THE STUDY

The Government of Zambia has since 1991 implemented policies that attract investors in the mining industry. Efficient and effective dissemination of geological information to various stakeholders has proved to be very vital. However, due to flaws in the Geological Survey Department (GSD) information systems, there has been an urgent requirement for an improved information system that is technology driven. The report is focused on finding ways to improve the geological information provision system that is being hampered by the inefficient and old system of documentation and archiving.

1.1.3. AIMS AND OBJECTIVES OF THE REPORT

This report aims at developing an information provision system that meets the increasing demand for geological information in Zambia. It is based on the following objectives

- To determine shortcomings in the current geological information storage, access and provision and suggest possible scenarios to change and /or improve the existing system.
- To give guidelines for developing an Electronic Front Door (EFD for geological information provision in the department based on the new information system)

1.1.4. STUDY QUESTIONS

To help understand the goal of the study the following questions are raised and matched with objectives:

Objective 1

What is the AS-IS method of documentation and archiving of geological information in the GSD?

What are the performance problems in the current system in the GSD?

What are the goals for improvement?

What are the available alternatives for archiving, database creation and updating?

How are you going to evaluate the impact of these given scenarios and what are the requirements for implementation of the scenarios?

Objective 2

What are the main guidelines for development and implementation of an electronic front door to enhance access, data sharing and geological information provision?

1.1.5. STUDY METHODOLOGY

To achieve the objectives of this study within the context of the questions raised, the following tasks need be carried out. The Figure ***1.1.5*** below gives a broad overview of the study planned.

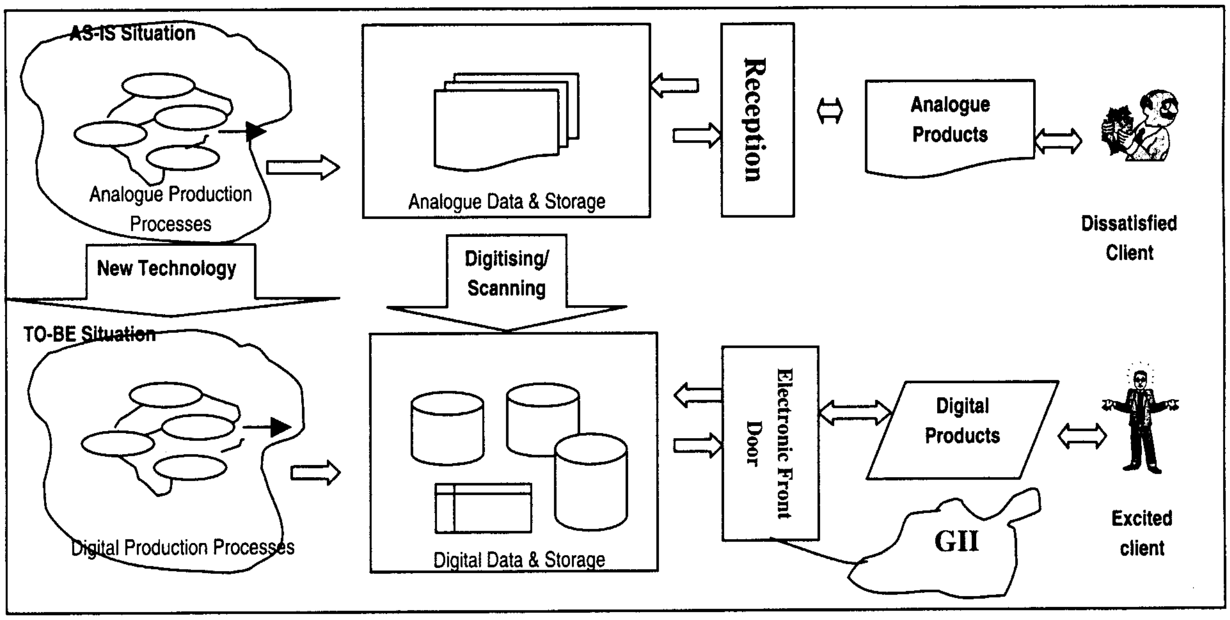

Figure 1.1.5 Conceptual Model of the study purpose

TASK 1: Comprehensive review of the AS-IS documentation and archiving system in GSD

- Methodology and Actions to take
  - ✓ Define the Product and services: the use, the user, frequency of production
  - ✓ Identify improvement goals within the department's information system
  - ✓ Discuss the steps and tasks involved in the provision of a geological information/map
  - ✓ AS-IS Flow Chart of provision of geological information/map

TASK 2: Proposed Re-engineering of the information system (TO-BE)

- Methodology and Actions to take

- ✓ Situation Analysis by environmental scanning: - identify change-triggering events, etc.
- ✓ Define current and possible new products and services and describe factors for the improvement of Quality and Quantity.
- ✓ Analyse user requirements and performance measures and describe the TO-BE information/data provision and database updating system.
- ✓ Study the Actions for change and strategic alternatives – SWOT and make the necessary changes in the processes to accommodate the desire for improvements and present the TO-BE situation.
- ✓ Define the information/Production system to support provision processes of geological information –terminators, DFD Context diagram, DFD Top Level Diagrams.
- ✓ Describe different scenarios of archiving, data basing, Information flow and show how they will provide different geological services and products (Achievements)

TASK 3: Critical review of the requirements for implementing the TO-BE situation

- ➢ Methodology and Actions to take
  - ✓ Identify technological support for implementing these scenarios by giving a brief description of GII and showing how the Geological Survey Information system will contribute to this GII.
  - ✓ What are the Human Resources required for the implementation? Does the Department have to recruit new staff, need for training the available staff; need to trim down the staff?
  - ✓ What type of organizational change is required: full and partial or none at all? And is there a need for Workflow change? Any additional processes, QC, WF concepts?
  - ✓ Any additional resources in terms of hard and software required for implementation
  - ✓ Identify the performance parameters

TASK 4: Describe how geological information can be provided through an electronic Front Door

- ➢ Methodology and Actions to take
  - ✓ Give a conceptual model for EFD
  - ✓ Give guidelines for the development of an EFD
  - ✓ State the requirement for implementing the EFD at GSD

1.1.6. STRUCTURE OF THE REPORT

To achieve the objectives if this study within the context of the aforementioned tasks, this report will be outlined as follows: -

Chapter 1 Introduction

This first chapter provides a brief background about the Ministry of Mines and Minerals Development Geological Survey Department (MMMD-GSD). It outlines the structure of the report as whole: Introduction, Aims and objectives, research questions and methodologies are discussed here.

Chapter 2 Existing Geological Survey Documentation system
This chapter describes the existing (AS-IS) information system in the geological survey and identifies the main performance problems. It reviews the current status of the archiving and documentation system and the role databases. It justifies the importance of good archiving, thus setting up general goals for improvements for the information system and services.
Chapter 3 Proposed Re-organization of the Geological Survey Information System
This chapter looks at possible reorganization of the Information system (TO-BE). It basically discusses the desired and improved information system that will give a diversity of products. The SWOT Matrix is used to analyse and identify Weaknesses, Strengths, opportunities and threats these are then used to identify actions for change and strategic alternatives.
Chapter 4 Scenarios for implementation
This chapter gives a range of possible scenarios of workflows that will support better archiving and database updating. It also looks at the system architecture for the Information. An evaluation of the impact of these scenarios is also given here.
Chapter 5 Requirement to implement these scenarios
This chapter discusses the main organizational and/ or technological support for implementing the scenarios and information system improvement in the department.
Chapter 6 Guidelines for developing an Electronic Front Door
Ideally, the information provision should be through the EFD and this chapter describes the main guidelines for its design and implementation.
Chapter 7 Conclusions and recommendations
The closing chapter shall contain concluding remarks and recommendations on the Business Plan for full implementation looking the Resources needed, full organizational change? Performance measures. How to introduce the change and How to test the impact of change

1.1.7. TIME SCHEDULE

Item	Task Name	Duration	Start	Finnish
0	Preparation/ Intro – GSD Background/ Status of GI in Zambia	5 days	Mon 16/07/01	Frid 20/07/01
1	Existing Documentation system - GSD	3 days	Sun 22/07/01	Tue 24/07/01
2	Proposed Re-engineering – GSD Information Provision	4 days	Wed 25/07/01	Sun 29/07/01
3	Scenarios for implementation /Technological support	5 days	Mon 30/07/01	Frid 03/08/01
4	EFD development guidelines & Conclusion/Recommendation	4 days	Sun 05/08/01	Wed 08/08/01
5	Reporting	14 days	Wed 01/08/01	Thu 16/08/01

Table 1.1.7 Time scheduling for the study

1.1.8. RESOURCES USED

- System Development Workbench (SDW)
- Microsoft Visio, Access, Project, PowerPoint
- Simple ++
- Laser Printer

2. CURRENT SYSTEM OF ARCHIVING IN THE GSD

2.1. INTRODUCTION

This chapter describes the existing system of archiving and documentation in the Geological Survey of Zambia. For the complete study and understanding of the topic, we shall also discuss the department's mandate, vision and mission. This chapter should therefore set a base for the analyses of the current situation (AS-IS) and the proposed (TO-BE) situation. Major problems and challenges that the geological survey encounters during the collection storage and dissemination of geological information are also discussed. Improvement goals are enumerated in line with the set objectives of the department

2.2. THE MANDATE: ROLES OF GEOLOGICAL SURVEY DEPARTMENT

The Exploration Consultants (1996) have stated that the vital role that the exploitation of mineral resources plays in development is self-evident, e.g., of Zambia's dependence on copper mining since the early 1970s. Zambia is endowed with many other mineral resources ranging from gems, industrial minerals and metals. These mineral resources have critically influenced its economic, political and social development, they have provided bases for internal industrial growth, for external income from world trade, and for national self-sufficiency. It is clearly evident here that one of the basic motivations in a country's national and international policy is desire for, and utilization of mineral resources. Its mineral wealth is not only a function of the original endowment, but depends upon the cost effectiveness with which such minerals as it might possess are sought for and developed.

The Geological Survey, being the national repository for all geological and mining information about Zambia, has a very important role to play in the search for mineral wealth. The nature of this role may range from the **provision of background information** to stimulate and support the activities of the private sector to a major direct involvement in exploration and prospecting.

The Director who is the officer responsible for all matters concerning survey and mineral exploration in the country heads the department, the Secretary to the Cabinet appoints him. The Department is composed of nine sections that are controlled by a Head of section who is responsible for all daily activities in that section. The sections include Regional Mapping, Economic Geology, Mineral Dressing/Metallurgical Laboratory, Chemistry Laboratory, Mineralogy and Petrologic Laboratories, Gemmology, Geophysics, Cartographic and Information Sections.

2.2.1. Services of The Geological Survey Department

Since it is the major function of the Geological Survey to provide the background geological information essential for assessing the mineral potential of any part of the country, it follows that the Survey's regional mapping program is the most important service, which it provides to meet more closely the specific requirements of that sector.

However, the other primary roles of the Geological Survey are to provide geological, geophysical and geo-chemical data on a countrywide basis, through its information section it acts as a national repository for all information relating to the geology of Zambia, and provide support and advisory services to the public. Contributing to these activities is a number of sections that provide a range of investigative services.

2.2.2. Products of the GSD: Geological Information (maps/reports)

Though there are many products and services that the department could provide, as discussed above in paragraph ***2.2.1***, the production, storage and provision of a geological map and report should be the main focus for this study. Mining and Exploration companies, Civil engineers, drilling companies, telecommunication companies, Geoscientists and other decision makers are the key users of geological information. Construction companies use geologic information to assess the suitability of potential areas for their construction purposes. Production of a geological map is usually done when funds are available. Lack of resources to implement some (old mapping) projects is a major problem for the geological survey. Consequently, there is usually a backlog of work to be done. Currently, a World Bank sponsored project has been going-on for the completion of mapping and sampling of the North-eastern and North-western parts of Zambia. This shall result in the production of more than 100 geological maps at 1:100,000 scale. The Figure ***2.2.2*** illustrates the production process for a geological map at GSD.

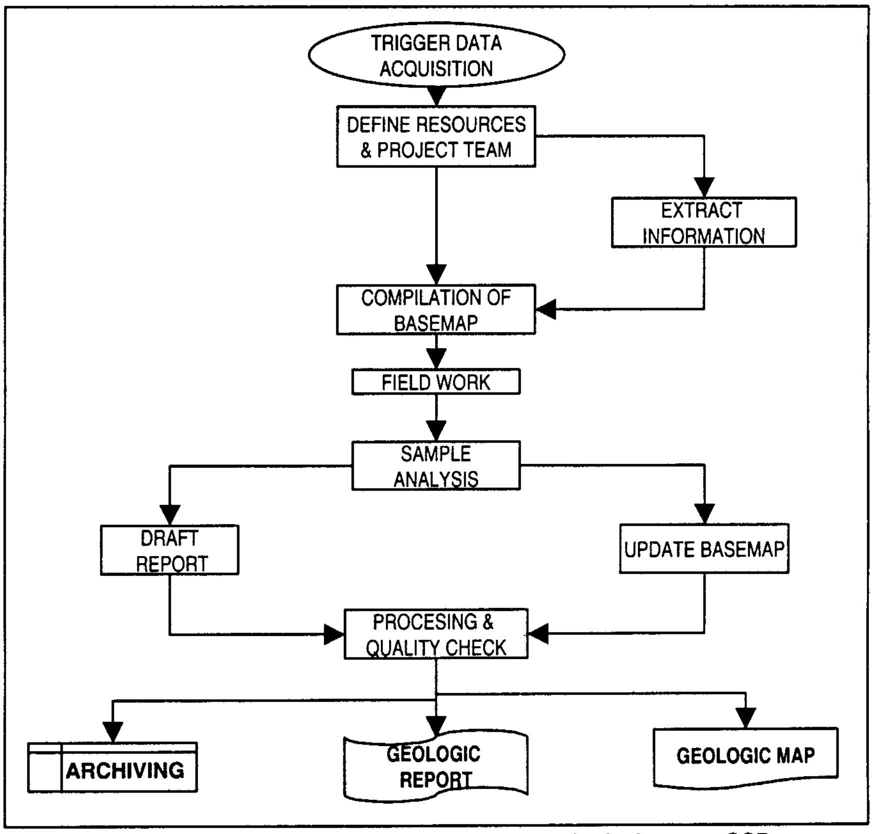

Figure 2.2.2 (AS-IS) Production process for a geological map at GSD

Mass production of standard products itself regardless of whether the products will be bought or not is another problem. Paper material has its own disadvantages; one is that the colour may fade with time especially in poor sanitary conditions as are prevailing in the department.

