Ingeniería Industrial/ISSN 1815-5936/Vol. XLVI/2025

ARTÍCULO ORIGINAL
INFORMÁTICA EMPRESARIAL

Framework for the design and implementation of government information systems

Marco de trabajo para el diseño e implementación de sistemas de información de gobierno

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ABSTRACT
Public administrations must stimulate citizen participation in decision-making by ensuring more accountable, transparent, and effective governance. To achieve this, they must manage agile, interoperable, efficient, transparent, accessible, and flexible information systems supported by information and communication technologies. The objective of this article was to design a work framework for the governmental sector using an enterprise architecture approach, taking into account the particularities of the public context. The research employed scientific methods and tools including analysis and synthesis, induction and deduction, observation, interviews, surveys, expert methods, checklists, and document review. The main result is a theoretical proposal of a framework consisting of a metamodel that shows the elements and relationships to be designed, and a procedure describing the stages and activities for its implementation.
Keywords: government information system; enterprise architecture; framework; metamodel; procedure.

RESUMEN
Las administraciones públicas deben estimular la participación ciudadana en el proceso de toma de decisiones haciendo que el gobierno sea más responsable, trasparente y eficaz. Para esto se deben gestionar sistemas de información ágiles, interoperables, eficientes, transparentes, accesibles y flexibles, los que deben soportarse en las tecnologías de la información y las comunicaciones. El objetivo del artículo fue diseñar un marco de trabajo para el para el sector gubernamental con enfoque de arquitectura empresarial tomando en cuenta las particularidades del contexto público. Para desarrollar la investigación se

utilizaron entre otros los métodos científicos y herramientas: análisis y síntesis, inducción, deducción, observación, entrevistas, encuestas, métodos de expertos, listas de chequeo, revisión documental. Como principal resultado se obtiene la propuesta teórica de un marco de trabajo constitutivo de un metamodelo que muestra los elementos y relaciones a diseñar y un procedimiento que describe las etapas y actividades para su implementación.
Palabras clave: sistema de información de gobierno; arquitectura empresarial; marco de trabajo; metamodelo; procedimiento.

Recibido: 29/09/25
Aprobado: 01/10/25

Introduction

Every information system originates from an organization's need for information to support the implementation of a specific set of decisions [1]. An information system is a set of interrelated elements that, among its main components, includes people, information, software, hardware, and processes, with the purpose of supporting decision-making within an organization. Such a system is effective when it provides the necessary information to the organization at the right moment, and efficient when it does so use the least possible technological, human, temporal, and economic resources. This is particularly relevant in the case of Information and Communication Technologies (ICT), which experience significant global use and expansion every day [2].

Current trends in governmental management consider citizen participation in the decision-making process as one of their guiding principles. To achieve this, public organizations must design and implement information systems that are accountable, transparent, and effective. This cannot be accomplished without the use of ICT as a tool for improving governance through enhanced information delivery and improved services provided by public entities to citizens [3]. In this context, Enterprise Architecture (EA) emerges as the framework that enables organizations to meet these demands by providing a roadmap for integrating emerging technologies, aligning IT investments with strategic business objectives, and ensuring that complex information systems evolve in a controlled and efficient manner [4]. It mitigates the negative effects associated with growing IT complexity by offering a structured approach to planning, investment decisions, and the continuous development of information systems [5], and it functions as a strategic mechanism linking technological innovation to the organizational mission, guiding investment and ensuring the sustainability of digital transformation initiatives [6].

The first author to conceptualize enterprise architecture was Zachman [7], who defined it as a framework for information systems architecture. However, the concept has evolved over time, focusing primarily on the alignment between business and IT rather than on a purely technical design of information systems. For this reason, EA models tend to emphasize the interrelationship between an organization's business and IT elements [8].

Although enterprise architecture encompasses the overall structure of an organization, it proposes the division into layers or dimensions as a means of grouping its main elements. While studies differ in how these dimensions are classified, many concur that the four fundamental dimensions are: Business, Information, Applications, and Technological Infrastructure [9,10,11,12].

Given that enterprise architecture is a highly complex process that covers all parts of an organization and requires individuals with different competencies, it is not feasible without predefined patterns and a coherent structure [13]. It is typically implemented with the support of various frameworks, modeling notations, and tools, which differ significantly across organizations and contexts [14]. An enterprise architecture framework is a multidimensional classification scheme that functions as a conceptual structure. These frameworks provide transparency in the development of the complex relationships manifested among business and architectural artifacts, supporting the planning of future scenarios. By providing a space for addressing generic problems, they foster a deliberately abstract and unambiguous conceptualization of the organizational domains. A framework is a horizontal component useful for architectural practice, capable of aligning different resources—including technology—across the current and future organization [15]. It can be understood as a set of principles established within an organization to articulate all the components involved in achieving its objectives [16] within a specific application domain or stakeholder community [17].

