International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 03 – Issue 03 || March 2018 || PP. 121-144

Geospatial Enterprise Architecture Principles for Ethiopia

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Abstract: Geospatial Enterprise Architecture principles are a central foundation for achieving national spatial strategic outcomes as they establish the basis for a set of rules and behaviors for all federal and regional geospatial authorities. The principles, as a key enabler for government outcomes, will contribute to aligning regional and federal spatial services and solutions with goals and strategies at both the regional and national levels. Geospatial Architecture principles define the underlying general rules and guidelines for the use and deployment of all spatial resources and assets across the nation. They reflect a level of consensus among the various elements of the enterprise, and form the basis for making future spatial related decisions.
Having appropriate geospatial enterprise architecture principles in Ethiopia will provide a framework within which the government makes conscious decisions about spatial management at the right time and supporting the national development process. They act as a guide to establishing relevant evaluation criteria for spatially related initiatives, thus exerting a strong influence on the selection of products and services that make up individual solution architectures in the later stages of managing geospatial Enterprise Architecture compliance.
Keywords: Enterprise Architecture; Geospatial Enterprise Architecture; Geospatial; Spatial; EA Principles; Ethiopia

1. Introduction

We live in an age in which change is the only constant. Complexity is omnipresent and so is the need to be agile and to transform. Developments such as globalization, the fusion of business and IT, new technologies, the introduction of new business models and new regulations, occur at a higher pace than ever. This requires modern day enterprises to be able to adapt themselves swiftly to these changes and make decisions at the right time for both short term and long term needs. The emerging instrument of enterprise architecture promises to provide management with insight and overview to harness complexity in a coherent and integral fashion (Martin op't land et al, 2009). Enterprise architecture is the instrument that helps organizations in analyzing and structuring their current complexity, and in designing and managing their continuous transformation process to become agile, efficient and effective. In the architecture framework proposed by The Open Group architecture has two meanings depending upon the context: The first one, it is a formal description of a system, or a detailed plan of the system at component level to guide its implementation; and the second one it is the structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time (TOGAF 2009).

Enterprise Architecture Principles are the fundamental part of an Enterprise Architecture Framework (EAF). They are considered as the shared and long-lasting beliefs that are used to guide all future architectural decisions and the use of geospatial technology in constructing, transforming, and operating at national or organizational levels. They are used to guide and influence the target-state enterprise architecture, and the development and maintenance of geospatial services. They provide a foundation for nationwide or enterprise-wide decision-making that determines the current and future use of geospatial resources (Ivan Wells, 2018). Moreover, Dirk Stelzer also proposed the following definition (2009): Enterprise architecture principles are fundamental propositions that guide the description, construction, and evaluation of enterprise architectures. Enterprise architecture principles fall into two classes: Design principles guide the construction and evaluation of architectures. Representation principles guide the description and modeling of architectures, as well as the evaluation of architectural representations.

Once the Geospatial Enterprise Architecture Principles have been established and stabilized, they need to be locked down following the Geospatial Enterprise Architecture (GEA) change management processes. As the strategic directions and goals of an enterprise continue evolving, the principles must be revised and refined. Any changes to the agreed upon GEA Principles must be managed through change control processes and should be approved by the governing body. Therefore, as parts of geospatial architecture governance process, a change control process needs to be established for adding, removing, or altering the GEA principles (Craig Douglas, 2015). Each new initiative is expected to explain how they will conform to the principles and justify any expectations.

It is important to establish a standard approach for defining GEA principles for Ethiopia. Doing so will improve the clarity, understandability, and the acceptance of the principles. Commonly used approaches include the following characteristics of spatial EA principles:

- GEA Principle Name need to be defined and communicated well to all stakeholders;
- GEA Principle definition statement need to use words that allow consistency and uniform interpretation;
- Motivations for defining the principles that provide the basis for justifying all proposed decisions and related activities need to be defined; and
- Implications or consequences (positive and negative) of adopting the principles that provide an outline of the key tasks, resources and potential costs to the business due to implementing the principle and also provide valuable inputs to future transition initiative and planning activities (TOGAF, 2010).

Geospatial Architectural principles in this study paper cover the full range of the architectural spectrum, which includes governance principles; business principles; information principles; application principles; security principles; and technology principles.

The objective of this study paper is to define enterprise geospatial architecture principles that will drive all future architecture design, development, maintenance, use and decisions in the areas of geospatial architecture by business, data/information, application, technology, and security domains in Ethiopia. The principles can be used by the federal and regional authorities to provide an architectural framework to support evidence-based decision making, as a guide to establishing relevant evaluation criteria in the selection of products or solution architectures, as drivers for defining the fundamental requirements of the GEA, as an input to assessing both existing and the future strategic portfolio for compliance with the defined architecture, and to support the architecture governance activities (AGIMO, 2014).

2. Geospatial Enterprise Architecture Principles

Geospatial Architectural Principle is defined as an enduring rule that governs the architectural design attributes and direction of a system or an overall enterprise. Architectural principles ensure industry best practices, cost and operational efficiencies, and compliance with the State's Statutes, Provisions, Administrative Rules, and Directives. Figure 1 provides a pictorial representation of geospatial enterprise architecture principles for Ethiopia, which are derived from the researcher experience working in multiple similar industries. Since GEA principles constitute a basic reference for every spatial projects and initiative, the principles need to be part of the requirements on any future architecture work and they should be treated as a primary set of requirements.

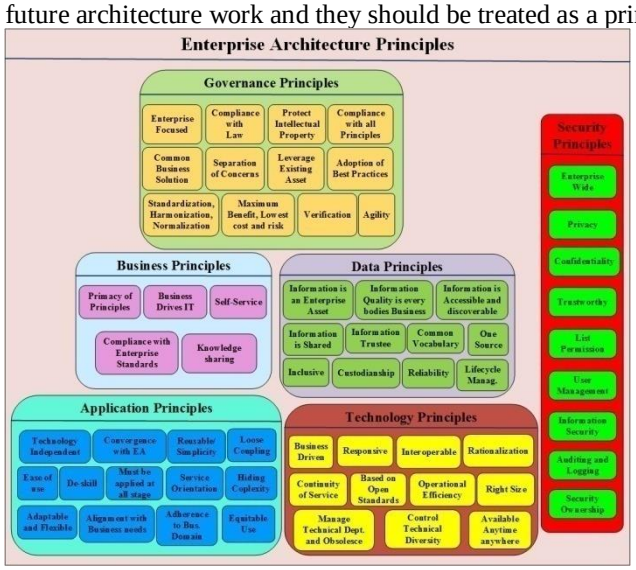

Fig 1. Geospatial Enterprise Architecture Principles

As you may see in figure 1, principles are inter-related and need to be considered as a set. Principles sometimes compete (for example, the principles of "accessibility" and "trustworthy" could establish a creative tension). At times strict adherence to one principle may require a loose interpretation of another. Therefore, a set of principles must be expressed in a way that allows a balance of interpretation (AGIMO, 2014). It is important to be able to decide which principles will take precedence on a particular issue. Ultimate design decisions will be made based on requirements, the risk associated and the justifications documented.