They also take-up a lot of space and create a storage problems. Sources of data acquisition for geological information production are field surveys, existing maps, and on a smaller scale from existing databases.

2.2.3. GSD: Performance towards rapid change in the GIS community

Despite the increasing need for quality geological information and other services, especially after the privatisation of the mining industry and revised the mining policy, the programs of the Geological Survey Department continue to be primarily concerned with the publication of geological, geophysical, structural and geo-chemical maps and reports that are of a standard nature. Through this system the department has accumulated a wealth of reports and maps. With the support of the World Bank and the European Union, the Department has almost completed the compilation and publication of a large backlog of geological maps and accompanying reports.

2.3. THE INFORMATION SECTION

Geological Survey Department has an Information Section; this is a documentation and archiving section of the department that is involved in the storage and dissemination of geological information in the department. Figure ***2.3*** below shows the processes for request handling in the geological survey.

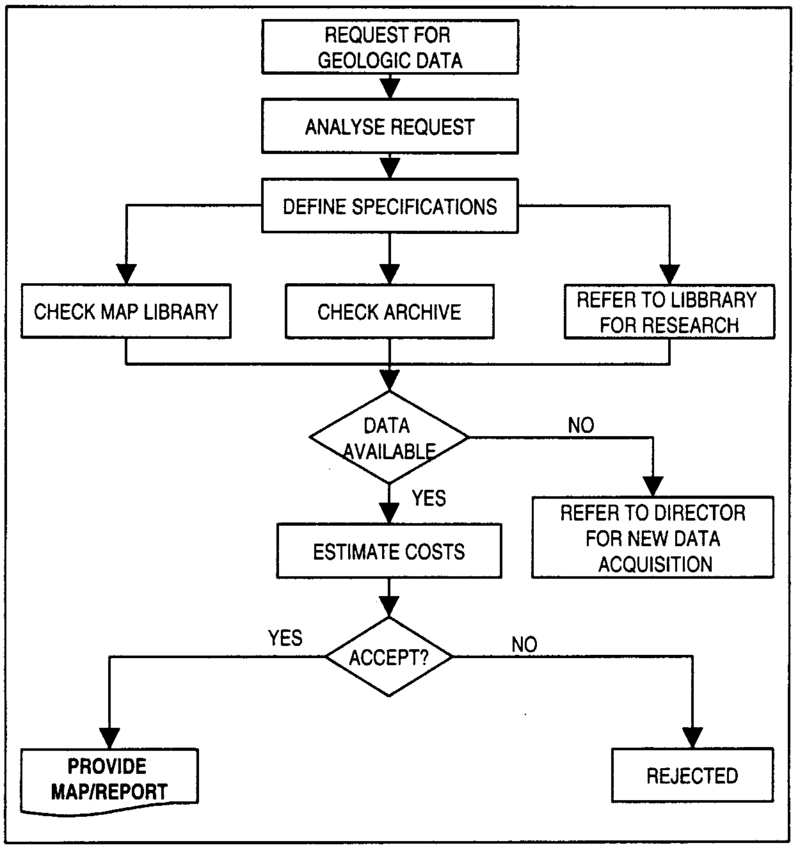

Figure 2.3.0 (AS-IS) structure for data capture and storage in the Geological Survey Dept.

2.3.1. AS-IS Method of documentation and archiving

In the section, there is no written system for documentation and archiving. Traditional methods of storing information are used. The placement under name of map/area, or report number is very commonly used in the archiving of largely analogue geological information in the section. Some old documents and reports that were received from prospecting companies (and continue to be received) have not been properly documented at all. Although data bases have been introduced in the section, they have not been utilised fully and are only on stand alone computers (mostly in one office). Besides the method of documentation, the section has been affected by the lack of trained staff in librarianship that is required in the handling of sensitive government information. Proper storage facilities for the available analogue information are lacking and retrieval becomes a problem because information has been unreachable and misplaced many a time. A lot of grey literature that is essential for the decision makers in the mining sector cannot be accessed.

The Information Section comprises mainly the following units

2.3.2. Archive

The section is responsible for the maintenance of an open file system through which unpublished reports are made available to the public. Base material in form of aerial photographs, mosaics, etc., are also provided in the section. Other information sources stored in the archive include: - geological records originating from the British South African (BSA) company, geological, geo-chemical and geophysical maps plus country coverage of air photographs. All data inherited from former Mineral Exploration (MINEX) Company under the defunct Zambia Industrial Mineral Company (ZIMCO) are kept here.
Another activity that the section carries out is to administer the Mineral Inventory database. This database is designed to provide a computerized system for the storage (and to a lesser extent retrieval) of information related to mineral occurrences in Zambia. The databases operate on a stand alone computers in one office. Main databases are The Mineral Inventory database, Pan African Network for Geological Information System (PANGIS).

2.3.3. Library

The Geological Survey library acts as a national repository of geo-spatial data on Zambia. It has an exchange agreement with several international institutions as a way of acquiring geological literature on other nations. Other journals and monographs are received as donation from other libraries or organizations like the USGS, BGS, etc. There are currently 4,000 monographs, 2,000 journal titles and 46,000 geological reports, maps, and periodicals.

2.4. CURRENT PROBLEMS AND IMPROVEMENT GOALS

2.4.1. Problems in the information section at GSD

There is lack of a well-coordinated information system that will be supported by all the leading production sections of the department. What seems to be in place now is far from being a satisfying system for the increasing demand for geological information in Zambia. Users have a different perspective of the type and manner in which they need to access information when they need it. Databases available are not linked together to enhance data sharing and online data entry and querying.

Poor documentation in the department and lack of adequate trained staff determined to work has also been a major obstacle. Personnel that have been forcibly asked to work in the section temporary have had no regard for the rules of archiving and librarianship. This has led to largely misplacement and loss of irreplaceable government documents. Access to the documents becomes difficult due to the fact that simple indexes available lead to "dead shelves." In some instances, loss of original documents for retention in cases where publications have run out of stock, have been experienced. This makes it impossible to have access to such works when need arises. Figure ***4.4a*** illustrates a conceptual process that would solve part of this problem of misplacements and information delivery.

Lack of proper sanitation for the storage rooms has also contributed to the loss of paper materials. Standard products like geological maps, that are produced en mass usually, are fading due to the heat and dust in these rooms. The library, which has been poorly staffed and run has its shelves filled with dust and many books and journals have been stolen from the shelves. The library requires up-to-date books and journals, most of the literature available besides being poorly maintained, are out dated and do not attract readers. Books and journals that are stored in staffs' offices need be brought back to the library so that they may be shared.

2.4.2. Improvement Goals

Internal Goals	External Goals
*The main processes of data acquisition in the department should change from analogue to digital and should be in compatible to the data models designed for the databases. *Develop EFD for provision of information. *Develop information system based on database technology *Be customer focused and offer diverse digital products and services through EFD. *Proper maintenance of storage infrastructure	*Improve access and sharing of geological data *To be the focal point for the development of GII *To be competitive *Respond to the rapid changes in the GIS market

Table 2.4.2 Internal and External Goals

2.5. CHAPTER SUMMARY

This chapter has discussed information storage, retrieval and dissemination as it is in the information section at the GSD. Problems that are encountered in the daily information provision have been enumerated, too. The need for an improved information system has been identified, thus highlighting goals for improvement both internally and externally. The next chapter 3 proposes necessary improvements to the information section as a follow-up to the problems and suggestions made here.

3. IMPROVEMENTS TO THE INFORMATION SYSTEM AT THE GSD

3.1. INTRODUCTION

The Information system in the department has to be re-organized if the department is one of the national repositories for the geo-spatial environment. The improvement goals as set out in paragraph ***2.4.2*** should be the basis for change. User requirements for diversity and quality products, timely and efficiently delivered must trigger departmental changes. This chapter suggests possible solutions for improving the information system that would enhance access and spatial data sharing.

3.2. DESCRIPTION OF THE TO-BE INFORMATION SYSTEM AT GSD

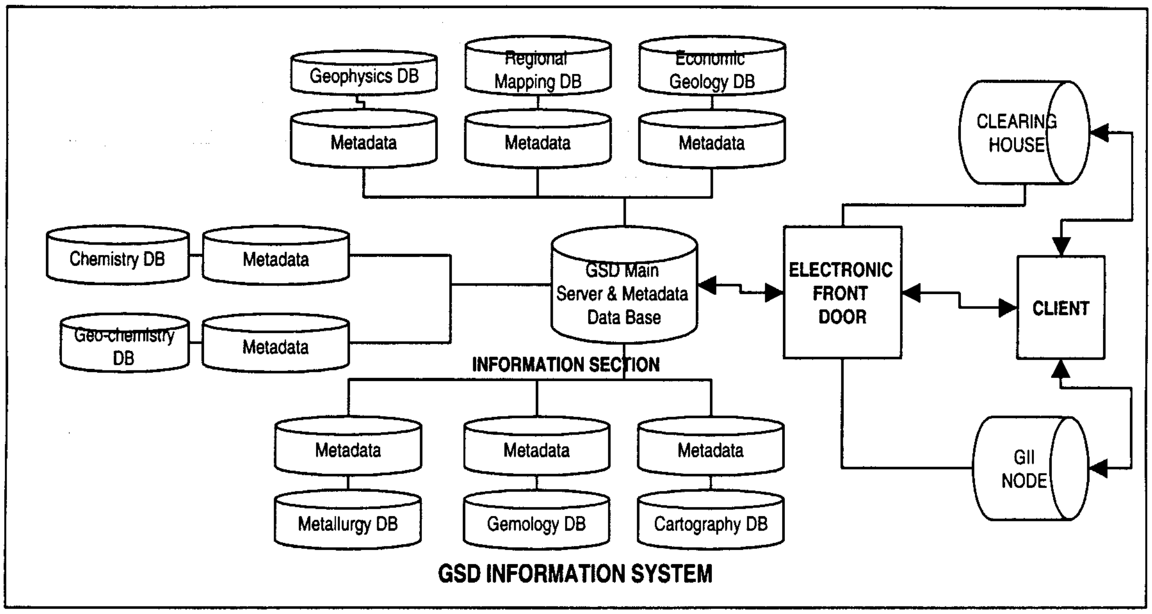

Figure 3.2.0 proposed Conceptual Model for the TO-BE situation

The TO-BE situation for geological information production should be customer/service oriented. Its main objective is to increase the number of services and products at minimum costs, making the processes more efficient in terms of database integration, improvement of service, management of quality and workflows and use of new technology. Although production processes are discussed here, it is not the purpose of the study to do so. Emphasis is on the manner that would make information storage much more convenient for the information section.

The proposed information system should therefore, be a well-structured system based on database technology and effective Information Communication Technology (ICT). This is essential for the enhancement of the creation and linking of sectional databases. Sectional staff will be responsible for data entry to the databases and ensuring that the data is uploaded to the main database in the information section. The Metadata database *(Appendix **D.7**)* should then be linked to a Geo-Spatial Data Infrastructure. There should be effective communication between the sections to indicate every time they have uploaded the data to the metadata database, this also helps to check on redundant data sets. There should be a 24 hours on-line service access to the selected data through the Internet. Queries for data should be made through Electronic Front Door (EFD). All on-line GIS service systems should provide centralized geological services based on a client/server computing architecture. These systems should allow users to access geological data sets from remote data repositories like the newly established Mining Bureaus in Zambian remote provincial districts.

3.2.1. Current and possible new services and products

Current Products	Possible New Products
Analogue Geological Maps, Reports	On-line services: querying, searches
	Digital Geologic Maps
	Metadata and Geologic DB

Table 3.2.1 Current and possible new products and services

3.3. INFORMATION SYSTEM TO SUPPORT PRODUCTION PROCESSES

The need to change the Information System at GSD calls for a better understanding of the environment in which the entire department is operating. This will require that the following to be done.