The literature includes comparative theoretical studies of various enterprise architecture frameworks [18,19,20,21,22,23]. These comparisons are based on the authors' identification of aspects or requirements they consider significant in the constitution of a framework; however, they do not analyze the specific characteristics of the organization where the framework will be implemented.

From the theoretical conception of enterprise architecture, it is recognized as a strategic tool for information systems management, structuring the organization into interrelated and synergistic dimensions. In this sense, frameworks constitute a superior methodological support that guides organizations in implementing these approaches by defining phases, activities, and technologies that facilitate systematic application. However, the application of EA in the governmental sector faces challenges due to its lack of consideration of certain public-sector particularities, such as transparency, accountability, and citizen participation.

Methods

To design the proposed framework, a systematic review was conducted to identify relevant elements for the development of government information systems. Bibliographic search criteria were established based on the following: databases (Scopus, Web of Science (WoS), and SciELO), time period (2003–2024), and the use of keywords related to the research topic. Likewise, inclusion and exclusion criteria were defined, primarily associated with the relevance of the references and the presence or absence of explicit methodological components.

Based on these criteria, 24 references were selected, covering maturity models [24,25,26,27,28,29,30], enterprise architecture frameworks [31,32,33,34,35,36,37,38,39], an international standard [40], and scholarly articles related to enterprise architecture [41,42,43,44,45,46,47]. Table 1 summarizes the publications analyzed.

Table 1 - Reviewed bibliography for the identification of elements.

Reviewed Bibliography	Name	Published by
Maturity Models (7)	EAMM	NASCIO
	EAMMF	U.S. GAO
	ACMM	U.S.DoC
	EAFF	U.S OMB
	E2AMM	IFEAD
	SAMM	Luftman
	GEAF	Gartner
Frameworks (9)	Zachman	Zachman
	TAFIM	U.S. DoD
	GERAM	IFIP-IFAC
	TOGAF	The Open Group
	Gartner	Gartner
	DoDAF	U.S. DoD
	FEA	U.S. DG
	TEAF	U.S. DoT
	EAMPC	Sebis
Standard (1)	ISO 42010: 2022	ISO/IEC/IEEE
Articles (7)	(Zelaya et al, 2018) (Oscar, 2011) (Arango, Londoño, Zapata, 2010) (Yu, Strohmaier, Deng, 2006) (Svyatoslav, 2017) (Sousa, et al, 2007) (Hernández, 2008)	

As shown in table 1, seven maturity models, nine frameworks, one international standard, and seven articles—two applied and five theoretical—were reviewed. These sources were considered the initial conceptual basis for identifying the elements and modes of operation of Enterprise Architecture (EA).

The framework was designed through an iterative process comprising five stages:

Stage 1. Definition of elements: Elements were identified and selected through a review and analysis of the literature. The elements were extracted, coded, and categorized within the four enterprise architecture dimensions, applying criteria such as frequency of appearance, relevance to the governmental sector, and feasibility of use.

Stage 2. Definition of principles and premises: The conceptual foundations of the framework were established: (1) Principles and (2) Premises, which constitute mandatory preconditions for applying the framework.

Stage 3. Framework design: All elements were integrated into a coherent structure showing their interrelations. The general architecture of the framework was defined, including its main phases, and the correspondence

with the TOGAF ADM was established to provide methodological grounding for the proposed approach.

Stage 4. Metamodel design: A graphical representation was constructed to illustrate the relationships and interdependencies among the elements within each dimension. Variants were defined according to organizational strategy, as well as the symbols and visualization rules to be used.

Stage 5. Design of the framework implementation procedure: A step-by-step guide was developed describing how to apply the framework, organized into phases and activities. It specifies the tools to be used, the inputs and outputs of each activity, the roles involved, and the iterative sequence of execution.

Results

Stage 1. Definition of elements

Based on the references used as the foundation, a total of 31 EA elements were identified, analyzed, and integrated into the four dimensions of enterprise architecture, as shown in figure 1.

