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Implementation Concepts of Sudan Integrated Geospatial Information Frame

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ABSTRACT

Sudan Survey Authority (SSA) initiated implementation of Sudan National Basemap System (SNBS) for Federal and State government entities. The SNBS has been designed and now at its implementation stage in the National Basemap Center in SSA. The SNBS shall be integrated with Sudan federal and state government entities as a common base map for the National integrated Geospatial frame, to be in line with United Nations Global Geospatial Information Management frames. SSA will take the role of prime SNBS implementer with the corporation of all its strategic Stakeholders in the country and the region.

This paper, demonstrates how SSA will fully meet SNBS requirements and the needs of all surveying, National Mapping and Geospatial authorities in Sudan. Throughout its initiative, SSA will utilize its existing networks to deliver collective benefits based upon collaborative development, and to build an effective partnership to ensure the utilization of geospatial services at all levels of government across the Sudan. Other primary objective of this initiative is to create an enhanced data management system that will improve the level of support for the activities in SSA by providing a solution that enables the effective and efficient provision of geospatial information to Sudan geospatial community.

KEYWORDS: *SNBS, SSA, UNGGIM, GNSS, OGC, AFREF*

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1. INTRODUCTION

Sudan Survey Authority (SSA), initiated implementation of Sudan National Basemap System (SNBS) for Federal and State government entities. The SNBS has been designed and now at its implementation stage in the National Basemap Center in SSA and the GIS Directorate, which is considered to be as the main part of the SNBS geospatial information services, data updating and quality control. The SNBS shall be integrated with existing GIS and geospatial systems in Sudan, to form, in the future the National integrated Geospatial frame to be in line with United nations Global Geospatial Information Management (UNGGIM) frames [13]. In Sudan, the SSA will take the role of prime SNBS implementer with the corporation of all its strategic Stakeholders in country.

This paper, demonstrates how SSA will fully meet SNBS requirements and the needs of all surveying, National Mapping and Geospatial authorities in Sudan. SSA has been working in Sudan for more than 100 years, and currently providing mapping and surveying services for the entire country. Recently (in 2020), SSA has been directed by the Sudan transitional Government to provide Sudan Basemap services to all government entities in Sudan [3]. To do this, SSA has established strong and successful relationships with multiple agencies and entities at the federal and state levels [5]. SSA is also, very proud of its relationship with Sudan federal and State governments as well as the Department of Surveying Engineering in four Universities in Sudan. These are considered to be as key partners to Sudan national Information Center [12], both during and following SNBS implementation.

Throughout this initiative, SSA will utilize its-existing networks to deliver collective benefits based upon collaborative development. Not only SSA will develop state-of-the art technical solutions, but will also implement them by building effective partnerships and encouraging positive collaborations

that will ensure that geospatial standardization, and any associated operational recommendations, are taken up willingly at all levels of government across the Sudan [1], [4].

SSA has also, had responsibility for Sudan surveying, geodetic control and mapping since it was founded in 1898; retaining and building on expertise in mapping, geodesy and positioning services and continue to ensure effective surveying and mapping deliverables and services which are considered to be as its fundamental core business.

SSA is acknowledged, as a national mapping agency and is recognized for its technical leadership and competence in all aspects of surveying and mapping. The technical staff maintain an international profile and influence geospatial policy and standards to be in line with UN-GGIM, and the Open Geospatial Consortium (OGC) [10]. This significant step by the government of adopting the SNBS to be at the forefront of geospatial development in the country, has provided an opportunity for SSA to use their skill and expertise to drive a collective and unified approach to promoting interoperability for the geospatial industry.

Other primary objective of this initiative is to create an enhanced data management system that will improve the level of support for the activities in SSA by providing solutions, that enable the effective and efficient collection, editing, storing and delivery of geospatial data. The benefits of increased efficiency and greater accuracy will translate into reduced costs and efforts in executing Sudan geospatial community activities and hence better value for all geospatial users in Sudan.

After a thorough investigation, SSA has outlined the requirements of its IT system components and the IT infrastructure as are required for delivery of the geospatial data, management system to an acceptable level of confidentiality, availability and performance. SSA under took needs assessment to capture requirements for its department's business processes [5].