Enterprise architecture principles in this paper represent the fundamental requirements defined at a micro and macro level related to the national spatial platform for Ethiopia that should be aligned with the national spatial strategy, vision, and business goals. In addition, it also defines the EA principles that are used as guidance for EA development, systems acquisitions, and implementation at national level.

2.1 Key Considerations

When developing GEA Principles customers' business strategy, goals, requirements, best practice and benchmarking are used as an input. Moreover, the business and technology standards and the involvement of key decision makers and thought leaders are taken into consideration. Figure 2 shows, the context of national geospatial architectural principles that represent the fundamental federal and regional authorities as well as stakeholder requirements and practices.

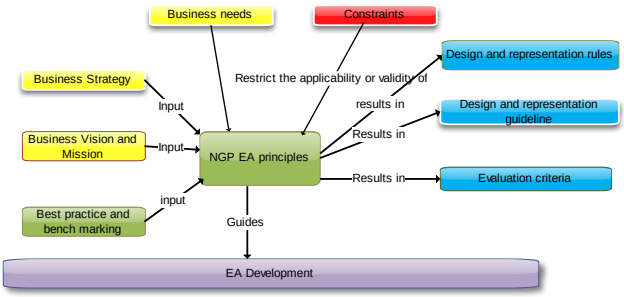

Fig 2. The context of Spatial Enterprise Architecture (Extended from the context of Architectural Principles by Dirk Stelzer, 2009)

The GEA principles need to be stable, as they define a "long-lasting" value and should not be changing frequently. The impact of such change is assessed through geospatial governance processes. If the change that needs to be introduced is minor, then it will be reviewed following exception management processes that may or may not trigger changes to the base principles. Any change needs to be presented to the governance body and the governing body must approve the required changes. Therefore, regardless of the size of change all updates should be documented, reviewed and approved by the governing body.

2.2 GEA Principles

It is useful to have a standard way of defining principles. In addition to a definition statement, each principle should have associated rationale/motivation and implications statements, both to promote understanding and acceptance of the principles themselves and to support the use of the principles in explaining and justifying why specific decisions are made (TOGAF, 2011). The statement communicates the fundamental architectural rule in sufficient detail to be clearly understood; the rationale gives the strategic and business benefits of adhering to the principle; and the impact statement communicates the cost, both for the business and spatial technology, for implementing the principle in terms of resources, costs, and activities (Ohio DAS, 2015). In addition to the experience that the researcher has in the areas of architecture, the Open Group's TOGAF standard template is used to define geospatial enterprise architecture principles. A comprehensive set of architecture principles in this section are structured as governance principles, business Principles, information (data) principles, application principles, security principles, and technology principles.

2.2.1 Governance Principles

Governance is the act of controlling compliance of an enterprise or an organization to the rules. Enterprise architecture is an integral part of the governance of an enterprise and its transformation (Martin opt, et al, 2009). The following are the geospatial architectural principles within the architectural governance domains. The governance domain includes national level focused, common business solution, standardization, compliance with the law, intellectual property protection, adoption of best practice, maximum benefit, leverage existing assets, compliance with all practices, verification, approval, and agility.

2.2.1.1 National Level Focused.

Name	Macro (national) level Focused
Statement	The national level spatial standards and policy directives are applicable to all federal and state authorities.
Motivation	• Spatial and non-spatial Information management decisions consider the impact and maximize the benefit to the nation. • Decisions made at the national level have long-term value compared to decisions made by any single organization. • Both Spatial and non-spatial information used to support nationwide decision-making, therefore, it needs to be standardized and more accurate.
Implication	• Adaptive governance model proposed by Abraham et al. (2018) must be implemented that will support nationwide decision-making process to be more efficient and effective. • Establish a governance body and architecture/solution review processes that will review and confirm adherence to the principles. • Achieving maximum benefit requires changes in the way geospatial technology is managed and planned, since technology alone cannot bring this change. • Initiatives within the nation need to be assessed from the national standard perspective to establish common grounds and serve throughout the nation. • Spatial and non-spatial Information management initiatives need to be conducted in compliance with the enterprise principles.

2.2.1.2 Common Business Solution

Name	Common Business Solutions
Statement	To minimize duplication of effort at national level reusable solutions and modules can be used across the nation.
Motivation	• Duplicative solutions are expensive so reusable solutions and modules need to be used. • Duplication of systems causes conflict in information sharing and process. • Encourages cost reductions and the use of nationwide accepted practices.
Implication	• Government and private sectors will not be allowed to develop solutions for their own use that can be shared at the national level. • Encourages sharing of spatial assets across organizational boundaries. • A common technology and organization infrastructure will be needed to support common business solutions.

2.2.1.3 Compliance with law

Name	Compliance With Law
Statement	Geospatial information management processes need to comply with all relevant laws, policies, and regulations at the national level.
Motivation	• Geospatial information management processes need to abide by all relevant laws and regulations at national and regional levels.
Implication	• Regional and federal authorities need to comply with laws, regulations, and external policies during geospatial data collection, sharing, processing, storage, and management of data, etc. • Authorities need to understand geospatial related policies and regulations that affect geospatial enterprises business. • Changes in the law and changes in regulations may drive changes in the geospatial solutions and initiatives.

2.2.1.4 Standardization, Harmonization and Normalization

Name	Standardization
Statement	Standardization is required to encourage sharing, interoperability, and efficiency in realizing the national geospatial environment.
Motivation	• Standard processes are predictable, repeatable, scalable, and more efficient. • Process standardization will help authorities to comply with legislative and quality standards. • It is easier to manage resources, knowledge, and investments in a standardized environment. • Open standards are encouraged to provide a flexible and consistent environment in responding to changing requirements. • Helps eliminate redundancy by leveraging the knowledge and efforts of others.
Implication	• The geospatial architecture needs to differentiate proprietary systems and open systems. • Review process needs to be in place to confirm standards adhere to processes including exception management processes need to be in place. • Deviation from standards must be presented to the governance body, and approval must be granted prior to deciding on non-standard tools, systems, software, etc. • Standardization helps achieve economies of scale, reduces complexity and improves flexibility.

2.2.1.5 Agility

Name	Agility
Statement	• Geospatial Capabilities are designed to evolve and adapt within the context of a dynamic and changing environment. • Enable Business and Information Readiness – ability to change with changes in business strategy and model.
Motivation	• Geospatial enterprise solutions need to be capable of evolving and adapting to meet changing priorities while minimizing the cost, risk, and impact of changes. • Services that support the business need to be designed in an agile manner, to adopt changes in a rapid and cost-effective way. • Continuous improvement in Geospatial EA processes and technology implementations will lead to cost reduction, improved efficiency, and effectiveness.
Implication	• Geospatial authorities must adapt and respond to the changing business needs and technological dynamism. • Geospatial authorities need to focus on service-oriented approaches to satisfy geospatial users. • Geospatial technology must be selected and deployed for its business value and business needs.

