USAID FROM THE AMERICAN PEOPLE

USAID/LIBERIA GOVERNANCE AND ECONOMIC MANAGEMENT SUPPORT (USAID–GEMS) PROJECT

DESIGN FOR A CONCESSIONS INFORMATION MANAGEMENT SYSTEM (CIMS)

System design describing business requirements, technical components (computing infrastructure, software, data) and specifications for CIMS implementation and ongoing operations.

FINAL May 2014

This report is made possible by the support of the American People through the United States Agency for International Development (USAID). The contents of this report were prepared by IBI International under contract number 669-C-00-11-00050. The views expressed herein are the sole responsibility of IBI International and do not necessarily reflect the views of USAID or

TABLE OF CONTENTS

Main Sections

Tables

Figures

REVISION HISTORY

This section provides information on revision history and authors of the document, *Design and Cost Estimates for a Concessions Information Management System (CIMS)*.

Version Number	Date	Revision Information	Author(s)/ Reviewer(s)*
Version 1.1	March 5, 2014	First draft released for formal review and comment	Peter Croswell
Version 1.2	March 7, 2014	Second draft with minor revisions from v 1.1	Peter Croswell
Version 2.0	March 20, 2014	Third draft—major editions with input from GEMS reviewers (Ford, Anderson)	Peter Croswell, Jerome Anderson, Ivan Ford
Version 2.1	March 22, 2014	Minor revisions based on additional research and proofing	Peter Croswell
Version 2.2	March 26, 2014	Additional revisions with review comments by Anthony Waddell.	Peter Croswell, Anthony Waddell
Version 2.3	March 30, 2014	Revisions based on input from March 27 Stakeholder Workshop, business process edits, and other updates.	Peter Croswell, Amadou Thera
Version 3.0	April 7, 2014	Revisions based on input from GEMS ICT consultant Peter Tobbin addressing GoL EGov and Enterprise Architecture Standards.	Peter Croswell, Peter Tobbin
Version 4.0	April 14, 2014	Major revisions based on additional research on mapping approaches and sources and input from mapping contractors who provided responses to questions.	Peter Croswell
Version 4.1	May 19, 2014	Minor revisions with more input on database development and applications	Peter Croswell
FINAL	May 27, 2014	Small revisions based on comments from GEMS Project personnel.	Peter Croswell

*Information for the primary authors and reviewers are as follows:

- Peter Croswell, Systems Design and Specification Expert, USAID-GEMS, pcroswell@gemsliberia.com
- Jerome Anderson, Concessions Advisor, USAID-GEMS, janderson@gemsliberia.ibi-usa.com
- Amadou Thera, GEMS Contractor, athera@gemsliberia.com
- Ivan Ford, GEM Contractor
- Anthony Waddell, IT Advisor, USAID-GEMS, awaddell@gemsliberia.ibi-usa.com
- Peter Tobbin, GEMS ICT Consultant, ptobbin@gemsliberia.com

EXPLANATION OF KEY ABBREVIATIONS AND ACRONYMS

CE	Concession Entity (GoL MAC with primary concession management responsibility)
CIMS	Concession Information Management System
CNDRA	Centre for National Documents, Records, and Archives
CORS	Continuously Operating Reference Station
DEM	Digital elevation model
EPA	Environmental Protection Agency
FDA	Forestry Development Authority
GEMS	Governance and Economic Management Support (USAID program)
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GoL	Government of Liberia
GPS	Global Positioning System
ICT	Information and Communications Technology
ISO	International Organization for Standardization
LISGIS	Liberia Institute of Statistics & Geo-Information Services Statistics
LPIS	Liberia Land Policy and Institutional Support (Project)
MAC	Ministries, Agencies, and Commissions (of the GoL)
MLME	Ministry of Lands, Mines, and Energy
MoA	Ministry of Agriculture
NBC	National Bureau of Concessions
NCC	National Concessions Cadastre
UTM	Universal Transverse Mercator map projection
WGS 84	World Geodetic System of 1984

KEY DOCUMENTS AND INFORMATION SOURCES PERTINENT TO CIMS

Full Name of Document or Information Source	Abbreviated Name Used in this Document	Date	Source Reference/Contact Information
A "Roadmap" to Develop the National Concessions Cadastre For Liberia	NCC Roadmap	May, 2013	USAID GEMS Project (Hoskins)
Land Rights Policy of Liberia		May 21, 2013	Liberia Land Commission
Liberian Spatial Data Infrastructure: Development of Minimum Standards for Spatial Data Sharing Volume I: A Spatial Data Infrastructure For Liberia	LPIS SDI Vol. 1	January, 2013	USAID Land Policy and Institutional Support (LPIS) Project.
Liberian Spatial Data Infrastructure: Development of Minimum Standards for Spatial Data Sharing Volume II: Data Sharing Manual	LPIS SDI Vol. 2	January, 2013	
ASPRS Accuracy Standards for Digital Geospatial Data		July, 2013	American Society of Photogrammetry and Remote Sensing (ASPRS), www.asprs.org
Act to Create the National Bureau of Concessions	NBC Act	September 15, 2011	Republic of Liberia
Public Procurement and Concessions Act	PPCA	2005, amended in 2010	
Strategy for Modernizing the Geodetic Infrastructure of Liberia		2011	Prepared by Millennium Challenge Corporation as part of the USAID Land Policy and Institutional Support Program (LPIS)
Geospatial Support Mission to the PROSPER Project—Community Mapping and Boundary Delineation		February, 2013	USAID People, Rules and Organization Supporting the Protection of Ecosystem Resources (PROSPER)
Government of Liberia *e-Government Interoperability Framework*	eGIF Standards	Draft, March 2014	Prepared by GEMS consultant Peter Tobbin for the GoL Ministry of Post & Telecommunications
Government of Liberia *Enterprise Architecture Framework*		Draft May 2014	
Concessions Business Analysis report		Final, April 2014	Main author is GEMS contractor Ivan Ford
Concessions Business Processes Assessment and Improvement report		Final, May 2014	Main author is GEMS contractor Amadou Thera

1. INTRODUCTION

This document describes the purpose, technology components, and specifications for the Government of Liberia (GoL) Concessions Information Management System (CIMS) which is proposed for development and operation. The information in this document is intended to be used as the basis for a detailed design and solicitation of products and services for CIMS implementation. Accompanying this is a companion document, *Implementation Plan for a Concessions Information Management System (CIMS)* which describes recommended tasks, timing, organizational responsibilities, and cost projections for CIMS development and deployment. CIMS will be automated system designed to provide data and applications to support the GoL's natural resource concession activities. One component of CIMS will be a National Concessions Cadastre (NCC). The NCC is a specialized automated property rights registry for overseeing the planning, review, granting, and ongoing management of natural resources concessions (see *NCC Roadmap*, 2013) as well as to provide an information management resource for a wide range of concession-related business processes. CIMS will be the primary tool used by the National Bureau of Concessions (NBC) to carry out its concession monitoring, evaluation, and technical assistance roles—in coordination with other GoL concession entities (CE) and non-governmental stakeholders (see NBC Act, 2011). While the CIMS design focuses on natural resource concession activities, its data and functionality has wide utility for many other GoL mapping and land management activities.

As defined in the GoL "Amendment and Restatement of the Public Procurement and Concessions Act" (September 2010 amendment of 2005 Act), a "Concession" is,

> "…the grant of an interest in a public asset by the Government or its agency to a private sector entity for a specified period during which the asset may be operated, managed, utilized or improved by the private sector entity which pays fees or royalties under the condition that the Government retains its overall interest in the asset and that the asset will revert to the Government or agency at a determined time."

The Public Procurement and Concessions Act (PPCA) identifies a number of different types of concessions (see Part VI). CIMS primarily is directed at support for Natural Resource concessions (see Part VI, Subpart 1.73(g)) with a specific emphasis on concession activities for mining, forestry, and agricultural operations. While the CIMS focus is on natural resources concessions, its data and capabilities will be of general utility to a wide range of GoL land administration and land management programs.

1.1 Definition of CIMS

The Concession Information Management System (CIMS) is defined as an information/communications technology system to be used to support Government of Liberia ministries, agencies and commissions (MACs) that have responsibility for any aspect of management or oversight of the country's natural resource concessions, especially mining, forestry and agriculture. An integral part of CIMS is the national concessions cadastre (NCC), a repository of digital spatial and tabular data about the extent of, and rights in, the land parcels granted by the GoL to concessionaires in the various concession agreements. CIMS supports: a) the coordination and oversight role of the National Bureau of Concessions (NBC), b) concession-related entities, and c) related land management functions of the Government of Liberia (GoL). CIMS is an automated system that combines a number of components and types of data into a seamless, robust whole that will allow all GoL personnel involved in the management of Liberia's concessions to have access to the data and tools they need to perform their jobs more efficiently, effectively and transparently. As described in this design document, CIMS will encompass a number of technical components and provide users with a range of information query, analysis, and reporting capabilities that support NCC activities. Geographic information system (GIS) technology is central to CIMS but the system will include other system capabilities and data sources organized in an integrated fashion to support user needs.

CIMS will be distributed, in that users in every GoL ministry, agency, or commission (MAC) that requires access to the system will have access. The National Bureau of Concessions (NBC) will manage and be the primary user of CIMS and it will be maintained and operated with necessary support from selected contractors—especially during the development and initial deployment period. The *CIMS Implementation Plan*, which accompanies this design document, calls for CIMS development and initial operations to be handled by a prime contractor which will oversee development and operations and build capacity with Liberian staff and facilities for a transfer to management by the NBC (or other designated GoL organization). While NBC will have CIMS management responsibility, specific decisions about the location and technical support of the CIMS central server will be made at a later date based on system and network infrastructure, system administration requirements, and other technical factors. Appropriate security and access policies and controls will be established to prevent unauthorized access to or manipulation of the data in the system. The CIMS design recognizes several key design principles:

- CIMS will adhere to applicable information and communications technology (ICT) standards and policies for computing infrastructure, security, software, data management, which are now being prepared through a GEMS initiative (eGov Interoperability Framework and Enterprise Architecture Framework standards).
- CIMS applications and services for user access will be deployed in a Web environment. CIMS software, data, and applications will follow Web services standards as defined in the framework documents referenced above.
- CIMS will follow enterprise information technology standards and will be designed in such a way to enable and encourage integration among multiple, external, databases and information systems.
- CIMS will use make use of applicable existing data sources in GoL MACs or other organizations (e.g., GIS data developed through programs managed by international donor agencies).
- With appropriate security policies and controls, CIMS is designed to allow broad access by GoL MACs, external organizations, local communities, and the public.
- To the greatest extent feasible, given functionality and support requirements, CIMS will make use of and/or allow access with open source software.

- The CIMS software and database environment will be flexible to respond to changes in user needs and business requirements. This means the CIMS should have software capabilities that provide flexible tools for revision and enhancing user applications and for making database changes.
- CIMS will have robust security an access control features to prevent unauthorized access and malware, and to keep a log of system transactions.

At a later date, as the spatial data capabilities of the GoL are advanced, CIMS can be the basis for a formal National Spatial Data Infrastructure (NSDI) program that will provide a management tool for administration of all land-based resources in Liberia.

1.2 Project Background and Objectives

The design and development of CIMS must be placed in the context of the USAID-funded Governance and Economic Management Support (GEMS) Project. The USAID-GEMS Project is a five-year project (2011 – 2016) implemented to build human and institutional capacity in the Liberian government. The project has five components, each focusing on a different area of Government of Liberia (GoL) operations. Component 4 concerns concessions. The objective of Component 4 may be stated as follows:

> **Objective 4**: Management of natural resource concessions is more efficient, effective, and transparent due to a modified legal framework that clarifies the roles and responsibilities of relevant GOL institutions, and the introduction of management and oversight tools utilizing automated ICT-based systems.

Pursuant to Objective 4, the USAID-GEMS Project defined scopes of work for a team of consultants to design and plan the implementation of "management and oversight tools utilizing automated ICT-based systems." CIMS is the "automated ICT-based system" that will meet the requirements of Objective 4.

An automated, ICT-based tool is needed because management of natural resource concessions is scattered throughout a number of GoL ministries, agencies and commissions (referred to collectively as MACs). The Ministry of Lands, Mines and Energy (MLME) is responsible for mineral concessions; the Ministry of Agriculture (MoA) is responsible for agricultural concessions; the Forest Development Authority (FDA) administers forestry concessions; the National Investment Commission (NIC) chairs the Inter-Ministerial Concessions Committees (IMCCs) that study, negotiate and recommend concessions; the Environmental Protection Agency evaluates the environmental impact of concessions. The NBC has overall concessions monitoring and evaluation responsibilities, among other assigned tasks. The NBC is a relatively new body established by a 2011 Act, which has a concession coordination role working with Concession-granting entities including the MLME, MoA, FDA and a number of other GoL ministries and commissions. As stated in the Act, NBC responsibilities are, among others, to: "…monitor and evaluate compliance.."; "…provide technical assistance to Concession Entities..."; "…support for all aspects of the concession process…"; "…improve the monitoring and evaluation of concessions…"; "…create a central repository of skills and knowledge…"; and "…develop and maintain a concession agreement database…". The solicitation, submittal of proposals, review, approval, and establishment of agreements for concessions is governed by the GoL PPCA. The NBC and all GoL concession entities are required to adhere to the terms of this Act. Business process workflows that address the Procurement and Concessions Act and operational requirements of GoL Concession-granting entities are documented in the *Concessions Business Processes Assessment and Improvement* report (May, 2014) and summarized subsection 1.4 of this report.

CIMS is designed to provide the information and ICT tools to meet statutory responsibilities and to support an effective and well-coordinated concession, solicitation, review, granting and monitoring program for all GoL entities and external stakeholders.

1.3 CIMS Stakeholders and Users

Key organizational stakeholders involved in the natural resources concessions program and which represent future users and contributors to CIMS include Government of Liberia (GoL) MACs and certain non-governmental organizations. The *NCC Road Map* report (USAID, May 2013) includes a description of stakeholder organizations and their role/relationship with concession activities. This subsection summarizes these stakeholders, most of which will be routine users of CIMS.

These CIMS stakeholders fall into the following groups:

- Concessions coordination and oversight (CO): Organizations with primary oversight roles on concessions activities.
- Concession entities (CE): GoL ministries with principle responsibility for review and approval of concession applications and proposals, ongoing monitoring of approved concessions and administrative work associated with concession management.
- Other GoL/MAC users of CIMS (CU): The GoL organizations and employees that will use CIMS or products (e.g., status reports) generated from CIMS.
- CIMS technical management and support (CT): This includes groups and individuals with responsibilities for CIMS technical development and operations—including GoL organizations, CIMS contractors, and donor agency technical support.
- Local officials and land owners: (LO): Officials having jurisdiction over sub-national government administrative areas (County, District, Clan, City) and individuals or organizations with land ownership rights (private or customary rights).
- Concessionaires: The companies which apply for and are granted concessions for mining, forestry, and agricultural activities and which are obligated to adhere to the terms of concession agreements.

Table 1 identifies these stakeholder organizations and summarizes their role with and use of CIMS.

Table 1: Summary of Main CIMS Stakeholders

Organization Name	Stakeholder Category[1]	Description of CIMS Role and Use
National Bureau of Concessions (NBC)	**CO, CU, CT**	The NBC has been granted, through the 2011 NBC Act, the lead role in coordinating, overseeing, and supporting the concessions process. The NBC will manage CIMS and will be its key user.
CIMS Technical Support	**CT**	Includes a number of organizations that may provide development services and technical support in CIMS design, implementation, and ongoing operation. These parties are not fully defined but may include USAID GEMS, other donor organizations, LISGIS, and contracted services.
Ministry of Lands, Mines, and Energy (MLME)	**CE, CU**	MLME is responsible for issuing mining permits, licenses, accepting and reviewing concession applications, and for granting mining concessions that allow exploration and extraction of minerals through surface mining or underground mining.
Forest Development Authority (FDA)	**CE, CU**	The FDA is the Concession Granting Entity for forest concessions. The FDA has responsibility for accepting and reviewing concession applications, and for granting concessions for forestry operations.
Ministry of Agriculture (MoA)	**CE, CU**	The MoA is the Concession Granting Entity (CE) for agriculture concessions. It has responsibility for accepting and reviewing concession applications, and for granting concessions for agricultural activities.
National Oil Company of Liberia (NOCAL)	**CE**	The GoL organization that is responsible for oil and gas exploration and production—with primary focus on offshore oil and gas concessions. It is included as a sector in the natural resource concessions defined in the PPCA. Since production activity is currently low (potential reserves not confirmed), NOCAL is not considered to be a main stakeholder in CIMS development at the present time but may be in the future.
National Investment Commission (NIC)	**CU**	Frequently investors will first go to the NIC when interested in making an investment in natural (nonrenewable and renewable) resources in Liberia. The NIC will direct the investor to the respective CEs.
Land Commission (LC)	**CU**	The LC's general mandate and purpose is to propose, advocate and coordinate reform of land policy, laws and programs in Liberia. The LC has responsibility for overseeing the GoL's policy on land rights and other land management activities and will have a role in concessions management when land rights issues are involved or in issues impacting concession agreements that impact LC responsibilities. The current Land Commission has a statutory expiration date in 2014.Legislation is being considered now for the establishment of a new entity for handling land administration and management functions.
Governance Commission (GC)	**CU**	The GC is the lead governance reform institution that conducts research and advises the Government of Liberia on governance issues and recommends policy and institutional reform. The GC does not have a direct role in reviewing or granting concessions but may have use of information from CIMS as it relates to their governance oversight role.

Organization Name	Stakeholder Category[1]	Description of CIMS Role and Use
Inter-Ministerial Concession Committee (IMCC) and Inter-Ministerial Technical Concession Committee (IMTC)	**CU**	The IMCC is appointed by the President for each concession. It takes on the role in the granting of concessions after a Concession Procurement Plan has been prepared. According to the PPCA, an IMCC is appointed by the President at the CE request for each concession procurement. It is appointed at the planning stage and should approve the concession procurement plan before it goes out for bidding. IMCC members are: • The chairperson of the National Investment Commission who shall be the chairperson of the committee • The Minister of Justice • The Minister of Finance • The Minister of Labor • The Minister of Planning and Economic Affairs (to be combined with the Ministry of Finance) • (The Minister of Internal Affairs • Two (2) other Ministers appointed by the President representing the collective interest of various sectors of the economy connected with the Concession • The head of the Concession Entity The IMCC appoints an IMTC to support concession review work.
Public Procurement and Concessions Commission (PPCC)	**CU**	The PPCC has oversight for all procurement of all goods and services procured by the GoL. The Commission has responsibility for oversight and enforcement of the Public Procurement and Concessions Act (PPCA) which defines requirements for concession solicitation, review, and approval.
Ministry of Finance, Planning, and Economic Affairs (MoFPEA)	**CU**	The MoFPEA must grant a certificate of Concession certifying that the proposed concession is in compliance with the Annual National Investment Plan.
Environmental Protection Agency (EPA)	**CU**	The EPA will need access to the NCC for its environmental impact monitoring and reporting of the area under the concession.
Concessionaires	**CU**	The Concessionaires will be a primary user of the NCC and may be a major contributor of spatial data related to the area under the concession. Concessionaires are the companies that apply for and enter into concession agreements to conduct mining, agricultural, and forestry operations.
Citizens of Liberia	**CU, LO**	A citizen of Liberia will need access rights to obtain public information related to the concession operations such as social impact, rights and obligations, extent of holdings, economic impact, building and maintenance of infrastructure obligations, environmental threats, and impact on private land rights.
Local Administrations Communities (Clans, villages, chiefdoms)	**CU, LO**	The Local Communities will provide administrative boundary data as well as data related to any other land rights granted by the community to the right holders.

[1]**CO**=Concessions Coordination, Tracking, Oversight, **CE**=Concession Granting Entity, **CU**=Users of CIMS data or generated products (e.g., reports, maps), **LO**=local officials and land owners, **CT**=CIMS technical management and operation support. **Note: some stakeholders may have more than one stakeholder category.

1.4 Business Processes Relating to CIMS

A business process is a series of steps or actions that result in the accomplishment of a certain objective—such as the granting of a new concession. Business processes usually have their basis in a formal organizational mandate (e.g., law, regulation, executive order, formal policy). Defining business process workflow is useful because it helps maintain efficient and consistent work practices. Defining these business processes also helps identify where information technology can streamline work. Business processes relating to CIMS and the GoL National Concessions Cadastre (NCC) are defined in a to separate GEMS documents: *Concessions Business Analysis* report (April, 2014) and the *Concessions Business Processes Assessment and Improvement* report (May, 2014) summarized below in Table 2, with a description of information and communications technology (ICT) requirements. This CIMS design focuses on providing information technology data and tools that:

- Supports these business processes and the work of stakeholder organizations
- Provides for a centralized coordination and tracking of concession activities
- Enhances data and information technology consistency, quality, security, and efficiency

There are 9 high level business process categories relating to the administration and management of natural resource concessions. Detailed concession business process descriptions and workflow diagrams are contained in a separate 2014 GEMS report (*Concessions Business Processes Assessment and Improvement*). The business process documentation has been based on a thorough review of applicable laws and policies and detailed discussions with stakeholder organizations responsible for concession activities. The nine high-level business processes listed below are summarized in Table 2. Within these 9 business process categories, there are a total of 27 individual business processes.