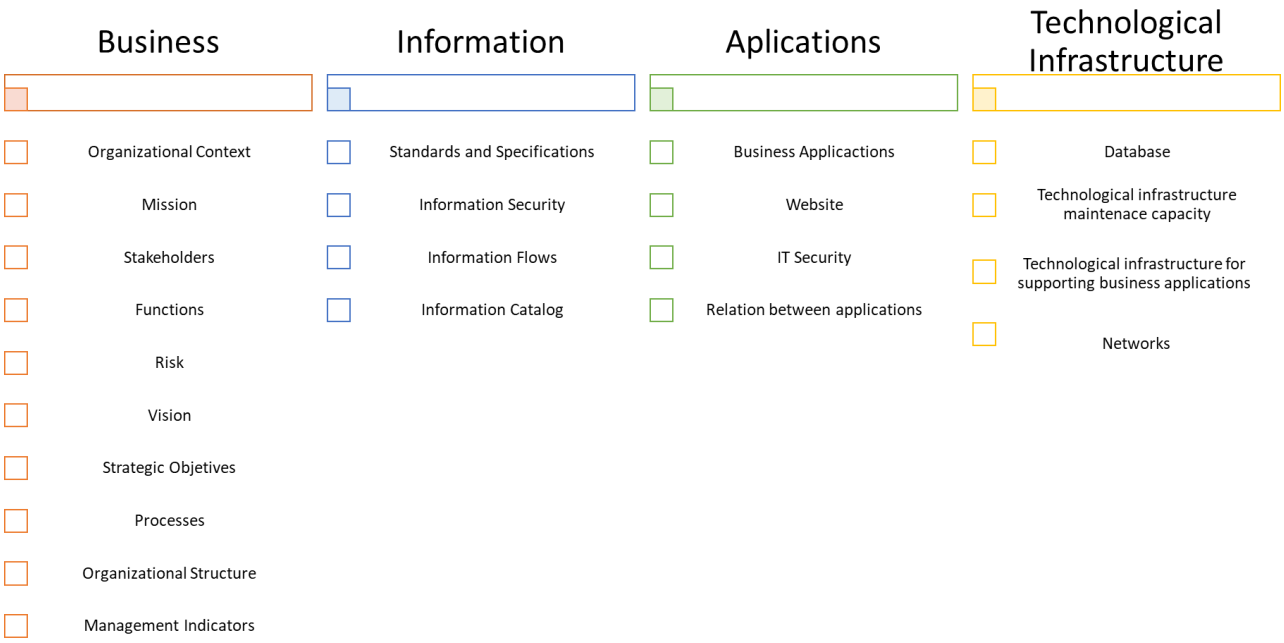

Fig. 1 - EA elements by architectural dimensions
Source: Author's elaboration

In the Business dimension, thirteen elements were identified, although three of them were excluded: (1) *Functions*, which were integrated into the element *Organizational Structure*; and (2) *Risk* and (3) *Management Indicators*, both already encompassed within *Business Processes*. In the Information, Applications, and Technological Infrastructure dimensions, four elements were identified in each case, all of which were included in the proposal. In the Applications dimension, it is worth noting that the element *website* appeared only once in the literature review; however, it was retained due to its relevance as a communication interface with citizens and other stakeholders.

For technology implementation, four principles were defined as the conceptual foundation that enables technological development, along with three premises that must be verified before any application. These principles and premises are outlined below.

Stage 2: Definition of principles and premises

The implementation of the technology requires consideration of four guiding principles that support its development, and three premises that must be met prior to execution.

Principles:

1. **Quality of Services:** Strengthening citizen–state relations by meeting service requirements and expectations, supported by a restructured information system.
2. **Business–ICT Alignment:** The framework facilitates organizational management and decision-making through the use of information and communication technologies.
3. **Interoperability:** The framework promotes interaction among applications for data and information management, enabling effective decision-making.
4. **Continuous Improvement:** The iterative procedure of the framework allows the organization to act on its own results, fostering continuous improvement.

The assessment of these principles is carried out throughout the theoretical foundations of the framework and its constituent elements.

Premises:

- **Commitment from Top Management:** Leadership must be informed and supportive of the changes derived from implementing Enterprise Architecture (EA).
- **Qualified Personnel:** Availability and involvement of trained staff to execute the EA processes.
- **Resource Availability:** Ensuring the organization has the essential resources required to implement EA.

All premises must be met; if any are not fulfilled, the proposed framework should not be applied.

Stage 3: Framework for the design and implementation of a government information system based on Enterprise Architecture

The aim of this framework is to deploy the information system of a governmental entity using Enterprise Architecture as the primary methodological tool. The framework map is shown in figure 2.