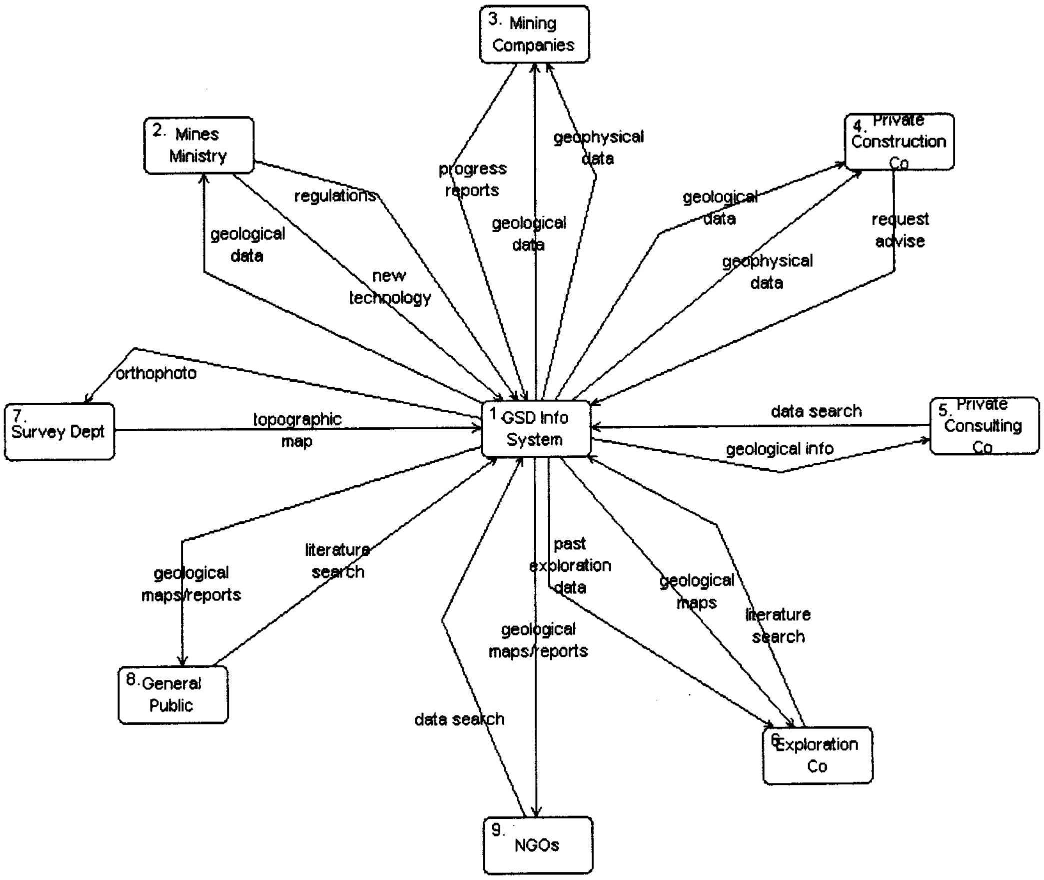

Figure 3.3.1 Information Context Diagram

3.3.1. Situation Analysis

It is important to know the changing user needs, what the current problems are and what is causing these problems, who are the users and what specifically are the possible products and services that these users will be satisfied with. There is need to accept change both internally and externally. A Context diagram is presented in Figure ***3.3.1*** and Top-level diagram in Appendix ***D.1*** to define the users and data flow between them.

3.3.2. Change Triggering Events

- External Environment
  - Government policies: fund reduction policy, cash budget, investment cost recovery and self-sufficiency.
  - Changing customer requirements: looking for specific and up to date products that are fit for their immediate use, e.g., Digital geological data, and timely delivery of products
  - Changing market situation/policy on pricing, information policy (copyright) security and user capability
  - Enabling technology: Interoperability
- Internal Environment
  - Organizational structure: too centralized management structure, production-oriented type of management and hierarchical management structure
  - Capabilities and resources: lack of capacity to satisfy the increasing user demand for products, lack of resources to diversify products and services in place of standard products

3.4. ACTIONS FOR CHANGE AND STRATEGIC ALTERNATIVES

After a comprehensive analysis of the strategic factors of the AS-IS situation, there is need to develop initiatives that will ensure the departmental change. The SWOT Matrix below gives us a broad definition of the main Strengths Weaknesses Opportunities and Threats and how they can relate to each other in the organization.

3.4.1. Actions for change

A SWOT Matrix as given in Table ***3.4.1*** below, is used to have a clear analysis of the environment in which the department operates. It helps identify the following: -

- Actions that will enable implementation of the initiatives
- Initiatives that will enable implementation of strategies
- Strategies that will enable achievement of goals and these are measured by performance measures set.

3.4.2. STRATEGIES

- **GOALS**

After critically analysing the current situation using the SWOT matrix in Table ***3.4.1***, The Department should set a number of goals in order to ensure the strategic initiatives are implemented and achieved. The following goals meant to improve the information system in the department:

- Generate an information section that is technology driven and service oriented

- Create and maintain a geo-information infrastructure to ensure effective dissemination of our products and services
- Create an up-to-date and state of the art Information System in the department that will ensure the satisfactory capture, storage and dissemination of information

EXTERNAL FACTORS (EFAS) / **INTERNAL FACTORS** (IFAS)	**OPPORTUNITIES** -Need for diversity of product and services -Enabling technology for GI -Infrastructure and equipment -Country need for regional mapping	**THREATS** -Impending cut in government subsidies and cash budgets -Emerging competitors in geo-information products and services -User dissatisfaction with current standard products and services
STRENGTHS -being custodian of framework (geology) data for the whole country -Production of standard products -There is adequate infrastructure and equipment in terms of Laboratories -Experienced in the traditional survey methods and services	**SO** -making use of the framework data and available infrastructure to produce a diversity of products -use standard production of products as a basis for re-engineering the system -utilizing infrastructure & enabling technology for the development of EFD, GII and clearing houses to improve product dissemination	**ST** -make partnerships with other competitors in the GI business that do not have framework data (geology) data or infrastructure to have a share of the market -anticipate and always strive to meet customer requirements -find new market niches to recover part of costs by capturing new users and new products
WEAKNESSES -Lack of Financial Resources to implement important assignments and projects on time -Lack of marketing strategy to read the ever changing user requirements and -lack of product diversity -lack of proper operations management	**WO** -develop a management structure that is service oriented and -use the country need for regional mapping to solicit for partnership with other organizations that have the capacity by contributing infrastructure to collect data, produce and timely deliver products and services	**WT** -develop a marketing system to identify user requirements and make strategic plans -Re-engineer production system using GI IT + optimization management techniques to diversify production

Table 3.4.1 SWOT Matrix defining strategies and initiatives for change at GSD

➢ PERFORMANCE MEASURES

Our performance in the implementation of our strategies and plans to achieve our goals should be done in a number of different ways: timeliness in the provision of information or processing information requests, the quality of the service itself, accessibility of the databases and shareability of the data. Performance should be reviewed each year. These should be publicized together with our achievements relative to the previous years' departmental annual report. In addition, we would undertake a variety of market research and surveys to measure our performance against the expectations of the stakeholders. We should strive to study the users' response to our products and determine any changes or improvements.

3.5. CHAPTER SUMMARY

Chapter 3 has proposed improvements to the information section if it has to respond to the changing GIS community. Change triggering events have been identified, the increasing need for geological information is also one factor for change, and new technological innovations are another. Rising challenges and competition from private companies that are offering better services in consultancies is another. The proposed changes are envisaged and expected to improve information storage, retrieval and provision at GSD. Strategies and initiatives for making these changes have been made using a SWOT matrix

4. SCENARIOS FOR IMPLEMENTING THE PROPOSED CHANGES

4.1. INTRODUCTION

This chapter is meant to put the scenarios as described in the previous chapter, for implementation. These scenarios are basically proposals that are felt by the author, that they could improve the operations of the information system for the purpose outlined there-of. All information discussed here-in is meant to fall within the mandate of the department

4.2. PROPOSED NEW STRUCTURE OF THE INFORMATION SECTION

As shown in ***Figure 4.2***, the Information section needs to be independent in the structure hierarchy. The head for this section should be at the same level with the other top officers after the Director. The information section has to play a pivotal role in the department by collecting and connecting all other sections to it to enhance effective management of the information section from a central point. The section should in the absence of a technical unit, be entrusted with the task of administering the servers, desktops, all accessories and entire network with the direct involvement of a qualified technical vendor.

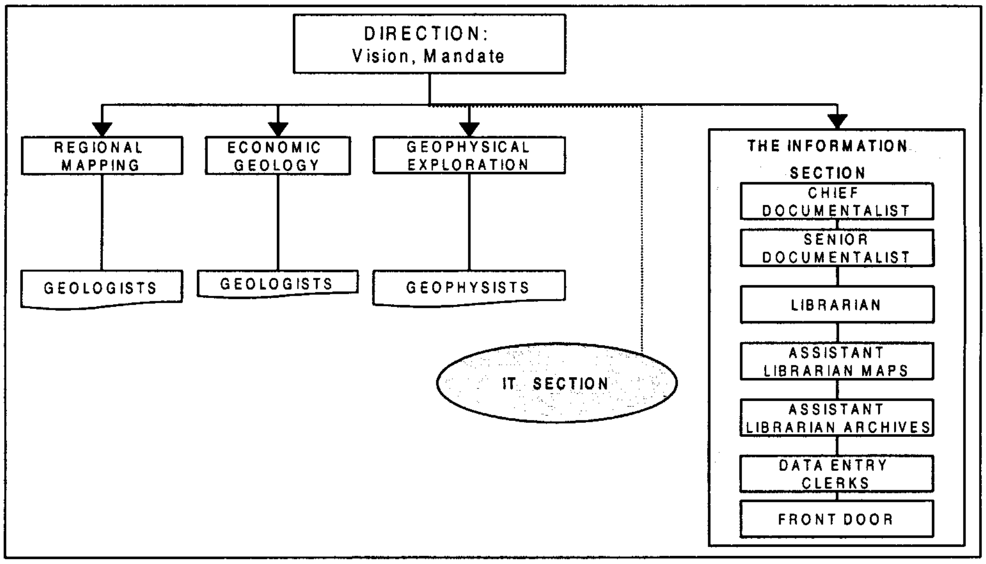

Figure 4.2 Proposed information section structure in context of GSD

4.3. REDESIGNING OF INFORMATION PRODUCTION PROCESSES

In the AS-IS processes of production of geological information (maps), it can be observed that information sources are mainly analogue data and field surveys. In the proposed scenario, it is intended that digital production processes be adapted to in order to achieve the production of diverse products. It is intended that digital databases be established in the production processes in the other sections of the department. This enables proper management of data by each section and consequently the production of metadata to satisfy our clientele.

Figure ***4.3*** below shows the proposed production processes driven by the use technology and databases. Note that the functions of geological information production remain the duties of the specific sections, it is for the sake of discussion in this study that the proposed redesigning of the production processes be envisaged to enhance the digital data storage in the information section.

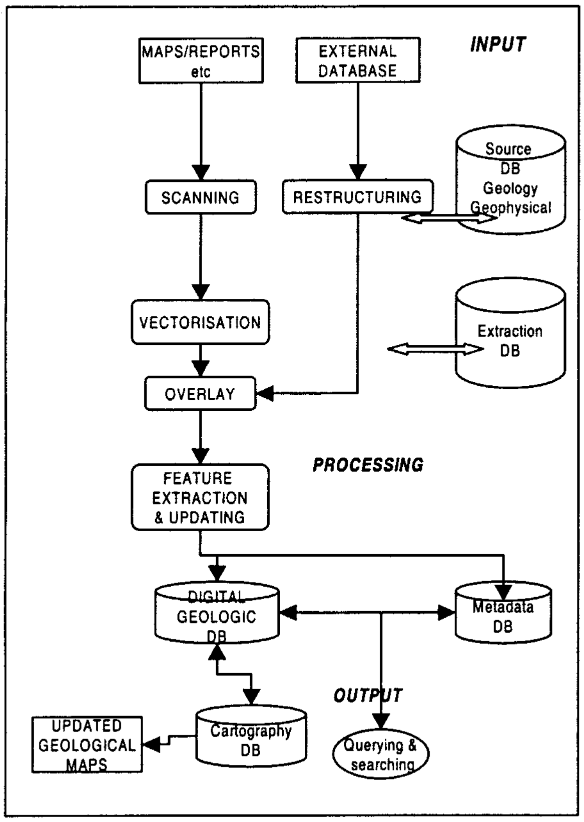

Figure 4.3 Redesigned production processes

Figure ***4.3*** above shows us how information can be extracted and used from different sources and used in the production processes. It also shows the importance of *databases* for the storage of processed information that can be used for other processes. The input data can be collected from different sources as indicated (aerial photography scanning, satellite images, existing geological maps and a link to external databases – this brings in the idea of an infrastructure for geo-spatial information sharing. This is made possible by establishing a departmental server and metadata base that should comply with the standards and other institutional issues between GII organizational members.

In the diagram, the next phase (Processing) is retrieving from the source database the required data for feature extraction, updating, and other processes. The Output from these processes and other processes can then populate the extraction database. Data is retrieved from the source databases when there is a new request. The availability of data determines the execution of the plan, but if data required is not available the source database should be linked to triggered processes of data acquisition. This will then trigger fresh data acquisition and updating processes.