1. Open Competitive Bidding (OCB)
2. Restricted Competitive Bidding (RCB)
3. Sole Source Bid (SSB)
4. Unsolicited Proposal (UP)
5. Post Agreement (PA)
6. Concession Renewal (CR)
7. Concession Transfer (CT)
8. Concession Agreement Amendment (CAA)
9. Concession Agreement Termination (CAT)

Table 2: Summary of Business Processes Relating to CIMS
(see the GEMS *Concessions Business Processes Assessment and Improvement* report for more details)

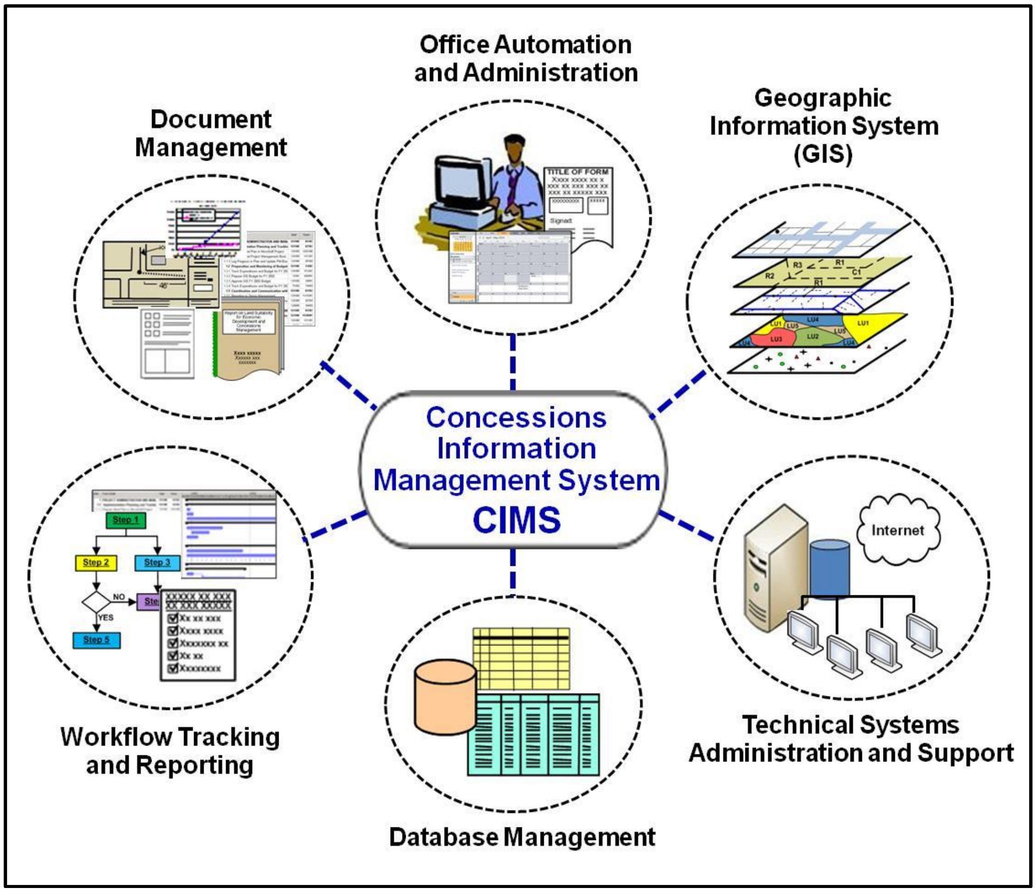
Business Process ID and Name	Brief Description
OCB: Open Competitive Bidding	Summary: Describes the procedures (planning, expression of interest, prequalification, invitation to bid, evaluation, negotiation and awarding) used by the Concession Entities (CE) to grant an identified concession to a concessionaire through an open competitive bidding procurement method in pursuant to Liberia Public Procurement and Concession Act (PPCA) approved in September 16th, 2010. ICT Implications: a) Workflow tracking capability to manage process, track progress, and trigger necessary actions, b) Web-based application entry and submittal, c) GIS capabilities to enter concession boundary and evaluate possible geographic conflicts (e.g., incorrect statement of total concession area, geographic conflict with other concession, protected area restrictions), d) document management capability to import, query, and access documents, e) integration with external procurement system (data transfer from CIMS), f) integration with any separate ministry-based systems used for concession activity management, g) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.
RCB: Restricted Competitive Bidding	Summary: Describes the procedures (planning, invitation to bid, evaluation, negotiation and awarding) used by the Concession Entities (CE) to grant an identified concession to a concessionaire through a restricted competitive bidding procurement method in pursuant to Liberia Public Procurement and Concession Act (PPCA) approved in September 16th, 2010. ICT Implications: All items listed above for OCB.
SSB: Sole Source Bid	Summary: Includes the procedures (planning, proposal request from source, proposal evaluation, negotiation and awarding) used by the Concession Entities (CE) to grant an identified concession to a particular concessionaire through a sole source bid procurement method in pursuant to Liberia Public Procurement and Concession Act (PPCA) approved in September 16th, 2010. ICT Implications: All items listed above for OCB.
UP: Unsolicited Proposal	Summary: Covers the procedures (proposal, evaluation, negotiation and awarding) used by the Concession Entities (CE) to grant a concession identified by a concessionaire through an unsolicited proposal procurement method as per Liberia Public Procurement and Concession Act (PPCA) approved in September 16th, 2010. ICT Implications: All items listed above for OCB.
PA: Post Agreement	Summary: Includes the procedures used by concessionaires to pay concession related fees and taxes to the GoL and to submit reports (Quarterly and Annually). PA also includes NBC's monitoring and evaluation procedure tracking of concessionaires' obligations (reporting, payments, social obligations etc.) defined in the concession agreement signed by the GoL and the concessionaire. In addition, PA covers the Environmental Protection Agency (EPA)'s internal processes to issue an Environmental and Social Impact Assessment (ESIA) permit to a concessionaire after the ratification of the concession agreement. ICT Implications: a) Workflow tracking capability to capture and report on status of actions in concession agreements and other stated obligations of the concessionaire, b) GIS capabilities for map-based queries to support monitoring, c) field-based access to CIMS with hand-held devices and use of GNSS positioning technology for navigation to sites and capture of data in field, d) document management capability to author, import, query, and access documents, e) integration with external procurement system (data transfer to/from CIMS), f) integration with any separate ministry-based systems used for concession activity management, g) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.

Business Process ID and Name	Brief Description
CR: Concession Renewal	Summary: Covers the procedures (renewal proposal, negotiation and awarding) used by a concession entity to renew an existing concession agreement with the same concessionaire. ICT Implications: a) Workflow tracking capability to manage concession renewal process, track progress, and trigger necessary actions, b) Web-based renewal application entry and submittal, c) document management capability to import, query, and access documents, d) integration with external procurement system (data transfer from CIMS), e) integration with any separate ministry-based systems used for concession activity management, f) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.
CT: Concession Transfer	Summary: Describes the processes involve when a concessionaire at its own will, decides to transfer its concession to another concessionaire. ICT Implications: a) Workflow tracking capability to manage concession transfer process, track progress, and trigger necessary actions, b) Web-based transfer entry and submittal, c) document management capability to import, query, and access documents, d) integration with external procurement system (data transfer from CIMS), e) integration with any separate ministry-based systems used for concession activity management, f) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.
CAT: Concession Agreement Termination	Summary: Describes the procedure used by the concession entities to cancel a concession agreement if the concessionaire doesn't fulfill its obligations and the procedure used by a concessionaire to surrender at its own will, its concession to the GoL (concession entity). ICT Implications: a) Workflow tracking capability to manage concession termination process, track progress, and trigger necessary actions, b) document management capability to import, query, and access documents, c) integration with external procurement system (data transfer from CIMS), d) integration with any separate ministry-based systems used for concession activity management, e) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.
CAA: Concession Agreement Amendment	Summary: Covers the possibilities given to both the concessionaire and the concession entity as per the initial agreement to request any amendment (like extending or diminishing: concession size, duration or agreement obligations). ICT Implications: a) Workflow tracking capability to manage concession amendment process, track progress, and trigger necessary actions, b) document management capability to import, query, and access documents, c) integration with external procurement system (data transfer from CIMS), d) integration with any separate ministry-based systems used for concession activity management, e) Office software for handling correspondence, document creation, meeting scheduling, and other routine administration functions.

1.5 CIMS Functional Requirements

CIMS will deliver a range of functionality to supports the needs of stakeholder organizations identified in Table 2 above. At a high-level, this system functionality is organized into the main depicted in Figure 1.

Figure 1: CIMS Functional Areas



A description of functional requirements for each of the components shown in Figure 1 (above) is provided in Table 3.

Table 3: CIMS Functionality and User Needs

CIMS Functionality	Description
Database Management (Note: basic ICT functional component which supports all CIMS functionality and applications)	
Database Design	Design of data tables for storing and managing alpha-numeric data and other data types , for setting up an efficient technical environment for data maintenance and application use (data table indexing, partitioning, etc.), and for managing metadata and data dictionary information.
Data Entry and Quality Control	Support for applications for database entry and update and tools for quality control (e.g., database element domains).
Data Query and Analysis	Tools that support user applications for data query, selection, and analysis of data. The capabilities of the database management system are often used by specific application software packages (in a transparent integration) to support user functions access through the application software interface.

CIMS Functionality	Description
Office Automation and Administration (Note: Office Automation software and applications will support the NBC's concession coordination and reporting and well as all general office management requirements. It is included as part of the CIMS functional environment because it supports CIMS functions but will use standard, off-the-shelf software (Microsoft Office or Open Source software).	
Word Processing	Creation, editing, formatting, saving, distribution, and printing of formatted documents
Spreadsheet Processing	Spreadsheet tools for managing alphanumeric data, calculations, table management, data-based graphs, and simple database query and management.
Email	Send, receive, and store email messages and attached files within organization and to external parties. May include special email archiving and search tools.
Scheduling/Calendar	Individual and group-based functions for scheduling events, generating schedule alerts, and communicating schedule information in a work group or entire organization
Office graphics and presentation creation	Basic tools for creating presentations and graphics for publications using text and graphic object creation and formatting.
Document/Records Management	
Scanning and Post-scanning Processing	Software supporting hardware devices for the optical scanning of hard copy documents and post-scanning processing for the generation of a raster image. Scanners are differentiated by their type (drum feed or flat-bed); media type accepted, including microfilm or other hard copy; size of media accommodated; speed in inches or pages per second; ability to handle black & white, gray tones, or color; capability for automatic processing like speckle removal or file compression; and ability to duplex (two-sided scanning). The scanning software includes the required device drivers, functions for users to adjust scanner settings (speed, contrast), image display and review, and post-scanning processing (image cropping, contrast adjustment, image rotation, or raster file translation.
Small format document scanning	Optical scanning of small-format documents, page size up to A3 size (approx 353mm × 500mm) depending on the scanner. Allow feeding of single or stacked documents in color or B&W and variable resolution. Produces a raster document stored in a selected file format—often PDF, TIFF, or JPEG.
Large format document scanning	Optical scanning of large-format documents and drawings, page size up to C0 size (917mm × 1297mm) depending on the scanner. Allows for adjustment of resolution and includes software for image enhancement (graphic quality improvement like speckle removal). Produces a raster document stored in a selected file format—often PDF, TIFF, or JPEG.
Document import	Tools to accept and store a document in any of a wide range of formats (Word, TXT, PDF, TIFF, Excel, JPEG) and store that as part of a document repository. Includes tools for file type translation and indexing the document for search and retrieval.
Database Indexing and Posting to Document Repository	This capability, normally provided through a relational database package, allows a user to define several database fields for identifying and describing a raster document or drawing—also referred to as metadata. These fields can then be used to drive search and retrieval for the documents and drawings. This requirement includes the capability to design intelligent data entry forms, data quality control, automatic data entry through selective optical character recognition, and other database indexing tools. Depending on the document management software in use, there may be a process to import a document and its index data into a document repository managed by the software.
File format translation	Tools to select a document of a specific file type and translate it to another file type. Includes capability for translation of a wide range of text, image, and CAD file types.
Document Image Enhancement	Capability to enhance the graphic quality and readability of a raster formatted or image file. Includes cropping, rotation, contrast and brightness adjustment, noise/speckle removal, edge/sharpness enhancement, erasing and drawing tools, color adjustment, and other operations.

CIMS Functionality	Description
Optical Character Recognition (OCR)	OCR capabilities, sometimes incorporated into document management packages, allow users to convert writing on raster documents to a text-based format and, if desired, to store it in a text or word processor format. In recent years, OCR software has improved greatly yielding accuracy results for printed documents in the 99% range. For handwritten documents, results vary considerably, but software advances have greatly improved accuracy. Accuracy suffers with image quality in documents in which text is not oriented horizontally.
Database Query and Document Access	This includes the standard capabilities of a database package (normally a relational database package) to perform queries of the database to select and retrieve desired documents or drawings. Searches would be performed on database indexes entered for each drawing or document. Searches could return a single document (e.g., if the search is based on drawing #), or the search could be more global involving multiple indexes to select multiple drawings that satisfy the criteria.
Document Printing	Printing refers to small-to-medium format printing of documents, including letter and legal size (8.5" x 11" and 8.5" x 14") up to ANSI "B" size (11" x 17"). This printing accesses local or network-accessible devices (normally using a Microsoft Windows-based print configuration) commonly using black & white laser and color ink-jet printers.
Large-format Plotting	Plotting of large-format documents requires plotters supporting ANSI C-Size (22" width) or larger. These devices may be low to medium speed ink-jet color devices or high-speed laser potters (usually just black & white). Supporting these large-format devices usually requires special hardware drivers and software that may support batch and remote plotting.
Transaction Monitoring and Versioning	This allows different versions of the same document to be managed and related to one another. This means that comments or marked-up changes may be associated with a specific user and retrieved independently but may also be combined and associated together for viewing or editing. Part of this capability is automated security procedures allowing a system administrator to assign and control appropriate access rights to staff.
Forms Management	Forms management software provides special functions for the creation and use of a special form with a standard layout (partitioned sections, check boxes, etc.). The software creates a form view and provides for formatted and intelligent entry with error checks, pick lists, etc. The entered content of the form is stored in a text file or database. The forms management software is invoked to generate formatted displays or hard copy printing.
Digital Signature	Digital signature functionality provides a way to automate what previously was a hard copy signature. It may be as simple as pasting an approved signature image to a document but should make use of more robust digital signature functions accompanied by a security and verification/authentication process in a network environment. Only authorized users are given rights to post a signature (including any technique for indicating approval) through the assignment of a personal ID. Part of an overall workflow tracking capability described below.
Automated Mark-up and Redlining	This capability allows an operator to add notation or mark-ups to a document at a workstation in the office or field using a mouse or pen-based entry method. These mark-ups are saved in a specific layer (associated with the Main document), or a new version of all of the drawings is created and stored.
Records Retention Management	Automated tools to capture information about legal or policy directives on the period of time specific types of records need to be maintained for access (before destruction or move to archive facility). May include triggers and alerts for record disposition actions.
Document/Record Security Controls	Robust tools for assigning security policies and access/use privileges for specific documents—involves assigning permissions to individuals or work groups (system accounts) giving specific rights for level of access, copy, and editing.
Workflow Tracking and Reporting	

CIMS Functionality	Description
Workflow modeling and diagramming	Graphic tool that supports the design of steps in a workflow process—the actions, individuals or groups, and timing associated with the steps. In a robust automated workflow system, this modeling tool is the basis for tracking completion of steps and overall workflow status.
Form-based data entry	Access to intelligent forms (using drop-down selections, automatic entry, and database domain controls) which accepts user entries and populates a database with records associated with workflow steps.
Process tracking with automatic alerts, triggers, notification	Tracking of the completion and timing of workflow steps (based on user actions) and issuance of alerts with notification to responsible individuals and supervisors (can use email) when a workflow action is upcoming or overdue.
Digital Signature	Digital signature functionality provides a way to automate what previously was a hard copy signature. It may be as simple as pasting an approved signature image to a document but should make use of more robust digital signature functions accompanied by a security and verification/authentication process in a network environment. Only authorized users are given rights to post a signature (including any technique for indicating approval) through the assignment of a personal ID. Also part of document/records management above.
Document attachment and access	Ability to associate and attached documents to specific workflow steps and actions (e.g., documents that require review and comment or formal approval). Will use document mark-up and digital signature capabilities.
Ad hoc query and reporting	User tools that provide easy-to-use capabilities to query the workflow database and retrieve data. Ideally would provide a form-based tool (with drop-down selections) to carry out a data search and filter results to narrow selected data.
Standard status report generation	Ability to design and store standard reports.
Geographic Information System (GIS)	
Central Geographic Data Management	Database administration tools for managing GIS data access by users, locking data during edit, providing version control, and other spatial data management functions.
Rule-based GIS feature management	Definition and storage of a range of spatial and database management rules associated with specific GIS data layers and attributes. Rules fall into the following categories: • Map display: Assignment of default symbology (point symbols, line types, colors) to map features and display criteria for scale thresholds (what features and annotation to display at specific scales). Also includes rules for annotation type and placement • Database domains: setting of attribute domains (valid values and number ranges) for attribute data fields for use in quality control • Feature connectivity: defines and guides allowable connections between line and point features in linear networks • Spatial relationship: defines and controls spatial correspondence about features in different layers (e.g., line feature in one layer must be coincident with feature in another layer)
Metadata maintenance and management	Functions to support the automatic generation and user entry of metadata for map layers and map features. These functions populate specific fields in a metadata schema as new GIS data is loaded or as existing layers are edited. Also includes tools for query and access to metadata. Ability to support geospatial metadata content and format standards as defined in ISO 19115 is critical.
GIS Web Services	Ability to deploy user applications as Web services with a need to support Open Geospatial Consortium (OGC) Web Map Services (WMS) and related OGC standards—Web Feature Service (WFS), Web Processing Service (WPS) and others.
Tabular attribute data management	Software environment and capabilities for storing and managing database attributes linked to map features in the GIS database. Uses one or more relational database management software packages.

CIMS Functionality	Description
CAD data access and viewing	Tools that allow the direct access to CAD files (e.g., AutoCAD) containing geographically-referenced engineering plan or design data. The CAD data would be access and displayed along with map layers in the GIS database.
Interactive feature capture (heads-up digitizing)	Access to a georeferenced scanned (raster format) or CAD drawing or map with tools allowing the interactive capture, tracing of features, and capture of attributes from that scanned or CAD file. Includes automatic feature vectorization from scanned raster maps or drawings.
Entry or import of GIS data	Tools to support the import of coordinate data (strings of x,y coordinates) to create GIS features. The system must support import and export to/from data formatted in compliance with Open Geospatial Consortium (OGC) standards—especially Geography Mark-up Language (GML) but also including other OGC data standards which may be specifically referenced in the future.
Import of GIS/CAD data from external systems	Tools to import data stored in different GIS or CAD formats to create new features in an existing GIS map layer or a new map layer. These tools carry out necessary format translation and migration of attribute data from the source file.
Map design and composition	Interactive capabilities for the design of map plots and displays, automatic creation of thematic maps and legends, and modifying map symbology and annotation for custom map displays.
Basic geographic query and Display	Basic tools for performing attribute or map-based queries, including display of attributes for a selected map feature or identification of map features that satisfy selected database criteria. This category also includes tools to create special thematic maps where areas or linear features are shaded based on their attribute values or classification.
Map-based query and access to documents	Capability to link digital documents (e.g., reports, drawings, site photographs) with a map feature or coordinate location in a map layer with tools to search and retrieve documents through and interactive map based selection (user clicking on map feature or delineating and area).
Server-based Web GIS query and map display	Basic query and map viewing functions accessible on a server using a Web browser.
Address matching/ incident mapping	Automatic mapping of point features from an imported file with site addresses through interpolation along a street segment coded with address ranges (right and left side of street). Locations are mapped as point symbols with designated offset and user-defined symbols.
Tabular report design and production	Allows users to design tabular reports from GIS data or derived from GIS applications.
Area and distance measurement	Interactive or batch functions that will calculate the length or perimeter of a line or polygon feature or the area of a polygon feature.
Radius/buffer zone analysis	Buffer area automatically generated around a point, line, or polygon feature based on a distance input. The buffer zone created can then be used to perform GIS operations within that area.
Map feature aggregation	A process of generalization in which features falling inside defined areas are counted, and that count becomes an attribute assigned to the areas. The aggregation process can also be described as point-in-polygon, line-in-polygon, and polygon-in polygon overlay. This function is useful for generating counts of features falling within predefined boundaries (maintenance districts) or ad-hoc areas delineated by a user.
Map overlay modeling	Use of spatial modeling capability to combine multiple layers to derive a resultant layer. It normally uses weights assigned to features on map layers that are combined to generate a result. One example might be an analysis of runoff potential based on information on slope, land cover, and drainage features.
Network analysis	Spatial analysis operations based on linear networks (e.g., road or pipeline systems), including such operations as "shortest path tracing" and "region allocation." Network analysis capabilities in GIS packages often allow users to design network models based on attributes of network segments.

CIMS Functionality	Description
Terrain and 3-D data processing and analysis	Capabilities for storing three-dimensional data normally in a grid or triangular integrated network (TIN) format with functions for 3-D analysis such as contour mapping, 3-D display, draping of map features over a 3-D display, slope and aspect analysis, etc.
Geographic registration	Tools to assist a user to apply control points to a non- geographically-registered data source (scanned raster map or CAD file) and store results in the GIS database.
Raster image processing capabilities	Capabilities for manipulation and processing of raster images (e.g., digital aerial photos or orthophotography, satellite images), including functions for the import and rectification of raw imagery, digital image enhancement, and automated classification of multi-spectral imagery.
Application development tools	Programming environment for customizing applications accessing software functions provided by the package, including proprietary languages included with the GIS software package or industry-standard tools (e.g., C++, Visual Studio, scripting languages, Web development tools) that may be used for application development.
Automated quality control	Tools that support automated checks on data quality—compliance with attribute data domains, graphic connectivity, proper symbology, etc.
System/Database Administration	
Server/operating system installation and configuration	Installation of servers (assumed to be Windows) and all operating system configuration including settings for Active Directory. Includes managing ongoing upgrades and patches and tuning configuration for best performance. If server is configured in a virtual environment, this includes use of virtual server provisioning and configuration tools to provide for necessary CIMS processing and data storage resources.
Set-up and monitoring of wired/dedicated networks	Set-up of local area networks including: physical cabling, installation and configuration of control devices (e.g., routers, switches), establishment of security controls (firewalls, intrusion detection/prevention), and set-up network and device controls for Active Directory. This also includes arranging for and setting up wide area communication services (dedicated or multi-point networks) with third-party communication service providers. Includes ongoing monitoring and intervention in case of problems (network failure, performance degradation, security breaches)
Set-up, management of wireless communication services	Establishment of wireless networks (on premises) an assignment of access rights to wireless networks. Includes setting up securing controls and ongoing monitoring and intervention in case of problems.
Set-up and management of user accounts	Setting up user and computer accounts and groups in Windows Server Active Directory. This includes entry of all user information, security policies, and permissions and ongoing changes to accounts.
Email administration	Includes setup of an email server (in-house or external email service provider). Includes allocating user accounts, security controls, monitoring email traffic, establishing inbox rules. May include special email archiving and search tools. Note: best option is to use external email provider (e.g., Google).
Application software installation and configuration	Installation and configuration (for proper user access) of new application software. Also includes license management and handling software patches and major version releases.
Web server set-up or administration	Installation and configuration of Web server-which may be in-house or use an external service. This may support internal users and/or external organizations Involves WebOS configuration, security controls, and monitoring of Web traffic
Desktop computer configuration and management	All work involving installation, configuration, and HW/SW upgrades to desktop computers.
Peripheral Device Set-up and support	Installation and configuration of dedicated or network accessible peripheral devices including small and large format printers and scanners. Includes diagnosing and fixing problems.