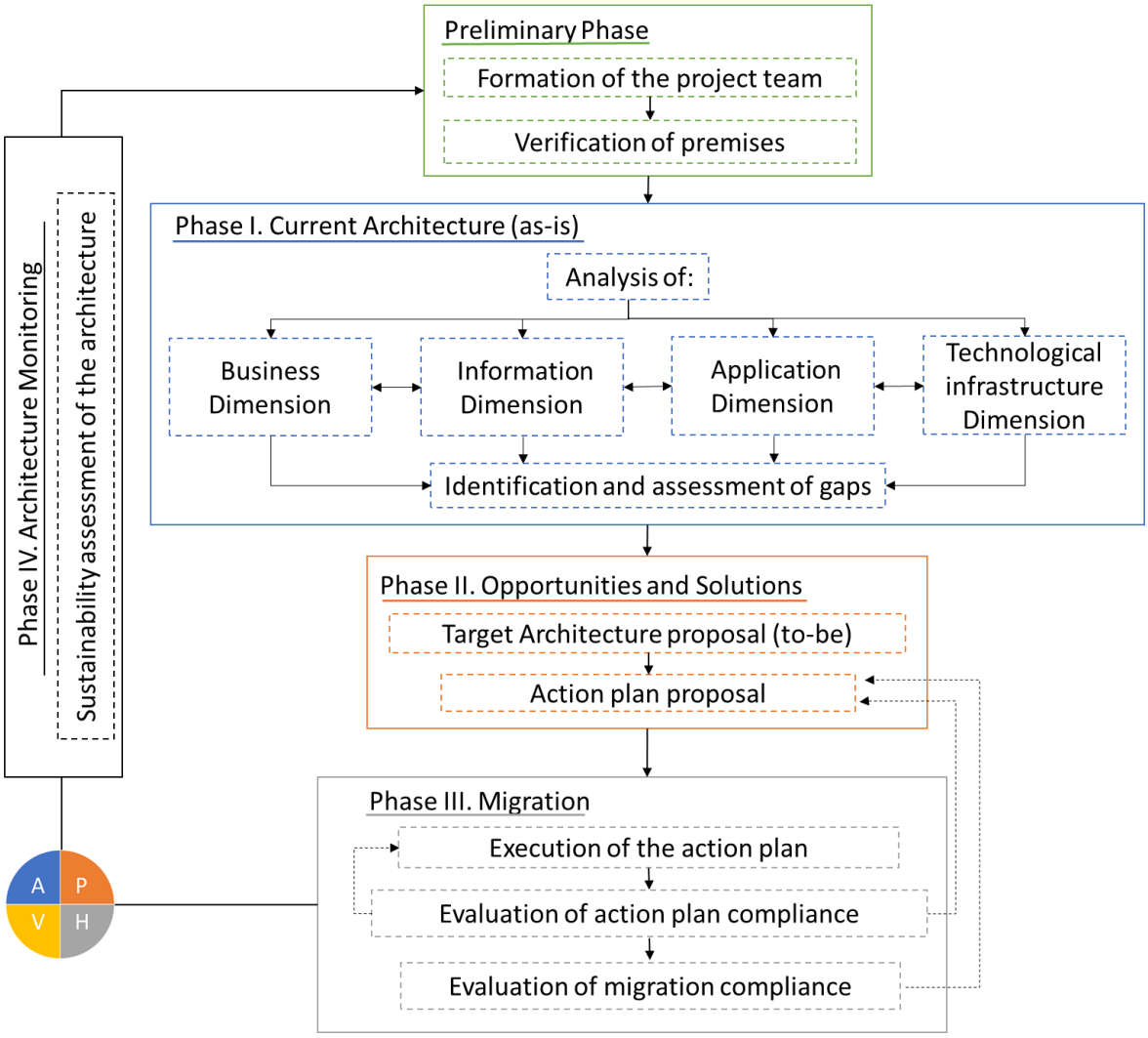

Fig. 2 - Framework for the design and implementation of a government information system using an enterprise architecture approach.
Source: Author's elaboration

The Preliminary Phase includes two activities: verifying the premises of the framework and forming the team responsible for guiding the transition from the current state to the target state.
Phase I comprises five activities focused on diagnosing the organization across the four dimensions of enterprise architecture, followed by the identification and analysis of the resulting gaps. In Phase II, an action plan is formulated to guide the migration from the current to the target architecture. These actions are executed and their compliance assessed in Phase III. Finally, Phase IV ensures continuous monitoring and improvement of the architecture, determining when adjustments are required.