4.4. PROCESS OF HANDLING REQUESTS (TO-BE)

The next scenario shows us how a single request for geological information should be handled in the information section of the GSD. Figure ***4.4a*** shows the proposed way to manage and deliver information in a desktop environment at the front door. The objective of this scenario is to give a possible solution to the loss and general misplacement of geological documents in the information section. In this illustration, the user makes a request *(1) through the information system accessing DB pointer (2)pointer points to appropriate database in the distributed (sectional) databases, (3) where the document is retrieved and stored in a temporal database in the information section under server name, data base and file names. (4) The document is either printed or provided as digital format depending on user specification. (5). The temporary files are deleted (5) Hard copy documents retrieved are returned to original location.*

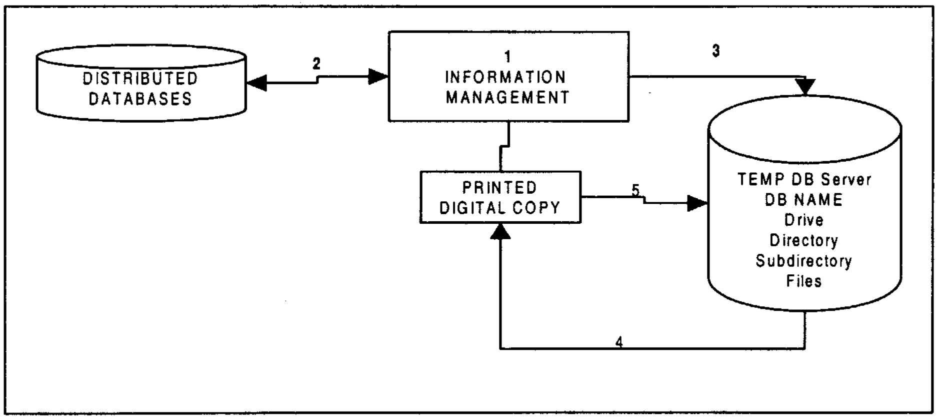

Figure 4.4a Possible solution to the loss and miss-placement of information at GSD

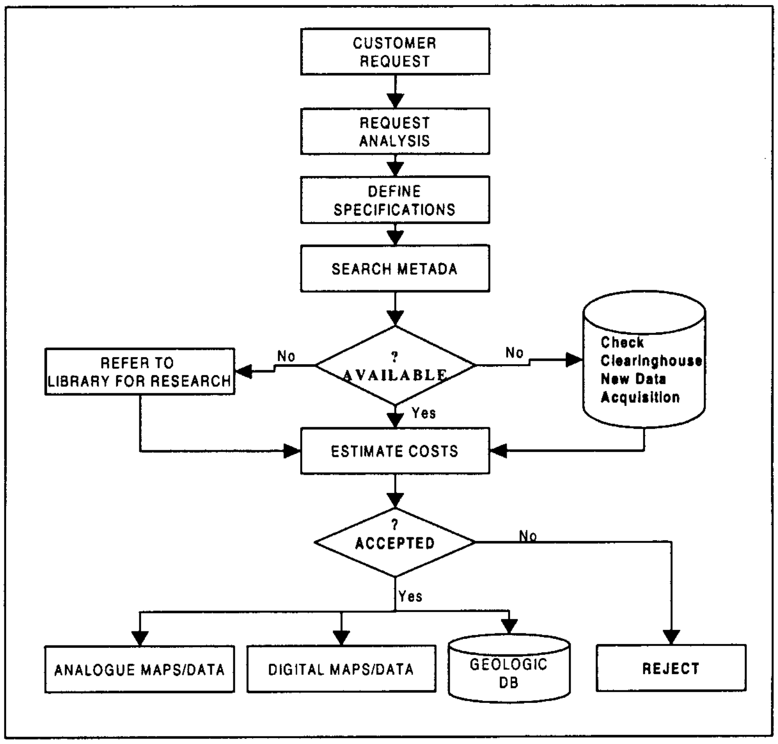

Figure 4.4b shows how requests could be analyzed, checking metadata, and triggering data acquisition in the event when data is not available.

The Figure ***(4.4b)*** above shows how a single request for geological information could be handled from the reception desk in the information section to the production trigger for data acquisition. This illustrates the checking of metadata database and clearinghouse *(Appendices **D.7-8**)* plus other possible sources of the data before giving any response to the client. The figure below gives overview architecture of the whole scenario for production of geologic information in the department to the storage and information provision.

4.5. CONVERSION/UPDATING PROCESSES IN THE GSD

The figures below illustrate the proposed guidelines for the design of geologic databases and processes for data conversion and updating. The processes are proposed for the purpose of data storage and provision in the department's information section.

4.5.1. Proposed Geologic Database Design Guidelines

Design of geologic database proceeds through several steps. Although it is not the scope of this study to design geologic databases, it is worth mention or describing the most critical stages in the designing of such databases. Mara et al (2000) have argued that after user requirement definition, the database structure is created conceptually; this involves the physical design of data models or structures to suit the purpose. The database is then constructed to run on a computer. In order to meet the future requirements, expansion capabilities must be taken into account. The creation phase almost always represents the most significant investments in the construction of a GIS.

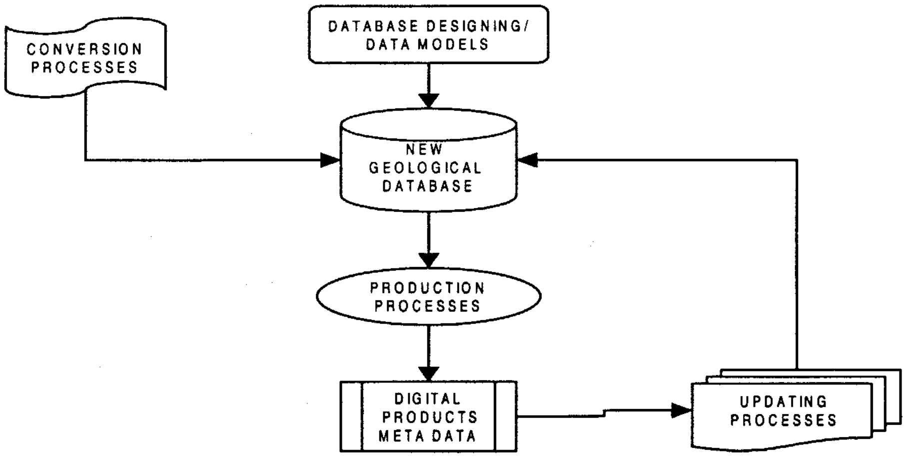

Figure 4.6 Conceptual Geologic database design stages

With the DB in place, processes of loading it with data begin through either converting existing analogue maps or updating processes through new data acquisition.

4.5.2. Data conversion process: analogue to digital format

The Geological Survey Department has a collection of old maps that require converting and updating. Most especially to be updated are topographical features that have changed tremendously over the years. For instance, the geological map for Lusaka that was produced in the early 70s has different representation of many infrastructures due to developments that have occured. The recommended processes are meant to not only update mainly the topographic features but also to add new geological features. This is also an opportunity to have the old maps made available in digital and updated format (Figure ***4.5.2***). The (Analogue) old geological maps will have to be converted to digital format and superimposed with this data with stereoscopic models by using digital photogrametry techniques. With the importance that this exercise carries – to convert approximately 44,000 analogue maps to digital format, it may be very vital for the department to acquire or solicit for the acquisition of digital photogrammetry software for the department. This may however, not be possible due to costs involved. An option to outsource the exercise could be considered. The proposed processes for converting and updating analogue maps are given hereunder in Figure ***4.5.2***.

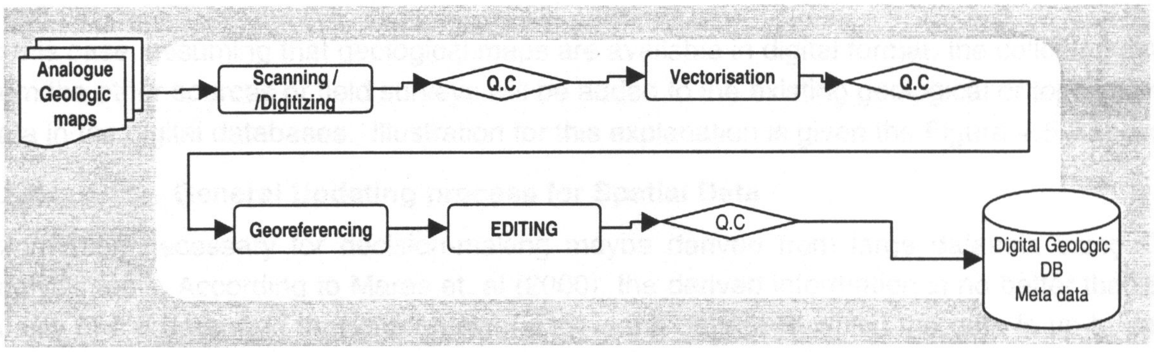

Figure 4.5.2 showing conversion process for geological maps from analogue to digital format

It may be argued that it is not the duty of the geological survey to update the topographic data, but the author is of the view that during the conversion processes, it could be possible to update topographic features and store them in digital format. This also helps avoid unnecessary acquisition of topographic data that can easily be accessed in the information topographic database. Mostly, topographic maps taken to the field are mutilated and have to be replaced in future.

4.5.3. Proposed Updating process for new geologic maps

It is hoped that the department will have acquired the new technologically driven techniques of mapping so as to store data and produce digital maps.

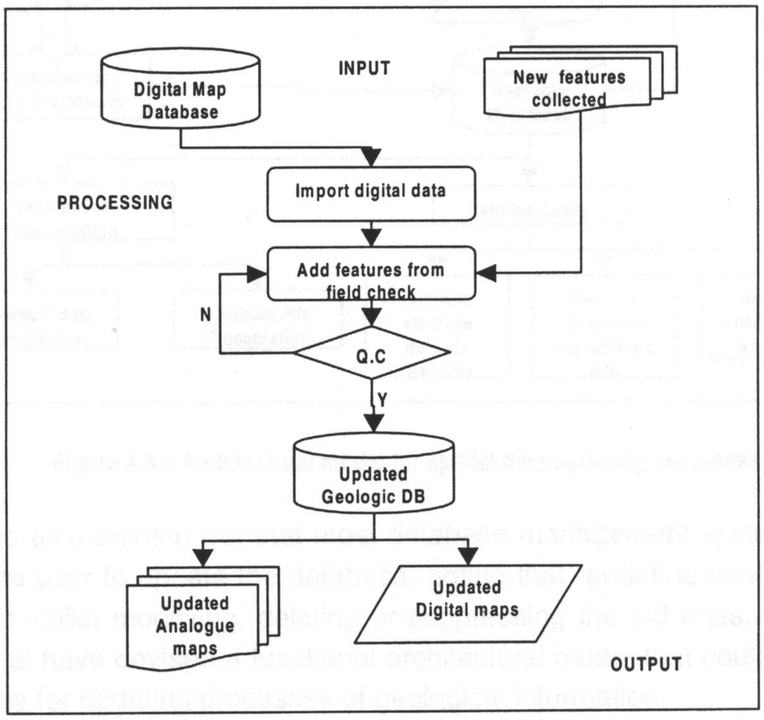

Figure 4.5.3 Updating process for new geologic maps

In this case, assuming that geological maps are available in digital format, the collected data from the other sources or field surveys will be added to the existing geological or topographic data in the digital databases. Illustration for this explanation is given the Figure *4.5.3* above.

4.5.4. General Updating process for Spatial Data

Information necessary for decision-making maybe derived from large datasets using GIS analysis tools. According to Maras et. al (2000), the derived information is no better than the quality of the data, and that one crucial factor is the degree to which the data is up-to date. This emphasises the need for regular updating of all kinds of spatial databases, perhaps as often as several times a day. And this should include updating the data dictionary that has all the metadata describing the properties of the databases as illustrated in Figure ***4.5.4*** below.

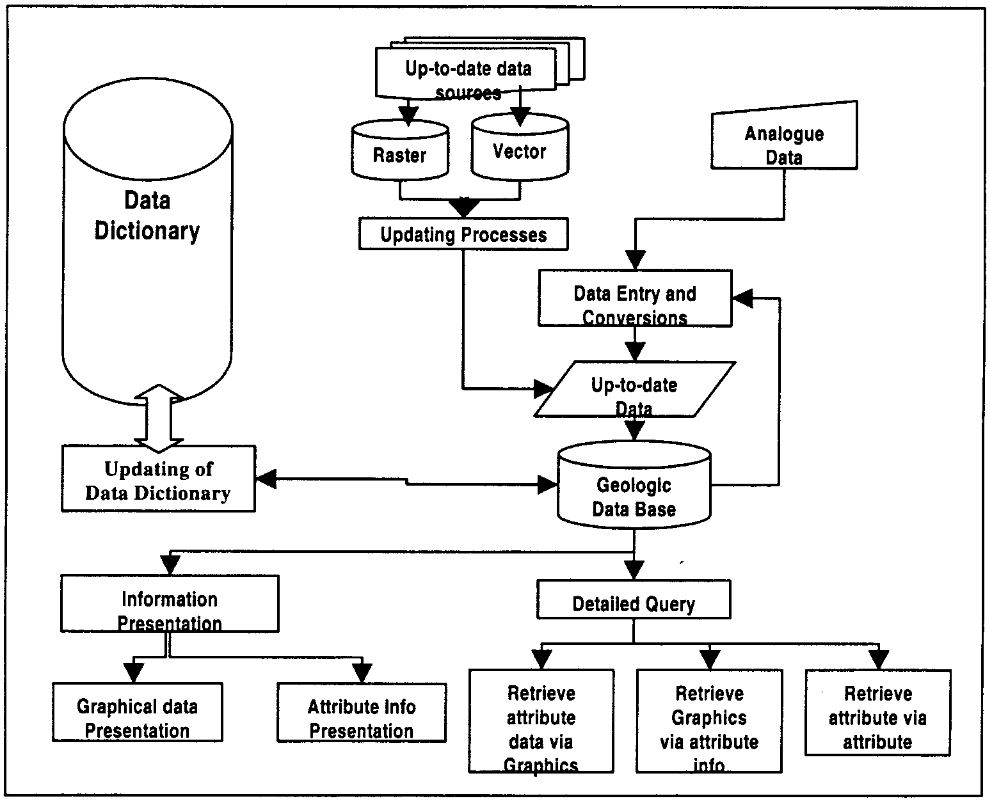

Figure 4.5.4 Architectural model for spatial data updating processes

Maras et. al has also pointed out that most database management systems have functions which enable the user to update the database, noting that updating consists of adding new graphic features whilst modifying, deleting or suppressing the old ones. In the Figure ***4.5.4*** above, Mara et al have devised a functional architectural model that could be adapted in the geological survey for updating processes of geological information

4.6. EVALUATION OF THE SCENARIOS

The scenarios above, if properly implemented would help the department achieve the following.