2.2.1.6 Intellectual Property Protections

Name	Intellectual Property Protection
Statement	The enterprise's Intellectual Property (IP) must be protected. This protection must be reflected in the geospatial architecture, implementation, and governance processes.
Motivation	• The need for IP protection to improve innovation in the area. • IP protection helps to avoid compromises and reduce liabilities.
Implication	• While protection of IP assets is everybody's business, much of the actual protection is implemented in the geospatial domain. • A security policy governing human and geospatial actors is required that can substantially improve protection of IP.

2.2.1.7 Adoption of Best Practices

Name	**Adoption of Best Practices**
Statement	GEA solutions and activities must always be aligned with industry and countries best practices.
Motivation	• Nations always strive to adopt best practices from their industries. • Geospatial Enterprise Architecture and all the domain architecture, geospatial management and support must align with Industry and countries best practices.
Implication	The following areas must be assessed and aligned with best practices: • Geospatial processes and use established metrics as well as the need for certification. • Specific risk perspectives, failures, and records of incidents and events. • The management of geospatial solution costs per service (revenues and expenses), must be financially comparable to those of the industry. • Personnel qualification requirements.

2.2.1.8 Leverage Existing Geospatial Asset

Name	**Leveraging Existing Geospatial Asset**
Statement	Geospatial assets need to be reused wherever possible, purchased as commodity solutions if necessary and only built if there is a unique requirement that cannot otherwise be fulfilled or if there is adequate reason to do so.
Motivation	• Reuse will provide value for money, simplifies the geospatial technology landscape, reduces or eliminates duplication and facilitates the adoption of common business processes, architecture, and tools. • Maximize the value of geospatial assets and optimize their return on investment (ROI).
Implication	• Funding for programs and projects that will cater for shared services across projects and business units to avoid unnecessary duplication or development of silos. • The need for the creation of asset repository. • Design scalable and modular re-usable components. • Develop a culture of re-use. • Current environment summary (“As-is” architecture) must be clearly defined and documented

2.2.1.9 Lowest Cost and Risk

Name	**Maximum benefit at lowest cost and risk**
Statement	Geospatial strategic decisions at the national level must always strive to maximize benefits for the enterprise while lowering the long-term risks and cost.
Motivation	Every strategic decision must be assessed based on cost, risk, and benefit perspectives; as lower costs often represent greater risks and perhaps fewer benefits in the long term.
Implication	• A solution must be selected based on a qualitative or quantitative assessment of cost, risk, and benefits. • Operating risks must be quantified whenever possible using quantitative assessment. • Geospatial infrastructure must be optimized based on business requirements and capacity requirements to generate lower costs and risks while providing maximum benefits to the organization.

2.2.1.10 Compliance with all principles

Name	Compliance with all principles
Statement	• GEA must abide by the set of Principles defined in this document. • In order to achieve stable systems and controlled migration paths, only approved modifications should be made to any system or application.
Motivation	• The GEA principles must be followed in order to provide a maximum benefit to companies and enable information readiness by delivering timely, quality and relevant information to the stakeholders.
Implication	• Compliance management processes and standards need to be developed and shared with all architects and geospatial professionals. • Audit processes should be in place to audit projects for their compliances with all principles.

2.2.1.11 Verification and Approval

Name	Verification
Statement	All activities must be subject to architecture review and approval at key stages throughout the delivery lifecycle.
Motivation	Verification and approvals: • Ensure that GEA follows the Enterprise Architecture guidelines and move in the technology direction that is specified as standards. • Ensure GEA completeness. • Prevent deviation from geospatial strategic vision and goals.
Implication	• GEA must provide clearly defined requirements that led to the proposed architecture and solutions. • GEA must provide a clear business justification for changes to the architecture. • An exception must follow change management and approved processes. Changes to the architecture need to be formally managed so that deviation from the standard is controlled.

2.2.2 Business Principles

Business architecture is defined as "A blueprint of the enterprise that provides a common understanding of the organization and is used to align strategic objectives and tactical demands. The most fundamental aspect of business architecture is that it represents a business. A business does not begin or end at the bounds of the enterprise. Business architecture must, therefore, be able to represent portions of a business that have been outsourced as well as stakeholder interests (OMG Business, 2013). Business requirements describe what must be performed and produced to provide the products and services by the geospatial authority. Business architecture is based on a core set of principles that guide the understanding and use of business architecture to solve business problems (Greg Suddreth and Whynde Melaragno, 2010).

The following are the geospatial architectural principles within the business architectural domain to guide the design and development process of geospatial business architecture. The business architectural domain includes principles of supremacy, business drives technology, compliance with standards, and knowledge sharing.

2.2.2.1 Supremacy of Principles

Name	Supremacy of Principles
Statement	The GEA Principles are supposed to be applied to all the architecture work and projects and they override all other considerations at the national level. The expectation is to either comply with the principles or to explain why they deviate from the principles.
Motivation	Compliance with this principle is the only way for promoting a consistent and measurable level of geospatial architecture and provides quality services to the business.
Implication	Compliance ensures inclusion and consistency with the geospatial business needs. Divergence from the principle will: • Increase architectural complexity and may result in a higher total cost of ownership. • Short-term considerations, exceptions, and inconsistencies would rapidly undermine the management of information technology. • Information management initiatives will not be permitted to begin until they are examined for compliance with the principles causing unnecessary project delays. • A conflict with a principle will be resolved by changing the conflicting activity, which could delay or prevent the activity.

2.2.2.2 Knowledge Sharing

Name	Knowledge Sharing
Statement	It is important to have geospatial knowledge management that facilitates knowledge sharing throughout the enterprise.
Motivation	• There are often new or infrequent tasks to perform where the user does not possess the knowledge necessary to do the job. The existence of knowledge sharing mechanism such as central knowledge management systems and enterprise asset repositories that will allow users to train themselves and enhance the use expertise assets helps users to accomplish tasks in a timely manner and also avoid duplication of existing assets. • Geospatial knowledge-sharing allows users to develop and conduct more than one task.
Implication	• Need to implement a knowledge management and knowledge repository where approved corporate information is stored and shared. • Define user access policies, for the stored geospatial knowledge available at the repository, to provide access to users based on their needs. • Knowledge management enables stakeholders to learn from experience and minimize doing similar errors continuously.

2.2.2.3 Compliance with Enterprise Standards

Name	Compliance with enterprise standards
Statement	Geospatial enterprise and technology management processes must comply with all applicable internal policies, standards, and regulations.
Motivation	• Compliance with enterprise standards will facilitate interoperability and consistency across solutions. • Standard-based solution will simplify software design, reduce application development time, facilitate learning, improve systems maintenance and support, and promote information sharing.
Implication	• A process must be established for setting, reviewing and revising standards periodically, and granting exceptions. • The processes must be sufficiently agile to support business and design drivers within required timeframes. • Standards must be followed unless there is a compelling business reason to implement a non-standard solution. • Changes in standards might lead to changes in GEA principles, policies and processes.