Stage 4: Metamodel of the Framework

The metamodel represents a significant methodological contribution that addresses the limitations found in existing frameworks. Following the tradition of frameworks such as TOGAF, which use metamodels to represent

architectural relationships, it illustrates the connections among the elements to be developed or assessed within each architectural dimension, based on the four dimensions, as shown in figure 3.

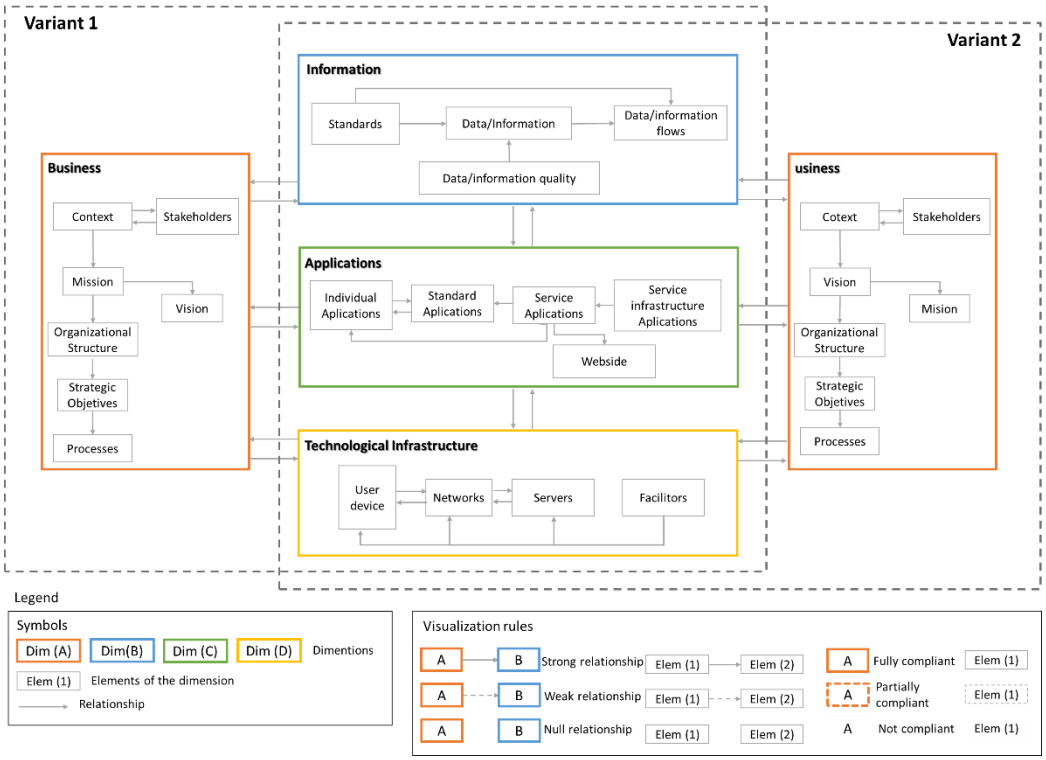

Fig. 3 - Metamodel of the framework
Source: Author's elaboration

The schema illustrates how these dimensions are organized in a hierarchical and synergistic manner: the infrastructure supports the applications, the applications manage the information, and the information in turn supports the business processes. This structure facilitates traceability between strategic decisions and technological resources.

The relationships among dimensions are bidirectional, reflecting both functional dependency and feedback between the different levels of the system. However, the completeness of each dimension may vary depending on the organization's level of enterprise architecture maturity or development. In more advanced cases, the model can reach full integration, demonstrating a consolidated architecture in which each dimension and their interrelations are fully articulated.

Thus, the metamodel functions not only as a reference framework for describing the structural components of EA, but also as a diagnostic and planning tool that enables the identification of gaps across dimensions, the prioritization of technological investments, and guidance for the organization's progression toward a more mature, coherent, and sustainable enterprise architecture.

Stage 5: Procedure for applying the framework for the design and implementation of a government information system based on an enterprise architecture approach

This procedure, conceived as an operational guide, outlines the stages, activities, and tools required for implementation. It ensures a systematic, reproducible process aligned with the organization's management objectives and supports the application of the concepts previously developed.

Preliminary Phase
Objectives: Establish the project team and verify the premises.
Activity 1: Formation of the project team.
The project team may be configured using two possible actor variants. These variants are shown in figure 4.