4.6.1. Improving the Production Processes.

Technology would enable a major restructure of the process of publishing and distributing analogue documents. For the department, which produces documents as a product or as support for a product, this change would reengineer the document production processes.

Figure ***4.3*** shows the steps in the revised publishing/distribution process using newer technologies. Documents are stored electronically, shipped over a network, and printed when and where they are needed. The major benefits result from the reduction of obsolescence (revisions are made frequently to the electronically stored version) Figures ***4.5.1 -3***, and reduction or elimination of delivery time.

4.6.2. Supporting Organizational Processes

Information is the vehicle or mechanism through which most processes in organizations are accomplished. Geological maps, reports or geophysical data etc., are primarily forms, which flow through the organization carrying vital information, and accumulating input and approval from a sequence of people. These "workflow systems" are still heavily based on the physical circulation of paper forms in the GSD and many other organizations.

The use of technology to support these processes would generate significant value in reduced physical space for the handling of analogue information (especially over geographical distances) and managing/tracking of data flow and overall workload. Two new trends in organizations are increasing the importance of these workflow systems: quality improvement processes and process reengineering, both of which tend to be heavily dependent on documents. Many organizations are finding that information is important to management processes of reporting, control, decision-making, and problem solving.

4.6.3. Supporting Communication Among People and Groups

Communication can take place without documents, of course. However, if the concepts, ideas, and information are to be communicated over time, they must be captured in a document. If they are to be communicated over distance, without voice or video connection, they must be captured in a document. Even when communication takes place between people at the same time and in the same place, a document might be used to improve the articulation or formation of the concepts. An additional value results from the sharing of documents among a group of people simultaneously, coupled with the rapid feedback and interaction that ensues. The purpose of the scenarios in this area would be to facilitate communication among people, and groups of people, in and outside the organizations.

4.6.4. Improving Access to External Information

The purpose of the scenarios in this area would be to provide better access to external information resources through the established communication link and GII. Traditionally performed by a library, these applications are increasingly computer-based with on-line card catalogs, direct user access to on-line text databases and circulation of full text research papers, etc. A major emerging document reference and access service is the wide area information system (WAIS). (Kahle and Medlar 1991) It consists of a consortium of Universities, government agencies, research institutes, and other organizations to share access to the full text of a document collection through a client/server network. Other document collections are available on the Internet.

4.6.5. Creating and Maintaining Documentation

The benefits of these scenarios are

(1) Quicker access to the documents,
(2) More efficiency in the search process,
(3) Simultaneous access by several people to the most current version of the document, and

(4) Reduced cost of printing and distributing documents.

For large records management applications, the savings from image processing in storage space and ease of retrieval alone are impressive. Other sources of value from the application of technology to information management include:

- Reduced misfiling of important documents
- Quicker and more accurate retrieval
- Better access and sharing over geographic distances
- Better version control
- Improved retention management

4.7. CHAPTER SUMMARY

This chapter 4 has given the proposed scenarios for implementing the changes as discussed in the earlier chapters, especially chapter 3. Emphasis is shown on the need for digital data acquisition and storage. The role of databases is re-emphasised and shows how important they may play in the effective storage and retrieval of digital geological data. It can be seen from the proposed scenarios that it would be easy to update and make changes to data that has been acquired and stored. The use of Meta data makes it easy for the producers and users to know what is available, what has been done and what need to be done and thus avoid the costly duplication of work. A brief evaluation of the scenarios is has also been given citing an example of the recent project that proposed and suggested the need for geological surveys in the region to improve on storage and retrieval of data to promote regional data sharing.

According to Schroot et. al. (1999), efforts exist to assist the Southern African Development Community (SADC) member states in going through their existing data sets. They have pointed out that this is to see where further processing steps like digitising of analogue data or copying to new media of old digital are needed in order to make the actual survey data more easily available to those who want to work with them.

5. REQUIREMENTS FOR IMPLEMENTING THE SCENARIOS

5.1. INTRODUCTION

The Information System at GSD requires upgrade and improvement; chapter 3 and 4 has discussed the reasons for the required changes. The changes would not take place unless the following issues are addressed in the department;

- Technological requirements of sectional data bases, the communication link between the sections, metadata for each section and metadata database for the entire department, intranet/internet, electronic front door, GII, clearinghouse
- Organizational (sectional) requirements of qualified personnel, proper infrastructure, maintenance of hard/software, workflow change, etc.

5.2. TECHNOLOGICAL REQUIREMENTS

5.2.1. Underlying Infrastructure

The rapid developments in Electronic Information Management are partly the result of advances in basic technology infrastructure. These underlying, enabling technologies would improve the handling of information in any form, but several have attributes that support information processing and management. These enabling technologies could be organized in five major categories.

5.2.2. Stronger desktop workstations.

Powerful desktop computers equipped with large, high-resolution color screens are recommended. These workstations would permit the display of documents, a full page or two at a time, delivering (and capturing) non-text media such as voice, video, and animation.

5.2.3. Storage media.

High capacity storage media would hold the large volume of bits required for multi-media documents. Optical storage media such as CD/ROMs and laserdiscs, perhaps in clusters called jukeboxes, would provide orders of magnitude increases in storage capacity.

5.2.4. Networks.

Networks would interconnect the workstations of most, if not all information workers, within and outside the department. These connections could have increasingly high bandwidth to transmit the large volume of data contained in electronic documents and forms.

5.2.5. User-friendly software.

The continued growth of graphic user interfaces (GUI), is enabling the multitude of people who handle paper documents, many of whom are not yet computer literate, to deal more easily with documents on computers. Even for experienced computer users, however, interface software must continue to advance so users can move beyond managing hundreds of files, to managing thousands of documents on the desktop workstation.

5.2.6. Operating Systems.

Client/Server operating systems and network management systems are increasingly document oriented. In fact, new operating systems should shift focus from the application to the document. This approach or paradigm is gaining popularity for improved software design, and for the design of operating systems. (Rymer 1989)

5.2.7. Sectional Databases

The sectional databases are an essential component for an improved information system. A well-established data base system in all the nine sections of the department would promote data management by the responsible sections. However, the sectional databases should be linked through an established communication link in the department. The section below discusses the communication link.

5.2.8. The communication link (LAN)

This could be a vital tool for the purpose of enhancing communication and data transfer in the department. It would be meaningless to even think of connecting to a GII if no proper information communication technology (ICT) is available in the department. A proper collection of multiple, logically interrelated databases distributed over an internal computer network are inevitable. The nine sections should be connected with their local servers as shown in Figure ***5.2.8*** below, through a Local area Network. A software system that would permit the management of the distributed DBS and make the distribution transparent to the users should be defined.

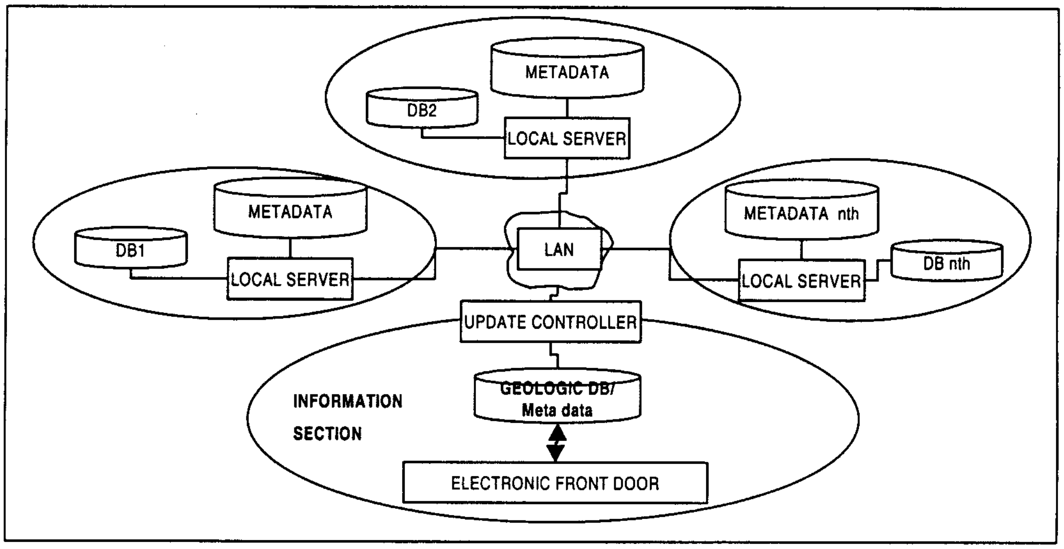

Figure 5.2.2 showing the proposed Communication Model LAN

5.2.9. The Internet

The role of the Internet in a spatial data infrastructure can never be over looked. It is argued that since 1990, Email, which is one of the Internet services, has played an important role in the dissemination and exchange of GIS-related information. According to Balek (1997), in 1993 the WWW began playing an increasingly important role in the organization and distribution of information. A growing number of organizations begun to employ the web in the distribution of their spatial and attribute data. It is therefore concluded that for the purpose of implementing the EFD and providing access to the data 24 hours a day through clearinghouse, Internet could be an essential tool.

5.2.10. The Metadata

Metadata or "data about data" describes the content, quality, condition for access, and other characteristics of data.. Access to the said data should be through the EFD. The data standards should specify the information content of Metadata for a set of digital geological data. It should specify information that will help prospective users to determine what data exists, the fitness of these data for their applications, and the conditions for accessing these data. See *Appendix **D.7*** for an example of metadata base content.

5.2.11. Electronic Front Door (EFD)

When a networked information system has been established in the information section, and most of the data is now in digital form, access to these databases can be made through an EFD. This is the computer-based reception desk, which would act as a service door to receive requests from clients and to disseminate data from the data provider via a computer network. EFD is one of the components of a clearinghouse and it acts as access to data by a wide range of customers. It would allow the sections of the department to reach a large group of customers at the same time through an organized mechanism without living their stations unnecessarily- as long as they update their sectional databases. Guidelines for implementing the EFD are discussed in the next chapter 6. See also *Appendix **B.1***.

5.3. DEPARTMENTAL REQUIREMENTS

The scenarios discussed in chapter 4 could be well implemented with the following requirements in the department's information section in place:

5.3.1. Qualified Personnel in the information section

The department has just been restructured according to the Public Service Reform Program and the Ministry of Mines under which the department falls, has been fully restructured and it's new structure should be in the process of implementation. The requirements as proposed in Figure ***4.2*** for qualified personnel fall within this establishment. The section has been understaffed for a long time now. It would be important to vigorously advertise for the new positions in the section if the changes are to be successfully achieved.

5.3.2. Workflow change in the information section

Workflow concerns who would do what and therefore, to create, promote, and support digital products, production sections of the department should then cultivate not only scientific and technical expertise but also specific training and experience in system administration, data management, and customer support. This would be important if quality data is to be produced at each level. However, it should not be assumed that these data producers have to create formal metadata. For many of these people this would not be a wise use of their time, because they typically produce no more than one or a few digital data products per year. Instead, formal metadata should be produced by data managers specifically charged with the task of facilitating the production and use of digital products. Producers should just provide information about the data product. Data managers working together with the creators of the data set could produce Metadata more efficiently.

5.3.3. Maintenance of hard/software in the department

The department need to understand that Systems would evolve over time due to a number of influencing forces, such as changing requirements, costs of continuing maintenance, and emerging and improved technologies, Hice (1992), see *Appendix **D4***. It would therefore, be very important for the department to plan for the best maintenance of its hardware and software in the department. A reliable supplier and vendor for the software should be identified to constantly maintain the software and hardware. Adequate training would be essential for all the sectional and departmental staff to be abreast with technological changes made to the system and its software, no one person involved in one way or the other with the handling and use of the available software should be left without training. Training and other handling requirements should be left to the Spatial Database Management Team (SDMT) that could be headed by the Chief Documentalist. The SDMT is discussed in the following paragraph *5.3.4*.

5.3.4. Spatial Database Management Team

The department should with the help of other sectional heads or producers of spatial information, form a spatial data management team that will primarily be responsible for the development and maintenance of a corporate **G**eographic **I**nformation **S**ystem for geoscientific and other spatial data, for ensuring consistency of spatial data and attributes, for the integration of the data with other spatially referenced data, for setting and maintaining spatial data standards and for developing methodologies for the use of such data by other scientists. It would also be responsible for the capture of spatial data and for various GIS-related projects e.g., Spatial database design and the maintenance of a logical data model, Spatial-database development, Development and maintenance of data standards, Formal training courses and ad hoc help and advice to users of GIS software within and outside the departments or organisations.

