Artificial Intelligence-based approach to IT Governance in public administrations

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Abstract:

To address the challenges of Administrative Information Systems (AIS) in the public sector, appropriate governance solutions are needed. However, governance in the public sector is often fragmented. This premise poses a challenge for governments, public administrations, professionals and researchers. Currently there is no comprehensive body of academic work on public sector governance, yet it is receiving increasing attention. To fill in this gap a principled approach is proposed here that has several IT Governance-related features: Firstly, relevant aspects of Governance linked to the need of aligning IT with the organisational strategy AIS are considered. Secondly, the COBIT19 best practice framework for the assessment, management and monitoring of IT for the public sector is introduced as the key process for achieving this alignment. Thirdly, a series of phases for the alignment of AIS objectives with the IT strategy proposed by an EU Member State European Administration is provided. Furthermore, in this work it is shown that the application of IT Governance models allows for the alignment of AIS objectives to the IT strategy. Also, some recommendations for future research are put forward.

Key words:

IT Governance (ITG)
Administrative Information System (AIS)
COBIT
E-Government
Rule Based Systems

1. Introduction

The Information Technology management perspective in many organisations has evolved from an operational support role into a more strategic one involving aspects such as business transformation, innovation and the realisation of IT-based business opportunities [1].

As an organisation's strategic management of IT increasingly relies on its IT Governance (ITG) [2-4], there is a need to achieve Business and Information Technologies Alignment (BITA) given its positive effects on business performance [5-7]. Organisations will operate best when key IT resources are aligned with the business/organisational strategy and when appropriate structures are used to monitor the implementation and effective management of these resources [8]. This practice has been constantly evolving and has always been dominated by the private sector, although it is increasingly being applied to the public sector.

In Spain, since 2014 the Central Administration (CA) has been undergoing a transformation process. This involves reviewing current organisational approaches in order to put an end to the high levels of atomisation of the actions carried out by the agents involved in the IT field [9]. In this research, a governance model is pursued aiming at (1) overcoming this situation in order to achieve a common IT policy for the entire CA and its public organizations; (2) making the process of innovation and improvement in the quality of the services offered by the administration sustainable; and (3) increasing the productivity of public employees. All these objectives were planned in an austerity context regarding public spending, demand for efficiency and co-responsibility, and the need to respond to EU commitments by establishing an operational and legally clear framework to eliminate fragmentation and the absence of interoperability [10].

Knowledge has become the distinctive element for the competitiveness of organizations, so Knowledge Management (KM) is one of the key factors in achieving organizational goals [11].

KM makes use of a wide repertory of procedures, techniques, and tools, including Artificial Intelligence (AI). Ontologies, which are the standard method of

knowledge representation in AI, have been used consistently in KM for a variety of organizational endeavours and application domains, including education [11-12].

Various types of knowledge can be allocated in different functional units of an organizational structure. At the same time, [13] pointed out that knowledge integration at an organizational level enables the organization to carry out better innovation processes.

Currently, the future of e-Government in Spain is defined through the EU initiatives contemplated in the «European Digital Single Market Strategy» [10], where the European Commission adopted the «e-Government Action Plan» [14]. This Plan aimed at accelerating the digital transformation of the administrations of the EU Member States. In Spain, it gave rise to the promotion of two action plans: the «Public Administrations Digitalisation Plan» [15] and the «Digital Transformation Plan for the General State Administration» [16].

In this context, some of the reform axes proposed by the «Digital Transformation Plan for the General State Administration» [16] have not been reformed in accordance with the IT strategy planned by the CA. One of them was the optimisation of the Administrative Information System (AIS), where there is a perceived lack of alignment between the organisational objectives to be achieved and the CA IT strategy [17].

The goal of the research described here was to generate a conceptual model for the optimisation of the Spanish AIS, so that it is aligned with the IT strategy (defined in the common IT governance model) of the Spanish National Government and its public organizations. To achieve this goal, the open standard Control Objectives in Information and Related Technologies (COBIT) was taken as the reference framework [18-23]. More precisely, the objective of this work was to conceptualise an IT Governance System based on COBIT, following the Spanish government´s strategy aiming at translating real administrative processes of the CA into logical processes for e-Government. Finally, a Rule-Based System (RBS) is proposed to assist in data analysis and decision making and to create a scorecard for the Governance of IT Systems was targeted.