CIMS Functionality	Description
Mobile device configuration and management	Includes configuring settings on allowed mobile devices (tablet computers and smart phones), applying proper security controls, setting up local apps, and setting up connections with server-based applications.
Database administration	Installation and configuration of major database software (e.g., SQL server) and access from designated applications and users. Includes setting up accounts and security controls, performance monitoring and tuning, transaction logging, and all configuration for specific software packages.
Software/Data back-up	Execution and management of routine back-ups and procedures for restore and recovery.
Management of vendor maintenance and support agreements	Management and monitoring or maintenance and support contracts with hardware and software vendors and third parties.
User support services	Set-up and management of user support services through an organized help/service desk process—using software for submitting request and managing response.
Template and application changes, fixes, enhancement	User services for the creation of revised forms, report templates, and other custom applications and associated access control parameters.

1.6 CIMS Applications

The basic functional requirements for the main CIMS components, described in 1.5, will be provided by specific software packages (see software recommendations in Section 2). The functionality provided by the software will provide specific applications that deliver results and products (e.g., query results, reports, maps) to users. To the extent possible, off-the-shelf user interfaces and menu selections will be used, with no or minimal customization to deliver the information and products needed by users. For some applications, customization may be required. Using customizing tools provided by the software package or a third-party tool, the following types of application customization may be required:

- Configuring a new or modified graphic user interface (custom arrangement of menu choices, toolbars, etc.) that meets the needs of a specific set of users.
- Designing "templates" for standard reports that define report content and format which can be accessed to automatically generate reports based on user parameters (e.g., date range).
- Designing custom map templates (predefined content, symbology, map layout) to be used for automatically generating screen displays or hard copy maps with user selected GIS data.
- Automating access, integrating with other systems or databases, or importing and exporting files from and to external databases and applications.
- Use of workflow modeling tools to define the steps in a business process and special features (timing alerts, document attachments, etc.), and to build the resultant electronic templates/forms and controls.
- Designing and developing "intelligent" interactive forms for entering attribute or graphic data, e.g., dropdown pick lists and automatic error checking.

- Creating data QC and QA applications using validation tools provided by the software package.
- Creating a library of standard queries accessible through a menu.
- Use of GIS application development tools to perform complex spatial analysis with a simple menu selection (e.g., custom GIS scripts which identify geographic constraints or overlaps of concession areas).

The software selected for CIMS should be powerful and flexible enough to allow for implementation of a wide range of applications—with tools to carry out the types of application customization listed above. Ideas on key CIMS applications are presented below.

Office Automation and Administration

- Word Processor Style Sheets: Prepare styles (defining document format) for specific types of documents (e.g., memos, reports) to streamline document preparation and ensure a consistent look-and-feel.
- Custom email management tools supporting email message archiving and search.
- Organization-wide calendar and event scheduling (using calendar tools from the office software).
- Tracking and scheduling for staff professional development program and training session.
- Customer relationship management tools to organize and facilitate interactions between stakeholders

Document/Records Management

- Custom interface to support document scanning and OCR (for concession-related documents that are provided in hard copy form).
- Document creation and maintenance with pre-defined document templates
- Version management with custom controls for managing access and displaying changes
- Assigning of rights/controls to limit access to documents to authorized parties
- Ability to publish selected documents on the web portal
- Custom form to capture document index data (metadata) to support document search and access.
- Custom form-based document search and retrieval tool for documents.
- Document import tools to automate submittal of concession-related documents by concession entities.
- Field-based form and data capture application (possibly using tablet computers) to support NBC concession monitoring activities.

- Web-based interface for concessionaire submittal of required forms and documents for concession applications.
- Web-based interface for submittal of concessionaire required reports.
- Web-based publicly-accessible portal for query and access to certain types of concession documents.

Workflow Tracking and Reporting

- Web-based access for submittal (by concessionaires and other stakeholders) concession application materials with automated tools to conduct a high-level check on compliance and tools to index and save the materials. Note: NBC will be the initial point of concession applications and concessionaire reports and will distribute to appropriate CEs and other users.
- Use of workflow modeling tools to define business process steps, triggers and alerts, assign tasks and actions to stakeholders for reviewing concession applications (review, comment, sign-off), and special functions (document mark-up and signature).
- Custom status checks, notification, and alerts for business process actions
- Automated process and forms to capture local review comments on concession issues.
- Reporting and notification on process status.
- Audit trail capture and reporting for all system transactions.
- On-line payment of fees and reporting

Geographic Information System (GIS)

- Import and loading of concession boundary and attribute data.
- Custom applications supporting GIS data update
- Geographic referencing and map-based query to retrieve concession documents.
- Spatial analysis (map layer overlay) for concession area validation to identify geographic conflicts of concession areas (overlap of multiple concessions, protected areas, other geographic conflicts).
- Query and listing of local government/tribal entities in proposed or existing concession areas (with demographic data).
- Analysis and reporting of physical characteristics in and around proposed or existing concession areas (e.g., land cover, elevation/slope).
- Environmental analysis (runoff, pollutant discharge modeling) to support EPA review.
- Preparation of custom maps of concession areas.
- GIS tools to support boundary delineation--updating of concession boundaries or administrative boundaries (e.g., Clans).

It is extremely important that CIMS remains flexible to respond to changes in user needs and business requirements. This means the CIMS should have software capabilities that provide flexible tools for revision and enhancing user applications and for making database changes.

2. CIMS TECHNICAL DESIGN OVERVIEW

2.1 Overview of CIMS Technical Configuration and Components

The technical components of CIMS encompass the computer hardware, networks, data, and applications that deliver needed information to users. This design has been based on an evaluation of concession-related business processes, review of current information systems, and previously documented design ideas. In particular, the following sources have provided a foundation for this design:

- *A "Roadmap" to Develop the National Concessions Cadastre for Liberia* (USAID GEMS Project, 2013).
- *Liberian Spatial Data Infrastructure: Development of Minimum Standards for Spatial Data Sharing*, Volume I and II (USAID LPIS Program, 2013).
- *Concessions Business Processes Assessment and Improvement* report, documenting workflows defining actions for key concessions procurement and management business processes (GEMS consultant Amadou Thery), May 2014.
- *Government of Liberia e-Government Interoperability Framework* (eGov standards prepared by GEMS consultant Peter Tobbin for the GoL Ministry of Post & Telecommunications), draft March, 2014.
- *Government of Liberia Enterprise Architecture Framework* (eGov standards prepared by GEMS consultant Peter Tobbin for the GoL Ministry of Post & Telecommunications), draft anticipated in May, 2014.

Figure 2 illustrates the overall CIMS architecture and key components and Table 4 explains these components. There will be a central site housing processing resources (server and storage), data, and software. Users will access the system, normally through a Web-based interface, over a wired local area network or using a wireless connection. As shown, the system will have the capability for access by external (non-Governmental) organizations through a specially configured Web connection.

Figure 2: Mature CIMS Technical Configuration

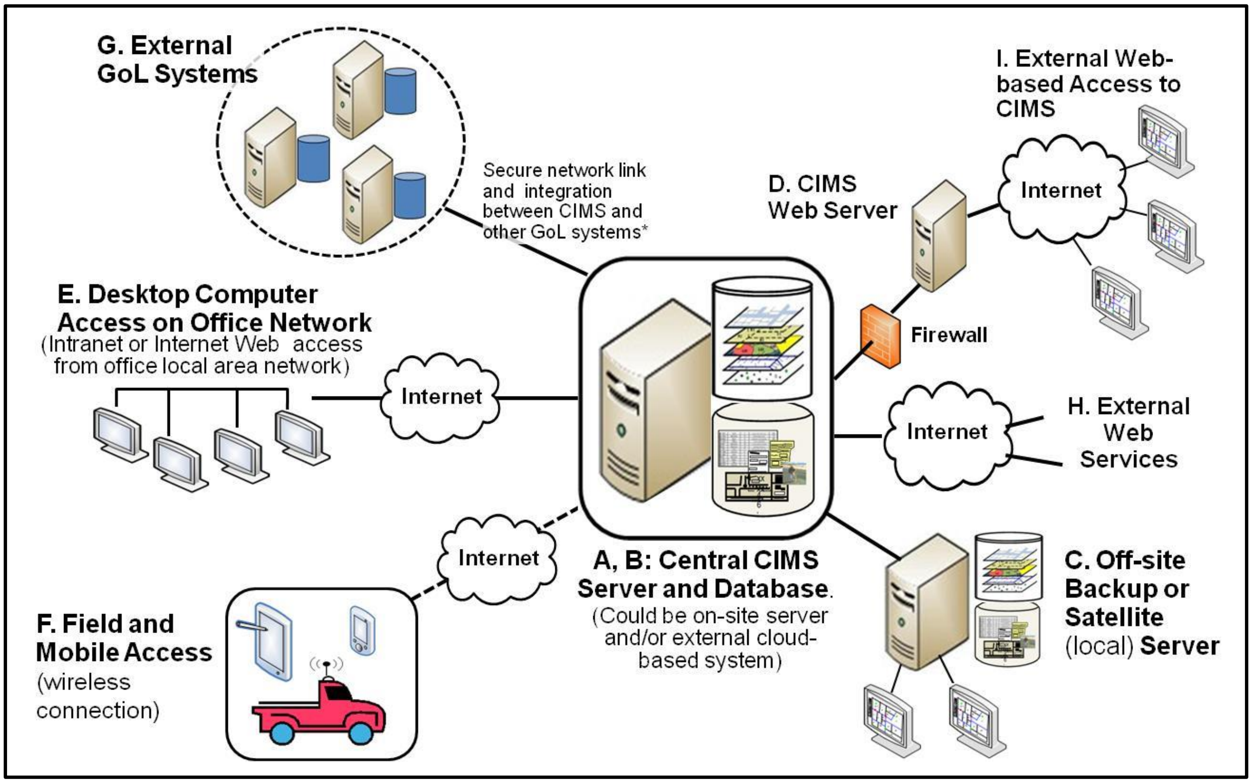


Table 4: Description of CIMS Technical Components

CIMS Technical Component	Description
A. CIMS Central Server	This is a Windows-based or Linux server environment that supports all central processing, data storage, and software/user applications. There are three main choices for how this is configured: a) dedicated server, b) virtual server using existing and available in-house servers, c) cloud-based services (external hosting services with robust ad secure Internet connection). The central server is tuned for optimal performance and is configured for high-speed access with robust access security control (with firewall and intrusion detection/prevention tools).
B. CIMS Central Database	The central database, managed as part of the central server environment (A), stores CIMS data and provides access from software and users in a secure environment tuned for good performance. As in the case of the central server (A), this could be configured: a) as a dedicated resource in-house, b) virtual environment, or c) external cloud-based hosted environment. In any of these environments, the assumption is that access is provided with appropriate, robust security controls.
C. Back-up or "Satellite" Server and Data Storage	This includes a separate, off-site server and data storage environment. At a minimum, this should include off-site back-up data storage that can be accessed in case of data loss at the main central server site. While optional and more costly, it could also be configured with back-up server resources with replicated data and software to provide fail-over service if the main central site fails. Such a back-up environment could be configured using in-house systems or Cloud-based services. In addition, there is an option to set-up local "satellite" servers at distributed sites (e.g., a GoL agency field office outside of Monrovia) if the location does not have good network access to the Central Server (A). In this case, data from the Central Server would also be stored (and periodically replicated) on the local server and users would access CIMS directly on that local server. Such a satellite server environment is an exception (as opposed to Web access to the CIMS server) and should only be considered where network connections warrant and where there are sufficient technical resources to support a local server, software, and data.

CIMS Technical Component	Description
D. CIMS Web Server	For external Web-based access, a separate Web server environment, with appropriate network connection to the main server and robust firewall and security controls would be set-up. As in the case with the CIMS central server (A), this could be set-up in-house (dedicated or virtual server) or using external, Cloud-based services. There is also option to configure CIMS Web services on the CIMS Central Server (no separate physical server), but in an environment in which public access is allowed, it would be best (from a security and performance perspective) to configure the Web Server as a separate device or Cloud service.
E. Desktop Computers on Office Network	Address users on desktop computers and peripheral devices on an office local area network. These desktop users would access CIMS through a private Intranet Web-based connection (if one is configured) or through a public Web-based connection. Desktop computers may, in compliance with established policies and technical standards, operate some local PC software and store some local data—example is desktop GIS software and data that is configured in coordination with the central server GIS software and data but the normal mode of operation is to access applications and data through Web services. CIMS users, as required, will also have access to peripheral devices including: small-format printers, large-format plotters (in limited cases), scanners (page-size and large-format).
F. Mobile Devices for Field Access	CIMS will allow for access by approved mobile devices (tablet computers and smart phones) for specific applications. They will access CIMS using a wireless connection through a Web-based application—which may or may not require an app to be loaded on the mobile device.
G. External GoL Systems and Databases	This includes an external server (separate from CIMS) with software and/or data managed by another MAC or independent organization. With proper security and network connection, a link would be set-up to allow the batch exchange of data or direct interactive access to external data or applications For example, this could include an integration with any dedicated servers used by Concession-granting entities (GoL ministries) for their own concession activities or GoL enterprise systems (e.g., a future procurement management system).
H. External Web Service	CIMS will allow connection with and access to external Web-based services that provide data and/or applications needed by CIMS users. These links would be configured through CIMS applications as hyperlinks to the appropriate URL—with necessary security controls. A common example be the use of Google Web services—which could include email, office apps (e.g., Google docs), and Googlemaps.
I. External/Public Users (Web access)	For specific applications, CIMS will allow external user access through Web-based services—which could be configured as fully public-based access or only by selected, registered external users with security controls. One example might be access to GIS data with tools to examine possible conflicts with proposed concession areas. CIMS users, as required, will also have access to peripheral devices including: small-format printers, large-format plotters (in limited cases), scanners (page-size and large-format).

2.2 Prototype Configuration

CIMS development and deployment, of the mature configuration described in 2.1, will occur over three Phases (see *CIMS Implementation Plan*). Phase 1 will include start-up activities and the development of a prototype—a limited system that will provide some CIMS functionality for the NBC, while all system components are being developed and deployed in Phases 2 and 3. The specific components in the prototype are not yet defined in detail but will likely consist of:

- 2 or 3 PC workstations on a local network in the NBC, one of which will have the role of a local server for storing selected concessions-related data. Another option is for the PCs to be connected to a GoL server if server resources are available and network access can be configured.
- Office software including (Microsoft Office or OpenOffice) providing word processing, spreadsheet, email, calendar, and possibly other software supporting office administration and automation.

- A limited GIS database that will include medium resolution orthoimagery with national coverage and selected GIS datasets from existing sources.
- A indexed database with selected concession-related documents for query and access.
- An Internet connection that provides access to Cloud-based services for certain CIMS GIS, workflow tracking, and reporting functionality. It is assumed that Flexicadastre software—deployed in a cloud-based configuration will be used to support most of the prototype applications.

2.3 Software

Specific software packages, with necessary configuration and customization, will be used to implement CIMS applications. There will be a focus on open source software (see subsection 2.5) when: a) there is a significant total cost of ownership (TCO) advantage over commercial packages, b) such software can meet user needs, and c) there are adequate software support options. To the greatest extent possible, CIMS will use off-the-shelf functionality of software with as little customization as necessary. It is recognized that in some cases, user application will require custom designed interfaces and coding work. This CIMS design does not include specific recommendations but suggestions are provided below in Table 5 which reflect the state of the industry and the software environment in Liberia.

Table 5: CIMS Software Suggestions and Options

CIMS Functional Component	Software Options
Database Management	Any SQL-compliant relational database management software package would be acceptable. Software should handle a full range of data types—including XML data. The software should have sound security and database administration capabilities and, ideally, application programming interface (API) tools that support integration with external software and databases. In addition, the DBMS should provide an effective user interface and specific application tools (e.g., report design/generation engine). Where possible, robust Open Source DBMS software could be used (MySQL, PostgreSQL) or, where applicable, a software vendor package (Microsoft SQL Server, Oracle) could be used.
Office Automation and Administration	Basic office automation (word processing, spreadsheet, presentation design) will use an accepted office software suite. This could be Open Software, such as Google Apps for business or Open Office or it could be a vendor package (Microsoft Office). There are similar choices for open or vendor proprietary software and Web-based services for email, calendar/scheduling applications, collaboration.
Document/Records Management	Basic document management capabilities could be put in place using office automation and database management tools described above. Several licenses for Adobe Acrobat could be used as well to institute a higher level of document control. There are also quite a few vendor software and Open Source document management software packages that could be employed. The Flexicadastre software package (by Spatial Dimension), which provides integrated tools for concession activity management, includes document management capabilities.

CIMS Functional Component	Software Options
Workflow Tracking and Reporting	Simple workflow tracking capabilities could be custom developed using database management software tools. More robust workflow capabilities that would include would include workflow process modeling, triggers and alerts, attachment of documents, etc. would best be implemented with a workflow management software package. This could employ capabilities of project management software (like Microsoft Project) or software specifically designed for workflow management. There are dozens of software packages (including some open source), that offer these capabilities. Also, the Flexicadastre software package (by Spatial Dimension), provides integrated tools for concession activity management, includes document management capabilities.
Geographic Information System	GIS software functionality can be provided by a mix of commercial vendor software and open source tools. GIS server-based software used for managing the GIS database and providing Web-based applications for users, and any client-based software should adhere to applicable standards, referenced on 2.5 for geospatial data management and Web services, To the greatest extent feasible, users should access GIS data and applications from the CIMS central server or approved Cloud-based service via a Web browser—avoiding need for local client-based software or local data storage. Currently in Liberia and around the world, GIS software from Esri has become a de-factor standard and is an option for CIMS implementation. This includes ArcSDE for managing GIS data and ArcGIS Server software for providing user access and a range of applications (Web-based access via Web browsers). In cases where local (PC-based GIS software is used, it should adhere to standards and preferably use Open Source licensing. There are a number of free and open source GIS software packages for desktop PCs and mobile devices (see http://en.wikipedia.org/wiki/List_of_geographic_information_systems_software) that could be used and would allow access to a centrally managed (or locally stored) GIS database. The Flexicadastre software package (by Spatial Dimension), which provides integrated tools for concession activity management, includes integration with the Esri GIS software.
System/Database Administration	Local database and systems administrators should be provided with all the necessary tools and functionality to administer, control, monitor and maintain all related systems. This includes tools included with the operating system (Windows Server or Linux) and application third-party packages to support system monitoring, performance management, event handling, back-up, account administration, etc.

Key CIMS components for oversight, coordination, and reporting on concessions activities is highly dependent an integrated system environment with robust database management, document management, workflow tracking, GIS, and reporting tools. To create such an integrated system, there are two basic approaches:

1. Deploy individual software packages and tools and perform custom integration and application development OR

2. Select a software package that already offers integrated functionality for all or most of the capabilities needed and, ideally, provides easy-to-use customization tools.

For approach #2, there are integrated workflow management packages that provide workflow/process design and workflow management functions integrated with document management and reporting functionality. Some of these are offered as modules in larger enterprise resource planning (ERP) software packages (e.g., packages from Microsoft, IBM, SAP, Oracle, and others) and other software is specifically focused on business process management. All of these general workflow packages would take a significant amount of customization for operational deployment. The Flexicadastre software from Spatial Dimension is designed specifically for concessions management and includes the key components—including a robust GIS interface. Fleixicadastre was used, until recently, by the MLME (funding for continuing software maintenance and support not allocated). With funding provided by two international donor organizations, GIZ and Ausaid, the MLME is currently using a software package called the Minerals Cadastre Administration System (MCAS) by the Revenue Development Foundation (RDF) to manage mining licenses and provides information about the concessions

Given the capacity constraints within GoL to meet its concessions oversight and coordination responsibilities, and in view of available software, the best approach is to use an integrated system to lessen the need for custom development and technical integration work.

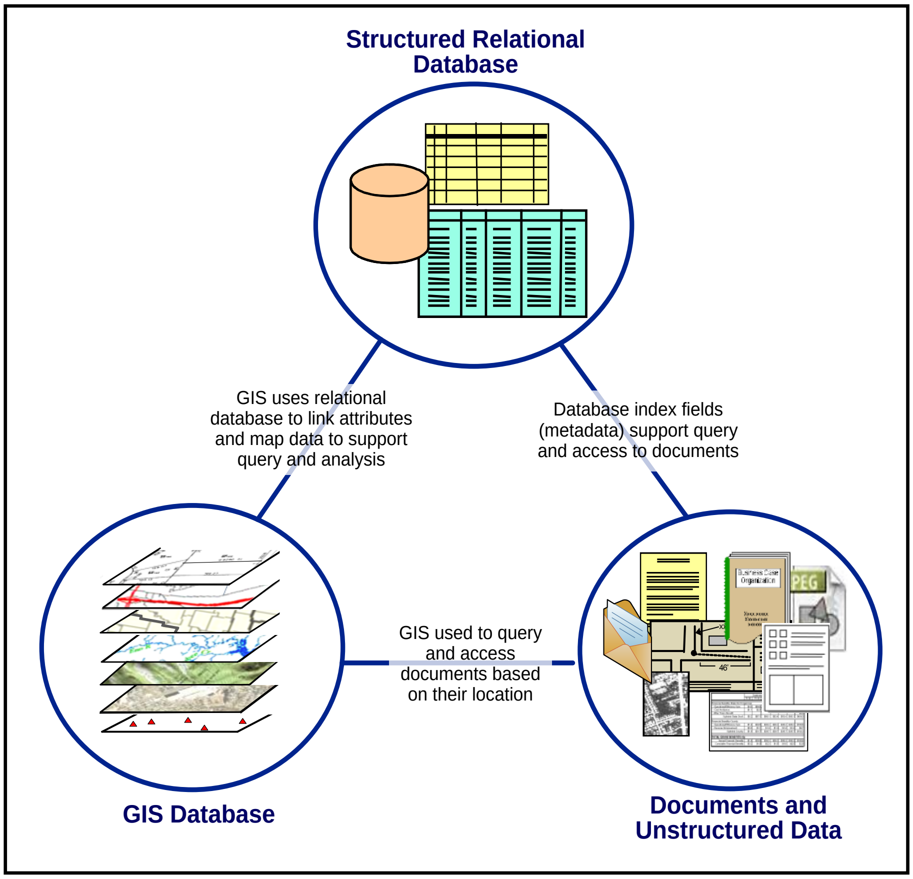
2.4 CIMS Concession Database

The NBC Act (September, 2011) calls for the NBC to "development and maintain" a "concession agreement database" and to make this widely accessible to GoL MACs, non-governmental entities, and the public. This "concession agreement database" for the purposes of the CIMS design is assumed to cover a wide range of information associated with concession-related business processes. CIMS will provide for the entry, management, query, and access to concession information stored in three main formats:

- Database tables
- GIS data
- Documents and unstructured data

The GIS (see Section 3) holds map-related features related to concessions (including boundaries of concession areas and a variety of map layers important for analysis of concessions. Database tables hold information in a structured format with specific data fields making up records that support query, analysis, and reporting. In CIMS an important example of structure database tables is data related to the status of a concession proposal review—the database holds information on status, dates, and review actions completed by stakeholder organizations. Structured database tables also store attribute information for GIS map features and metadata fields that support queries and data retrieval. Much of the information associated with concessions is stored as documents (e.g., concession forms, plans, reports) and unstructured data which does not follow a pre-defined format (e.g., email messages, Web site content, photos). A high-level model of the CIMS database environment is shown in Figure 3.