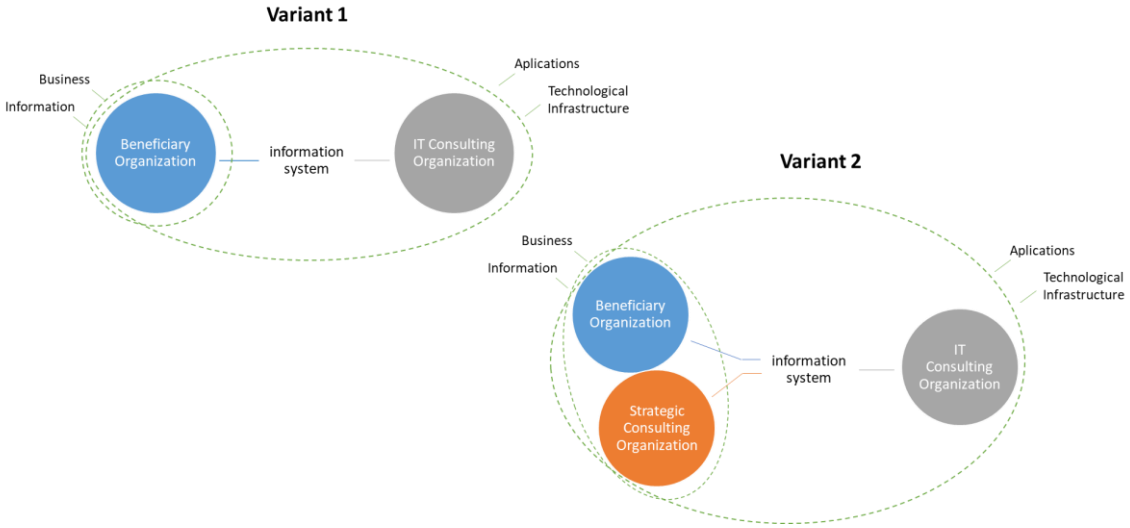

Fig. 4 - Variants in framework Stakeholders
Source: Author's elaboration based on Pavón (2019)

The first variant includes the Beneficiary Organization and the IT Consulting Organization, while the second variant also incorporates the Strategic Consulting Organization. It is recommended that the working team consist of 4 to 10 members.
Note: Any expert-selection method may be used to form the working group. A single individual may perform multiple roles, and a single role may be fulfilled by several individuals.
Activity 2: Verification of premises. Before beginning the implementation of the procedure, the team evaluates whether all premises are met. These premises are mandatory for applying the proposed framework.

Phase I - Current Architecture (As-Is)
Objective: Analyze the gaps between the current and target architecture.
Activity 3: Business dimension analysis.

This includes evaluating the organizational context (external: legal–political, technological, competitive/market, cultural–social, economic; internal: values, culture, knowledge, performance), stakeholders, mission, vision, organizational structure, strategic objectives, and business processes.

Activity 4: Information dimension analysis.

This includes reviewing norms and specifications, the data/information catalog (names, formats, content), information flows, and data quality.

Activity 5: Application dimension analysis.

This involves evaluating business support applications/software (types, interconnections, manuals) and the institutional website.

Activity 6: Technological Infrastructure analysis.

This includes assessing existing equipment that supports business applications (end-user devices, servers, networks, and enabling components).

Activity 7: Identification and assessment of architectural gaps.

Based on Activities 3-6, the team identifies gaps and opportunities for improvement in the current information system.

Phase II - Opportunities and Solutions

Objective: Define the target architecture and the actions needed to address the deficiencies identified in Phase I.

Activity 8: Design of the target architecture (to-be).

Using the analysis of deficiencies and improvement opportunities, the team determines which issues should be addressed and proposes the desired architecture. Indicators may be defined to later verify compliance.

Activity 9: Development of the action plan for managerial approval.

The team prepares the action plan and submits it to the entity's Executive Council for approval.

Phase III - Migration

Objective: Implement and monitor the actions defined in the action plan and evaluate migration outcomes.

Activity 10: Coordinated implementation of the action plan.

All activities defined in the plan must be executed in the proposed order, ensuring coordination across dimensions.

Activity 11: Monitoring progress and making necessary adjustments.

Progress on the plan is evaluated. If actions are incomplete or deficiencies arise, the team determines whether the issues stem from implementation or from the plan itself, and adjusts accordingly.

Activity 12: Verification of migration compliance.

The team assesses whether the migration has been successfully completed. If not, a new action plan must be designed.

Phase IV – Architecture Monitoring

Objective: Assess sustainability and identify improvements to be introduced into the architecture.

Activity 13: Monitoring indicators and managing organizational change.