The structure of this work is as follows. Section 2 introduces the theoretical framework and addresses the need to establish a Governance System to align organisational objectives with IT. It also underlines the importance of applying process-based models and ontologies for the optimisation of the services offered by public

administrations. In Section 3, the phases to implement an IT Governance System through the COBIT open standard are detailed. The results of the alignment proposal providing a scorecard for ITG with the help of a Rule-Based System are pointed out in Section 5. Finally, in Section 6 some conclusions are put forward.

2. Theoretical framework

This research is based on two research streamlines: (1) the studies addressing ITG [24-25] and the alignment between IT and organisational strategy, which have shown the important role of best practice-based ITG frameworks and standards in the implementation of IT practices [26]. In the professional area, the most comprehensive framework that can be used as a toolkit for organisational governance and IT management is COBIT [27]; (2) knowledge structuring and representation architectures, such as process-based models and ontologies for the optimisation of services offered by public administrations. Such models are aligned to the continuous innovation in e-Government. Ongoing regulations, models and/or methodologies used as a reference to assess the evidence and informational behaviour of citizens when they access to e-Government, have been studied elsewhere [28-34]. Besides, some works allowing for the continuous use of e-Government services have made use of such models [31-34].

2.1. IT Governance

ITG has been defined as «specifying the decision rights and accountability framework to encourage desirable behaviour in the use of IT» [35]. Other authors [32-39] have argued that ITG is an interaction framework between three key components: The first one alludes to structures, which are derived from business units, functions, roles and responsibilities, for appropriate IT decision making. The second component refers to processes, which account for the contents to guide the design of procedures to implement management strategies following IT strategies and policies. The last component deals with relational mechanisms, which are considered to be the devices seeking opportunities to ensure the effectiveness of ITG implementations. These authors have also stated that ITG can be implemented using a combination of various structures, processes and relational mechanisms.

In the public sector, the idea of ITG emerged in the 1990s as a response to government regulations on information policy, such as privacy of personal information and greater transparency of financial information [40]. At the beginning of the 21st century, the use of ITG was reinforced to achieve better compliance and control over IT spending in government and at the same time to achieve value and performance in the public sector [41]. Although the public and the private sector are different from one another, both require for effective ITG, as IT investments play an important role for the economic and social life of the community [42]. ITG in practice is related to five important components: IT strategic alignment, value delivery, risk management, resource management and performance measurement [43]. These elements, known as domain areas, are important factors in decision-making while supporting an ITG framework [44].

In [45], the author has identified the IT and business strategies alignment problem, which is yet a concern in the private and public sectors world-wide [46]. A literature review determined that the effect of IT strategic alignment on organisational performance is a priority research topic [47-50].

In [46], four lines of research on enterprise IT alignment that are perfectly extrapolable to the public sector have been identified. The first one focuses on the Strategic Alignment Maturity (SAM) model, which has been characterised as a description of all possible alignment relationships in four key components: business strategy, IT strategy, business infrastructure and processes, and IT infrastructure and process [51]. The second line focuses on how to measure alignment. There are diverse methods that are based on a static perspective. In essence, each of such methods can lead to different types of results [46]. The third line focuses on the antecedents of enterprise IT alignment. Some studies have identified numerous antecedents that have been grouped into four dimensions (i.e., social, cultural, strategic and structural dimensions) [46] and some ITG practices. These studies are concerned with the individual effects of some ITG practices on business IT alignment, rather than the overall effect of ITG practices on IT alignment [45]. The fourth research line studies the dynamics of enterprise IT alignment, arguing that there are two basic ways of looking at alignment. The first way is to view alignment as a continuous process, which is subject to variations resulting from decisions made, adjustment of strategies adopted over time and improvement of IT management capabilities. The second way is the approach to

alignment as an end state, which is conceived as a result of actions taken or strategies that the organisation has planned [45, 52].