Figure 3: High Level CIMS Database Architecture



Concession-related documents are a critical source of information to be managed by CIMS and a major part of the "Concession Agreement Database" as called for by the NBC act. The main types of concession documents are listed below:

- Concession business process and workflow documents.
- Concession planning documents from concession entities (CEs).
- Concession solicitation documents prepared by CEs.
- Concession proposals and application materials (from concessionaires).
- Concession review documents (formal comments and materials prepared by CEs and other GoL organizations in the course of concession proposal and application review).
- Records of concessionaire invoices, statements, and fee payments.
- Records of concession negotiations.
- Pre-feasibility reports
- Concession agreements and certificates along with any amendments or referenced documents
- Environmental and Social Impact Assessment (ESIA) reports, permits, and certificates issued by EPA

- Social agreements
- Reports resulting from special research or studies related to concession proposal
- Quarterly and annual reports from concessionaires
- Concessionaire 5-year development plans
- NBC quarterly monitoring and evaluation reports
- Correspondence related to concession applications or activities
- Records documenting concessions monitoring and review (after concession granting)

Currently, most of these documents are maintained in hard copy form. One part of CIMS implementation is to automate those hard copy documents through scanning to create image files in one of several standard file formats (TIFF, PNG, GIF, JPEG or PDF). In many cases it will be important to process those scanned files using optical character recognition (OCR) software to convert them to readable text format and possible use of optical character recognition to convert scanned image data into readable text and storage in PDF or a word processor format. The eventual goal is to automate the steps of document creation, submittal and routing to remove or reduce the reliance on hard copies. The relational database would be used to capture index data (metadata) about these document files to support query and retrieval.

To support efficient storage, query, and access to these documents, the CIMS database (using the database management software) will capture database index fields (metadata) for these documents. Key index attributes will include:

- ID number(s) for concession solicitations, agreements, permits, certificates
- ID number(s) associated with financial transactions (payments by concessionaire)
- Document type (based on a classification scheme characterizing all concession documents)
- Concession Number and Sub-numbers (referring to concession area and specific tracts of land inside the concession boundary)
- Receipt number
- Version numbers
- Keywords
- Date information for key milestones
- GoL agency(cies) responsible
- Location fields (County, District, Clan)
- Document authors/editors

2.5 Technical Standards

CIMS development and decisions for acquiring and implementing CIMS software, databases system infrastructure, will require policies and standards to guide an overall enterprise ICT and e-Government strategy for the GoL. Specific standards, as explained in the GoL E-Government

Interoperability Framework Standards (GEMS, April 2014) are selected based on the principles of: flexibility, documentation as formal or de-facto standards, vendor/product neutrality, Internet-based, scalability, reusability, openness, market support, security, and privacy.

In summary, CIMS data content, format, and management will adhere industry standards and specific GoL ICT standards being developed by the GEM Project and documented in the Government of Liberia *e-Government Interoperability Framework* and *Enterprise Architecture Framework* standards reports. More specifically the following design practices and standards will be followed:

- Focus on Web-based services and access with adherence to applicable Internet and Web-based standards defined by standards bodies—including the Worldwide Web Consortium (W3C), the International Organization for Standardization (ISO), the Internet Engineering Task Force (IETF), and others. This includes basic architecture and data format standards—e.g., use of accepted standards for HTML/XHTML mark-up languages, XML data formats, and Resource Description Framework (RDF). This also covers higher level standards for Web-based services and protocols for communication among Web services and with external systems—e.g., Web Services Description Language (WSDL), Simple Object Access Protocol (SOAP), and the Universal Description, Discovery, and Integration (UDDI) standard for Web service registration and search. Management and deployment of CIMS applications as Web services is meant to provide a more effective management environment (on the server side) and a more flexible and efficient environment for access by users.

- Applying robust standards and practices for security and access authentication applying to software, data, and all system transactions. Security practices and standards follow the specific items of the "Security Domain" of the GoL E-Government Interoperability Framework.

- Maximum use of open systems. "Open Systems" in a broad sense applies to any ICT hardware, database, or software component which are not subject to restrictive terms or licensing associated with vendor proprietary systems and which promote a high-level of interoperability and portability. In keeping with emerging ICT policies for Liberia, CIMS development will focus on use of open systems products with meet functionality requirements and for which there is an active user community. This includes use of Linux for system servers, open source software on servers and or clients (e.g., open source database management software like MySQL or PostgreSQL), and open source application software tools. Open source software packages are those to which accepted open licensing terms apply (e.g., from the Open Source Initiative-OSI) and which generally allow free or low-cost use and user modification. There are specific Open Systems standards applying to GIS software and Web services—espoused by the ISO (Technical Committee 211), the Open Geospatial Consortium (OGC), and other government-sanctioned and independent organizations. A decision to use a specific Open Source product should be based on its functionality (and ability to support user needs), available support, and a projection of total cost of ownership (TCO) as compared to commercially available software.

- Applicable standards for storing and managing metadata associated with different types of CIMS data: GIS data, structure database content, documents, and unstructured text data (e.g., email, Web page content). For GIS data, the applicable standard is ISO19115. For other data types, the Dublin Core Metadata Initiative (DCMI) provides the basic framework for metadata elements (DCMI metadata element set, ISO standard 15836:2009).
- Use of GoL eGovernment standards and services as it applies to CIMS transactions for business communications—including certain types of messaging, document routing and approval, and financial transaction (e.g., concession fee payments and receipts). The GoL E-Government Interoperability Framework standards (GEMS, April 2014) Electronic Business XML (ebXML) standards provide the framework for applicable CIMS business transactions and Web services.
- Adherence to applicable Cloud-based computing standards defining accepted interface standards for CIMS implementation that may use external Cloud-based infrastructure, data, or Web services. Cloud-based implementation should follow appropriate industry standards now emerging from such organizations as the Open Grid Forum, Distributed Management Task Force (DMTF), Open Cloud Consortium (OCC), Organization for the Advancement of Structured Information Standards (OASIS), and other organizations.

2.6 Software and Database Integration

Selection of software for CIMS should be based on functional capabilities as well as its capability to support integration among software packages and databases. As described above in 2.3, software packages should provide a high-level of integration to avoid needs to build custom interfaces between separate software packages and databases. This said, it is still important for the CIMS design to include capabilities for flexible integration between separate systems. Some possible scenarios in which such integration may be required are:

- CIMS integration with an external financial management package to get information on concession fee payments.
- Access concession workflow status data maintained by a specific ministry using a separate software package (different workflow tracking software than that used by CIMS).
- Import of map data (GIS or CAD format) captured and maintained outside of CIMS (e.g., GIS data from a concessionaire).
- Concession-related documents created outside of CIMS that need to be accessed through CIMS.

The term "integration," as it is used here, in its most general sense, implies merging, combining, or establishing a connection to a system among separate processes, applications, or databases. Integration normally involves one or more of the following actions: a) transferring data among multiple systems in real-time or batch mode, b) passing messages from one system or application to another to invoke a certain software process, c) embedding links of a system into the User Interface of another to allow use of the two systems, or d) allowing user access, from one system or application, to a different system or application, through a shared sign-on, single sign-on, or other means of system access.

The objectives of any integration effort are to accomplish one or more of the following:

- Eliminate duplicate data or redundant data maintenance processes.
- Simplify the software environment (including the possibility of consolidating and/or migrating multiple software platforms into a fewer number; such as is employed in examples a-d above).
- Simplify, standardize, and unify user interfaces.
- Create links between separate systems to support easy exchange of, or access to, data maintained on different system platforms.
- Establish a flexible environment (often transparent to the user) for linking software and application transactions between multiple systems (to cut down on repetitive steps to access multiple systems).

System integration may take one of two forms:

1. "Loosely coupled" integration in which case the external system would be maintained and operated independently with a process set up for periodic batch transfer of data to and from the source and destination systems to support applications that do not require real-time or near real-time integration. This periodic transfer could be a regularly scheduled batch transfer and data loading (e.g., daily, weekly) or a more sophisticated data replication process that is set up to run automatically on a frequent basis (e.g., daily or even more frequently such as transactional or as maintained via replication processes at the database level). This type of integration is sometimes referred to as "extract-transform-load" (ETL).

2. "Tightly coupled" integration involves a real-time or near real-time connection between two systems or databases in which one system sends information to the other over a shared connection (either private or over the Web) to pass data or a command to invoke an action on the other system. This could be in the form of a message, database trigger, or other method of calling for action or information such as leveraging an exposed API. This type of integration is much more technically complex than the "loosely-coupled" approach as it requires real-time transactions of commands or messages and data between the systems.

At this point in the design process, it is not possible to identify specific integration scenarios that CIMS will need to address but the main software components of CIMS—database management and GIS are both designed to support integration with other systems and databases. It is likely that initially, most integration needs for CIMS will follow the "loosely-coupled" approach described above in which data will be imported or exported by CIMS as a batch file transfer. The important issue is to identify a database field (a key field) that uniquely identifies the data and can be used for the data integration. A simple example is the transfer of a document file (e.g., Microsoft Word or PDF) which is associated with a specific concession agreement. A key field such as "concession agreement ID#" associates that document file with the correct records in the CIMS database.

2.7 Technical and Infrastructure-related Challenges

The Liberia environment presents a number of challenges to implementation and operation of any major ICT system. For CIMS, there are some important limitations, addressed in more detail in the *CIMS Implementation Plan*, which need to be taken into account in CIMS development and deployment—in particular, the following:

- Power supply is limited and dependent on generators and a supply of fuel which can sometimes be interrupted.
- Computer system and network maintenance (basic computer hardware maintenance services) are more limited than in more developed locations.
- Network access and bandwidth is limited in many locations. While dedicated network services and 3G/4G wireless access is available in Monrovia and other urban areas, access limitations are present in other areas.
- IT and GIS expertise (systems administration, database administration, and software) is currently limited and presents obstacles in recruiting staff to support systems operations.

The infrastructure and human resource limitations listed above have been taken into account in this CIMS design and in the accompanying *CIMS Implementation Plan*. One of the key design principles that address problems of computer hardware and software administration, license management, support, and requirements for regular hardware upgrade is to deploy CIMS in a server-centric, Web-based environment in which users access data and applications as Web services through a Web browser. This reduces hardware requirements for local computers, the need for local software license maintenance, system administration, etc. Web services protocols provide an efficient and secure environment for user access. While network access limitations and some specialized user needs may call for some cases of data and software maintenance on local computers, the overall goal is to deploy CIMS in a Web services, "thin client" environment.

The *CIMS Implementation Plan* defines a multi-year approach to development and deployment beginning with a prototype and phased implementation. This includes main responsibility for CIMS development and deployment to be assigned to a Prime Contractor with oversight by the GoL and donor organization support. CIMS implementation will follow a Build-Operate-Transfer (BOT) approach in which the Prime Contractor will develop the system, provide operations and user support for a specified period, and then transfer operations to the GoL. The Prime Contractor will have responsibilities for CIMS implementation, capacity building, and facilitating the transfer so that systems, staff, and management are ready for the transfer to Liberian management and operations. The type of BOT operation recommended for CIMS follows what may be referred to as a "turnkey" model. The assumption is that funding will be established to cover the full contractor costs for setting up and operating the BOT facility and transferring operations to Liberian control.

3. GIS DATABASE DESIGN

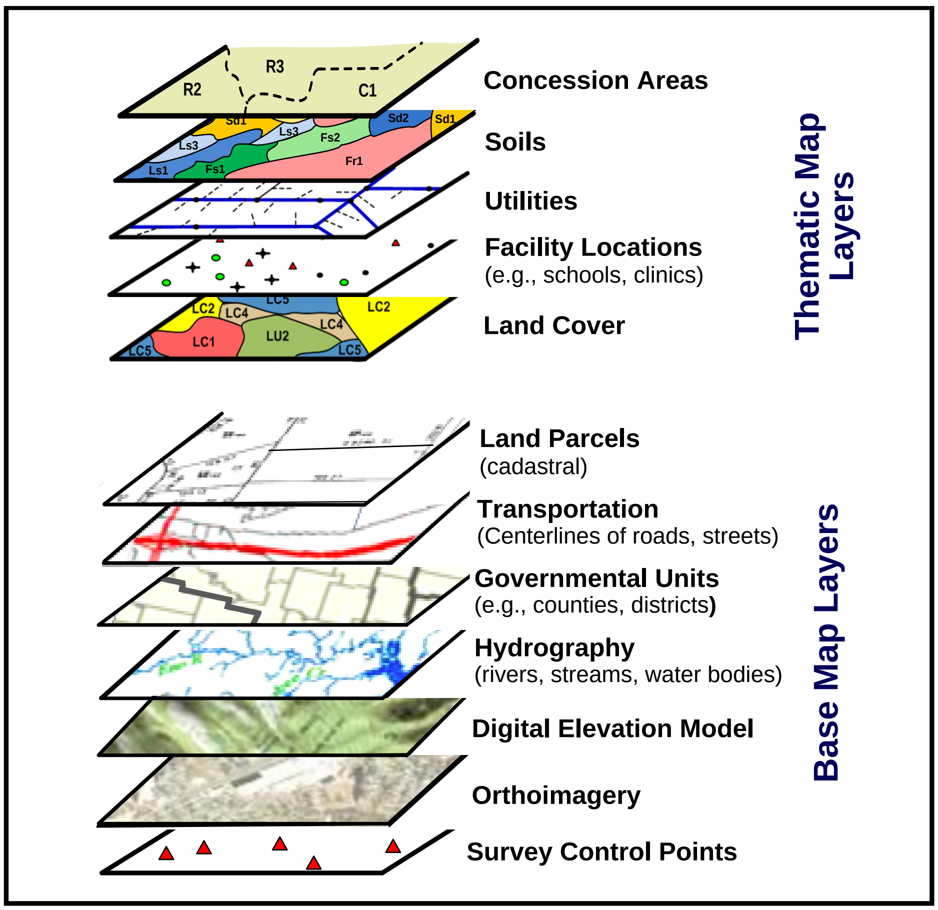
3.1 GIS Database Concepts

3.1.1 GIS Feature Types and Format

A GIS database can be conceived as a series of digital map layers each of which includes map features and attribute data about those features. GIS databases are often organized into two main categories as shown in Figure 4.

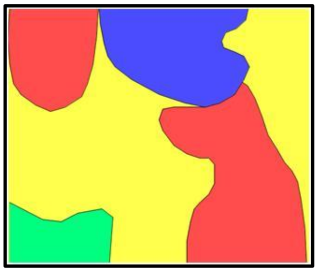
- Base Map Layers: Map layers that contain features which will be used widely (by multiple ministries and organizations) and which provide a spatial reference for thematic map data and applications (e.g., orthoimagery, road network, political and administrative boundaries).
- Thematic Map Layers: Map layers which contain features which are needed for specific groups of users and address applications related to a specific discipline or program (e.g., land cover, concession areas).

Figure 4:
Concept of GIS Map Layers

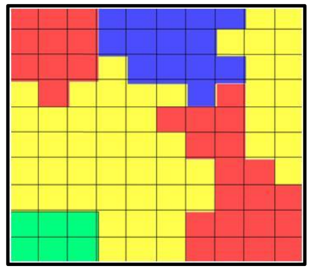


GISs store map data in a variety of formats depending on the type of features and the needs of users. Map features and geographic conditions are normally represented in a GIS database in one of the formats as shown in Figure 5.

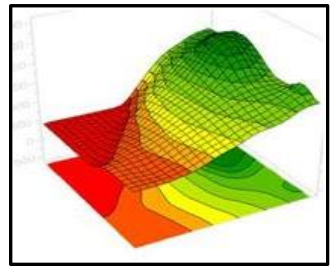
Figure 5: Major GIS Map Data Format Types



Vector Format: are depicted in their actual position on the ground (in x, y) coordinates. Examples: Road network, administrative areas



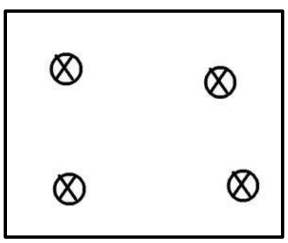
Raster Format: Features are generalized from their actual position on the ground as grid cells. Example: Aerial images



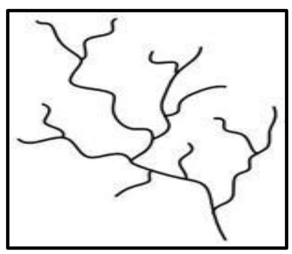
Three-Dimensional Surfaces: Geographic features are depicted with their horizontal position (x, y coordinates) and their height or elevation. GIS databases have a variety of formats for storing 3-dimensional data

Vector, the most frequently used format in GIS databases, stores features as strings of coordinates, represents actual boundaries or locations of features on the ground as illustrated in Figure 6.

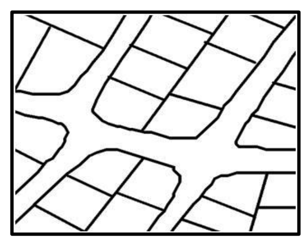
Figure 6: GIS Vector Format Feature Types



Point Features: Position represented as a single x, y location. Example: survey monuments



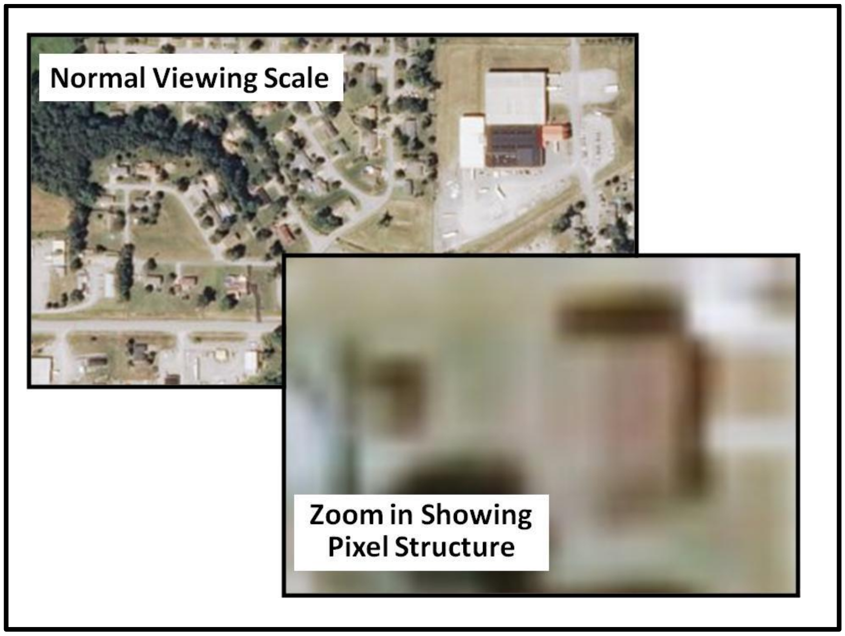
Line Features: Represented as a series of x, y coordinates. Examples: Centerlines of roads, streams.



Polygon (area) Features: Features represented as a closed boundary and the interior space inside that boundary. Examples: Political/administrative areas, cadastral parcels

The raster format generalizes surface features as grid consisting of a matrix of cells or "picture elements" (pixel). The most common example of the raster format in GIS is orthoimagery—digital air photography in which raster cells have a value representing a color or gray tone value. Raster orthoimagery uses a very small pixel size so that the image appears to be continuous and approximates the image quality of a traditional film aerial photograph. If an orthoimage is enlarged to a sufficient level, the grid-based structure is revealed (as shown in Figure 7).

Figure 7: Raster Structure Example--Orthoimagery



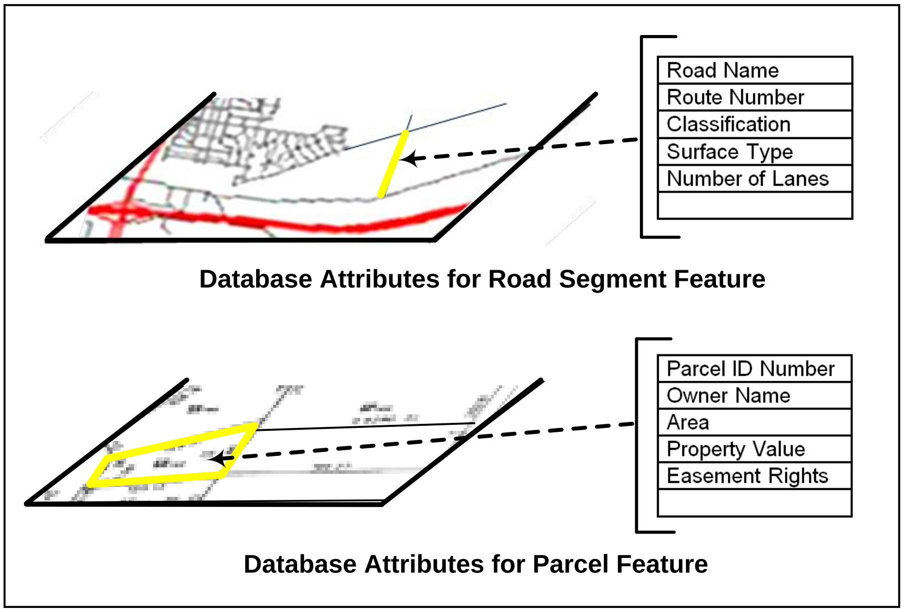
Three-dimensional data (e.g., surface terrain) may be represented in a GIS in a number of different ways. Common GIS formats for storing 3-D data include:

- Contour lines (vector line features of equal elevation).
- Raster format digital elevation model (DEM) in which grid cells have an elevation value.
- Vector features (e.g., a building outline) have an attribute value for the elevation or height of the feature.
- Triangular Irregular Network (TIN) in which the surface is modeled as a mesh of interconnected triangles whose vertices have elevation values.
- As three-dimensional coordinates in which GIS features have their positions stored as x, y, and z coordinates.

3.1.2 GIS Attribute Data Linkage and Management

GIS software and database architecture supports the linkage map features and database tables containing attribute information about the map features. The attribute data includes unique identifying information (i.e., primary key fields) about map features such as feature names (road name, river name) and/or a feature ID code (e.g., cadastral parcel ID #). The attribute tables may any additional attributes that provide information about a map features characteristics, status, etc. Figure 8 illustrates this GIS map feature-attribute linkage data content. GIS software provides capabilities for query, analysis, and display of features based on these attributes.