2.2.2.4 Business Drives Geospatial Technology

Name	Business Drives Geospatial Technology
Statement	Geospatial architecture and technology must align with the business in order to generate maximum benefits for the enterprise as a whole.
Motivation	• Geospatial technology direction will be driven by what the business needs to serve its customers. Without knowing the business, the geospatial technology solution could be over or underbuilt, and this can result in architectural complexity, cost, and delays. • An optimal return on investment (ROI) can only be achieved when geospatial management decisions are driven by the business needs, strategies, goals, and priorities. • This principle fosters a culture where the geospatial environment changes in response to the business needs, rather than having the business change in response to geospatial technology changes. • Decisions based on customer service, the business and the missions of the enterprise have long-term value.
Implication	• Minimize unintended business impacts due to geospatial technology changes. • Build what is needed, not what the authorities may want. • Easier to identify technical impacts when business events change. • Plans need to be flexible with the ability to be modified whenever necessary depending on business priorities. As new needs arise, priorities and plans must be adjusted.

2.2.3 Data/Information Principles

Data architecture principles guide the decision-making process about data and its related technologies through all levels in an organization, because they state an organization's values as well as guide product selection and implementation. For data, architecture principles are key in aligning the portfolio of enterprise data with business needs, form the basis for decisions regarding data, and define the processes for managing data through its life cycle within an enterprise (John Van, 2006).

Geospatial architecture principles define the underlying general rules and guidelines for the use and deployment of all geospatial resources and assets across the organizations. They reflect a level of consensus among the various elements of the enterprise and form the basis for making future geospatial decisions to guide and support architecture design and decision-making. The following are the geospatial architectural principles within the data architectural domain. The data architecture domain includes principles of inclusive, one source, data custodian, data is an asset, data sharing, accessibility, reliability, and quality.

2.2.3.1 Inclusive

Name	Inclusive
Statement	All impacted geospatial stakeholders at the national level must participate in spatial management decisions to successfully meet business objectives.
Motivation	• Geospatial users are the key stakeholders, or customers, in the application of spatial technology to address the business needs. In order to ensure alignment of spatial technology management with the business, all stakeholders must be involved. • Business experts across the enterprise and the technical staff responsible for developing and sustaining the spatial environment need to come together as a team to jointly define the goals and objectives of Spatial Technology. • Knowledge management is essential for growth and survival of all authorities.
Implication	• To operate as a team, every stakeholder, or customer, need to accept responsibility for developing the national spatial environment. • The commitment of resources will be required to implement this principle.

2.2.3.2 Single Data Source

Name	**Single Data Source**
Statement	Each type of spatial data should have only one source. For example, governmental data, citizen data, community data, etc.
Motivation	• Helps to align with the government-wide shared services strategy • Increases Efficiency. If multiple data sources exist, more time is often consumed in reconciling the data. • Encourages entering data only ones, but make use of it in many different systems. Less time is consumed to enter the data as it is entered only in one system. • Cost efficient– (reduction in software licensee, Data management, and support costs). · Enhances data security.
Implication	• Geospatial Data consolidation – if there are multiple data sources, moving to one source requires consolidation. • Geospatial Data cleansing – data consolidation may require additional validation and cleansing.

2.2.3.3 Data has custodian or stewards

Name	**Data has custodian or stewards**
Statement	Data custodian is responsible for ensuring personal, private, or sensitive data will not be disclosed improperly.
Motivation	• Timely access to accurate data is essential to improving the quality and efficiency of enterprise decision-making. • The role of a data steward is critical because obsolete, incorrect, or inconsistent data could be processed and it may adversely affect the decisions made/to be made by the enterprise. • Erroneous data or information may be passed to the customer and affects the reputation of the organization.
Implication	• Defining the role of data stewards who are responsible and accountable for properly managing the quality of the data. • Stewards must have the authority and means to manage the data for which they are accountable and develop processes that: • Prevent erroneous data from being created (i.e. data validation Processes); • Will be followed to correct errors; • Improve those processes that produce erroneous information; • Used to measure and improve the data quality;

2.2.3.4 Geospatial Data is national asset

Name	**Geospatial data is national asset**
Statement	To enable geospatial data sharing at the national level, it needs to be managed at national level. Data is an enterprise asset that has value to an enterprise and needs to be managed effectively and accurately.
Motivation	• Data represents a valuable asset that is a foundation for most decision-making processes. Therefore, it needs to be considered as a national asset and must be managed in a similar manner to any highly valuable national assets. • Improves data sharing capabilities across the organization (or business units). • Reduces costs of acquiring and managing data. • Accurate, timely geospatial data is critical to support informed business decisions.
Implication	• Geospatial data used to support enterprise-wide decision-making will be standardized. • Geospatial data standards and quality must be utilized across the enterprise. • Ensuring geospatial data quality is the responsibility of data owners. • Geospatial data governance and management processes listed below must be developed and approved:

	▪ Processes that prevent erroneous data from being created. ▪ Processes that should be followed to correct errors (when errors occur). ▪ Improving or fixing those processes that produce erroneous data. ▪ Processes that will be used to measure and improve the data quality. • All projects that handle a significant amount of data must have a data management plan and information asset registry that describes the data, its usage, and its security classification.

2.2.3.5 Geospatial data is shared

Name	**Geospatial data is shared**
Statement	Geospatial data must be shared across all users within enterprise functions, business units, and organizations.
Motivation	• The Geospatial Platform enables the sharing of data, services, and applications across the government on a shared infrastructure • Timely access to accurate spatial data is essential to improve the quality and efficiency of enterprise decision-making. • It is less costly to maintain data through the use of a single shared application than the use of multiple silo applications and databases. • Enterprises store and manage the wealth of data, but they are stored in hundreds of incompatible data stores that could cause potential data inconsistency, inaccuracy and security breaches. • The speed at which data is collected, created, transformed, and assimilated is driven by an organization's ability to effectively share the information throughout the organization.
Implication	• Normalized spatial data models, data elements, and metadata that define the shared data must be developed and maintained. • Geospatial technology solutions may necessitate technical copies. Any such technical requirement must have its architecture reviewed to ensure that the copies are replicas of the approved master sources. • A common set of spatial policies, procedures, and standards that govern data access; sharing and management must be developed and followed to regulate data management for both short and long-term needs. • As existing systems get replaced, common data access and developer guidelines must be adopted and implemented to ensure that data from the new application is available in the shared environment. • The data-sharing principle is constantly confronted with the information security principles. Under no circumstances, the data sharing principle should cause confidential data to be compromised. • Education must be provided to personnel to ensure that they understand the policy around data access, sharing, management, and the impact of mishandling data.