5.3.5. Information Policy

Much as we would like to have institutes that work on spatial data to be linked, some data may not be shared simply like that, issues of privacy would be involved. The producers of the data would require that their concert be sought each time their data are used or referred to. An information policy would therefore assist the stakeholders acquire copyright laws to protect the use and reproduction of their information. The geological survey would therefore, as a custodian of framework data (geology), require a policy that would protect it's works. This policy should be in line the national information policy. *A national information policy document is currently being presented to the Zambian government cabinet for debate, it would not be prudent for this study to dwell on this matter other than the mention.*

6. CONCEPT OF EFD:REQUIREMENTS FOR ITS DEVELOPMENT AT THE GSD

6.1. INTRODUCTION

The principle of EFD is still in its infancy in Zambia. This brings about the need to educate the people concerned – the stakeholders and the people that support is expected from, about the importance and benefits that this would bring to an organisation. Many organisations have received resistance where mere technological innovations have been introduced in their daily running of business.

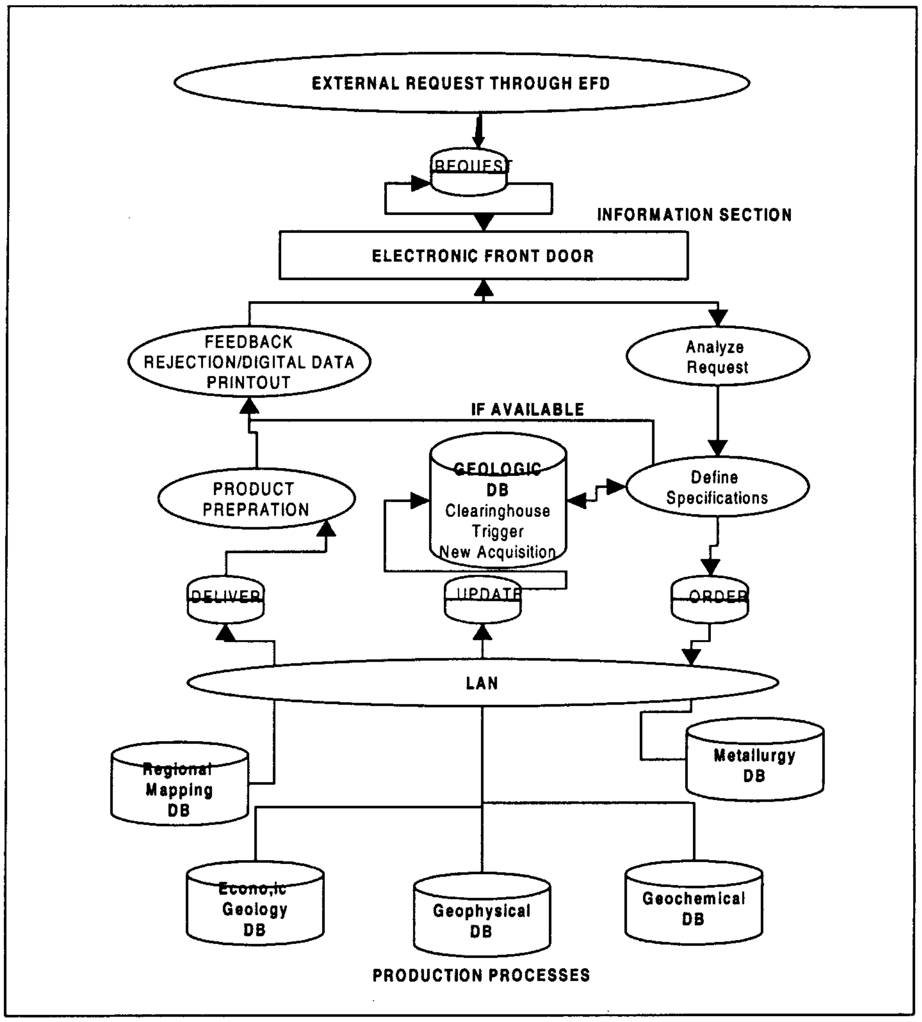

Figure 6.1 showing the Conceptual model for EFD at GSD

People are still content with their old style of running business. This should be a tireless battle that will only be accepted with proof of it operating and giving positive results. The task is therefore, to try to put the conceptual framework of EFD on paper before getting to implement it, Figure ***6.1*** above. Further description of the communication link, the local area network and other details about the EFD are illustrated in the Appendices.

6.2. OBJECTIVE OF EFD AT GSD

There are definitely a number of objectives that the EFD is going to serve, but for the purpose of this study, two main objectives will suffice.

- ✓ To serve a wide group of internal/external user community in an efficient and effective manner
- ✓ To provide a means for the sections in the department and the department as a whole to advertise their services and products much more conveniently.

6.3. EXAMPLE OF DATA TO BE PROVIDED THROUGH EFD

Data that will be provided can be summed up as Spatial Data (objects), Descriptive data and Legends. This can be represented in the following diagram adapted from Johnson et al. (1999). In *Appendix **D.2***, each circle represents a class of objects and a portion of the model and *spatial objects* are the digital representations of the real world geologic features that have been observed and mapped. *Descriptive data* represents the archive of characteristics, or attributes, or spatial objects, and *Legends* are used to extract the appropriate spatial objects from the archive and to symbolise and describe those objects for a particular map.

6.4. ANALYSIS OF PERFORMANCE

The performance of the EFD should be based on the consistency of the Workflow Management System in the department. It is not for this study to discuss Workflow Management System (WFMS) but it suffices to say that the introduction of WFMS in an organization has large operational and financial consequences, it is thus very crucial to test workflow models before introducing them in the department in terms of quality aspects (consistency and syntax) as well as quantitative aspects (performance of the workflow). Simulation technique in Simple ++, should be used for performance testing. *(This test has not been done due to limited time for the study)* Other criteria used to analyze workflow performance are Quality, Costs and flexibility, Paresi (2000).

6.5. REQUIREMENTS FOR DEVELOPING THE EFD AT GSD

This section discusses the specific requirement for the GSD to implement the EFD.

6.5.1. Hardware

The choice of what hardware to use for the implementation of an EFD should be based on the following questions and analyses;

- ✓ What software is needed to satisfy the job that is about to be executed as opposed to the common question asked 'what hardware is available?'
- ✓ What is the purpose of the server?
- ✓ Who are the possible users and approximately how many hits will the server get per day.

According to Maleko (1999), If the server is intended to disseminate a list of services, then microcomputer-based servers can handle thousands of hits per hour, if not tens of thousands of hits. In short, microcomputer based servers offer a number of distinct advantages like, the use of an operating system that is already familiar to the organization.

6.5.2. Software

Every operating system can choose different HTTP servers, which range from high-level applications to absolutely free applications, and those, which would deliver what is expected. The decision of the introduction of hardware/software, should be a response to an actual functional need as a part of the information technology architecture already defined to supply the geological information process requirement and not the other way round. There must be a co-ordination between software and hardware providers and the GSD so that support after the establishment of the system would continue. Testing a prototype (selected parts of the system) with the providers and involved sections would also be essential.

6.5.3. Sectional Databases

Each section would be responsible for maintaining its database and updating it regularly and reporting the update to the update controller in the information section. This will enable possible changes to the metadata database. These databases should be linked in the LAN, through EFD. Data to be shared should be defined and should be based on the agreed standards. The following is the explanation of each section's database:

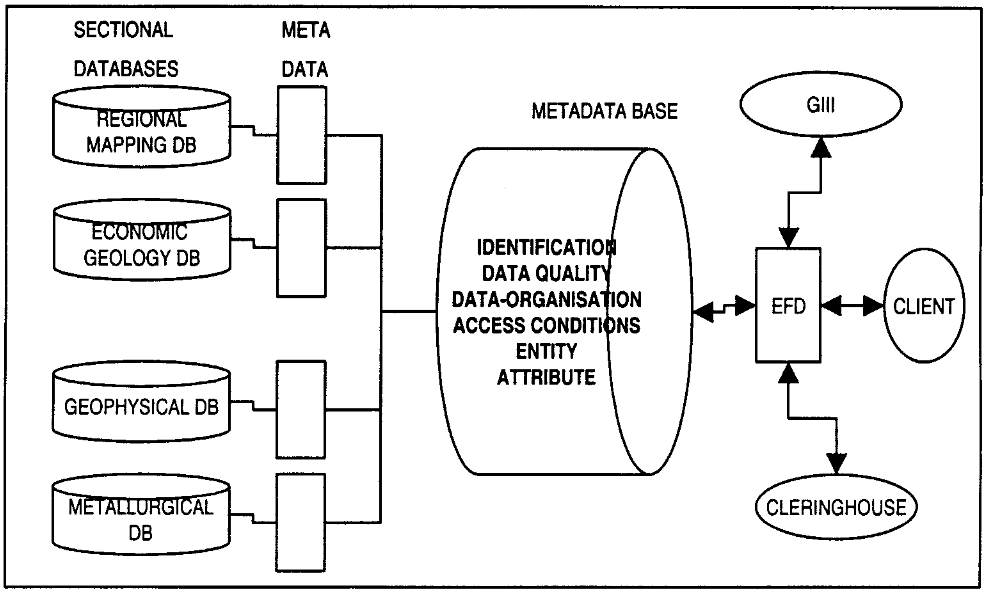

Figure 6.5.3 illustrating sectional databases and metadata

6.5.4. Electronic Front Door Applications

EFD applications range from simple, pre-dawn maps on a Web page to network-based collaboration geological information system in which users at remote locations share common data and communicate with one another in real time.

The technologies being developed to make EFD applications possible include software for servers (which store data and applications), clients (which use the data and applications), and network communications (which control the flow of information between servers and clients). Implementation of the EFD would make the user to be able to identify who has what data and locate the desired information. The user would be able to do the search through metadata by means of search and browse mechanism.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. CONCLUSIONS

The following conclusions have been made from the study

- Competition should not be used to prevent access to the much-needed data, but should be used for the improvement of customer service
- Proper documentation and archiving is required for the already existing data. New databases have to be created based on the new data models designed for the collectors of data.
- Databases will improve access and encourage data sharing once properly implemented. They avert duplication of works as what is already done is properly listed and made known through indexes.
- The departments' external environment will dictate its success based on the prevailing opportunities and threats. The capacity of GSD to change and stay afloat is determined by its internal strengths and weaknesses.
- At any time in the department, it also important to ask whether users are provided with a system allowing them to access and integrate geo-processing software tools over the network

7.2. RECOMMENDATIONS

The following recommendations are made

- Assign the task of tracking and forecasting the emerging information technologies to a small group with technical proficiency in several areas (IT Unit). The assignment should cover both the infrastructure and/or information technologies. *Appendix **C*** contains a questionnaire that could be used for this project. *See also Figure **4.2**.*
- Ensure that the information section is re-organized in terms of storage rooms, which must be thoroughly cleaned, and air-repellers or air conditioners put to work.
- The vacancies in the portfolios and the proposed structure in the section must be filled. Critical areas of information storage and retrieval, data entries are an essential tool to make the changes. A deliberate move to attract and or advertise the positions directly to the colleges that train librarianship must be made.
- Formation of a task force that will comprise all heads of sections to be spear headed by the Chief Documentalist must identify the urgent needs for the sections and the entire department if it has to make the changes. This task force will also evaluate the impact of the changes make recommendations on any need to improve.
- Hardware/Software Vendor – a reliable software/hardware vendor must be identified to help identify the necessary software and hardware that will be required to create an EFD, LAN sectional data bases, Internet, etc.
- In-house training should be conducted once the changes have been made to all members of staff.
- The changes to the information section should be made in gradual and convenient way, allowing the old system to phase away slowly.

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9. APPENDICES

A. STATUS OF GEO-INFORMATION PRODUCTION IN ZAMBIA

A.1 INTRODUCTION

This chapter gives an overview of geo-information production and use in Zambia. It looks at the geo-related information handling and identifies the main stakeholders in the collection and use of geo-information in Zambia. Our goal is to identify the status of data sharing between these organization, their main challenges and problems in terms of access, sharing and availability of specifically geo-information to support GIS and decision-making.

In Zambia, like many countries around world, Geo-information as largely used by many organizations in their daily decision making processes. In his thesis, Nyambenge (1998) has defined decision-making process as a series of interrelated activities that lead to a choice among alternatives. He states that it begins with the identification of dissatisfaction with the present state and ends with the solution through the help of Decision Support Systems (DSS) that often appear as computer programs but can be based on paper, videos, or emanate from human beings themselves. Decision Support Systems (DSS) are thus defined as computer based support systems for management decision makers and these may rely on geo-information that has been generated for various purposes.

There are basically three categories/classifications of 'spatial' data in view of decision making, data sharing, etc., these are mainly: -

- Foundation spatial data (Everybody needs)
- Framework data (discipline orientated: soil, hydrology, vegetation, etc) and
- Mission specific data (for problem solving)

A.2 PRODUCERS OF GEO-INFORMATION IN ZAMBIA

Producers of spatial data in Zambia range from Government to the private and little known Non-Governmental Organizations. Largely, Spatial data is produced for multiple uses by a greater section of every country. A few examples are outlined for the purpose of this study.