Figure 8: GIS Attribute Data Linked to GIS Features



3.1.3 GIS Data Quality and Access Parameters

For GIS databases, the term "quality" refers to how closely the GIS database meets specifications for data content, format, and accuracy. Different levels of quality may apply for different GIS databases or map layers. In summary, the following data quality parameters apply to GIS databases:

- File and Layer Naming: Adherence to standards for naming of files and database layers.
- Map Feature Completeness and Organization: Inclusion of all valid features that appear on source material and inclusion of the features on the proper database layer.
- Graphic Quality: Proper graphic closure and topology, feature segmentation and connectivity, edgematching, and other graphic concerns, including feature connectivity rules and proper line coincidence of related features (e.g., parcel vs. zoning lines).
- Positional Accuracy: Proper positional placement of map features based on established absolute coordinate accuracy standards (expressed as a maximum ground distance error).
- Attribute Completeness: Population of all database fields for map features.
- Attribute Accuracy: The correctness of entered attributes and proper adherence to database format, established domains, and proper values from source material.
- Symbology, Annotation, and Sheet Format: Adherence to established symbol, line type, color, proper feature labeling and annotation placement, and map sheet layout criteria.
- Image Format and Quality: For data conversion projects involving scanning or drawings, documents, or the production of orthoimagery, this covers such criteria as image rotation and cropping, raster file format, pixel resolution, and overall image

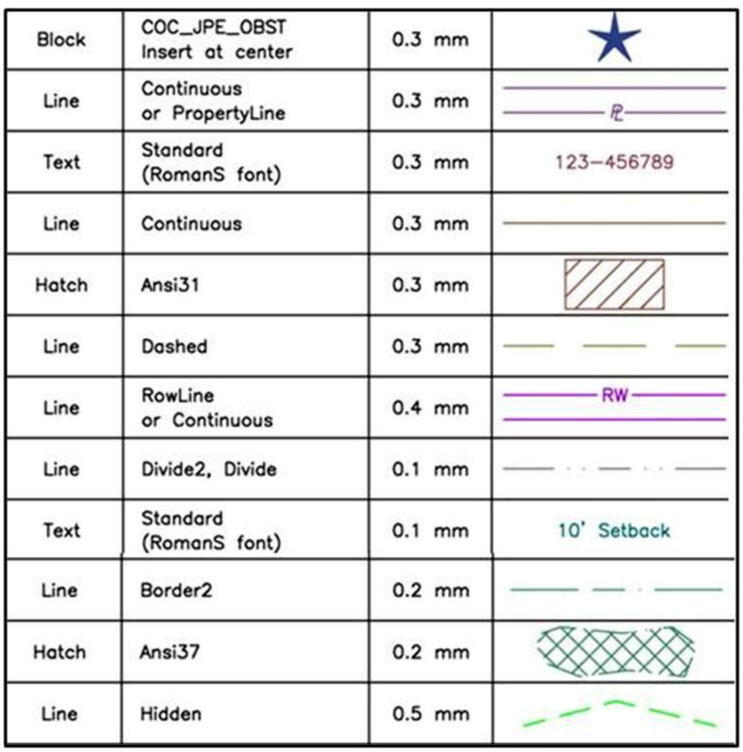
quality (contrast, speckles, or artifacts, etc.). For aerial orthoimagery, one other key consideration is cloud-free (or close to cloud-free) coverage—requiring proper planning and timing for imagery acquisition.

In any GIS database development project, specifications should be defined for the level of data quality that is required. To the extent possible, accuracy criteria should be stated in quantitative terms (e.g., percent correct values for attribute accuracy, maximum ground distance for positional accuracy). These data quality specifications should take into account the source materials and methods being used for data capture and compilation and well as the intended use of the data. Systematic quality control and quality assurance checks and testing should be conducted to ensure that the GIS data meets quality standards.

3.1.4 GIS Map Feature Symbology and Annotation

Map features in a GIS database are displayed according to specific standards and parameters that address: a) point symbol type, orientation, and color, b) line pattern, weight, and color, c) shading patterns and colors for polygon features, and d) font type, size, color, and orientation for text annotation. Figure 9 illustrates this concept.

Figure 9: Concept of Map Symbology and Annotation



Block	COC_JPE_OBST Insert at center	0.3 mm	
Line	Continuous or PropertyLine	0.3 mm	
Text	Standard (RomanS font)	0.3 mm	123–456789
Line	Continuous	0.3 mm	
Hatch	Ansi31	0.3 mm	
Line	Dashed	0.3 mm	
Line	RowLine or Continuous	0.4 mm	RW
Line	Divide2, Divide	0.1 mm	
Text	Standard (RomanS font)	0.1 mm	10' Setback
Line	Border2	0.2 mm	
Hatch	Ansi37	0.2 mm	
Line	Hidden	0.5 mm	

One of the very useful capabilities of GIS software is to change these display parameters for the production of different types of map displays but it is important to establish standard default symbology standards for different features. GIS software provides capabilities to set default symbology and display criteria for map features.

3.1.5 GIS Data Quality, Display, and Spatial Rule Management

Many GIS software packages provide powerful tools for establishing "rules" for GIS databases. In the context of GIS, a "rule" is a defined parameter that is used to control database content, format, or map display. Proper assignment of rules, for specific map features and layers can help to control database quality (during GIS database development and ongoing update) to automate map display, and to support GIS query and spatial analysis applications. A summary of the types of rules typically available in GIS software is provided below:

- Attribute data domains: Defines valid values for attribute fields (acceptable values or ranges) and other database controls (acceptance of null values).
- Feature connectivity and spatial coincidence: Addresses a range of graphic and spatial relationships including: a) allowable connectivity of point and line features (e.g., water pipe segments must connect at valve or fitting point features), b) spatial coincidence of polygon or line features (e.g., a cadastral parcel boundary and administrative boundary must coincide).
- Map display scale thresholds: Controls which features or GIS map layers are displayed at a certain scale and how the features are displayed (point symbols, line types, colors) at different scales.

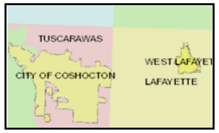
3.2 GIS Database Design—Content and Format

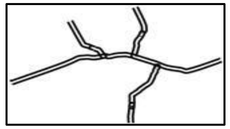
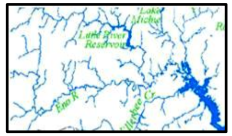
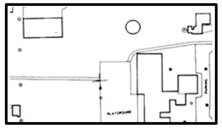
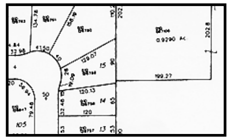
The GIS design in this Section is based on a review of business needs of NCC stakeholders (see Section 2). In addition, the design uses work already carried out through the Land Policy and Institutional Support (LPIS) project involving spatial data infrastructure (SDI) recommendations. The two-volume LPIS report summarizes current GIS-related programs and challenges in Liberia and provides recommendations for GIS database development.

Tables 6 and 7 provide information on the recommended content of GIS data layers—including an identification each layer, the GIS map feature format, and geographic coverage (national coverage or just specific regions). The table also identifies a priority category (Very High, High, Moderate, Low) which is a reflection of the level of need and importance to support natural resource concessions business processes and the needs of the NBC and concession entities. Some of the map layers described in Tables 6 and 7 showing Moderate or Low priorities may have a higher priority for other (non-concession related) programs.

Table 8 provides information on expected attribute data elements associated with features in the GIS database layers. The detailed GIS database design should include attribute data schemas that allow for the population of these attribute data elements. This is an initial identification of key attributes which may be modified to some extent as part of a detailed GIS database design process. One very important characteristic of that most of the attribute schemas should allow for the entry of a user-defined ID (primary key) that is the main attribute by which a feature is identified (e.g., a Concession Agreement Number for a mapped concession area).

Table 6: Recommended GIS Base Map Layer Description and Priority

GIS Data Layer Name	Priority[1]	Format[2]	Description of Map Feature Content	Geographic Coverage	Example
Survey Control Points/Local Monuments	VH	V-PT	Locations of permanent with accurate horizontal (and often vertical) coordinates used to support survey and mapping activities. Also included are local property markers (e.g., pins, monuments) used as references for local surveys but not referenced to geographic coordinates (Lat/Long) or map coordinates (e.g., UTM).	Full national coverage	
Orthoimagery-National Coverage	VH	R	Geographically corrected high to moderate resolution (1 to 2 meter pixel size), panchromatic for full national coverage with digital imagery captured from satellite or aircraft platform.	Full national coverage	
Orthoimagery-Urban Areas	VH	R	Geographically corrected high-resolution imagery (from satellite or aircraft platform) at resolution 30 to 60 centimeter resolution.	Full national coverage	
Digital Elevation Model	H	R, V-PT	Model of the surface terrain based on elevation relative to the established vertical datum. Raster (grid-based) DEM is recommended. The digital elevation model may be used to generate topographic contour lines (Vector Line features). Ideally, the DEM should capture elevations at ground surface with the understanding that densely vegetated areas will present obstacles to getting a precise ground surface measurement. Elevation data (ideally orthometric height above sea level) could be compiled photogrammetrically from satellite or aircraft captured imagery or from LiDAR. In addition to the grid-based (raster) DEM, raw elevation point data would also be included.	Full national coverage	
Governmental Administrative Units	VH	V-PG	Areas delineated by established boundaries of Enumeration Areas, Clans, Administrative Districts, Counties, Region (multi-County area).	Full national coverage	
Incorporated Municipalities	VH	V-PG	Areas delineated by formal boundaries of major cities.	For major incorporated cities	

GIS Data Layer Name	Priority[1]	Format[2]	Description of Map Feature Content	Geographic Coverage	Example
Villages, Communities, Populated Places	VH	V-PT	Point locations for small local communities, villages, and populated places.	Full national coverage	
Transportation- Public Roads	VH	V-LN	Centerlines of a) national road/highway network (primary and secondary highways).	Full national coverage	
Transportation-Local Roads and Streets	M	V-LN	Centerlines of local roads, streets, alleys for urban and settled areas. Also includes roads built to support mining, forestry, and agricultural operations.	Full national coverage (for developed areas)	
Transportation-Private Roads	M	V-LN	Roads built and maintained by a private company or entity for access to a specific area normally with restricted access by the public (e.g., roads for access and transport to/from mining, forestry, or agricultural operations).	For specific identified sites	
Transportation-Railways	M	V-LN	Centerline depictions of railroads (active or not-in-use)	Full national coverage	
Hydrography	H	V-LN, V-PG	Drainage network (rivers, streams represented as line or polygon features) and water bodies (natural or man-made lakes and ponds).	Full national coverage	
Important Planimetric Features	M	V-PG	Major man-made structures—selected buildings, airports, industrial facilities, and other structures.	Major urban areas and areas with major development (e.g., mining activity).	
Cadastral Parcels	VH	V-PG	Boundaries encompassing areas of land ownership and legally granted land rights (public and private land).	Eventual full national coverage (Note: Will involve long-term effort nationally. Initially focus on high-priority areas in and around concessions)	

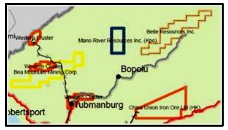
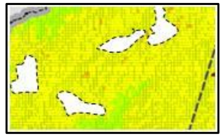
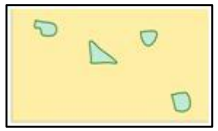
[1]Priority refers the level of need and importance for the data to support CIMS and the NCC program. VH="Very High"—essential for full CIMS operations and NCC stakeholders. Database development should be initiated and completed as soon as possible (full national coverage), H="High"—important for CIMS operations. Development focuses first on critical areas and full

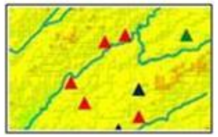
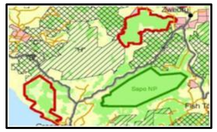
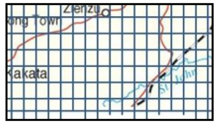
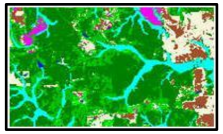
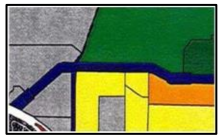
national coverage is completed over a number of years, M="Moderate"—very useful for CIMS operations but development may be scheduled as resources are made available. NOTE: Priority of these map layers for other (non-NCC programs) may be higher.

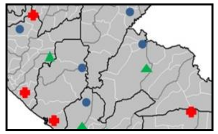
[2]GIS format type includes: V=vector, R=raster, TIN=Triangular Integrated Network (digital terrain model), PT=point feature, LN=line feature, PG=polygon feature

[3]Boundaries of cadastral parcels and information on land rights is extremely important for the GoL Concessions Program and many other applications. Sources of information from which to compile boundary and land rights information is greatly lacking so full national cadastral mapping should be considered a long-term effort with an initial focus on high-priority areas (urban areas and active concessions areas where there are boundary and land rights conflicts).

Table 7: Recommended GIS Thematic Map Layer Description and Priority

GIS Data Layer Name	Priority[1]	Format[2]	Description of Content	Geographic Coverage	Example
Concession Areas	VH	V-PG	Boundaries defining the areas of current, past, and proposed concession areas (mining, agricultural, forestry).	Locations where active or proposed concessions exist	
Project/site Specific Aerial Imagery	H	R	This includes aerial imagery for specific sites (small project areas or larger regions) which may be acquired periodically to support specific projects (e.g., monitoring of activities in a specific concession). Aerial imagery could be acquired by an aircraft or unmanned aerial vehicle (UAV) or satellite. It would be geographically corrected and available for access with other GIS data.	Specific project areas	
Mining Operations	H	V-PG	Areas undergoing major, legally licensed active mining operations (as opposed to small-scale illicit mining activity). This includes surface mining and quarry operations for iron ore, stone, precious metals, diamonds, or other minerals.	Full national coverage where mining and quarry operations exist.	
Large Agro-Forest Plantations	H	V-PG	Areas delineating use for large plantation production—primarily palm oil and rubber.	Full national coverages where areas exist	
Farms	M	V-PT	Locations of farms used for the commercial production of food or non-food crops. Point location represents approximate geographic center of cultivated area.	Full national coverage where farming operations exist	
Timber Sale Contract Areas	H	V-PG	Existing and proposed timber sale contract areas.	Full national coverage where areas exist.	

GIS Data Layer Name	Priority[1]	Format[2]	Description of Content	Geographic Coverage	Example
Community Forests	H	V-PG	Forest areas used by communities should be delineated to the extent possible. Any Community Forest Management Agreements approved by the FDA should be delineated and shown on the map.	Full national coverage where areas exist.	
Illicit Mining Locations	H	V-PT	Point locations for existing, small-scale illicit mineral extraction (mainly gold and diamond mining).	Full national coverage where activities exist.	
Protected Areas	VH	V-PG	Existing and proposed parks, conservation areas, and other areas of environmental value in which development is restricted.	Full national coverage where areas exist	
Concession Block Grid (Cadastral Unit)	M	V-PG	Square grid blocks used as a basis for new concessions. Note: No grid currently exists but may be created to manage future concessions.	Full national coverage or specific regions (as implemented)	
Easements	M or L	VPG	Delineated areas for which special land rights exist for a stated party such as ingress/egress or utility line corridors.	Full national coverage.	
General Land Cover	H	R, V-PG	Areas classified by major types of surface land cover (e.g., vegetation, water, agricultural). This is a high-level classification using an accepted classification scheme and mapping methodology based on satellite imagery.	Full national coverage where areas exist	
Land Use	M	V-PG	Mapping of areas according to use of the land—using a more detailed classification scheme than the General Land Cover layer—breaking down areas into subcategories of use (e.g., different types of agricultural land).	Ideally full national coverage but may be compiled just for specific areas as project needs arise.	

GIS Data Layer Name	Priority[1]	Format[2]	Description of Content	Geographic Coverage	Example
Soils	M	V-PG	Areas that delineating type of soil on the surface (based on a classification scheme reflecting physical and chemical characteristics). Mapping work uses best available topographic (landform) data and considerable field work with well-documented methodology.	Full national coverage where project areas exist	
Schools	L	V-PT	Point locations of public and private schools.	Full national coverage.	
Hospitals and Health Facilities	L	V-PT	Point locations of hospitals, clinics, heath centers, and other facilities providing health services. Location represents approximate center of settled area.	Full national coverage.	

[1]Priority refers the level of need and importance for the data to support CIMS and the NCC program. VH="Very High"—essential for full CIMS operations and NCC stakeholders. Database development should be initiated and completed as soon as possible (full national coverage), H="High"—important for CIMS operations. Development focuses first on critical areas and full national coverage is completed over a number of years, M="Moderate"—very useful for CIMS operations but development may be scheduled as resources are made available. NOTE: Priority of these map layers applies to uses in support of the NCC. Priority for other (non-NCC programs) may be higher.

[2]GIS format type includes: V=vector, R=raster, TIN=Triangular Integrated Network (digital terrain model), PT=point feature, LN=line feature, PG=polygon feature

Table 8:
GIS Data Layer Attributes

GIS Data Layer Name	Primary Keys[1]	Attributes	Comments
Base Map Layers			
Survey Control Points/Local Monuments	• Survey Point ID # • Survey Point Name	• Control point type • Monument and cap type • Location information • Order (precision level) • Latitude/Longitude • Plane Coordinates • Horizontal and Vertical Datum • Date Established	For geodetic control points, other information contained in documents providing details about monument placing and positioning information should accompany the GIS database.
Orthoimagery-National Coverage	• Not applicable	• Not applicable	
Orthoimagery-Urban Areas			
Digital Elevation Model	• Not applicable	• Elevation value for each grid cell	
Governmental Administrative Units	• Unit Name • Unit ID #	• Administrative Unit Type (Region, County, District, Clan, Enumeration Area,) • Population (from most recent official census)	See list of Counties, Districts, and Clans below. In existing GIS data maintained by the Liberia LISGIS organization, There are official names and ID numbers for County, District, and Clan: CCNA, CCOD, DCOD, DNAM, CLCO, CLNAME). Region is a multi-county area used for administrative reporting by LISGIS.
Incorporated Municipalities	• Municipality Name • Municipality ID #	• County ID and District ID (within which city is located) • Population (from most recent census)	
Villages, Communities, Populated Places	• Village/Place Name	• Alias Name • Population (from most recent census) • District ID code and County ID	See note above about coded fields (by LISGIS) for County, District, and Clan units.

GIS Data Layer Name	Primary Keys[1]	Attributes	Comments
Transportation-Public Roads	• Road Name • Road or Route ID#	• Road Classification (Primary, Secondary, Other) • Surface Type (Asphalt, Macadam, Laterite, Dirt), • Number of Lanes • Use/Jurisdiction Type (Public, Private) • Maintenance/Status (Maintained and In Use, Not Maintained	
Transportation-Local Roads and Streets	• Street/Road Name • Segment ID #	• Street Classification • Responsibility for Maintenance • Surface Type • Number of Lanes	
Transportation-Private Roads	• Road ID Number	• Company • Surface • Status	
Transportation-Railways	• Railway Name • Segment ID #	• Status (Active, Inactive)	
Hydrography	• River/Water Body Name	• Stream Type (Main or Tributary) • Stream Order • Water Body Use Code • Data Source	The "Data Source" attribute is a coded or text field that describes the original source (e.g., national topographic maps) and any adjustment (e.g., position adjustment from high resolution ortho imagery).
Important Planimetric Features	• Building or Structure Name • Building or Structure ID#	• Building/Structure Ownership (Public, Private, other) • Building/Structure Type (Government Administration Building, Office, Industrial, Residential, Aviation, Utility, Transportation) • Building/Structure Subtype • Area (square meters)	Population of attributes (Ownership, Type, Subtype, Area) is dependent on source materials and method for data collection which is dependent on specific project specifications.

GIS Data Layer Name	Primary Keys[1]	Attributes	Comments
Cadastral Parcels	• Parcel ID#	• Type of Land Rights (Public, Government, Customary, Private) • City/Community Name • County Name and Number • District Name and Number • Street Address (if urban area) • Legal area • Parties with granted land rights • Type of granting documents (deed, tribal certificate) • Deed registration number • Owner Name • Official Valuation	Population of attributes, particularly owner name (Ownership, Type, Subtype, Area) is dependent on source materials and method for data collection which is dependent on specific project specifications. Note: Cadastral parcels are an important part of any comprehensive GIS database but it is recognized that nationwide cadastral mapping is a long-term effort taking into account lack of source documents (e.g., deeds) and poorly documented land rights at the local level (e.g., customary rights) This table shows a basic set of attributes supporting CIMS but not necessarily a fully implemented land registration process. Several external sources of information should be consulted for consideration of a broader cadastral data management data model: • Land Administration Domain Model, Christiaan Lemmen and Peter van Oosterom (http://www.fig.net/news/news_2013/ladm2013/01.pdf) • *Social Tenure Domain Model*, International Federation of Surveyors (www.fig.net/pub/figpub/pub52/figpub52.pdf)
Thematic Map Layers			
Concession Areas	• Concession Name • Concession Agreement Number (license, certificate number)	• Concession Classification (Mining, Agricultural, Forestry) • Concession Type (Sub-categorization of concession type) • Resource Type(s) • GoL MAC Responsible (MLME, FDA, MoA) • Concession Status (Proposed, Applied For, Granted, Expired) • Concession Date-Original • Concession Date-Latest Renewal • Concession duration (years) • Concessionaire (company applying for or granted concession) • County IDs • Area (hectares	"Concession Type" allows for a further characterization of Concession Classification (e.g., for a mining concession, this could include "Exploration", "Reconnaissance", "Active Mining" "Resource Type" identifies the specific type of agricultural, mining, or forestry activity (e.g., for an agricultural concession, this could include, "Palm Oil", "Rubber Plantation", etc. Some concessions may include multiple resource types.

GIS Data Layer Name	Primary Keys[1]	Attributes	Comments
Mining Operations	• ID #	• Commodity(ies) • Company	
Large Agro-Forest Plantations	• ID #	• Commodity(ies) • Company	
Farms	• Not applicable	• Licensed Area (hectares) • Production Area (hectares)	
Timber Sale Contract Areas	• Contract ID	• Status (Active, Proposed)	
Community Forests	• Agreement ID #	•	
Illicit Mining Locations	• ID #	• Types of Activity (e.g., gold, diamond) • Date identified • Status	
Protected Areas	• Protected Area Name • Protected Area ID #	• Protected Area Type (e.g., "National Park", "Conservation Area") • Protected Area Status (Active, Proposed) • Total Area (hectares or square km)	
Concession Block Grid	• Block ID #	• Concession Type (this could be used to identify the type of concession to which the block grid applies—if future grids are designed separately for different types of concessions.	
Easements	• Easement ID # • Parcel ID #s	• Easement Type (e.g., Ingress/Egress, Utility) • Grantor • Grantee • Date Granted • Date Terminated	Parcel ID # is the official cadastral parcel number(s) in which the easement is located or which the easement overlaps
General Land Cover	• Not Applicable	• Land Cover Classification[2]	Land cover classification scheme will be based on the 2004 land cover mapping conducted for the FDA (see Figure 11). Appropriate changes to this classification scheme may be made based on source imagery and design decisions.
Land Use	• Not Applicable	• Land Use Classification	
Soils	• Not Applicable	• Soil Classification	

GIS Data Layer Name	Primary Keys[1]	Attributes	Comments
Schools	• School Name • School ID #	• School Type (Public or Private) • City/Community Location	
Hospitals and Health Facilities	• Facility Name • Facility ID #	• Facility Type (Hospital, Clinic, Health Center) • City/Community Location	

[1]Primary keys are attribute data fields used to uniquely define a geographic feature. Most often these fields are a unique name (e.g., road or street name) or use a number or alphanumeric code (e.g., land parcel ID number). For the entries indicated as "Not Applicable", the GIS software will automatically assign a unique database ID (i.e., record number) but there is no user-assigned ID.