The team analyzes the performance of the indicators defined in the to-be architecture. This analysis determines which activities or phases of the framework must be revisited to achieve improvement.
Two types of change may occur:

- Contextual or organizational changes: Top-down; focused on improving or creating new capabilities.
- Technological changes: Bottom-up; aimed at correcting or improving operational or maintenance capabilities.

The procedure follows an iterative approach that supports continuous improvement, allowing the organization to cycle between the current and the desired architecture in each iteration.

Discussion

The proposed framework is grounded in the methodological principles of TOGAF's Architecture Development Method (ADM), widely regarded as the *de facto* standard for enterprise architecture development. TOGAF was selected as the methodological foundation for three main reasons: first, its international recognition as the most widely adopted reference framework among public and private organizations; second, its structured approach that covers the entire architectural development lifecycle; and third, its flexibility to adapt to different organizational contexts [10, 11, 48].
TOGAF was originally created for the private sector, where the primary objective is profitability and market competitiveness. When applied to the public sector, several of its concepts must be reinterpreted: "clients" become citizens with rights, goals must balance efficiency with equity and universal access, and investment decisions must comply with far more stringent procurement regulations. This necessary adaptation introduces a level of complexity not considered in the original model and may generate tensions between TOGAF's business-oriented logic and the principles of public administration.
Among the major government reference frameworks worldwide—DoDAF, TEAF, and FEA—all offer solid structures for public-sector management, although each was designed for the administrative, legal, technological, and budgetary environment of the United States. DoDAF, developed for the Department of Defense, defines more than 50 architectural products organized into eight views, with a strong emphasis on military operational capabilities, critical-system interoperability, and the stringent security requirements of the defense domain. While indispensable in that context, such features are unnecessarily complex for civilian administrative systems. TEAF, created by the Department of the Treasury, focuses on financial management, treasury, and tax collection systems, rigorously incorporating audit controls, financial compliance, and internal control mechanisms, but with a scope limited to that specific governmental function. FEA, conceived as an integrated framework for the entire federal government, operates under assumptions of high technological maturity and substantial IT budgets.
However, both TOGAF and these governmental frameworks were designed within particular institutional and regulatory contexts, which limits their direct

applicability in other environments. For this reason, a tailored framework is proposed—one that leverages the conceptual and methodological strengths of TOGAF while adapting to the legal, technological, and organizational characteristics of the Cuban public sector. The aim is to provide a practical and context-sensitive guide for the design, implementation, and continuous improvement of government information systems. Figure 5 illustrates the correspondence between the phases of TOGAF's ADM and the proposed framework, showing a structured adaptation that preserves the methodological logic of the original model while incorporating the specific needs of the governmental context.

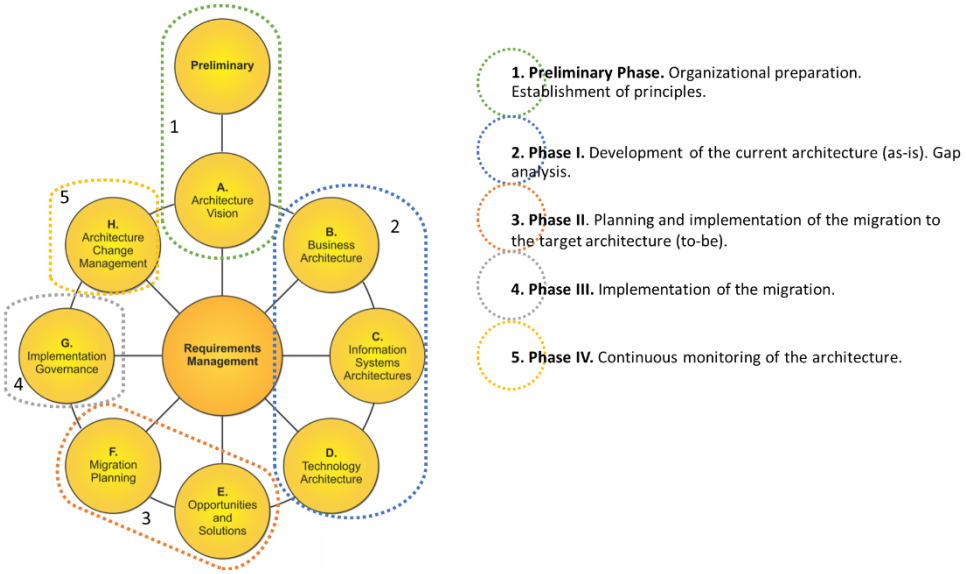

Fig. 5 - Relationships between TOGAF's ADM and the Framework for the design and implementation of the government information system using an enterprise architecture approach.
Source: Author's elaboration

The reduction of TOGAF's eight phases into four main phases within the proposed framework responds to a need identified in the literature: public-sector organizations—particularly those operating in resource-constrained environments—face significant barriers when attempting to adopt highly complex methodologies [9]. This design decision seeks to balance methodological rigor with practical applicability, acknowledging that TOGAF's level of detail can become an entry barrier for organizations with low technical maturity. However, this simplification results in a lower level of granularity in architectural analysis, which may limit its effectiveness in large, highly complex government bodies, such as national ministries with multiple subsecretariats and interdependent processes.