For sustainable implementation, SSA has applied a quality system and approach to include testing, for the formal system and user acceptance testing. Then SSA has to train identified trainers and ensure lead users are trained to support the system at a departmental level with sufficient supervision at all stages of the implementation, and to ensure a full recognition of the new system all government entities and end users. To have a clear picture about SNBS implementation, its success and related problems, SSA highlighted most of the implications on SNBS implementation and focused in the main factors that characterizing the SSA local conditions [13].

2. Sudan Survey Authority

Sudan Survey Authority (SSA) is the national surveying and mapping authority in Sudan, and considered to be as a national leading geospatial data and technology organization. SSA is responsible for maintaining the nation's fundamental geospatial reference Basemap. The Sudan government, the general-public, and businesses have relied (since 1898) and to be relied on Sudan Survey Authority as a legal and regulatory body for accurate and up-to-date geospatial information, until now and the years to come. Currently Sudan Survey Authority has set the standard for data capture, data management and planning for geospatial services, shaping the geospatial industry and helping Sudan to become a digital nation. The paper is focused on the SNBS implementation together with the collection, creation, maintenance, management and supply of geographic information, designed to meet the needs of all aspect of national geospatial infrastructure requirements [11]. SSA creates and maintains the geospatial database for Sudan from which its geospatial products, services and solutions are to be derived.

The Sudan Survey Act, illustrated that, Sudan Survey Authority being responsible for the creation of geodetic network, aerial photography data capture processing and mapping, and to plan for the design of national Global Navigation Satellite System (GNSS) network, which can form a part of the critical national infrastructure of the Sudan, as well as, to be part of the Unified African Reference frame (AFREF). SSA believe that location and geospatial data is integral to every nation's economy and infrastructure, it enables efficiencies in the commercial sector and improves end-to end services in retail and finance, property, energy and utilities. In the world of today, countries rely on high-quality geospatial data to support their sustainable development goals, and that, location and place information connects governments, businesses and individuals to their physical environment, and including but not limited to: Effective government and data driven policy making, National and federal economic growth, Safe, secure and sustainable local communities, efficiencies throughout organizations, National infrastructure development, the protection of assets and resources, and citizen ad community engagements.

3. SSA Existing and Future services

The specialized, SSA Existing and Future services shall include:-

1. Geospatial services: are generally identified as geomatics, usually used for visualization,

measurement, and analysis of features or phenomena that occur on the earth. In which, geospatial technology composed of a combination of three (GNSS, GIS, RS) different technologies that are all associated to mapping features on the surface of the earth. Services provided by SSA covers design, development, and implementation of GIS system that are required for short- and long-term objectives as per Federal and states government requirements.

2. The services offered including but not limited to: Establishing Reference Station, Data Collection, Raster/Vector Data Processing, Internet/Intranet Deployment, GIS applications, Satellite Image Processing, Remote Sensing (RS) application development, Digital Terrain Modelling (DTM), Data Publishing and Documentation, Database Management Systems and Design.
3. Surveying & Mapping: Accurate surveys and mapping techniques have vital role in development and planning of Sudan engineering projects. SSA provides complete range of services in engineering surveying and Mapping.
4. Services offered: Geodetic Surveys, Aerial & LIDAR Survey, Lidar Bathymetry & Hydrographic Surveying, Map Updating, Land, Boundary and Cadastral Surveys, Topographic & Contour Surveys, Site Development Surveys, Route Location Surveys, Construction Surveys, Cartographic Surveys, Satellite imagery Processing, Digitization and Scanning (Raster-to-Vector Conversions).
5. Mobile 3D Laser Scanning is also considered to be utilized, as it has some advantages over Aerial Mapping and conventional ground surveys. This method of surveying together with the Unmanned Aerial Vehicle (UAV).
6. 3D As built for Corridor mapping, including Roadway and Rail, Transportation, Pipelines and Electric Transmission Lines, 3D Asset Inventory Mapping, Digital Terrain Models (Limited Area), Forensic Mapping, Archeological.
7. Feasibility studies related to potential network layouts, site selection and potential seismic systems, Supply and system installation, Network operation (data transmission, data processing and archiving), Training, Network servicing, maintenance and long-term support.
8. Marine Data Services: Bathymetry and seabed data collection, Acquisition, processing and production of mapping and bathymetric charts derived from: Coastal margins and shallow water environment data using airborne bathymetric LiDAR acquisition technology. On-shore coastal zone mapping using airborne LiDAR, Inshore and offshore environments using ship-borne hydrographic systems including side scan sonar, multibeam / swath sounders and geophysical profilers. Provision of hydrographic solutions expertise for: the planning and management of surveys; capacity building and development; marine mapping & charting and associated services.