[2]The 2004 FDA Classification Scheme is shown on Figure 11

3.3 GIS Database Accuracy and Quality Specifications

This subsection contains information on accuracy and quality specifications for each GIS data layer. These specifications are designed to provide a basis for GIS data contractors to propose specific sources and methodologies for data compilation. Table 9 presents recommended data quality parameters for vector format data (base map and thematic map layers). Table 10 provides information on resolution and accuracy for raster GIS data which includes orthoimagery and digital elevation data. In both of these tables, the horizontal and vertical accuracy figures are targets to be met in the map compilation work. Actual accuracy figures depend upon the amount of ground survey control captured and used in processing, the specific sources, and the data compilation approach. In a solicitation for responses from mapping vendors, these accuracy figures should be stated (as goals) and responders may respond with options, expected levels of accuracy, and costs.

In Table 9, horizontal positional accuracy is expressed in reference to the draft "ASPRS Accuracy Standards for Digital Geospatial Data". Accuracy is expressed as root mean square error (RMSE) in centimeters (ground distance). Specifications for mapping should make reference to this maximum RMSE by stating that contractors are required to employ mapping methodology and use of available sources to meet this horizontal accuracy level. In practice, this means that if actual accuracy checking is carried out with an adequate sample of "well-defined" points on the ground (with positions determined using techniques of higher accuracy than the mapping) the GIS would comply with the maximum RMSE. Further, in accordance with the U.S. Federal Geographic Data Committee (FGDC) National Standard for Spatial Data Accuracy (NSSDA), all points would adhere to a 95% confidence level—95% of all points would fall within the stated RMSE (see the NSSDA specifications at www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/).

Table 10 provides accuracy and resolution targets for raster GIS data—orthoimagery and digital elevation model (DEM) data. The Accuracy Class (I, II, or III) and the Horizontal and Vertical Positional Accuracy figures reference the ASPRS "Accuracy Standards for Digital Geospatial Data". See Table 3 of the ASPRS draft standard which defines 10 vertical accuracy classes for vegetated and non-vegetated areas.

It is important understand the concept of *absolute accuracy* and its relationship to *relative accuracy*. The accuracy targets stated in Tables 9 and 10 are absolute accuracy which reference allows displacement from actual positions on the horizontal and vertical datums which based on the WGS84 ellipsoid and geoid (mathematical modes of the Earth's shape). Relative accuracy refers to local measurements—how close a horizontal or vertical distance measured from the GIS database is to the actual distance measured on the ground. For the mapping approaches called for in this IMS design, one can expect that relative accuracy will be better than the stated absolute accuracy.

Table 9:
GIS Map Layer Accuracy and Quality Specifications for Vector Format Map Data

GIS Data Layer Name	Format[1]	Scale Factor and Accuracy Class[2]	Horizontal Positional Accuracy (RMSE)[3]	Completeness[4]	Polygon Size or Line Length[5]	Comments
Base Map Layers						
Survey Control Points/Local Monuments	V-PT	Not applicable	varies	Not applicable	Not applicable	Survey control points (permanent monuments) would be established at a high order of accuracy (within several cm) to support mapping and survey activities. Positions would be determined with survey grade GNSS equipment or Total Stations and processing software
Governmental Administrative Units	V-PG	SF=5,000 Class= II	75cm	All Counties, Districts, Clans	Not applicable	
Incorporated Municipalities	V-PG	SF=5,000 Class= II	75cm	All formally incorporated areas	Not applicable	See Table 11 for a reference to the main cities in Liberia
Villages, Communities, Populated Places	V-PT	SF=5,000 Class= III	75cm	All locations identified on source material	Not applicable	Accuracy refers to the approximate geographic center of the settled area.
Transportation-Public Roads	V-LN	SF=15,000 Class= II	225cm	All public roads identified on source material	Segments 50 meters or greater	
Transportation-Local Roads and Streets	V-LN	SF=5,000 Class= II	75cm	All public roads and streets for the urban areas included	Segments 25 meters or greater	
Transportation-Private Roads	V-LN	SF=15,000 Class= II	150cm	75% of roads (based on total length) captured for designated project areas	Segments 50 meters or greater	The horizontal accuracy and the completeness parameters take into account the accuracy and resolution limits of digital orthoimagery (assumed to be 1-meter) and vegetation coverage obscuring roads.
Transportation-Railways	V-LN	SF=15,000 Class= II	400cm	All currently operating railroads.	Segments 100 meters or greater	Capture all currently operating railroads and as many inactive railroads as sources allow.
Hydrography	V-LN, V-PG	SF=20,000 Class= III	25cm	All "blueline" streams mapped on the national 1:50,000 and 1:250,000 scale topographic maps	Segments 300 meters or greater	Horizontal accuracy will be best possible through capture of blue line streams on existing GIS data compiled from 1:50,000 and 1:250,000 scale topographic maps with position adjustment to high-resolution (1-meter) orthoimagery.

GIS Data Layer Name	Format[1]	Scale Factor and Accuracy Class[2]	Horizontal Positional Accuracy (RMSE)[3]	Completeness[4]	Polygon Size or Line Length[5]	Comments
Important Planimetric Features	V-PG	SF=2,000 Class= II	75cm	All features specifically identified in mapping specifications	Structures larger than 10 square meters	Completeness depends on the specifications for a specific area (e.g., government buildings in Monrovia)
Cadastral Parcels	V-PG	Urban areas: SF=2,000 Class= II Rural Areas: SF=5,000 Class II	Urban areas: 25cm Rural Areas: 100cm	All parcels for which source materials exist.	Not applicable	Completeness and positional accuracy is highly dependent on the location and availability/quality of sources (including deeds and legal property records) and property corner monumentation on the ground. Boundary demarcation may require adjudication where apparent boundary conflicts among adjacent parcels exist. The horizontal positional accuracy noted represents a goal with actual accuracy dependent on the quality of available sources and boundary evidence.
Thematic Map Layers						
Illicit Mining Locations	V-PT	SF=20,000 Class= II	300cm			
Concession Areas	V-PG	SF=5,000 Class= II	300cm	All active concessions should be identified	Not applicable	The horizontal accuracy is stated as a goal. Actual accuracy of concession boundaries is dependent on quality of sources (boundary coordinates or text description in concession agreements).
Mining Operations	V-PG	SF=20,000 Class= II	75cm	All current or past licensed/certified mining areas	Areas 5 hectares or greater	Horizontal accuracy is dependent on available sources including data from MLME, mining companies, and interpretation from high-resolution (1-meter) orthoimagery.
Large Agro-Forest Plantations	V-PG	SF=20,000 Class= II	300cm	All licensed plantations	Areas 100 hectares or greater	Horizontal accuracy is dependent on available sources including data from MoA, agricultural concessionaires, and interpretation from high-resolution (1-meter) orthoimagery.
Farms	V-PT	SF=20,000 Class= II	225cm	Dependent upon available sources	Not applicable	No specific completeness parameter is stated since this will be dependent on a variety of sources including land cover mapping and field-based reporting. Positional accuracy refers to the approximate center of farming operations.

GIS Data Layer Name	Format[1]	Scale Factor and Accuracy Class[2]	Horizontal Positional Accuracy (RMSE)[3]	Completeness[4]	Polygon Size or Line Length[5]	Comments
Timber Sale Contract Areas	V-PG	SF=15,000 Class= III	300cm	All current and proposed areas	Actual size of contract area (generally greater than 1000 hectares)	
Community Forests	V-PG	SF=5,000 Class= III	75cm	All Community Forests should be identified	Not applicable	
Illicit Mining Locations	V-PT	SF=10,000 Class= III	300cm	Goal of greater than 75%	Minimum disturbed area of about 400 square meters	Completeness dependent on imagery resolution (minimum of 1-meter) and supplemental sources to confirm activity. Accuracy refers to the approximate geographic center of the mined area.
Protected Areas	V-PG	SF=5,000 Class= II	75cm	All active and proposed areas should be included.	Not applicable	
Concession Block Grid	V-PG	Not applicable	Not applicable	Not applicable	Not applicable	
Easements	VPG	Urban areas: SF=2,000 Class= I Rural Areas: SF=5000 Class II I	Urban areas: 25cm Rural Areas: 100cm	All easements for which source materials exist.	Not applicable	Completeness and positional accuracy is highly dependent on the location and availability/quality of sources. The horizontal positional accuracy noted represents a goal with actual accuracy dependent on the quality of available sources.
General Land Cover	R, V-PG	SF=25,000 Class= II	375cm	Classification accuracy (percentage of land properly classified—compared to actual ground conditions) has a goal of 90%.	Minimum polygon size of 100 hectares or better	Horizontal accuracy is dependent on rules set for automated image classification and level of calibration using actual "ground truth" for sample sites. Classification accuracy
Land Use	V-PG	SF=10,000 Class= I	125cm	Not applicable	Minimum polygon size of 100 hectares or better	

GIS Data Layer Name	Format[1]	Scale Factor and Accuracy Class[2]	Horizontal Positional Accuracy (RMSE)[3]	Completeness[4]	Polygon Size or Line Length[5]	Comments
Soils	V-PG	SF=25,000 Class= III	500cm	All land in project area surveyed and mapping	Minimum "mapping unit" size of 1 to 2 hectares	The recommended horizontal accuracy and minimum polygon size is consistent with a detailed soil survey and mapping project. Soils can be mapped at considerably small scales. Accuracy and minimum polygon size are greatly dependent on methods and physical conditions in the area being mapped.
Schools	V-PT	SF=5000 Class= II	100cm	All schools included in most recent inventory	Not applicable	
Hospitals and Health Facilities	V-PT	SF=5000 Class= II	100cm	All facilities included in most recent inventory	Not applicable	

[1]GIS format type includes: V=vector, R=raster, TIN=Triangular Integrated Network (digital terrain model), PT=point feature, LN=line feature, PG=polygon feature

[2]The denominator of the map scale expressed as a Representative Fraction (RF). This is used in the horizontal accuracy calculation (see footnote 3)

[3]Refers to maximum ground distance error of the GIS feature compared to its actual position (which would be measured by comparing GIS features with a sample of well-defined points whose location would be determined through a higher accuracy source. Horizontal accuracy refers to data accuracy class (Horizontal Accuracy Standards for Digital Planimetric Data) from the draft "ASPRS Accuracy Standards for Digital Geospatial Data" (see www.asprs.org/a/society/divisions/pad/Accuracy/Draft_ASPRS_Accuracy_Standards_for_Digital_Geospatial_Data_V12_07-11-13.pdf). Accuracy is expressed as root mean square error (RMSE) in centimeters (ground distance displacement from actual coordinate location). The standard describes accuracy in three classes (Class I, II, III) of decreasing accuracy—based on a percent of the Map Scale Factor (numerator of Representative Fraction). The horizontal accuracy stated is a target—the actual accuracy is dependent on the level of ground control and the specific sources and compilation approach selected.

[4]Indicates the expected compliance for capture of features in the GIS relative to actual features on the ground

[5]General mapping rule to guide delineation of features captured from aerial imagery or other source—indicates the minimum feature size or length that should be captured

Table 10:
Orthoimagery and DEM Accuracy and Resolution Specifications

GIS Data Layer Name	Format[1]	Accuracy Class [2]	Pixel Resolution[3]	Horizontal Positional Accuracy[4]	Vertical Positional Accuracy[6]	Comments
Base Map Layers						
Orthoimagery-National Coverage	R	II or III	2.0 meters or better	1 to 3 meters	Not applicable	Pixel size and horizontal accuracy will vary depending on the data source choice—from a number of satellite imaging devices. Goal is for approximately 1-meter pixel with 1 meter horizontal accuracy. The horizontal accuracy stated is a target which will be impacted by the amount of ground control established and the imagery source.
Orthoimagery-Urban Areas	R	II	About 30cm	.5 meter	Not applicable	Pixel size and horizontal accuracy will vary depending on the data source choice—from a number of satellite and aircraft imaging devices. Goal is for approximately 30cm pixel with 30cm horizontal accuracy.
Digital Elevation Model (DEM)	R	IV to VIII	1 to 3 meters	Not applicable[6]	1 to 5 meters	Elevation is orthometric height (height above the accepted geoid for the datum being used). Vertical accuracy will vary depending on the data source and compilation method (e.g., photogrammetric compilation from stereo satellite imagery) and on the density of vegetated cover (which can limit capture of a ground surface point) Land cover varies greatly in different regions of Liberia (see Figure 11 and Table 13). An elevation accuracy range is given—more detail should be provided in the preparation of specifications by mapping contractors.

1GIS format type includes: V=vector, R=raster (DEM), TIN=Triangular Integrated Network (digital terrain model), PT=point feature, LN=line feature, PG=polygon feature

2 Refers to data accuracy class (I II, or III) from the "Horizontal Accuracy Standards for Digital Orthophotos" from the draft *ASPRS Accuracy Standards for Digital Geospatial Data* (see www.asprs.org/a/society/divisions/pad/Accuracy/Draft_ASPRS_Accuracy_Standards_for_Digital_Geospatial_Data_V12_07-11-13.pdf)

3Indicates the image or DEM pixel size (as ground distance).

4Refers to horizontal positional accuracy of a pixel based on the "Horizontal Accuracy Standards for Digital Orthophotos from the draft *ASPRS Accuracy Standards for Digital Geospatial Data* (see www.asprs.org/a/society/divisions/pad/Accuracy/Draft_ASPRS_Accuracy_Standards_for_Digital_Geospatial_Data_V12_07-11-13.pdf). Accuracy is expressed as the Root Mean Square (RMSE) of the displacement of the pixel from its actual position. See Table 1 from the ASPRS draft standard. Given the level of control that is feasible for this mapping effort, Class II is selected as a target—this calls for horizontal accuracy (RMSE) to be within 1.5 times the pixel size.

5Horizontal accuracy is not directly applicable to digital elevation data—vertical accuracy applies and refers to the error in elevation, for a point on the surface, relative to the Earth's geoid and vertical datum in use (WGS 84).

6Vertical accuracy refers to the acceptable variance of the DEM pixel's elevation (relative to the WGS 84 vertical datum) expressed as a root mean square error (RMSE) following the Vertical Accuracy Standards for Digital Elevation Data" from the draft "*ASPRS Accuracy Standards for Digital Geospatial Data*" (see www.asprs.org/a/society/divisions/pad/Accuracy/Draft_ASPRS_Accuracy_Standards_for_Digital_Geospatial_Data_V12_07-11-13.pdf). Accuracy is expressed as the Root Mean Square (RMSE) of the displacement of the pixel from its actual location. See Table 3 of the ASPRS draft standard which defines 10 vertical accuracy classes for vegetated and non-vegetated areas. The accuracy values shown refer to elevation at the ground surface.

3.4 Liberia Geographic Background Information

Basic geographic statistics are provided in Table 11 support planning and cost estimation for GIS database compilation.

Table 11: General Geographic Statistics for Liberia

Total Area:	111,369 square kilometers/ 42,988 square miles.
Governmental Administrative Units:	Governmental administration is organized, at the highest level into Counties of which there are 13. Counties are divided into Districts (total of 70) and Districts of further subdivided into Clans (total of 816). See Figure 10 and Table 12 for a map and lists of governmental administrative units.
Cities and Settled Areas	There are about 13 major cities[1] and about 13,000 small villages and communities.
Description of Terrain:	Liberia can be divided into three distinct topographical areas. First, a flat coastal plain of some 10 to 50 mi (16–80 km), with creeks, lagoons, and mangrove swamps; second, an area of broken, forested hills with altitudes from 600 to 1,200 ft (180–370 m), which covers most of the country; and third, an area of mountains in the northern highlands, with elevations reaching 4,540 ft (1,384 m) in the Nimba Mts. and 4,528 ft (1,380 m) in the Wutivi Mts. Liberia's six main rivers flow into the Atlantic
General Description of Land Cover	The 580 km coastline is characterized by lagoons, mangrove swamps, and river-deposited sandbars. The inland grassy plateau supports limited agriculture. Much of the southern half and northeast quarter of the country is tropical forest. See Figure 11 and Table 13 for more information on land cover.

[2]Cities include: Monrovia, Gbarnga, Kakata, Bensonville, Harper, Voinjama, Buchanan, Zwedru, New Yekepa, Greenville, Ganta, Robertsport, and Sanniquellie

Figure 10 depicts the boundaries of Liberia's Counties and Districts and Table 12 lists District Names by County.

Figure 10: Liberia County and District Boundaries

Table 12: List of Liberia's Political Districts by County

Bomi County Dewoin District Klay District Mecca District Senjeh District Bong County Fuamah District Jorquelleh District Kokoyah District Panta-Kpa District Salala District Sanayea District Suakoko District Zota District **Gbarpolu County** Belleh District Bopolu District Bokomu District Kongba District Gbarma District **Grand Bassa County** District #1 District #2 District #3 District #4 Owensgrove District St. John River District	**Grand Cape Mount County** Commonwealth District Garwula District Gola Konneh District Porkpa District Tewor District **Grand Gedeh County** Gbarzon District Konobo District Tchien District **Grand Kru County** Buah District Lower Kru Coast District Sasstown District Upper Kru Coast District **Lofa County** Foya District Kolahun District Salayea District Vahun District Voinjama District Zorzor District **Margibi County** Firestone District Gibi District Kakata District Mambah-Kaba District Maryland County Barrobo District Pleebo/Sodeken District	**Montserrado County** Careysburg District Greater Monrovia District St. Paul River District Todee District **Nimba County** Gbehlageh District Saclepea District Sanniquelleh-Mahn District Tappita District Yarwein-Mehnsohnneh District Zoegeh District **River Gee County** Gbeapo District Webbo District **Rivercess County** Morweh District Timbo District **Sinoe County** Butaw District Dugbe River District Greenville District Jaedae Jaedepo District Juarzon District Kpayan District Pyneston District

Figure 11 shows the general land cover for Liberia based on a 2004 Landsat image classification project for the Liberia Forestry Development Authority. Percentages of land cover categories are in Table 13.

Figure 11: Land Cover Map of Liberia

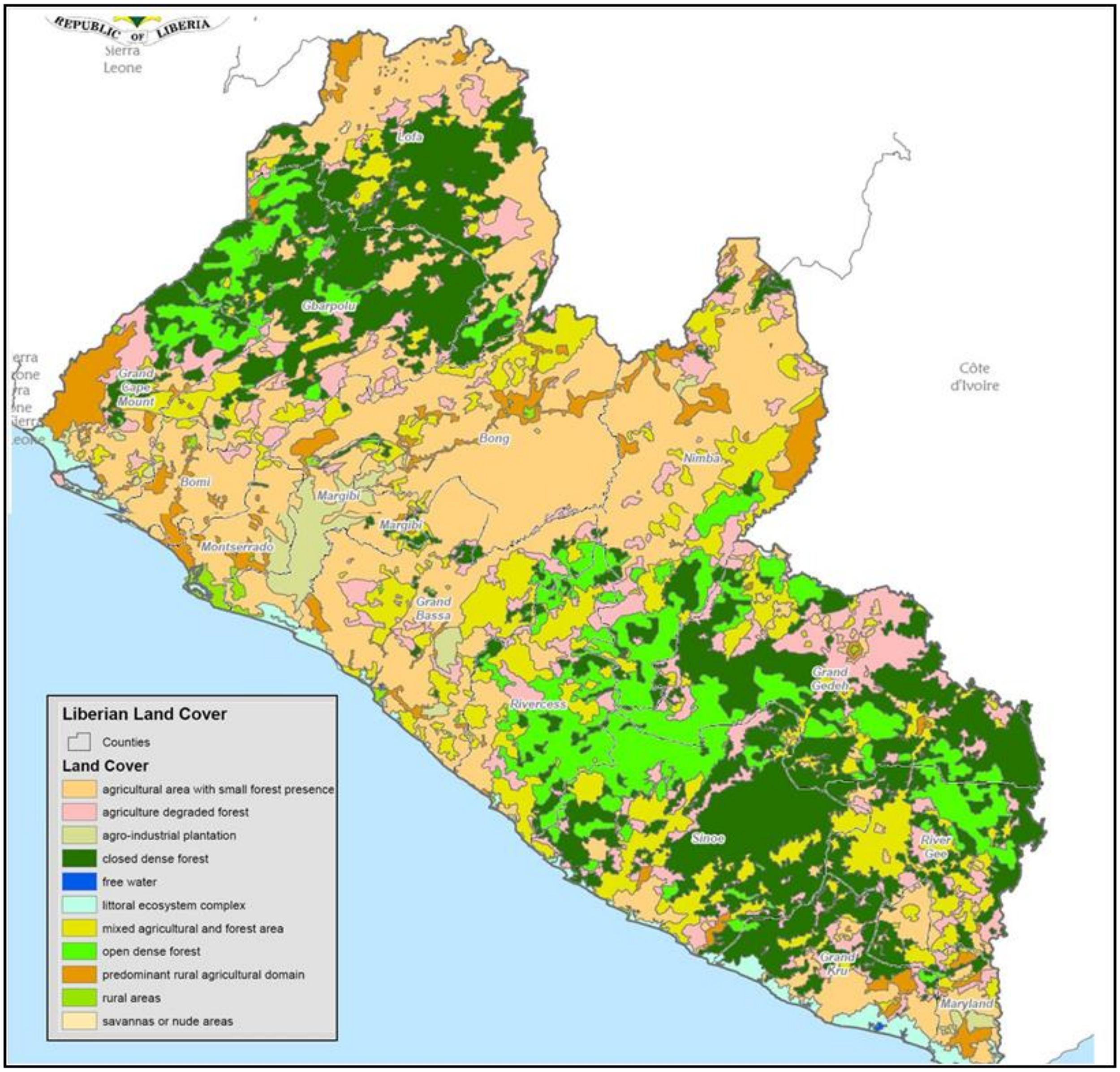


Table 13: Percentage of Land Cover Types for Liberia

Agricultural Area with Small Forest Presence	32%
Agriculture Degraded Forest	10%
Agro-Industrial Plantation	2%
Closed Dense Forest	25%
Open Dense Forest	11%
Free Water	Less than 1%
Littoral Ecosystem Complex	1%
Mixed Agricultural And Forest Area	14%
Predominant Rural Agricultural Domain	4%
Other Rural Areas, Savannas, Bare Ground	Less than 1%

3.5 GIS Database Standards

3.4.1 Datum and Coordinate System

Mapping work and GIS data capture will use the current World Geodetic System of 1984 (WGS 84) as the vertical and horizontal datum. GIS feature coordinates will be expressed in meters in Universal Transverse Mercator (UTM) Zone 29 (North). It is important that sufficient survey control information be gathered to achieve a sufficient level of horizontal and vertical position accuracy. In geodesy and mapping work, horizontal positions WGS84 defines two mathematical models of the earth—the ellipsoid and the geoid. An ellipsoid is a mathematical model of the shape of the earth and is used as a basis for defining horizontal positions. The geoid is defined as the surface of the earth's gravity field, which is approximately the same as mean sea level. The geoid is the basis from which elevations are measured—referred to as "orthometric heights". The UTM system is the accepted projection and "coordinate system" used to represent the Earth's curved surface as a flat plane. While the WGS84 ellipsoid and geoid will be the basis for mapping work in Liberia, it is a global system and, when applied for region-specific areas, may result in inaccuracies. It is important to gather sufficient survey control, in Liberia, to make adjustments or "realization" of the WGS84 datum for Liberia—thereby establishing a firm foundation for accurate mapping.