2.2.3.6 Geospatial Data is Accessible

Name	**Data is accessible and discoverable**
Statement	• Data must be accessible for all users to perform their respective duties and it must represent a single version of the truth. • Data that are included in the portfolio will be “tagged” as trusted Geospatial Platform assets
Motivation	• The National Geospatial Platform services will help customers discover desired geospatial data, through the platform interface results in timely response to information requests and service delivery. • Wide access helps to enhance data consistency and accuracy. • Spatial data access facilitates an efficient mechanism for users to obtain the information they need.

Implication	• Define the way data is accessed and displayed to meet a wide range of enterprise users and their corresponding methods of access. • The mechanism spatial data is accessed and displayed must be sufficiently adaptable to meet a wide range of users and their corresponding methods of access. • Spatial data access does not necessarily mean granting access privileges to users to modify or disclose information. Accessing information must be granted on a needs basis. • Personnel must be trained to ensure that all members of the enterprise understand the policy related to data access, data modification processes. They also need to understand the value of data and the impact of providing inaccurate data.

2.2.3.7 Geospatial information reliability

Name	**Geospatial information reliability**
Statement	Spatial data and information systems need to be reliable, accurate, relevant and timely.
Motivation	• Reliable services that provide consistent outcomes will help reduce complaints, reviews, and appeals from consumers. • The government needs to provide trusted geospatial information to all ranges of users.
Implication	• Geospatial authorities need to deliver information that consumers can rely upon. • Since process improvement will result in improving the reliability, accuracy, relevancy, and timeliness of the information, processes need to be reviewed at regular intervals and should be improved when and if required. • Allow government offices and other users to shape the information they consume, and ensure innovation occurs in a safe and secure environment for digital services that the national geospatial platform offers. • Geospatial authorities need to devote their effort to data quality, business continuity, and business process improvement to enhance the reliability of data.

2.2.3.8 Spatial Data quality is everybody's business

Name	**Spatial Data quality is everybody's business**
Statement	Spatial data quality is required to make quality decisions that promote business objectives and satisfy stakeholder needs.
Motivation	Having quality spatial data allows making accurate, relevant, timely decisions.
Implication	• Educate stockholders to ensure that they understand the value of decision-making based on quality spatial data. • All geospatial stakeholders must be responsible for creating and managing quality data. • Standards for accessing, presenting, consuming and management of spatial data must be developed and enforced.

2.2.4 Application Principles

To guide and support architecture design and decision-making, a number of application principles are identified. The following are the spatial architectural principles within the application architectural domain to guide the spatial application architecture for Ethiopia.

2.2.4.1 Principles must be applied at all stages

Name	**Principles Must be applied at all stages**
Statement	GEA principles and methods must be applied at all application development stages.
Motivation	To be successful, geospatial enterprise architecture must be integrated with all stages of geospatial initiations at the national level. (I.e. inception, planning, designing, and acquisition).
Implication	• Partnership and efficient communication among business, acquisitions, contract management, and geospatial authorities are required to get the benefits offered by the enterprise architecture. • Geospatial Enterprise Architecture training should not be limited to geospatial professionals only. Procurement team must receive enterprise architecture training. • Geospatial system acquisitions must include requirements based on the geospatial enterprise architecture.

2.2.4.2 Technology Independence

Name	**Technology Independence**
Statement	The geospatial architecture must be technology neutral so that applications developed can operate on a variety of technology platforms.
Motivation	• Independence of applications from the underlying technology allows applications to be developed, upgraded, and operated in the most cost-efficient and timely manner. Otherwise, technology, which is subject to continual obsolescence and vendor dependency, becomes the driver rather than the user requirements themselves. • To encourage an innovation culture in the geospatial industry the geospatial applications need not dependent on specific hardware and operating system.
Implication	• This principle requires the inclusion of cost-effective standards such as open standards. • Application interfaces must be developed to provide the ability to integrate and leverage the capability of existing applications and/or to inter-operate with existing applications and operating environments. • The national geospatial platform with service bus should decouple applications from specific software solutions.

2.2.4.3 Reusability and Simplicity

Name	**Reusability and Simplicity**
Statement	• Don't do everything yourself, the functionality you may need could be provided by an existing service or component. Consider consuming or using existing Interfaces. • The geospatial enterprise architecture must promote the implementation of loosely coupled, reusable, modular components or services. • Systems architecture must be as simple as possible to maintain and meet all business requirements.
Motivation	• Reusable components minimize development efforts, timeline, and cost. • Reusable components leverage investment in existing systems. • Modularization enhances the systems adaptability to different needs because the required changes are either isolated from affected modules.

Implication	• A service catalog needs to be developed and maintained and this needs to clearly communicate all services (i.e. existing, proposed, under development, in operation and tagged for retirement). • To create shared service among stakeholders service oriented geospatial architecture can be adopted, and architecture standards and guidelines must be established to develop system components. • Initially, the systems might require more time to design and develop while considering operations that go beyond the systems' traditional boundaries. This also requires balancing over architecting with flexibility. • Initial costs might be higher, but the integration process will be less expensive. Systems will last longer; therefore, the return will be greater. • Geospatial architects and specialists need to understand existing services so that they can estimate project activities accordingly.

2.2.4.4 Hiding Complexity

Name	**Hiding Complexity**
Statement	The programming model used while developing the geospatial platform should hide their underlying implementation details as well as the complexity of interfacing with existing systems.
Motivation	• Over time, existing systems will change and new ones may be added. It is important to simplify the programming model and insulate applications from changes. • Insulate the internal details of services from consumers to avoid creating dependencies on internal structures and logic that may change. • Handle errors and exceptions where they occur to prevent 'cascading errors syndrome'. • If the system is complex, users will get frustrated and adoption may take a long time or users may opt to fall back to the old systems.
Implication	• It helps users to work in an integrated environment in the way that best suits the business, instead of developing isolated systems for each stakeholder. • Common business interfaces must be designed to realize the simple way of developing and using the platform. • Programming model must be selected which can realize the simplicity of development.

2.2.4.5 Easy to use

Name	**Easy to use**
Statement	The technology used for application development needs to be user-friendly in order to let users focus on their objective rather than taking more time to understand the system.
Motivation	• The underlying technology must be hidden from users, so they can concentrate on tasks. • The more users need to understand the underlying technology, the less productive they will be. • Ease-of-use encourages users to work within the integrated information technology environment instead of developing isolated systems to accomplish the task outside of the enterprise's integrated information environment. • Most knowledge workers will be more productive if the system interfaces are similar. This will promote efficiency, reduce training time, and eliminate the risk of using a system improperly.
Implication	• Applications will be required to have a common "look-and-feel" and support ergonomic requirements. • Hence, the common look-and-feel standard must be designed to be adaptable to the environment it operates, and usability test criteria must be developed. • Guidelines for user interfaces should not be constrained by narrow assumptions about user technology, location, language, and physical

	capability. • Factors such as linguistics, customer physical infirmities (visual, ability to use keyboard/mouse), and proficiency in the use of technology have significant influence in determining the ease-of-use of an application.