4. Sudan National Basemap System

4.1. General Outlines of SNBS

The primary objective of this paper is also, to highlight how to implement an enhanced data management system that will improve the level of support for the activities of SSA and the Sudan geospatial community, by providing solution that enable effective and efficient collection, editing, storing and delivery of geospatial information. After a thorough investigation, SSA has outlined the Sudan National Basemap System (SNBS) requirements, so that, the SNBS team shall undertakes revision process of the previous needs assessment to capture all requirements for SSA business processes [4], [5]. It is recognised that the SNBS will be influenced by the base map and geospatial data provision, [12], in addition to the following:

1. Hardware, Servers and End-user Computers, Physical Security.
2. Networks and Telecommunications: Local Area Network
3. Internet addressing and web mapping
4. Observations on the Current Infrastructure and data volumes.
5. Database: database architecture, merging and database solutions.
6. Application Development: this relates to enabling the business processes to be modelled through the development of custom software applications for the greater benefit of all users.
7. Software Licensing: SSA shall indicates the Operating System licensing implications of the system. In particular, an explanation shall be given of the requirements for Access Licenses resulting from system implementation, stating versions and preferred licensing model, with the description of the licensing structure to be purchased or to use open-source modules as part of the final system [10].

For sustainable implementation SSA planned to apply quality systems and approach to include testing,

formal system and user acceptance testing. Then SNBS team shall train identified trainers to ensure lead users are trained to support the system at a departmental level with sufficient supervision in all stages of the implementation. Post implementation support shall be planned and offered in a structured and logical manner. A clear picture about SNBS main components and the data types was illustrated in UNGGIM-12 Sudan Country report [13].

4.2. SNBS functionalities and Operations

SNBS technical staff will be able to support all operational mandates of SSA by providing support to the fundamental operations and functions of its departments. The operational capabilities of SNBS now facilitate its recognition as a required information resource and that the operational services require systems and applications to be built for the most unfamiliar users of computer technology, e.g., maintenance crews, office clerks, and public service staff. To provide users efficient data access and query capabilities, most systems require substantial amounts of application programming to occur. Access to the information must be transparent to the staff that perform the operations on a daily basis. The implementation of operational programs can be greatly enhanced by utilizing technologies that are recognized as industry standards. Cost effective solutions for the implementation of SNBS programs, and their future integration with other existing Information System programs such as those implemented by other Sudan government entities, should be considered for becoming part of the mainstream in the future. The implementation of operational systems can define future standards for hardware, software, and database design. Potential applications can use the existing technology in similar operational programs. This will reduce application development costs, and maximize investments for the entire organization and future expansions. Looking forward to the future, SNBS technical team will focus on the establishment of the SNBS database, as a viable source of information along with application software built upon standard data dictionary that permits the integration of distinct Sudan operational activities.

In the SNBS implementation the following shall also addressed, reviewed and performed. The creation and implementation of SNBS shall be reviewed to essentially perform the following processes:

A. Import and Data Entry: All available georeferenced geospatial data of Sudan can be input and used in a geospatial environment.

B. Manipulation, Editing & Maintenance: all Basemap geospatial data are to be produced to develop a GIS system using licensed/open-source software, which will be capable of presenting clear and easy-to-understand visualisations, and document all possible GIS applications, depending on the client geospatial data quality, database and software availability. The SNBS will be capable to import common vector and raster formats to make use of the remote sensing images. Data entry refers to the way in which geo-spatial information is entered into the SNBS, which requires to allow graphic elements and attributes to be entered in the same software environment. All the functions for capturing data must also be available for editing data. In addition, to the consideration of all possible and necessary means for facilitating adequate data manipulation, editing and maintenance.