3.4.2 GIS Metadata

Geospatial metadata will be prepared and maintained for all GIS data sets (map layers and attributes). Metadata is "data about the GIS data" providing users and maintainers the necessary information to: a) understand data content, format, and quality, b) get access to the GIS data and information about restrictions on use, c) learn about sources and update procedures to support routine data update. Metadata will be captured and stored when GIS data is compiled for the CIMS GIS database and when updates are made. The specific content and format of the metadata will follow International organizational for Standardization (ISO) Standard 19115. At a minimum, the following ISO 19115 metadata categories will be populated for each GIS dataset (layer):

- Maintenance Information: Information about how the resource is updated
- Spatial Representation Information: Information about the grid or vector models used to represent features
- Reference System Information: Information about the coordinate system used to georeference the resource
- Content Information: Description of the content of the database (feature catalog), discrete grid cells (coverage), and continuous grid cell
- Data Source and Quality: Information about the source, horizontal and positional accuracy, completeness, and other quality information specific to a particular data set.
- Distribution Information: Information about how one can access the resource

The Content category is especially important. It includes the creation and maintenance of a "data dictionary" that identifies the format of GIS database features and the format and description of all attribute data fields associated with GIS features.

In addition to the dataset metadata categories above, each GIS feature should include an attribute indicating the source of its capture and or update and the most recent date of capture or update. CIMS will make maximum use of tools in GIS software for GIS metadata population, entry, access, and management.

3.4.3 Data Quality

Data quality standards (see subsection 3.1.4) will be applied to all GIS database collection and development activities and for ongoing GIS database update. Specific quality parameters apply to each GIS data layer. Key data quality parameters are included in Tables 9 and 10. GIS data quality standards common to all or most GIS data layers are stated as follows:

File and Layer Naming: All files will be delivered with properly spelled and formatted names and the names of all feature datasets, feature classes, and data entities will be properly spelled 100% of the time.

Graphic Quality:

- Graphic Data Structure: Map features will use valid GIS feature types (point, line, polygon) 100% of the time.
- Edge-matching/Spatially Continuous Database: While data capture may be carried out on a sheet-by-sheet basis, the data shall be spatially continuous with no invalid breaks in map features across map sheet or tile boundaries.
- Feature Duplication and Graphic Data Quality: No duplication (multi-digitization) of map features is permitted. Base map and utility features will be depicted accurately and consistently. For example: a) there should be adequate shape points for a smooth representation for curved features for features; b) utility line features which are straight (no bends) should be shown as straight segments bounded by two end points; and c) no overshoots or undershoots for line features that intersect.
- Attribute Accuracy: The correctness of entered attributes and proper adherence to database format, established domains, and proper values from source material. The following rules contribute to attribute accuracy:
- All attribute table schemas are correct 100% of the time.
  - Relationship classes have proper cardinality (origin-destination) and the Primary and Foreign keys are properly assigned and all Primary keys have properly formatted unique values 100 percent of the time
  - Other attribute fields defined in the schema will be properly entered at least 99.5 percent of the time.
  - No null values for attribute fields where null entries are not valid
  - Entry is consistent with the data type format (e.g., integer, decimal, date) for the attribute field: 100 percent compliance required.

- Adherence to all domain rules (lists of valid entries or within stated range for numeric fields).
- Proper spelling for all text entries.

3.4.4 Standard Symbology

All GIS features will be assigned standard symbology—based on a "palette" of symbol types provided by the GIS software. Symbology includes point symbols, line types, and colors—with parameters for size, line weight, and orientation (for point symbols). See 3.1.4 for a description of GIS feature symbology and annotation concepts.

4. GIS DATABASE DEVELOPMENT REQUIREMENTS AND ISSUES

4.1 Existing GIS Programs, Projects, and Data Sources in Liberia

4.1.1 Summary of Current GIS Data Sources for Liberia

As is described in the LPIS spatial data infrastructure report (Volume 1), there is a limited amount of detailed, up-to-date GIS data for Liberia. The LPIS report also points out that there is little coordinating mapping and GIS data management in Liberia and little in the way of formal standards for GIS data and metadata. Topographic base mapping is limited—the only full national coverage is a 1:250,000 scale mapping (total of 10 quadrangles) prepared in the 1970s by the U.S. Geological Survey. These are not available in digital vector form but have been scanned and georegistered—and stored in GeoTiff format. There is also topographic map coverage at 1:50,000 scale prepared in the 1970s and 1980s by the U.S. Geological Survey and the British Ordnance Survey for parts of the northern and western regions of the country (about 60% of the country covered). These are also available as scanned georegistered sheets (no digital GIS vector data). This topographic mapping work was based on the older, Liberia 1964 Geodetic Datum, not the World Geodetic System (WGS 84) datum which is considered the current standard for mapping.

The most comprehensive source of GIS data (national coverage) was prepared for a recent study of economic development corridors. This "Corridor Study" was carried out with support from USAID, by the Liberia Ministry of Planning and Economic Affairs in 2010. A comprehensive GIS database, with full national coverage, was prepared to support this project. This database used available map and data sources with some compilation and feature adjustment using Landsat imagery. This GIS data, available as Shape Files (.shp) and an Esri GIS personal Geodatabase is available from IBI International, the primary contractor supporting the USAID GEMS Project. While much of this data is at a lower level of detail and accuracy intended for CIMS, it does provide source data to help in projections of cost and approach and as a general reference to guide CIMS GIS database development. A summary of selected GIS data sets of particular importance for CIMS GIS database development is provided in Table 14.

Table 14: Summary of GIS Data Sets from the Corridor Study

GIS Data Set	Source ID[1]	Description
Concession Boundaries	CN1	There are several GIS data sets with boundaries of existing mining, agricultural, and forestry concessions. These are polygon features with boundaries obtained from individual concession entities—GoL Ministry of Lands, Mines, and Energy (MLME), Ministry of Agriculture MoA), and the Forestry Development Authority (FDA). Positional accuracy of the boundaries varies significantly and is dependent on how boundaries were defined for each concession.
County Boundaries (county_2007)	GA1	Polygon features based on boundaries collected in the field with GPS equipment by crews organized by LISGIS in 2007 (project supported the 2008 Census). District boundaries were verified in the field and Clan boundaries (total of 816) were captured with Garmin GPS devices—in a process involving local officials (delineating boundary following natural features and observable points).
District Boundaries (district_2007)	GA2	
Clan Boundaries (county_2007)	GA3	

GIS Data Set	Source ID[1]	Description
Roads (road infrastructure and twa_coastal highway)	TR1	Public roads and highways (not including city streets). Data from the digital chart of the world (DCW)[2] and re-aligned with Landsat imagery.
Railroads (railway infrastructure)	TR2	Line features from DCW[2] with some adjustment to Landsat imagery.
Topography (elevation contours, elevation image)	DE1	Contour lines (100-meter contour interval) and digital elevation model (raster format) generated from the Shuttle Raster Terrain Mapping (SRTM) in 2000 with pixel resolution of 90-meters.
Protected Areas (protected areas)	GA4	Obtained from FDA in 2009 revised with data from Conservation International (http://www.conservation.org/where/africa_madagascar/liberia/Pages/liberia.aspx)
Hydrology (openwater; rivers)	NF1	Major rivers extracted from DCW* data and re-aligned with Landsat in places. Names derived from 1:250,000 topographic base maps. Open water bodies delineated from Landsat imagery.
Land Cover (Lib_landcover_frm)	LC1	Polygons classified with high-level land cover categories. Used original land cover mapping manually compiled by the Forestry Development Authority (FDA) in the 1980s. Updated in a digital image classification project using Landsat imagery in a 2004 World Bank supported project by the organization Fauna and Flora International (FFI).
Agro-Forestry (agro-forestry)	LC2	Large rubber and oil palm areas. Extracted from Land Cover database; adjusted in places with Landsat imagery.
Large Food Farms (large food farms)	LC3	Point locations of large food farms. Extracted from Ministry of Agriculture Comprehensive Assessment of the Agriculture Sector Report
Large Rubber Farms (large rubber farms)	LC4	Extracted from MOA Comprehensive Assessment of the Agriculture Sector Report
2014 Land Cover Mapping	LC5	Project initiated in March, 2014 with planned completion in 12 months involving satellite imagery classification (with ground truth support) providing national land cover map. Being carried out by private contractor (through FDA) in a project funded by the Forest Carbon Partnership Facility (FCPF). Will use RapidEye 5-meter resolution multispectral imagery a primary source with classification scheme with 10 to 12 classes and expected 80%-90% classification accuracy. Lead contractor is Swedish firm Metria (contact Erik Willén, erik.willen@metria.se). See information on a 2012 demonstration project at: http://web.worldbank.org/wbsite/external/topics/extsdnet/exteofd/0,,contentMDK:23135600~pagePK:64168445~piPK:64168309~theSitePK:8426771,00.html
Geology (iron ore deposits; Regional Geology; Regional Faults)	NF2	General small-scale mapping of surficial geology (as polygons) and geological features (fault lines, iron ore deposits) by the SIG Afrique organization.

[1]The Digital Chart of the World (DCW) is a GIS database with map data compiled at a 1:1,000,000 scale. Includes transportation infrastructure, political boundaries, land cover, and physical features originally prepare by the U.S. Defense mapping Agency using a variety of sources not more current than about 1990. Data is not actively updated. See http://worldmap.harvard.edu/data/geonode:Digital_Chart_of_the_World

[2]Source ID is an identification code used in this document to provide a reference to specific data sources for possible use in future GIS data conversion.

The Liberian Institute of Statistics and Geo-Information Services (LISGIS) is an autonomous agency which was formed through an Act of Parliament. LISGIS was formed to serve as the prime authoritative agency of government responsible for collecting, managing, coordinating, supervising, evaluating, analyzing, disseminating and setting quality standards for statistical and associated geographic information for overall national socio-economic reconstruction and development. LISGIS is the most active GoL agency involved in the collection and dissemination of spatial data in Liberia. LISGIS contributed data for the Corridor Study described above and has compiled some additional GIS data including:

- Georeferenced topographic maps: Scanned and georeferenced (to WGS 84, UTM coordinates) paper topographic maps (planimetric features, hydrography, contours). These exist in two series: a) 1:50,000 scale with coverage of about 60% the country in parts of the southeast and northeast regions of the country and b) 1:250,000 scale maps prepared for the entire country in the late 1960s by the U.S. Geological Survey and the British Ordnance Survey. These sheets are available in GeoTIFF format. (Source ID: BM1)
- Enumeration Areas: Polygon features based on field GPS-captured boundaries to support the 2008 National Census. Total of 7,012 features. (Source ID: GA5)
- Electoral Districts: These districts (different from Administrative Districts) used to support the 2008 election were compiled by LISGIS (based on population statistics) from Clan, District, and Enumeration Area boundaries. (Source ID: GA6)
- Public Roads: coordinates for primary and secondary were collected in 2010 using GPS-equipped vehicles. Project was supported by the UN Humanitarian Information Centre (HIC) for Liberia—now the National Information Management Center (NIMAC) in a joint project between the UN Development Program and LISGIS. Coordinates for centerlines of primary and secondary roads were captured with a GPS-equipped vehicle. Road segments defined by observable points on the route. (Source ID: TR3)
- Villages/Communities: Point locations gathered in the field (GPS-based) representing a centroid for settled areas as part of the 2008 Census mapping project. Total of about 13,000. (Source ID: PP1)
- Timber Sales Contact Areas: Boundaries of Timber Sales Contract areas (Source ID: CN2)
- Schools: Point locations for schools (all public and private) were captured in the field with GPS devices by LISGIS staff in a project coordinated with the Ministry of Education in 2011. There are about 5,000 point locations. (Source ID: PP2)
- Human Resources (Health facilities): Point locations for hospitals, clinics, and health centers countrywide were captured in the field in a 2004 project coordinated with the Ministry of Health. A total of 472 locations were identified. (Source ID: PP3)
- Cell Towers: Point locations for cell towers of the main telecommunications companies were captured in the field. Towers are identified with company owner (LoneStar, Novaphone, CellCom, etc.) (Source ID: UT1)
- Waterfall Locations: Point features of waterfalls with locations captured with GPS and height (based on top and bottom elevations) for the entire country. (Source ID: NF3)
- Monrovia Municipal Boundaries: LISGIS has captured accurate coordinates for the municipal boundary of Monrovia, Communities (193), and Zones (16). (Source ID: GA7).

Some other orthoimagery and GIS data covering specific parts of the country include:

- 2009 high resolution orthoimagery (50cm) for Monserrato County (Monrovia urban area) funded by the Japanese Development International Cooperation Agency (JICA) maintained by the Ministry of Public Works and used for mapping and urban planning work in Monrovia (Source ID: IM1)
- National water points database—GIS Shape File points locating water bodies and including data in the nature and status of the water bodies.

There is also some imagery and GIS data maintained by individual concessionaires and by the UN Mission in Liberia (UNMIL) but the specific content, coverage, and format of the data is not fully known and is not easily accessible.

4.1.2 Cadastral Data Sources

Digital or hard copy information from which to compile property boundaries (cadastral parcels) is very inconsistent in quality and availability. Four categories of land rights are recognized in Liberia: Government Land, Public Land, Private Land, and Customary Land (see Liberia Land Rights Policy, Land Commission, 2013). Precise boundary delineation for areas to which these rights apply often do not exist. Also, many property records were destroyed in the recent conflict period (1989 to 2003). Property records that do exist come in a variety of forms:

- Deeds and legal property records: The Liberia Centre for National Documents, Records, and Archives (CNDRA) is the official repository of legal land records and information on land transfers. CNDRA personnel have been involved in the scanning and indexing of Grantor/Grantee books and individual deeds.
- Tribal Certificates: These are documents that are issued by local officials (Tribal Chiefs) to individuals for use of land. These are not considered documents that confer ownership but only the rights for use of land. Often they are not specific either to the boundaries of the land of allowed types of use. There is no central repository for these records. The Land Commission is conducting a pilot to examine how these Tribal Certificates should be used in establishing land rights.
- Other Records: There may be hard copy deeds and property surveys stored by individual GoL MACs (MLME, Internal Affairs) which have not been inventoried

Compiling GIS data with reasonably accurate cadastral boundary delineation will be a long term process which will require research, on-the-ground surveys, and formal arbitration/adjudication to resolve information gaps and land rights conflicts. CIMS is designed to include this cadastral data where available but assumes that it will be a long-term process with high-priority locations (major urban areas, active concessions) to be covered initially.

4.1.3 Orthoimagery Sources and Compilation Approaches

The CIMS design calls for the use of orthoimagery as a primary GIS base map layer (see subsection 3.2). There are a number of sources for high-resolution (1-meter or better) and medium-resolution (2 to 30 meter) orthoimagery for GIS applications. While the CIMS design calls for full country coverage at about 1-meter resolution, funding for such coverage may not be immediately available. There is an option to acquire medium resolution imagery at lower cost, and to use existing GIS data for initial CIMS operations. Many satellite imaging systems today provide imagery in panchromatic form (1 band imaging full visible light spectrum) and multispectral (multiple bands each imaging a portion of the visible and often infrared portions of the light spectrum). Multispectral data is required to provide color imagery and certain types of analysis like land cover classification. Table 15 provides a summary of these current sources. There is considerable private sector interest in near earth imaging satellite programs and there are several new projects and satellite launches planned for the near future. Table 15 does not list radar sensing satellite programs of which there are several (e.g., Sentinel 1, RadarSat, TerraSar).

See the IEEE Spectrum article (March 28, 2014) for more information: http://spectrum.ieee.org/aerospace/satellites/9-earthimaging-startups-to-watch. While all of these satellite systems have ongoing repeat coverage for large parts of the globe (based on orbital specifications), there are different approaches for capturing, processing, archiving, and distributing data so one cannot assume that imagery is available for a particular area without making inquiries about specific locations and dates.

Table 15: Currently Available High and Medium Resolution Satellite Imaging Systems (with status as of May, 2014)

Satellite Name	Country/ Source Organization	Launch Year	Status	Resolution (P)[1]	Resolution (M)[2]
Advanced land Observation Satellite (ALOS) aka: Daichi[3]	Japan Aerospace Exploration Agency (JAXA)	2006	Lost power in 2011	2.5	10
ASTER	NASA-USA.	1999	In Operation	NA	15 to 90[4]
Cartosat-1	Indian Space Research Organization (ISRO)	2005	In Operation	2.5	None
Cartosat2	Indian Space Research Organization (ISRO)	2007	In Operation	1	None
DMC3 (constellation of 3 satellites)	DMC International Imaging (UK)	N/A	Planned for 2014	.75	3
IKONOS (formerly Ikonos 2)	DigitalGlobe	1999	In Operation	1	4
Pleiades 1A, 1B	Astrium-Geo (now Airbus Defence and Space)	2011	In Operation	.7	2
FORMOSAT-2	Taiwan National Space Program Office (NSPO)	2004	In Operation	2	8
SPOT5	Astrium-Geo (now Airbus Defence and Space)	2002	In Operation	2.5	10
SPOT6	Astrium-Geo (now Airbus Defence and Space)	2012	In Operation	1.5	8
SPOT7	Astrium-Geo (now Airbus Defence and Space)	N/A	Planned (2014)	1.5	8
Quickbird 2	DigitalGlobe (USA)	2001	In Operation	0.6	2.4

Satellite Name	Country/ Source Organization	Launch Year	Status	Resolution (P)[1]	Resolution (M)[2]
WorldView 1	DigitalGlobe (USA)	2007	In Operation	0.5	None
WorldView 2	DigitalGlobe (USA)	2009	In Operation	.46	1.84
WorldView 3[5]	DigitalGlobe (USA)	N/A	Planned (11-2014)	.31	1.24
RapidEye Constellation	RapidEye AG (now Blackbridge) Germany	2008	In Operation		5
GeoEye-1 (formerly OrbView 5)	DigitalGlobe (USA)	2008	In Operation	.41	1.65
Landsat 8	USA (NASA, USGS)	2013	In Operation	15	30
KOMPSAT-2 (Arirang-2)	South Korea--Korean Aerospace Research Institute (KARI)	2006	In Operation	1	4
KOMPSAT-3 (Arirang-3)	South Korea	2012	In Operation	.7	2.8
Sentinel-2	European Space Agency	N/A	Planned (2014)		10 to 60[6]
Ziyuan 3 (ZY3)	China-Ministry of Land and Resources	2012	In Operation	2.1[7]	6.0
SkySat-1	Skybox Imaging, USA	2013	In Calibration		.8
SkySat-2	Skybox Imaging, USA	N/A	Planned for 2014		.8
SkySat-3	Skybox Imaging, USA	N/A	Planned for 2015		.8

[1, 2]Resoultion (P) is the pixel size (ground distance in meters) for panchromatic imagery and Resolution (M) is the pixel size for multi-spectral imagery. Most of the systems with multi-spectral sensors include bands for the visible light and near infrared wavelengths. In a few cases, thermal infrared is included.

[3]ALOS has, in addition to the 10m resolution multi-spectral sensor and the 2.5m panchromatic sensor, a side-looking radar scanner (10 to 100m resolution).

[4]Aster had a number of different multi-band sensors including a 3-band visual and near-infrared with 15m resolution, a shortwave infrared at 30m resolution and a thermal infrared at 90m resolution.

[5]Worldview 3 includes a number of multi-spectral sensor devices including an 8-band visible/near infrared scanner (1.24 meter resolution), 8-band shortwave infrared scanner (3.7m resolution), and a specialized 12-band hyperspectral scanner (CAVIS) at 30m resolution.

[6]Sentinel-2 will have three multi-spectral sensors: a) 4-band scanner (10m resolution), b) 6-band scanner (20m), c) 3-band scanner (60m resolution).

[7]The Ziyuan-3 has an array of 3 panchromatic sensors—one pointed down at nadir and 2 others pointing forward and after with scene overlap

Options for national coverage of high-resolution orthoimagery and the very high-resolution coverage for urban areas include satellite imagery or imagery captured from an aircraft. Each of these sources (satellite vs aircraft) presents advantages and disadvantages. In both cases, a very important limiting factor is the need for cloud-free skies. In the Liberia, the best time period for clear days is from about early November to early April. The key points differentiating factors and trade-offs between satellite vs. aircraft acquired imagery are presented in Table 16.