2.2.4.6 Service Orientation

Name	**Service Orientation**
Statement	• The architecture is based on a design of services that mirror real-world business activities that comprise the enterprise business processes. • Applications will be built as a collection of services that could be combined to deliver business capabilities.
Motivation	• Service based solution delivers business agility and system adaptability, empowering businesses to quickly adapt to changing business needs. • Service-oriented solutions enable discoverability, reusability, discoverability, loose coupling and autonomy. • Services are standard based and help promote a standard based solution that enhances flexibility and agility boundary-less Information Flow.
Implication	• Service representation utilizes business descriptions to provide context (i.e., business processes, goals, rules, policies, and service interfaces) and implements business capabilities through the use of service orchestration. • Service standards need to be defined and adhered to. • Should use open standards to realize interoperability and transparency. • Strong governance of service representation and implementation is required. • An overlap of functionality can exist within multiple services. This must be managed to prevent unnecessary duplication of services.

2.2.4.7 Adaptability and Flexibility

Name	**Adaptability and flexibility**
Statement	• Adaptability and flexibility reduce complexity and facilitates the introduction of changes in timely and cost-effective manner. • If the geospatial system is flexible such changes in laws, regulations, and business needs can be incorporated in a timely and cost-effective manner. • Applications will be architected to minimize the cost of future changes.
Motivation	• The goal is to avoid dependency failures that can result from highly coupled systems. • Excessive customization increases costs and reduces the adaptability and flexibility of the overall system. • Spatial data may be designated as multi- year or no- year to ensure their availability over time and maximize flexibility • Adhering to this principle has several benefits which include: ▪ Allowing the infrastructure to support changes that occur in business processes. ▪ Rendering the infrastructure more adaptable to geospatial technology changes. ▪ Promotes simpler and faster systems integration. • Introduce flexibility to ensure that no frequently changing component of the system is hard coded.
Implication	• Initially, the systems might require more time to conceive and greater systemic consideration that goes beyond the systems' traditional boundaries. • Initial costs might be higher, but the integration process will be less expensive. • Adaptability and flexibility performance metrics must be established. • The development of applications that are based on components or services must be promoted and facilitated. • Excessively complex configurations of components, undue hardware and software customization based on transient, local, or other conditions must all be avoided.

2.2.4.8 Alignment with business needs

Name	**Alignment with business needs**
Statement	Business needs will be discovered from direct participation of the users of the system and evidence gathered on existing services or systems usage.
Motivation	• Understanding the business and user needs including the functions and features that are regularly used in existing systems helps the prioritization and planning activities when architecting, developing and delivering the new system and also making the necessary changes to the existing ones. • It supports the needs of the business. • Enhances user satisfaction.
Implication	• Assessing user needs and how they utilize existing systems (Existing system could be manual as well). • Analyzing the capabilities of the existing system. • Understanding the drivers and the objectives.

2.2.4.9 Convergence with Enterprise Architecture

Name	**Convergence with enterprise architecture**
Statement	• Convergence with the enterprise architecture must take place as new applications are built, new technologies are implemented, and older systems are updated or decommissioned. • Exceptions might be supported for specific cases if there is a consensus that the benefits of using a solution from a specific technology exceed those arising from the adoption of the enterprise architecture. This needs to be approved by the architecture governance body.
Motivation	Convergence offers several benefits: • It allows the enterprise architecture to evolve and accommodate changes in business and technologies. • Over time, it preserves the investment in Enterprise Architecture while promoting the benefits of the enterprise architecture. • More aligned with the company's investment strategy. • Helps reduce the time required for decommissioning existing system.
Implication	• Deviating from this principle could reduce the benefits of the enterprise architecture. • Exception process needs to be defined to handle exceptions to this principle. It must establish temporary or permanent exceptions, as well as exit strategies for temporary exceptions. • It requires an explicit transition strategy for current systems and processes after the target technology is identified. • Convergence requires sponsorship to replace obsolete technologies when the need arises to replace existing legacy systems.

2.2.4.10 Loose-coupling

Name	**Loose-coupling**
Statement	The geospatial architectural interfaces need to be loosely coupled in order to allow acceptable changes coming through time.
Motivation	Loosely coupled interfaces are preferable because when interfaces between independent applications are tightly coupled, they are less generic and more susceptible to causing unwanted, secondary effects when they are changed.
Implication	• This principle will require the inclusion of cost-effective standards such as open standards. • Loose coupling means that services are conceived with no affinity to a certain type of service consumers. Therefore, services are completely uncoupled from the service consumer. However, the service consumer needs to adhere to the standards the service is adhering to.

2.2.4.11 Adherence to functional domains

Name	**Adherence to functional domains**
Statement	The business rules and functionality are consistent with the mission of the system under consideration. There is complete adherence to the functional domain in which the system is located.
Motivation	• The purpose of this principle is to avoid functional redundancy between systems. • Functional redundancy can cause loss of data integrity, higher maintenance cost, and inconsistent business rules.
Implication	• Systems must be located in proper functional domains, with an explicit definition of the functional domain. • Each new functionality request must be submitted to the respective governance body. • Applications that are already in production with functional redundancy should be replaced entirely or partially in a timely manner or progressively in a manner that is cost-effective to the corporation.

2.2.5 Security Architecture Principles

Security is the quality or state of being secure- to be free from danger. In other words, protection against adversaries-from those who would do harm, intentionally or otherwise-is the objective. The history of information security begins with the history of computer security. The need to secure physical locations, hardware and software from outside threats arose during World War II. The growing need to maintain national security eventually need more complex and more technologically sophisticated computer security safeguards. This time, the Internet brings millions of unsecured computer networks into continuous communication with each other. The security of each computer's stored information is now contingent on the level of security of every other computer to which it is connected (Thomas, et al, 2005). The philosophies adopted in this study paper while defining the security architecture principles are: Security is the aspect of everything; the easy way of doing things should also be the secure way of doing things; security mechanisms should be appropriate, minimal and invisible to users; security choices should be based on business need, and risk and return on security investment.

Successful organizations should have multiple layer security in place to protect their operations. Information security is defined as the protection of information and its critical elements, including the systems and hardware that use, store, and transmit that information. Information security includes management of information security, network security, policy, and computer and data security (Steve G. Watkins, 2008). Hence the security architecture principles should include privacy, user management, confidentiality, risk assessment, auditing throughout the enterprise under consideration. Confidentiality is there when disclosure or exposure to unauthorized individuals or systems is prevented. Confidentiality ensures that only those with the rights and privileges to access information are able to do so. Risk management helps to identify, classify, and prioritize enterprise information assets (Charles A. Sennewald, 2003). Once the enterprise level assets are identified, a threat assessment process is undertaken to identify and quantify risks facing each asset and risk control strategy is defined to control each risk.

The following are spatial architectural principles within the security architectural principles domain to guide the design of secure spatial architecture.