C. Attribute and Spatial Analysis & Visualisation: The national Basemap Center users shall be able to view and edit the attributes of any element selected spatially as agreed with the concerned entities, to make buffer zones defined by radius or width, to analyze data contained within the buffer zone and to support user-defined activities and other display parameters.

D. Implementation: It is divided into Systems review and needs assessment, functional design and unification of existing solutions and development of end-to-end solutions for the users in different departments. The future SNBS implementation shall offer tools for making Internet-enabled Geospatial applications. The Internet applications needed are to allow geo-spatial data to be viewed and edited, not only by SSA staff, but also by managers within SSA stakeholders and other external organisations such as related government [8], [9] and private sector institutions.

4.3. Application Development

For a successful SNBS implementation within SSA and its stakeholders, user needs assessment shall be carried out again, to detail the functional analysis of the organizational system, and to align geospatial data required to achieve overall understanding of the current operations and activities of SSA and all of its stakeholders. This needs assessment should be considered as a tool for enhancing coordination, cooperation, communication and understandings among Federal and State government departments, so as to work together on a common unified database and geospatial system. This will help in adopting the same standards and specifications of system, looking into the potential applications, and planning for geospatial information integration and sharing processes between various entities in Sudan.

4.4. Database Development

There is a need to establish an effective database to satisfy the needs of SSA and its stakeholders, from spatial and non-spatial data, that, to be used for all kinds of activities, including data processing, management and analysis. In this, the SNBS center should be established to develop the database and all technical specifications, regulations, laws, standards and all necessary policies for the implementation and operations of the database [14]. The laws, regulations, standards and specifications and all organizational matters concerning the database should be adopted, approved and implemented by the Federal and State government and geospatial community in Sudan.

Mechanisms to support the construction of the database and to access the geospatial data are needed. Many kinds of geographic data exist in SSA departments and the stakeholders. Access to the available information is presently constrained by a variety of factors. Foremost among these, is the lack of awareness about database design and development, lack of technical expertise and lack of standards and working procedures and operations of the database. In addition to that, SSA is not having Metadata describing the quality, accuracy and other information concerning the data sources and procedures.

To develop an effective database, SSA have to get use of international experience, standards and specifications in this regard, to address the following key issues:

A. Since, at present there is no common Metadata documentation, this indicates that, there is an urgent need to prepare a complete Metadata, establishment of the database with the use of commonly accepted data documentation standards.

B. The need of catalog development and establishment of a mechanism to help the participating organizations to update or add additional information to the catalog. This illustrates the importance of the development of an easy to access and use catalog of geospatial data.

C. Development of a mechanism for sharing and integrating data with the common database, and ensuring compatibility and accessibility.

D. The geospatial responsibilities to be assigned by decree should be issued, and must be backed up with all necessary means to meet the required mandates. This shows that, there is a need to re-access and clarify some mandates relative to geospatial data production, maintenance and dissemination.

4.5. Organisational Characteristics

The SNBS organisational characteristics are planned to include the following:

A. Organisational Structure –Stability of higher management, availability of skilled staff, Communication and co-ordination and formalisation.

B. As well known in geospatial systems implementation, one of the major elements of organisational characteristics related to inter-departmental communication and co-ordination. SSA may emphasised that, a lot of data could be shared among its stakeholders' departments, and the success of SNBS implementation, will be related to how the problems of data sharing and integration are to be resolved.

C. Before proceeding to SNBS implementation, all SSA functions are to be investigated to determine their involvement with geographic information. The investigation will result in understanding of SSA needs for geographic information, how geographic data are acquired, what information they share, and what problems were encountered in these processes.

SSA currently realized many problems related to availability and quality of data to be used, the data acquisition processes and accuracy requirements. In this regard intensive investigations are to be carried out to study the elements of SNBS applications, emphasizing setting procedures and regulations for data acquisition, data sharing and regulate updating of data and information. As well, the investigation shall also focus in the necessity of adopting data formats, standards and specifications for SNBS implementation. The investigation should, also, identify the main strengths, weakness, opportunities and threats that facing SSA and its stakeholder departments, related to SNBS implementation and to the conditions to be improved.

4.6. Factors Affecting SNBS Implementation

The conditions of SSA in relation to the implementation and development of geospatial system shall be assessed by examining the factors which shall be identified including major factors that affect the implementation of the geospatial technology in the organisations, such as: (1) Organisational characteristics, (2) Current Activities and potential geospatial applications, (3) Data availability and quality, (4) Human resources, (5) Financial resources, (6) Geospatial technical support.