Table 16: Trade-offs in Selecting Satellite vs Aircraft Platform for Orthoimagery and DEM Compilation

Factor	Satellite Imagery	Aircraft Imagery	Comments
Logistics for Acquisition	Good	Good	Satellite imagery from a number of sources (see Table 15) is generally available for a cost for Liberia but, the high-resolution imagery providers may not archive data for the full coverage area so there may be obstacles to getting high-quality scenes for full national coverage. Aircraft imagery requires pre-planning and organizing staff, aircraft, sensors, and ground facilities in Liberia so operational aspects are complex. Once on the ground however, an aircraft can be quickly deployed for data capture under best weather conditions.
Capture of Cloud-free	Fair to Good	Very Good	Both platforms have the limitation of the November to April window of time for best chance of cloud-free days. With satellite imagery, getting cloud-free images dependent on timing of the satellite pass over Liberia. For aircraft, flying schedule would be predictable—aircraft would be on-site and actual flight would be tied with cloud-free days.
Legal Limitations on Use	Fair	Very Good	Most of the commercial providers of orthoimagery have some data license limitations on use and redistribution of the imagery. Contracted services for aircraft acquired imagery would give full rights for use or redistribution
Accuracy/Ground Control	Good	Very Good	Establishing an adequate level of ground control for horizontal and vertical positioning is somewhat more complex for satellite imagery than for aircraft imagery. For satellite imagery, it is likely that a higher number of identifiable ground points would need to be surveyed. For aircraft, use of on-board GNSS and inertial positioning equipment would reduce the level of need for ground based survey control.
Suitability for DEM Compilation	Good	Very Good	Aircraft imagery would be the best option for accurate elevation data capture since it would use better on-board positioning and acquire images with high overlap for photogrammetric elevation data capture. In addition, using an aircraft platform provides an opportunity for incorporating a LiDAR device which, all other things being equal, is the most effective elevation data capture method. Elevation data can be photogrammetrically captured from satellite imagery although scanner and orbital factors make availability of suitable overlapping imagery somewhat more difficult.
Cost	Very Good	Fair	In general, satellite imagery cost is considerably less than aircraft imagery although cost varies considerably among the various sources (see Table 15).
Image Quality	Good	Very Good	Both satellite and aircraft imagery deliver acceptable image quality. In general, aircraft image quality is better—because flying height is considerable less and opportunity for cloud-free, haze-free images is better.

For procurement of orthoimagery, both satellite and aircraft acquisition should be considered. Mapping contractors should be given the flexibility to propose for either approach or to present options for both aircraft and satellite imagery.

4.2 GIS Database Development Methodology

GIS database development methodologies will employ industry best practices and standards and best available sources necessary to meet the data accuracy and quality specifications and standards described in Section 3. This subsection provides general information on GIS data acquisition, sources, and development methodologies as a guide from which detailed specifications should be prepared. This information should be provided in a tender for solicitation of proposals from qualified contractors to give potential responders information about expectations on data content and quality. The database development work will include the establishment of ground survey control sufficient to meet horizontal and vertical accuracy specifications. A summary of key points about GIS database development and sources (addressed in more detail in Table 17) is a follows:

- A principal component of the GIS database in national satellite-acquired high-resolution ortho-corrected imagery (approximately 1-meter resolution panchromatic). It is expected that some on-the-ground survey control will be established to support the orthocorrection work.
- A digital elevation model (grid-based) using photogrammetric compilation from stereo satellite images. Depending on the cost and timing, DEM production will use compiled linear breakline features representing major topographic breaks (major drainage lines and ridge-tops) and selected man-made features (major roads). The resolution and positional accuracy will determined based on options provided by contractors. To the extent possible, the DEM will represent the actual land surface but limitations in areas of dense forest cover will be taken into account in final specifications.
- The GIS database development work will include an option for automated generation of topographic contours from the DEM.
- Selected GIS map layers will use existing GIS data sources (described in 4.1.1) as cited in Table 17. In some cases, these data will be imported and included in the GIS data deliverable without geographic adjustment and other cases, some adjustment will be made (with the high-resolution orthoimagery).
- A national land cover map will be created using multi-spectral satellite image classification software augmented with basic ground-truth data collection and calibration. This land cover mapping will use medium-resolution (5 to 30 meters). satellite imagery—the specific data source will be decided based on cost and timing factors. Mapping products will be provided in grid-based and vector polygon format. Planning work will include preparation of a suitable land cover classification scheme.
- Data will be provided as ArcSDE geodatabase feature classes and raster datasets.
- Metadata for each GIS data layer will be compiled (see 3.4.2 for standards). Metadata entry forms will use templates provided by Esri ArcCatalog functionality.
- Efficient manual and automated quality control (QC) checking will be conducted prior to delivery of data. This QC work will be sufficient to check and support correction of data quality problems (see 3.4.3).
- Acceptance of data products will be subject to an independent quality assurance process.

Table 17:
GIS Database Layer Sources and Potential Development Methods

GIS Data Layer Name	Existing Data[1]	Sources for GIS Database Development	Ideas on Database Development Methodologies[2]
Base Map Layers			
Survey Control Points/Local Monuments	No existing data	No existing data.	There is no established survey control network in Liberia. A design for an initial geodetic network was completed as part of the USAID LPIS Project ("Strategy for Modernizing the Geodetic Infrastructure of Liberia" by the Millennium Challenge Corporation, 2001). A total of 10 survey monuments were placed but project funding and timing did allow for establishment of a CORS point or positioning for the 10 monuments. There is a plan in place, by the MLME—Bureau of Lands, Surveys and Cartography to establish one CORS site at the Forestry Development Authority headquarters near Monrovia. Making this network operational is a condition precedent for the development of CIMS.
High Resolution Orthoimagery-National Coverage	No existing data	New imagery from satellite or aircraft platform	Acquire imagery (satellite or aircraft platform) sufficient to meet type and resolution requirements (approximately 1-meter panchromatic) with necessary ground control sufficient to meet accuracy requirements and cloud-free coverage. Best flying period is the dry season (November to April). There is no "leaf off" season. Source of imagery could be satellite or aircraft.
Very High Resolution Orthoimagery-Urban Areas	IM2	New imagery from satellite or aircraft platform	Acquire imagery sufficient to meet type and resolution requirements (30 to 60 cm color or panchromatic) with necessary ground control sufficient to meet accuracy requirements and cloud-free coverage. The main urban areas to be covered are identified below. See footnote[3]. This source of this very high-resolution imagery could be satellite or aircraft.
Digital Elevation Model	DE1(scanned topo maps), DE2	High resolution (1 to 3-meter satellite or aircraft imagery or LiDAR	Main approach would be stereo photogrammetric compilation from satellite or aircraft-acquired image pairs with vertical and horizontal control sufficient for best possible accuracy. Use land cover information to improve vertical accuracy (approximate ground surface) in highly vegetated areas. For selected areas (e.g., dense forest coverage) use of LiDAR from aircraft is an option.
Governmental Administrative Units	GA1, GA2, GA3, GA5	Use existing data sources from LISGIS (GA1, 2,3,5)	Use the existing data sources (accept these boundary files as the best available source. Run automated QC to ensure proper line closure for polygon features. Be ready to incorporate any updates (e.g., enumeration areas) gathered in preparation of the 2018 national census by LISGIS. Boundaries were captured in the field but the timing of this timing of this mapping effort did not allow full consensus building with local officials to identify boundaries—a particular concern with Clan boundaries. A future objective should be to re-visit and get full consensus on boundary placement. Planning is starting now for boundary data compilation to support the 2018 national census. Work will include some additional capture and revision of boundaries.
Incorporated Municipalities	GA7	Use existing data and newly compiled data from LISGIS	Use existing data from LISGIS and coordinate with LISGIS for acquisition of additional municipal boundary data. Planning is starting now for boundary data compilation to support the 2018 national census. Work will include some additional capture and revision of boundaries.
Villages, Communities, Populated Places	PP1	Use existing LISGIS data (PP1).	Use these point locations as authoritative source. Be ready to incorporate any updates gathered in preparation of the 2018 national census.

GIS Data Layer Name	Existing Data[1]	Sources for GIS Database Development	Ideas on Database Development Methodologies[2]
Transportation-Public Roads	TR3	Use existing LISGIS data (TR1)	Use the existing source data but check against 1-meter imagery and make line adjustments where significant mismatch occurs.
Transportation-Local Roads and Streets	None	Use existing street data where it exists or urban area orthoimagery (30-60 cm resolution.	No new compilation is included in this effort but incorporation of existing or future data from municipal mapping projects should be incorporated. Streets captured in heads-up digitizing from urban area from orthoimagery.
Transportation-Private Roads	No available data sources[3]	Use data from mining and forestry companies if available	Capture road lines in heads-up digitizing from high-resolution satellite imagery for designated areas of mining and forestry operations.
Transportation-Railways	TR2	Use existing data from Corridor Study (TR2)	
Hydrography	NF1	Use existing data (NF1)	Adjust stream line segments from NF1 to visible channels on 1-meter orthoimagery in heads-up digitizing. An option, in addition to use of the existing "blue line stream" data (NF1), there is an option to use the DEM data for automatic delineation of additional drainage lines.
Important Planimetric Features	No existing source	Use existing street data where it exists or urban area orthoimagery (30-60 cm resolution.	No new compilation is included in this effort but incorporation of existing or future data from municipal mapping projects should be incorporated. Streets captured in heads-up digitizing from urban area from orthoimagery.
Cadastral Parcels	No existing digital GIS data	Available deeds and property records.	Compile boundaries and capture attribute data from existing sources and carry out field surveys-followed by formal arbitration and adjudication to resolve questions and conflicts. Focus on high-priority areas first (major urban areas, active concessions) in a long-term (decades) effort.
Thematic Map Layers			
Concession Areas	CN1	Use existing Corridor Study data (CN1)	Use existing data as best available source. NBC works with GoL entities (Land Commission, MoA, MLME, FDA) to resolve boundary questions and overlaps.
Mining Operations	No available source[4]	Mining companies is possible source.	The Land Cover mapping could provide an initial source for existing mining areas (disturbed surface) although the automatic image classification process would not fully differentiate mining areas from other bare or disturbed ground. More accurate mapping could be done through manual image interpretation and heads-up digitizing from high-resolution orthoimagery. Mining companies are probably the best source of this data although this has not been explored.
Large Agro-Forest Plantations	LC1, LC2	Use the existing data (LC1, LC2) as starting point and 1-meter orthoimagery.	Adjust boundaries of existing GIS data and use a combination of new Land Cover mapping and interpretation from orthoimagery to delineate boundaries. Mapping data from concessionaires could be an additional source but this has not been explored.
Farms	LC3, LC4	Existing sources (LC3, LC4)	Use existing point locations as best available source. MoA provide updated data as it becomes available.

GIS Data Layer Name	Existing Data[1]	Sources for GIS Database Development	Ideas on Database Development Methodologies[2]
Timber Sale Contract Areas	CN2	Use CN2.	Use existing data (CN2) as authoritative source but get updated data as available from the FDA.
Illicit Mining Locations	No available source	High-resolution imagery	No full national mapping of illicit mining locations is called for in this project but points can be compiled and incorporated into CIMS as they are captured—using orthoimagery in combination of field data collection.
Protected Areas (protected_areas)	GA4	Use existing data (GA4)	Use GA4 as authoritative source. Update with updated boundary data as available from FDA.
Concession Block Grid	Not applicable	Not applicable.	No grid has been defined. Include when and if it is designed and implemented as a basis for concessions.
Easements	No available source	Not applicable	No national mapping for easements is called for in this project. Capture boundaries as sources are available as part of cadastral data compilation.
General Land Cover	LC 5	Medium-resolution multispectral satellite data	Based on automated image classification from national orthoimagery with classification process guided by training sets and "ground truth" to get best possible classification accuracy. Will use data from current project sponsored by Forest Carbon Partnership Facility. Will use RapidEye 5-meter multispectral data.
Detailed Land Use	No available source	Not applicable	Detailed Land Use mapping is not called for in this project but can be incorporated from any projects (e.g., for major urban areas) where it is collected—from a combination of urban orthoimagery and field data collection.
Soils	No available source[5]	Digital elevation data, hydrography, and land cover layers.	Soil mapping is not called for in this project but can be incorporated in CIMS if it becomes available. Would use existing base map and land over mapping as starting point for major field data collection and sampling.
Schools	PP2	LISGIS data (PP2)	Use the existing LISGIS as best source, Update as new data becomes available from Ministry of Education or other sources.
Hospitals and Health Facilities	PP3	LISGIS data (PP3)	Use the existing LISGIS as best source, Update as new data becomes available from Ministry of Health or other sources.

[1]Refers to codes for existing Liberia data sources (see Section 4.1). These existing digital data may be used, in some cases, for creation of the GIS data layer and, in other cases, may provide a geographic reference to support database development

[2]Information on database development methodology is provided as a guideline for possible techniques and methods. Proposals for specific approach database development approaches will be requested from responding companies through a formal tender

[3]Urban areas to be considered for orthoimagery and mapping include:

City	Sq. Km
Monrovia	900
Gbarnga	220
Kakata	163
Bensonville	159

City	Sq. Km
Harper	156
Voinjama	130
Buchanan	125

City	Sq. Km
Zwedru	125
New Yekepa	120
Greenville	80

City	Sq. Km
Ganta	70
Robertsport	55
Sanniquellie	55

[4]Concessionaries (Mining and Forestry companies) may have GIS data for their sites but is not likely to be accessible)

[5]There were apparently some significant soil survey and mapping projects undertaken in Liberia from the 1960s into the 1980s supported by USAID but sources indicate that soil maps and survey documentation has been lost.

4.3 GIS Data Update and Organizational Responsibilities

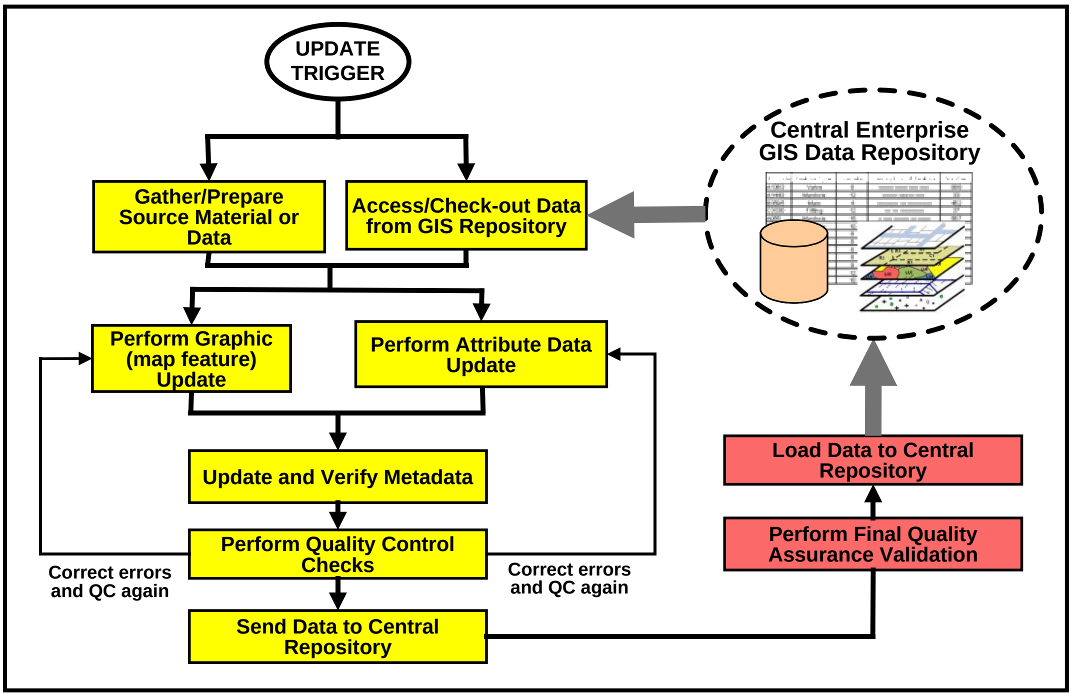
The *CIMS Implementation Plan* calls for the NBC to have the lead role in management of CIMS but ongoing database maintenance will require participation of and designation of specific roles to a number of GoL MACs. This is particularly the case with the GIS database which will be updated as source material becomes available. It is a basic tenet of GIS database maintenance that a data update role (for a specific data layer) should be assigned to the organization that has he primary responsibility for generating or managing source materials that will be used for the update.

GIS database update procedures and role to which responsibilities are assigned should reflect careful planning and the characteristics of different data sets. The following are key factors to take into account when planning and managing data updates:

- Frequency of changes to field conditions and source materials that influence the timing of database update
- Format and availability of sources to be used in the update
- Update triggers that procedurally notify GIS of physical changes that require data updates (e.g., building permit or field inspection showing changes)
- Workflow, technical tools, and applications for performing the update
- Formally assigned responsibility (e.g., person or organizational entity) for performing update
- Approaches to quality assurance and posting updates to a central GIS database
- Metadata update
- Tracking update transactions and informing users of database revisions.

Figure 12 illustrates a generalized workflow for GIS database maintenance which includes update to GIS features and attributes with appropriate quality control measures applied during the update. This is followed by delivery of updated data to the central GIS database repository where final quality assurance checks are run, and when data passes these quality checks, it is posted to the central repository for user access.

Figure 12: General Workflow for GIS Database Update



As a general rule, the expected timing and events that trigger an update (e.g., new Concession boundary or amendment to an agreement changing a boundary; changes from upcoming 2018 national census) should be identified. Then, specific responsibilities for update activities need to be assigned. For CIMS, there will be update roles assigned to GoL MACs that oversee specific program areas—including, most importantly, the MLME, FDA, MoA, and EPA. In addition, a new agency is being considered by the Liberian Legislature is evaluating possible creation of a new agency to address land administration and other land related functions and it is likely that this group will have certain geographic data responsibilities. Finally the LISGIS organization is expected to play an important role in GIS database development, quality control, and update.

5. OVERVIEW OF CIMS DEVELOPMENT APPROACH

The *CIMS Implementation Plan*, a document that accompanies this design, provides details about the planned approach, roles and responsibilities, timing, and cost projections for CIMS development and deployment. This plan calls for this development and deployment to occur over a 5-year period organized into the four Phases described below. Phases 1, 2 and 3 cover the main period of design and development including a prototype system to be put in place in Phase 1. The NBC will be the lead GoL organization and will work closely with international donor organizations for CIMS implementation. The Plan recommends that full CIMS development and early operation, which occurs in Phases 2 and 3, will be carried out with the services of a competitively-selected Prime Contractor. This Prime Contractor will be responsible for CIMS development (including subcontractors) and will set-up a facility in Monrovia for CIMS operations and user support. This facility will follow a "build, operate, and transfer" (BOT) approach in which the Prime Contractor will manage the system but train GoL personnel and hand over full CIMS management and operations to the NBC in Phase 4. The type of BOT operation recommended for CIMS follows what may be referred to as a "turnkey" model. The assumption is that funding will be established to cover the full contractor costs for setting up and operating the BOT facility and transferring operations to Liberian control.

The planned Phases are:

Phase 1-CIMS Prototype and Preparation for Full CIMS Implementation (July 2014 to December 2016): This Phase includes all project preparation and start-up activities for CIMS as well as Prototype development and deployment which will put into operation partial CIMS functionality for NBC and concession entities and provide a foundation for full CIMS implementation and operation in Phase 2. Included in Phase 1 is the critical activity of securing funds for this full implementation. Work in this Phase includes making adjustments to the CIMS design and implementation plan, procurement of system products and services, and the establishment of a team and project organizational structure to oversee and support implementation work. This includes selection and hiring of a Prime Contractor which will set-up and operate the Build-Operate-Transfer (BOT) facility and provide project management, technical operations, and oversight on CIMS implementation. In addition the Prime Contractor will support and train Liberian staff and support transfer to Liberian control in Phase 4.

Phase 2-Detailed System Development and Early Operation (January 2017 to December, 2018): The 2-year period for Phase 2 will focus on acquisition of high-priority CIMS products, data, and services, installation and testing of system components (hardware, software, data), development of critical user applications, and deployment for access by GoL stakeholder organizations. Based on procurement work done in Phase 1, this Phase will include the set-up of on-site a BOT facility by the selected CIMS Prime Contractor and the operations of this facility. This Phase will also include acquisition of national, high-resolution imagery and the development of a detailed GIS database following the content, format, and quality specifications in the *CIMS Design* document. In an expansion of application customization for concessions business processes carried out during the Phase 1 prototype, additional development of work flow and document automation, query and reporting, and GIS applications will be designed and developed. Liberian staff will be hired to support BOT operations and training will be carried out during this phase.

Phase 3—System Enhancement and Full Deployment (January 2019 to December 2020): This Phase builds on development work in Phase 2 and includes development of additional system components, databases, and applications. The user CIMS user community will expand including access by external organizations (e.g., concessionaires, local officials, general public) via Web-based services. With the presumption that that the NBC will use contracted services to oversee CIMS development and early operation, this Phase will include preparation for the "handover" of system operations to NBC or another designated GoL organization.

Phase 4—Transfer to GoL Management and Ongoing Operational Use and Maintenance (after December 2020): This Phase includes handover of CIMS management and operations from the CIMS Prime Contractor to the NBC (or other designated GoL organization). After this transition CIMS will be in full ongoing system operation, routine maintenance, and user support activities. .

APPENDIX A: GIS AND INFORMATION TECHNOLOGY FIRMS PROVIDING INPUT

CIMS design and planning has been based on detailed research and information gathering on mapping, GIS, and information technology methodologies, standards, and information technology. In the process, contact was made with a number of private firms that have practical and up-to-date information on methods, practices, and costs. Representatives of these companies agreed to examine GIS database development approaches and sources and provide high-level ideas on costs for the various components. Input from these firms contributed valuable information which was used in preparation of the *CIMS Design* and the *CIMS Implementation Plan*. The contributing firms and contact information are below:

Quantum Spatial

Contact Information:
Andrew Brenner, Ph.D.
Senior Program Director
Photo Science, a Quantum Spatial Company
315 W. Huron St., Suite 260,
Ann Arbor, MI 48103 USA
P: (734) 680-6424
abrenner@quantumspatial.com

www.quantumspatial.com

Merrick and Company

Contact Information:
Brian Raber, Vice President, GeoSpatial Solutions
5970 Greenwood Plaza Blvd.
Greenwood Village, Colorado 80111
Direct: 303-353-3900 Cell: 720-320-4843
Main: 303-751-0741 Fax: 303-751-2581
Brian.Raber@Merrick.com

www.merrick.com

Fugro Geospatial B.V

Contact Information:
Address: Dillenburgsingel 69, 2263 HW Leidschendam/
P.O. Box 3000, 2260 DA
Leidschendam, The Netherlands
Telephone: +358 405049355

- Jukka Kangasmaa, General Manager, International Operations
  j.kangasmaa@fugro.com, mobile +358-40-5049355
- Laurent Pronier (Marketing Manager for the Western Africa)
  L.PRONIER@fugro.com, mobile : +33-67-2079330
- Louis Demargne (Sales Director for Europe, Africa and Middle East)
  L.Demargne@fugro.com, mobile: +33-65-9050790

www.fugrogeospatial.com

Spatial Dimension

Contact Information:

Jaco Crafford, Regional Manager: EMEA
Cape Town, South Africa
Telephone: +27 21 531 3132
jaco.crafford@spatialdimension.com

www.spatialdimension.com

Trimble Navigation, Land Administration Solutions Group

Contact Information:

Jill S. Urban-Karr
Executive Director
Consulting Services/landfolio® Solutions
17806 IH-10, Suite 300
San Antonio, TX 78257 USA
Telephone: +1.210.819.7500, ext. 7311
jill_urban-karr@trimble.com

www.trimble.com