A distinctive feature of the proposed framework is its explicitly iterative approach, in which the organization cycles from a current architecture (As-Is) to a desired architecture (To-Be), achieving incremental improvements to the information system in each cycle, as illustrated in figure 6.

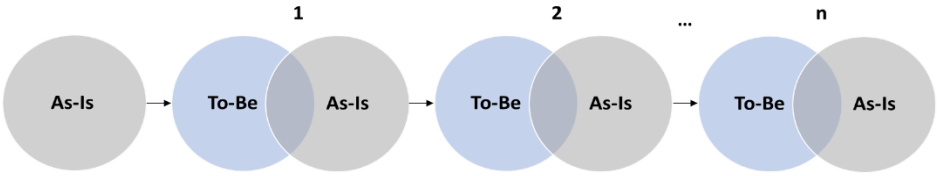

Fig. 6 - As-Is / To-Be iterations
Source: Author's elaboration

However, the iterative approach also presents challenges that are not fully addressed in the proposed framework—particularly how to prioritize improvements across iterations when multiple gaps compete for limited resources. The long-term sustainability of an iterative approach remains an unresolved empirical question. The framework implicitly acknowledges this challenge by structuring short iterations that generate tangible results.

The metamodel represents a significant methodological contribution, as it makes explicit the architectural relationships that are often implicit in generic frameworks. Its dual function—serving both as an analytical tool (guiding what elements must be examined) and as a visualization tool (graphically representing the current state and its relationships)—supports the technical work of the team and improves communication with non-technical stakeholders, especially decision makers who require conceptual understanding without technical depth.

A specific innovation of the metamodel is the inclusion of two architectural development variants determined by the strategic deployment approach within the Business dimension:

Variant 1 – Mission-Based Approach: This variant is used when the organization structures its strategic planning around a clearly defined institutional mission. The mission acts as the guiding element from which strategic objectives, organizational structure, key processes, and other components of the information system are sequentially derived. This approach is typical of entities that prioritize a clear definition of their fundamental purpose before establishing specific goals—commonly found in organizations with explicit legal mandates (e.g., regulatory agencies, basic service providers).

Variant 2 – Vision-Based Approach: This variant is applied when the organization develops its strategy starting from a well-established long-term vision. In this case, the vision defines the desired future state and guides the articulation of strategic objectives and alignment of organizational processes. This approach is often seen in entities undergoing institutional transformation or modernization that emphasize future projection as the foundation of their planning.

The selection of the appropriate variant depends on the strategic management model used by the organization and determines both the sequencing of the analysis and the prioritization of elements within the four dimensions of enterprise architecture.

Conclusions

1. A framework was presented for the design and implementation of government information systems using an enterprise architecture approach, grounded in a systematic review of 24 specialized references and a structured adaptation of TOGAF's ADM method.
2. The proposed framework constitutes a methodological contribution that integrates four architectural dimensions (Business, Information, Applications, and Technological Infrastructure) with public-sector–specific elements, distinguishing itself from generic frameworks by explicitly incorporating aspects such as transparency, accountability, and citizen participation.
3. The developed metamodel enables visualization of relationships among elements and provides two strategic deployment variants (Mission-based or Vision-based), offering flexibility to accommodate different governmental management models.
4. The implementation procedure structures the process into four phases (As-Is Analysis, Opportunities and Solutions, Migration, and Monitoring), encompassing thirteen specific activities and providing an operational guide for transforming government information systems.
5. Several limitations are acknowledged: (1) empirical validation of the framework remains limited, requiring multi-case implementation studies to verify its effectiveness; (2) standardized impact evaluation metrics have not yet been developed; and (3) methodological complexity may pose barriers for organizations with low digital maturity.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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Patricia Suárez Fernández: Research design, literature review, data collection, results analysis, drafting of the article, and critical review of the content.
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Marta Beatriz Infante Abreu: Results analysis, drafting of the article, critical review of the content, and final approval.