Investigation of the current activities will be resulted in understanding the SSA needs for handling geospatial information, how spatial data are acquired,

what information they share, and what problems were and are encountered in these processes. A matrix, showing the functions of the departments and the data needs to fulfil these functions [6], shall be developed to help identify the common data. By matching the departments' functions with capabilities that the geospatial technology offers, potential geospatial applications will emerge.

5. SSA Main Stakeholders and Partners

The SSA stakeholders include Sudan geospatial community, namely, all federal and local governments' entities, private and public sectors organizations. SSA has met and coordinated with the following entities for the implementation of the Sudan National Basemap and has already, signed memorandum of understanding with many federal ministries and all States ministries of infrastructures and urban development (table.1).

No.	Government Federal Entities		Government States Entities
1	Ministry of Defense	16	Khartoum State Ministries such as Planning, Infrastructure and Agriculture
2	Ministry of Finance and Economic Planning	17	White Nile State Ministries and Localities
3	Ministry of Interior: Buildings Security, Custom Department, Civil registration	18	Blue Nile Region and States
4	Ministry of Justice: Land registration	19	Darfur Region and States
5	Ministry of Mining: Geological Research Authority and National Mining Company	20	Al Jazeera State
6	Ministry of Council of Ministers	21	Northern State
7	Ministry of Irrigation	22	North Kordofan State
8	Ministry of Higher Education	23	West Kordofan State
9	Ministry of Transportation	24	South Kordofan State
10	Ministry of Health	25	Sinnar State
11	Ministry of Energy: Oil Information Center	26	Nile River State
12	Civil Aviation Authority	27	Al Gadarif State
13	National Information Center	28	Kassala State
14	National Statistics Authority	29	Red Sea State
15	General Intelligence Authority	30	Electric Distribution Company

Table.1: shows the list of the Main SSA Stakeholders

6. Implications of the Findings on SNBS Implementation

6.1. General

The successful implementation of geospatial information in SNBS system, shall be as a function of management and institutional capabilities rather than of technology. Here, SSA higher authorities are to play active roles in supporting and improving capabilities for evaluating SNBS stakeholders needs (e.g., through training, workshops, advisory and consultancy projects); encouraging and strengthening communication and co-ordination among, strategic stakeholders, data producers and data users; providing a framework for data standards and data sharing among various departments; development of data standards within the departments; and supporting the provision of basic geospatial data (e.g., geo-referenced, satellite imagery).

The successful SNBS implementation, therefore, includes successfully dealing with characteristics of organisational culture, the dynamics of people interacting in teams, change processes, and the impacts of introducing new technology. The primary goals of SNBS implementation are to make information readily available to decision makers, geospatial producers and users and to provide tools to facilitate integrated management and analysis of the data.

6.2. Management Perspective on SNBS Implementation.

SSA aware that, any attempt of SNBS implementation should indicate that a series of management and organisational issues are to be addressed at the early stages of the implementation. This is because the organisational problems are often more complex and more crucial to the geospatial implementation success than the technical problems involved. Therefore, a documented guiding principle are to be prepared, supported by policy and management guidelines [7], and an organisational structure to implement and monitor the policy and guidelines [15], [17].

6.3. Data Exchange Standards

The data sharing and data integration among government departments is a corner stone for a successful SNBS implementation. The benefits of data sharing and integration are many, but the most noticeable ones include: access to more geospatial

data; improved interface between systems; shared programs; reduced data capture expense; reduced data storage requirements; avoidance of inconsistent data; and ease of access.

For the issue of data sharing and integration, several questions to be considered during the SNBS implementation planning stage to identify: the source of each data item; regulations and arrangement for data sharing; ownership of each data item; how each data item is integrated in the SNBS data layers; who will be responsible for geospatial data updates; and how will the data be archived and who will be responsible for that; [18].

The main role of standards in SNBS is to facilitate the integration of data sets from various distributed sources. The format and structure for holding geospatial information is likely to differ between computer systems, so the exchange of information requires the use of standardised formats, which are understood by both the provider, and the customer. With the understanding of the above-mentioned considerations, the cycle of the SNBS implementation can be planned and designed to cover all geospatial aspects.