2.2.5.1 Enterprise-wide

Name	**Enterprise-wide**
Statement	Geospatial enterprise architecture and solutions should enable enterprise-wide security (not only at the system or departmental level).
Motivation	• A common security solution for the entire enterprise results in cost-effective and consistent solution. • Technical management and support costs are better controlled when support needs are companywide instead of supporting silo solutions. • Required changes could be introduced more efficiently compared to implementing changes to multiple silo security solutions.
Implication	• Policies, standards, and procedures that regulate the acquisition of technology or contracting with new suppliers must be directly bound to this principle. • Procedures to increase the set of acceptable technologies to meet business needs must be developed and implemented. • The selection of suppliers must be a strategic decision, always considering other types of services that could be provided by the same supplier, the stability of the supplier and the experience of the supplier in providing security solutions.

2.2.5.2 Privacy

Name	**Privacy**
Statement	There should be business and technology processes that support corporate privacy requirements and define how individual (employees and customers) privacy is managed in a secure manner. It also needs to outline when, how, and to what extent information about them is communicated to others.
Motivation	• Legislative requirements are increasingly requiring corporations to formally address privacy issues. • The Privacy Policy prescribes management's direction to guide an organization in meeting their corporation's privacy objectives according to its business needs and privacy laws. • The privacy policy needs to clearly demonstrate management's commitment to an enterprise privacy program and define privacy responsibilities within the organization. • Lack of a comprehensive privacy policy is likely to expose an organization to possible legal suit as well as consumer objection.
Implication	• Need to create a privacy program that defines business and technology processes that support privacy requirements and obligations. • Need to train spatial system architects, security architects, and information architects.

2.2.5.3 User Management

Name	**User Management**
Statement	All geospatial systems must have defined processes for requesting, issuing, and closing user accounts.
Motivation	• Ensures access could only be provided for those who are authorized. • Enhances the security of the overall system. • Security policies will be applied consistently across the enterprise.
Implication	• Define processes for user access management and ensure the processes are enforced, requires being tied to HR management system and process to ensure that whenever a user is terminated access revocation notice is sent automatically. • Training to support and HR staff.

2.2.5.4 Confidentiality

Name	**Confidentiality**
Statement	The confidentiality of geospatial users and sensitive data must be maintained.
Motivation	• Prevent unwanted access to geospatial information. • Helps enforce government and corporate privacy policy and standards. • People with appropriate and correct privileges should solely view information.
Implication	• Understand the confidentiality laws, regulations, information classification requirements and policies. • Understand contractual obligations and protect the value of the information assets accordingly. • Data encryption requirements must be understood and appropriate processes and policies must be defined and suitable encryption technology must be selected and implemented. • Employee training may be required. Each employee needs to be aware of his responsibilities in maintaining the confidentiality of the information delegated to him to perform his/her duties.

2.2.5.5 Regular Risk Assessment

Name	**Regular risk assessment**
Statement	The security risks for each system should be assessed based on the value of the asset and transactions being protected, the threats, and the impact of the threats and the likelihood of occurrence.
Motivation	• Protect against loss of, or damage to financial, personal and physical assets, due to threats, such as: ▪ Impersonation. ▪ Disclosure (e.g. theft of data, passive wiretapping). ▪ Modification of data (e.g. file corruption, active wiretapping caused by (e.g. virus, worm Trojan horse, logic bomb). ▪ Denial of Service.
Implication	• Need to maintain a current inventory of business-critical information assets. • Need to have a standard risk assessment method and processes as part of the business processes that support application development, management, and support. Such an assessment will provide a good understanding of the security risks, both threats, and vulnerabilities to organization assets. Normally assessments and timeline to conduct the assessment are based on the value and importance of the assets.

2.2.5.6 Information Security

Name	**Information Security**
Statement	All information must be protected from unauthorized use and disclosure.
Motivation	• Enterprise information will be secure from unauthorized access, modification, or destruction. Hacking, viruses and inadvertent or unauthorized alteration, sabotage, disaster, or disclosure. • Existing laws and regulations require the safeguarding of citizens and the privacy of data while permitting free and open access. • Open information sharing or access and the release of information due to relevant legislation must be balanced against the need to restrict proprietary and sensitive information. • Secure systems ensure the business continuity. • Temporary information (ongoing projects for which disclosure is still not defined or authorized) must be protected to prevent unjustified speculation, misinterpretations, and improper use. • Systems and data must be secured using security best practices and conducting security assessments on a regular basis. • Every piece of information must be submitted to a security assessment based on integrity, availability, confidentiality, and authenticity requirements.

Implication	• Results in loss of trust if not done correctly. • Must identify, publish, and keep applicable policies current. • In order to adequately provide access to information while maintaining secure information, security needs must be identified and developed at the data level, not at an application level. • Security must be designed into the system from the beginning. Adding it later is expensive, time-consuming and may result exposing the system prior to implementing the security capability. • It is extremely costly to repair systems that have been compromised. • Information must be safeguarded against inadvertent or unauthorized alteration, sabotage, disaster, or disclosure. • Security must be an enabler and it should not impede business. • Sensitivity levels must be established for accessing temporary, confidential, or proprietary information.

2.2.5.7 Auditing and logging

Name	**Auditing and logging**
Statement	All significant user and system actions should leave an audit trail.
Motivation	Facilitates auditing by any external bodies such as regulatory bodies.
Implication	Security traceability includes proper inception and application of the information, security auditing system and monitoring tools as well as processes.

2.2.6 Technology Principles

Technology Architecture defines baseline and target views of the technology portfolio, detailing the roadmap towards the target architecture, and to identify key work packages in the roadmap. Technology Architecture completes the set of architectural information and therefore supports cost assessment for particular migration scenarios. The following are the spatial architectural principles within the technology architectural domain to guide the design and development of spatial technological architecture.

2.2.6.1 Changes must be driven by Business

Name	**Changes must be driven by business needs, not by technology**
Statement	Changes must be driven by business needs not a technology advancement
Motivation	• Foster an environment where changes are made in response to the needs of the business, rather than having the business change in response to IT changes. • Unintended effects on business due to IT changes will be minimized. • A change in technology may provide an opportunity to improve the business process. This circumstance is considered as changes are driven by business changes, although technology change was the catalyst to initiate business changes. • Involuntary effects on businesses resulting from IT changes are mitigated.
Implication	• Business need-based changes must be documented, evaluated, reviewed and approved. Their impacts also need to be accessed to understand and confirm any other changes that may be required (I.e. changes to business process). • Change management processes conforming to this principle may need to be developed and implemented or if it already exists, it needs to be reviewed to ensure its validity. • A business need must be evaluated to ensure alignment with other enterprise architecture principles.

2.2.6.2 Available anytime from anywhere

Name	**Available anytime from anywhere**
Statement	Access must be available to those entitled regardless of where they are or the device they are using.
Motivation	• Leads to a very responsive solution that will allow: ▪ Staff to obtain or update information on-demand. ▪ Deliver information where and when needed, via multiple channels (devices), to maximize its value as an asset, while ensuring information security and privacy. ▪ Increase customer satisfaction.
Implication	• Availability of support staff to provide the required support at any time. • Validating the robustness of the solution to ensure a high level of availability. • All applications may need to publish their availability targets that have been agreed upon with the business.