A.2.1 Government Ministries e.g., the Ministry of Lands: Survey Department

The Ministry of Lands is one of the key economic Ministries in the Government of the Republic of Zambia. Its Survey Department under the Ministry of Lands is responsible for the production of cadastral information, maps and other services as well as topographic maps that are widely used as base maps by a wide range of users, e.g., the geologists, engineers, etc.

A.2.2 Private Sector: - NGOs, Banks, – Mining and Exploration companies, Consultancy Companies

The private sector are involved not only in the use of spatial data but also produce spatial data during their execution of daily activities. Exploration companies for instance, use spatial data to generate or are a means to the production of other spatial information that is usually submitted as required by law to the relevant authority in government

A.3 STATUS OF SPATIAL DATA EXCHANGE AND SHARING IN ZAMBIA

There has been an increased lack of coordination among the producers of spatial data. This has created a lot of problems in the way that spatial data is be handled and or even made available. The ***Figure A.3*** below illustrates some of the major problems.

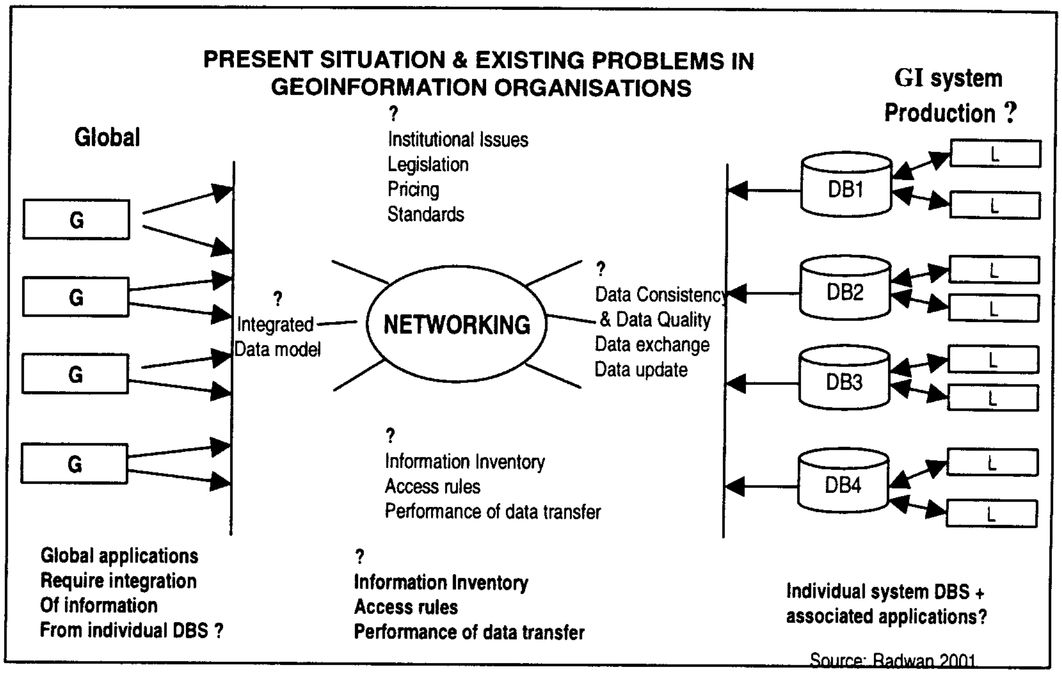


Figure A.3.0 Present situation and existing problems of data sharing and access.

A.3.1 General Problems and challenges of spatial data sharing in Zambia

- Mass production of spatial data (e.g., topographic, geological, cadastre), mostly in analogue form. The main objective of the organization is to satisfy many users with a product at affordable cost
- Lack of up-to date maps/information
- Relevant information items (such as DTM) are not collected on regular bases
- There is lack of a well-structured information system, based on database technology
- There's no direct access to geo-information available in other related organizations
- Relevant information archives in these organizations are not linked electronically with equivalent archives in related organizations
- The current strategic plans need to be revised to match with the continuous advances in the GIS applications
- No mechanism (and associate standards) is available to facilitate data sharing amongst organizations
- Lack of policy for marketing and cost recovery, to compensate the reduction in government funds

A.3.2 General challenges

- Need to be customer focused and offer diverse products and services
- Responding timely to changes in GIS market by effective use of IT technology
- Development of well-structured information system based on database technology
- Optimisation of production processes and resources
- Be the focal point to develop an information infrastructure at the national/local level to improve access to sharing. Also to develop information policies related to access and use of geo information

A.3.3 General Improvement goals

- Customer focused
- Offer diverse products and services
- Respond to the rapid changes in the GIS market
- Be competitive
- Assess the management of the organization, both at the corporate and operational levels, from business perspective

B. FURTHER READING ON EFD DEVELOPMENT AT GSD

(Adapted from Maleko (2000) Msc Thesis)

B.1 ELECTRONIC FRONT

B.1.1 EFD in relation to metadata base

The EFD would be linked to a metadata database and main geologic server that would be uploaded from the different metadata in the sections of the department. The metadata base in the EFD should contain guidelines of the data to be loaded from the different sectional databases. It should also contain explanations on how to access the data. Each section should maintain its own detailed database that would describe its own schema and contain shareable framework data.

B.1.2 The need for EFD at GSD

The EFD is a timely requirement for delivery of data and query handling in the geological survey department. It would ease communication between the sections of the department and allow people to know what is available and in what format. It would facilitate the dissemination of data through remote locations and front desks to a wide range of customers in an effective and efficient manner. EFD would help the user know who has done what and in which areas of the country to base their decision-making. Organizations should be able to know what has been done and avoid loss of resources through duplication of works by way of proper compilation of electronic indexes in the EFD.

B.1.3 How the EFD would work at GSD

The EFD should consist of multiple local servers and clients connected to the EFD server (main server) via a local area network. There should be a main server (EFD server) in the proposed model, the EFD metadata database, a related browsing service, and an update controller for the updating of the EFD metadata. The EFD metadata database should supply general information about the data available at different nodes such as the location of the data in the networks, the quality indicators, the access rules, the data of validity, the authority body responsible for the data, etc.

The proposed model would ensure that upon receiving the query, the EFD server refers to the metadata database to locate the data providers. This implies that the search, which would be done by the query string, is done locally within the EDF server. As a result the user woukd visit the node of interest.

The proposed system would require that each update of the Department's metadata database be reported in time to the EFD. By means of the metadata database search engine and the advertisement of special products, the customer could still get an idea of the various geological products the organization is able to produce based on the data available. Furthermore, it would allow the user to specify requirements for his/her order.

The EFD services interface should consist of three services

B.1.3.1 Browser service

This service would enable the user to discover datasets. Asking a question in the form of queries would do this, in which one can specify, for example, the title or a part of the title of the dataset, or the area the dataset must cover.

B.1.3.1 Access service

This service should make it possible for the user to retrieve data. If a user finds the dataset in the browser, would like to view or retrieve it for further use, then this service could be used for retrieval or processing orders.

B.1.3.2 Management service

This service would enable users to add metadata records on geologic datasets to metadata database. The record could be modified or removed.

B.1.4 Technology review

There are four critical components required for the development of an EFD.

B.1.4.1 Local server

- This is a node in the EFD network that contains a standard schema that is used for exporting data in the defined shareable format.

B.1.4.2 EFD's server

- This is the interface between the clients and all local servers. The servers provides two main services to the user, the browsing service that allow the access to the metadata base, and the retrieving service that allow the user to access data stored in the local database. This server includes the WWW server, the form processing, the search module, the metadata base and the update controller

B.1.4.3 The client

- The client is also a node in the EFD. He runs a graphic interface that allows the user to interact with the EFD's server. The graphic interface connects the user interface and client interface. The user interface translates the user request to the client interface.

B.1.4.4 The Data

- In the GSD the data are produced through the activities of its sections. These data should then be modeled and stored in local databases through prepared data models. Maleko (1999) has defined a model as that which ties human thinking with computer processing. He argues that it provides a blue print for database and applications system design. Data models also addresses three distinct orders, or levels of data structure: conceptual, logical and physical. A data model of sufficient functionality must be used to tie together the different data structures so that meaning is not lost when translation takes place between them.

B.1.5 Standardization

To create, manage, and disseminate digital earth science information, it is increasingly clear to data producers and users that certain widely accepted standards are essential. In the past, many organizational units (e.g. projects or programs) have of necessity developed their own standard practices for creating and managing digital map data. Because the resources needed to develop widely accepted standards are difficult for a single organization unit to justify, many of these standards developed in an adhoc fashion, with scant input from other groups, NGMDP September 2001 (*http://library.usgs.gov*).

B.1.6 The Conceptual Process Model for the system

The EFD in the department should be a network of servers (main server at the EFD level and local servers at the sectional level) and clients (users). The Local Area Network (LAN) should connect the internal server with sectional nodes as data providers. The databases should be connected to each other through the EFD via a link of local area networks, too. Figure ***6.1***.

The nine sections of the Department plus the other Departments of the Ministry of Mines have to be connected by a communication link that should be established through the network and the network architecture. The sharing of the data should serve two types of users – the internal users (the sections and departments) and external (unknown/known) users. Each of the nine section's databases contains specific information but because of the sharing of data it becomes possible for data from another section to be used in the other for a specific internal purpose. The EFD would give a briefing about each section's local database data sets.

B.1.6 The communication link

There are two types of network architecture: peer to peer and client server. In peer-to-peer networking, each node or workstation has equal importance, capabilities and roles. They are usually less expensive, simpler to set-up, less secure and could be more difficult to manage. An example of this is Micro Soft Windows 95/98 networking, each computer can also share resources like files, printers, CD-ROMs, etc.

In Client/Server architecture, each node or workstation is classified either as a client or a server. Clients are usually desktop or regular computers on which users run their day-to-day applications and routines. Servers are more powerful computers that are dedicated to sharing files, drives, printers, applications, databases, etc. Client computers rely on servers for resources; such as files, directories, printers, etc.

B.1.7 The Local Area Network

The EFD is intended for GSD in its initial stages, this fact makes it suitable to adapt to a Local Area Network (LAN) operating system. If in future, with a possibility to improve and expand, a Wide Area Network (WAN) could then be used to link the GSD and The Ministry of Mines to many other spatial data stakeholders in the GII.

C. PROJECT REQUIREMENTS QUESTIONNAIRE

C.1 INTRODUCTION

This questionnaire will help the department to implement the changes as proposed in this study.

C.2 PROJECT OBJECTIVES

To develop an improved geological information storage and provision system in the Geological Survey Information section

C.3 SCOPE

Focus should initially be on the improvement of the available documentation system, converting analogue maps and reports to digital format. Development and EFD prototyping becomes a separate project.

C.3.1 Constraints

- Are there existing systems that this project should be compatible with?
- Are there specific time constraints? E.g. We cannot start until May or We have to deliver something by?
- Are there any specific resource constraints? E.g. "There will be no business resource available between May and June because of workload"
- Are there Compliance/Regulatory constraints affecting this project?
- Are there any relevant Infrastructure constraints? (e.g. it has to support Microsoft Exchange, etc.)
- Are there any budgetary constraints?
- Are there any organizational/political constraints that need to be taken into account?
- Are there any defined targets that the system has to meet?
- Are there specific client/supplier relationships that need to be taken into account?

C.3.2 Assumptions

No assumptions

C.3.3 Solution Requirements

Wherever possible, please clarify if the requirements stated below, are mandatory or optional.

C.3.4 Information Overview

Describe the types of information the system will need to handle:

- What Data, What Document types, specific indexing requirements, attributes, formats, etc.
- How is that information held and used at the moment?
- How much of it is on paper and how much is in electronic form?
- Are there any documented processes that control the creation/use of this information?
- How is document ownership defined?
- Are there any related SOPs?

- What is the security access model? i.e. who has permissions to do what with which documents?

C.4 FUNCTIONAL REQUIREMENTS

C.4.1 Creation & maintenance

- Which documents are created internally?
    - Are more than one author involved in a document?
    - What is the authoring process?
- Are there existing documents that would need to be included in the system?
    - What percentage is on paper vs. Electronic?
    - Is it necessary to scan existing paper documents in the system or can they just be referenced?
- Are there any existing indexing systems, which would need to be included/interfaced with the system?
- Is it necessary to integrate/relate to paper archives?

C.4.2 Information Storage

- How often are documents accessed?
- How quickly would they need to be retrieved?
- How long are documents retained for?
- What determines when documents may be deleted?
- What document retention policies are in place?
- What are the legal retention/archiving requirements?
- Are their existing legacy archives that need to be considered?
- If documents are stored for long periods, how is Format Refresh going to be handled?

C.4.4 Information Retrieval

- How are documents located? What are the main retrieval criteria?
    - Hierarchical organization
    - Attributes / keywords
    - Thesaurus
    - Free-Text index
- How are the documents used once retrieved?
    - For reference
    - to update them
    - as templates for a new document
    - to print
    - to distribute to third parties
- How many people would need access to these documents?
- How do we ensure that the most up to date copy is always used when people are printing documents?

- Do external contractors require access to these documents?

C.4.7 Integration

- Is this a requirement for a stand-alone system, or does it need to integrate with other existing (or upcoming) systems?
- If so, what systems and what interfaces are available?

C.5 OTHER FUNCTIONAL REQUIREMENTS

Any other requirement/information not covered above

C.5.1 Performance Requirements

1. User Volumes:

- Number of users now
- How will that number be affected in the future?
- How are these users geographically distributed?
- What is the expected "concurrent" use of the system?