6.4. Establishment of SNBS Centre

A Center for SNBS to act as the core of SNBS businesses is initiated to be established in SSA premises. The mission of this Center planned to be concentrated on the provision of geospatial information services and co-ordination of systematic implementation of SNBS, including the simplification of geospatial data and information transfer between all departments and related agencies, as well as to minimize data redundancy, and to ensure availability of suitably trained personnel to operate and manage the various components of the SNBS system.

Generally, the cycle of SNBS development and implementation in the SNBS centre can be described as a series of actions which are to be executed before SNBS implementation, such as:

A. Need assessment: is to be carried out through interviewing key geospatial users and conducting inventory surveying for the functions and work flows, geospatial data used in these work process, and output of the potential geospatial users. The need assessment should provide a list of the required geospatial functions.

B. Conceptual design: This design includes formal modelling of the intended SNBS database taking into account the initial stage of the database planning activity. The conceptual design starts with the identification of the needed data sets and continues to cover inclusion of the data in the geospatial data model, creation of the meta data describing the data sets, collection and entry of the data into the database, updating and maintenance and, finally, retention. The product of the conceptual design activity is an improvement to the previous conceptual data model [5], which defined the geospatial database and supports to its detailed planning.

C. Survey or inventory of the available data: to inventory and document mapped, tabular and digital data within the potential geospatial users within SSA as well as data available from other sources.

D. Survey of available geospatial hardware and software in the country: to inventory and document the hardware and the commercial software in use by the potential geospatial users and the geospatial functionality of each geospatial system.

E. Detailed database planning and design: In this, a logical or physical database design based on the data model should be developed, the potential data sources are to be evaluated, the quantities of geospatial data and costs of building the SNBS database are to be estimated and the data conversion plan is to be determined.

F. Database construction: this is the process of building the digital database from the source data, including quality assurance and quality control of the geospatial data.

G. Acquisition of geospatial hardware and software according to the plans agreed upon.

H. SNBS integration: Once the hardware and the software are acquired and the database is created, these components must be integrated and tested. Users must be introduced to the system, system-specifically trained and given adequate assistance to start using the system.

I. SNBS application Development: these include SNBS-system-management functions needed to create, edit, build, and maintain the database, and user applications as determined in the needs assessment step.

J. SNBS use and maintenance: since the SNBS databases may be very dynamic, formal procedures for all the maintenance and updating activities shall be created and strictly followed by the SNBS system staff and all users to ensure continued successful operation of the SNBS.

K. Geospatial standards: is to specify the reference and co-ordinate system, which is to be used to

describe the location of objects in SNBS. The co-ordinate system specification involves the geodetic frame and properties that underlies the system and is extremely important in establishing basic principles of the survey to be used in collecting location data for use in SNBS. Many other components of the spatial structure, such as scale, resolution and accuracy requirements, can be modified from application to another if a common geodetic frame and co-ordinate system is maintained. Selection of a co-ordinate system will definitely depend on the availability of pre-established Sudan-wide geodetic control network, associated with national, or international standards. In this regard, the ITRF2008 reference system was adopted by SSA to be used as a unified Sudan Geodetic Reference Frame (SGRF).

7. Conclusion

Sudan Survey Authority (SSA) initiated the implementation of Sudan National Basemap System (SNBS) for Federal and State government entities. The SNBS has been designed and now at its implementation stage in the National Basemap Center. The SNBS Center is to act as the core for the provision of geospatial information services and coordinating systematic implementation of SNBS in Sudan.

The SNBS shall be integrated with Sudan various entities existing GIS and geospatial systems to form in the future the National integrated Geospatial frame to be in line with United nations Global Geospatial Information Management (UNGGIM) frames.

SSA currently providing mapping and surveying services for the entire country, and in 2020, has been directed by the Sudan Translational government to provide Sudan national Basemap services to all government entities and geospatial community in Sudan. This paper, demonstrates how SSA will fully meet SNBS requirements and the needs of the geospatial authorities in Sudan, and highlighted the outlines of how to implement an enhanced data management system that will be used to improve the level of support for the activities of SSA and the Sudan geospatial community.

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