2.2.6.3 Responsive

Name	**Responsive**
Statement	Changes to the enterprise information environment are implemented in a timely manner.
Motivation	Enterprise information technology environment must be responsive to clients' needs.
Implication	• Develop processes that support managing and implementing changes in a timely manner to address immediate business needs. • Architecture artifacts must be updated to reflect current states and incorporate the approved changes. • This principle may conflict with other principles (e.g., maximum enterprise-wide benefit, enterprise-wide applications, etc.), check and balance must be applied when implementing this principle.

2.2.6.4 Continuity of services

Name	**Continuity of services**
Statement	Enterprise activities must be performed despite system interruptions. Especially enterprise-critical systems (e.g. Corporate back-office activities, intranet, internet, email, etc.) must be available regardless of interruptions.
Motivation	• Given that the world is moving towards digital services, dependency on information technology has increased tremendously and the credibility of organizations relays upon perceived 24x7 operations. Therefore, it is critical to ensure that businesses are able to continue conducting their normal activities regardless of external events that may affect normal operation such as hardware failures, natural disaster, political issues, and lack of data integrity. • Business activities must be able to employ alternative mechanisms to convey reliable service regardless of external events such as natural disaster, Internet interruptions. Data corruption, hardware failure.
Implication	• Dependence on digital service implies: ▪ Designing, developing and managing robust architecture that supports the continuous availability of mission-critical systems. ▪ Assessing and documenting each mission-critical applications and impact on the company's mission to determine the continuity level required and the corresponding recovery plan. ▪ Periodic revisions, vulnerability and exposure tests and other tests that will help ensure the system operates as expects if and when the primary service is interrupted. ▪ The need to approach recoverability, redundancy, and maintenance at inception. ▪ Anticipated and managed business interruption risks in advance.

2.2.6.5 Rationalization

Name	**Rationalization**
Statement	Rationalization minimizes redundancy and reduces duplication.
Motivation	• Rationalization helps reduce complexity and promotes greater efficiency. • Cost effective way of operation through the rationalization of technology. • Rationalization ensures maximum operational capability and flexibility by redistributing and virtualization.
Implication	Developing Processes and strategies that promote periodic evaluation of existing systems and Rationalization.

2.2.6.6 Control Technical Diversity

Name	**Control Technical Diversity**
Statement	Technical diversity needs to be controlled to minimize the cost of training, implementation, maintenance, and support and also reduce architecture complexity.
Motivation	• Common technology across the enterprise brings the benefits of economies of scale. • The substantial cost of infrastructure required supporting several technologies. • Limiting the number of supported technology components will simplify maintainability, supportability and reduce costs. • A smaller number of suppliers and software packages represent a greater ease and lower integration costs. • Business advantages of minimum technical diversity include: ▪ Standard component packaging; ▪ Predictable implementation impacts; ▪ Greater flexibility to accommodate technological advancement; ▪ Help contain the cost required to support diverse technologies and maintain connectivity between several different technologies; ▪ Simplifies maintainability.
Implication	• The target architecture, as well as existing assets, must be consulted in conjunction with the organization's investment management process and technology investment plans. Relying on the target architecture as an integral component of Information Technology decision-making helps control the introduction of incompatible technologies. • Policies, standards, and procedures that govern the acquisition of technology must be tied directly to this principle. • Technology choices will be constrained by the choices available within the technology blueprint or architecture. This should not be interpreted as "the need to freeze a defined set of technology baseline". Technology advances must be welcomed when it provides an improvement in operational efficiency and delivery of the business needs and does not result in compatibility related issues with existing systems.

2.2.6.7 Interoperability

Name	**Interoperability**
Statement	• Enterprise Assets where possible must leverage established standards that promote data, application, and technology interoperability. • Maximize interoperability by using common standards and mechanisms for the exposure and use of services. • Enable systems and services to communicate and work together for greater synergy and efficiency.
Motivation	• Standards help ensure consistency, thus improving the ability to manage systems and improve client satisfaction; protect existing IT investment, thus maximizing return on investment. • Standards for interoperability facilitate application and data integration.

Implication	• Interoperability must facilitate information sharing and exchange. • A process for setting standards, reviewing and revising them periodically, and granting exceptions must be established. • Interoperable, open standards need to be followed unless there is a compelling business reason to implement a non-standard solution. • Existing custom built application interfaces must be understood and wrapped to enhance their ability to be reused.

2.2.6.8 Based on Open Standard

Name	**Based on Open Standard**
Statement	• Open standards must be used in all solution designs to enable interoperability. • When selecting technology solutions, open source software must be compared and considered alongside commercial software.
Motivation	Closed proprietary standards restrict reuse, reduce interoperability and expose you to vendor locked-in solution that may result in unforeseen financial costs.
Implication	Capital costs must be taken into consideration during procurement decisions and best value for money analysis must be conducted to determine best alternatives between open source and proprietary solutions. The comparison should not be limited to cost only. Selection criteria should include other parameters such as supportability and availability of experienced resources.

2.2.6.9 Operational Efficiency

Name	**Operational Efficiency**
Statement	Real-time monitoring promotes proactively resolving failures and incidents with minimal cost and disruption to the business.
Motivation	Helps identify security breaches and other security-related issues in a timely manner. · Minimizes system outages maximize customer satisfaction.
Implication	• Monitoring and management tools need to be acquired and implemented. The tools need to cover all IT monitoring and management aspects (network, infrastructure, Information, application, and security). • Operations team needs to be trained utilizing the monitoring and management tools. • Processes and policies need to be developed. • SLA standards need to be defined.

3. Conclusions and Recommendations

This study paper contains a comprehensive list of geospatial enterprise architecture principles for Ethiopia. In order to develop an enterprise architecture for geospatial in Ethiopia, there should be a principle that guides as a rule and guideline that the enterprise architecture need to comply. The geospatial enterprise architecture principles defined in this study paper should be considered when making any decision regarding the use, selection, evolution, and integration of all geospatial systems and assets at the national level.

Though the study work tries to address exhaustively the required architectural principles there might be business specific principles for specific business needs depending on the federal and regional authorities geospatial roles and responsibilities. Therefore, it should not be limited by the principles listed in this study document, rather it is important to explore and validate if there are industry-specific principles that may be required for specific customer and discuss the findings with the governing body defined in the national spatial information technology policy before they are implemented.

Based on the study the following recommendations for further research has been given. First, in the near future, similar research works could be done to develop hi-tech related enterprise architecture principles for Ethiopia. Second, based on the principles defined in this study work national geospatial enterprise architecture can be done. And, last but not least, as the study only focuses on Ethiopian context, further study works can be done for other developing countries in Africa.

4. Acknowledgments

I would like to thank my colleagues Robel Tesfaye, and Dereje for their valuable technical contribution in the development of this paper. I would also like to thank all my kids and my wife Halal, as it would have been a lonely and difficult journey to achieve this without them.

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