2. Information Volumes

- How many documents?
- How much does this number grow per month/year, etc?
- How often are they updated?
- How many document types?
- What is the typical document size? (Either in A4 pages or in Kbytes)
- What is an extreme document size?

3. What is the required access time for a document of average size?

- Time to locate the document?
- Time to open the document?
- How long is a document typically used for, each time it is accessed?

C.5.2 Implementation Requirements

(Not required to be filled until the other requirement sections are defined)
1. Where will the system be hosted?
2. Installation/Roll-out plan:

- Big bang
- Pilot group(s) followed by big-bang
- Incremental roll-out

3. Training

- How much is needed?
- How many users?
- What level of IT literacy?
- Refresher courses?

4. Data Take-on

- All existing data
- Data from a date onwards
- On demand
- None

C.5.3 Operational Requirements

1. At what times does the system need to be available?

- for local access?
- For remote access?
- Are fallback mechanisms required? E.g. CDROM?

2. Roles & Responsibilities

- Who will be the system owner?
  - From IT?
  - From the business?
- Who is the primary business contact?

3. Backup Requirements
4. Support requirements
5. What SOPs need to be written for the use of the system?

C.5.4 Quality Requirements

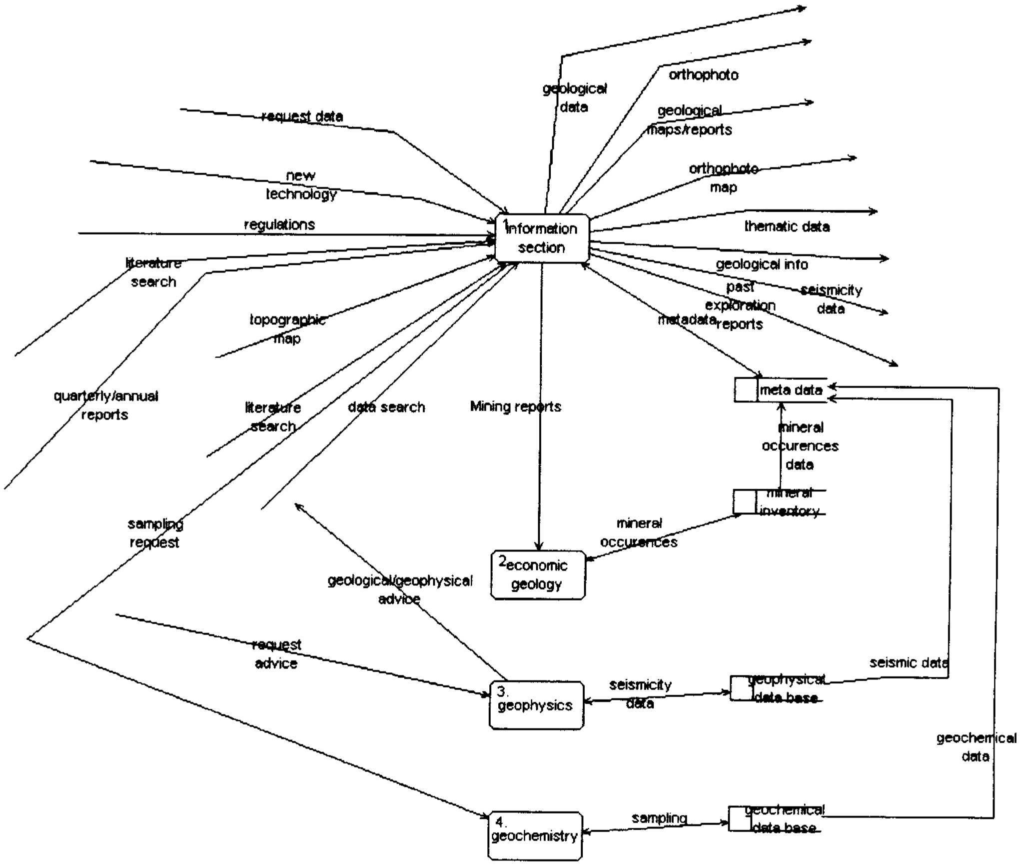
1. Security

- To what extent is secure access an issue?
- Who would need secure access?
- How are documents transmitted securely?

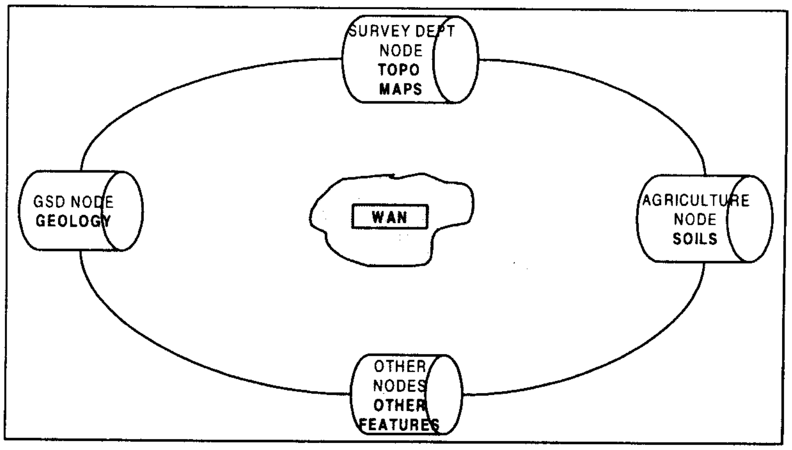
2. What are the Validation Requirements for this system?
3. Will the system be GMP compliant?
4. Will the system need to support any other regulations?

D. FIGURES

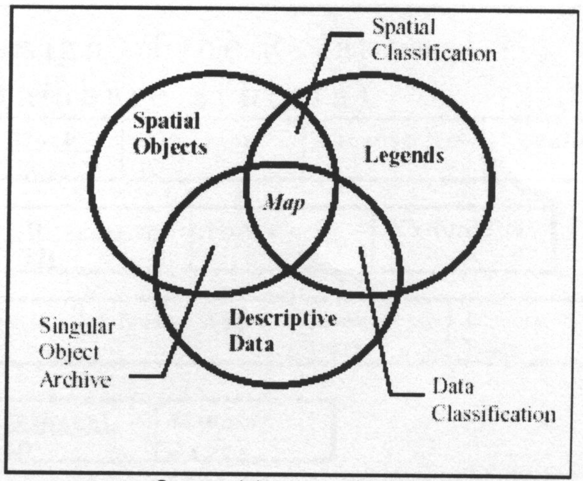
D.1 Top Level Diagram



D.2 Conceptual Model for GII in Zambia

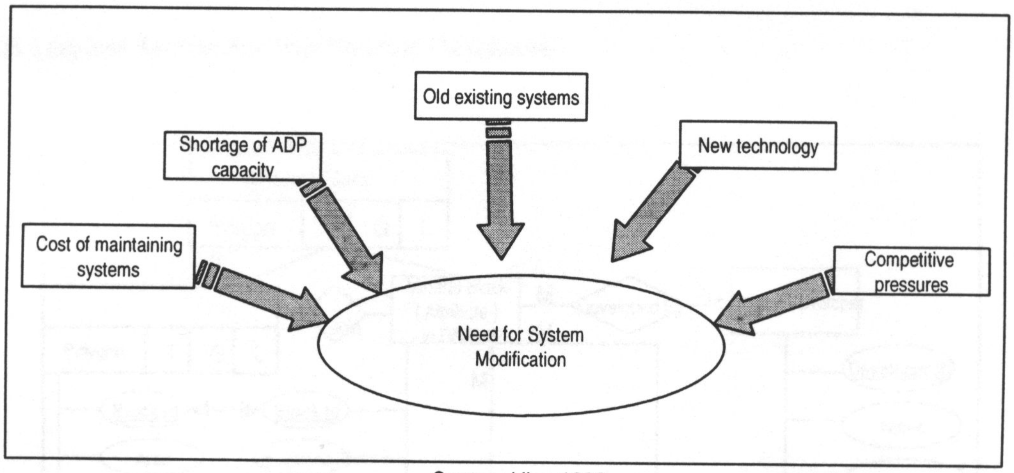


D.3 Managing And Delivering Information In A Desktop Environment Examples



Source: Johnson et al. 1999

D.4 Factors Forcing System Modernisation And Change



Source: Hice 1992

D.5 Example of Physical designed Relational database schema

Physical Design of the Relational Database(Database Schema)

MINERAL BLOCK	**Block ID**	Developer ID	License No	Locality	Area

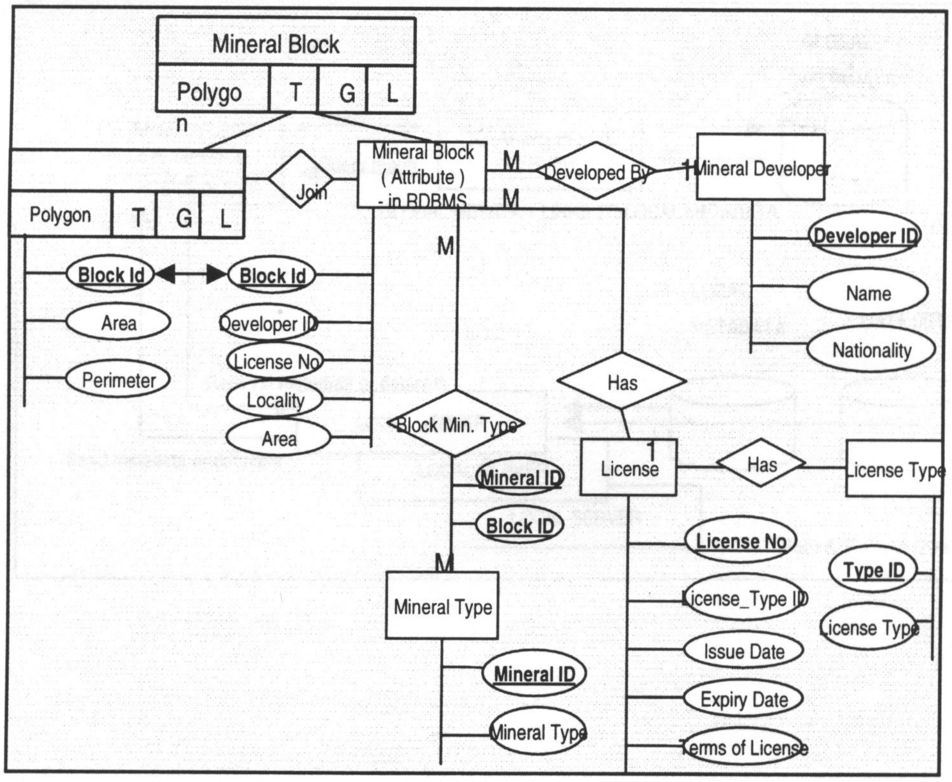
MINERAL Developer	**Developer ID**	Name	Nationality

LICENSE	**License No**	License Type	Issue Date	Expiry Date	Terms of License

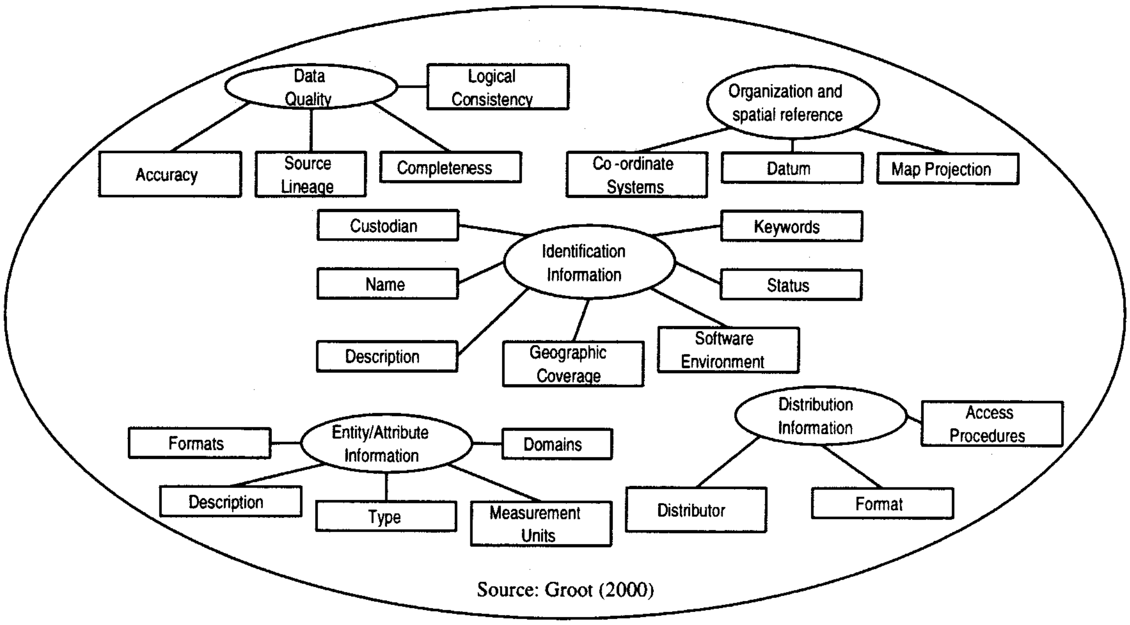
MINERAL TYPE	**Mineral ID**	Mineral Type

Block_Min.Type	**Block ID**	**Mineral ID**

D.6 Logical Model for the Spatial Database



Appendix D.7 Example of metadata base content



Source: Groot (2000)

Appendix D.8 Conceptual system architecture for the proposed national clearinghouse