Looking at the perspectives of enterprise IT alignment, this research focuses on the current state of alignment in the public sector as a continuous process and as a set of ITG practices for organisational IT alignment.

2.2. COBIT2019 framework

COBIT, which is the leading professional framework on ITG and management good practices, is based on the ideas mentioned above by specifying a comprehensive set of five domains: assessment and audit; coordination and planning; development and implementation; service and support; and monitoring. It consists of 40 fundamental objectives to be taken into account when implementing IT governance and management, namely, 5 governance and 35 management objectives [53]. A governance/management objective in COBIT relates to a process and to a set of specific components to help achieve the objective. On the other hand, in COBIT a governance objective always relates to a governance process, while a management objective does to a management process.

COBIT was first launched in 1996 as a set of IT control objectives to help the audit community improve the performance of IT environments [22]. In 2018, the Information Systems Audit and Control Association (ISACA) announced a new version, COBIT19. This standard can be implemented to align organizational goals (e.g., business policy, business objectives and IT institutions) with IT objectives by establishing links between them to create solutions that contribute to closing the gap between IT and management [21].

In [54] it has been show that one of the problems detected at a global level is the identification of those IT governance and management processes that seem to be the most important ones in practice to explain the achievement of alignment and security. In this work, it is assumed considers that the identification of the set of activities that define these processes is a challenging endeavour.

2.3. Process Based Models

In the case of public administrations, the Conceptual Description Model (CDM) is a process-based approach that has been proposed to account for the entities involved in institutional processes. More precisely, this approach is aimed at achieving the representation of associations, interrelationships between concepts, analogies and inferences that respond to more particular information needs [84].

In the following lines, a theoretical framework is presented that allows the verifications and analyses indicated by the methodologies described above to be carried out, so that the entities involved in institutional processes can be described.

In the literature, studies can be found that refer to the assessment that public administrations can carry out to measure their operational capabilities. The models by [28] and [29] follow the e-Government Maturity Model (eGov-MM) [85], this model integrates the assessment of technological, organisational, operational and human capital capabilities under a multidimensional, holistic and evolutionary approach, based on other classic capability maturity models, the best known being those belonging to the CMM/CMMI (Capability Maturity Model and CMM Integration) family [87], government models such as the Australian Service Delivery Capability Model (Australian Government Information Management Office AGIMO, 2006 - 2007) [99] and the Canadian e-Government Capability Testing Model [100]; holistic approach models for e-Government projects in Austria [64, 101, 102]; the United States [103]; e-Government evolution models of the UN and ASPA (2002) [104 - 107]. In this type of models, one of the areas assessed concerns process management in e-Government.

The domains are logical groupings of key domain areas (business process management, performance Management, services for citizens and business, interoperability, quality assurance and security), they are usually the ones that need to mature the most in practice, therefore, they are subject to assessment, which is done by measuring their capabilities through their critical variables. Capability level is a property of each key domain area; it is a measure of its readiness to support organisational development, and is determined by measuring the capability level of its critical variables. Each key domain area variable is assessed along seven dimensions: awareness, human capital formation, communication within the organisation, procedures and practices, compliance with norms and standards, tools and support for automation, and staff commitment.

CDMs are an earlier abstraction necessary to create more complete information representation systems [95]. It should be noted that it is important to know the sequence of actions in the administrative process environment and how to document those that have evidential value, as well as their relationships [57]. Several studies have determined that from the analysis of the most elementary documents of a process it is possible to better extract institutional functionalities, i.e. to obtain more relevant data for the organisation [28, 29, 30, 59].

2.4. Ontologies

The increasing number of autonomous e-Government applications has raised several software engineering issues as reusability, maintenance, integration, and interoperability of these applications [60-64].

Ontologies, which are the standard method of knowledge representation in AI, have been used consistently in KM for a variety of organizational endeavours and application domains [97, 98].

Due to the complexity of government processes, several government departments need ontologies to optimise, reorganise government services and facilitate the integration, maintenance and interoperability of their e-Government systems [65-66]. In an attempt to address the above problems, semantic model ontologies using the OWL web service standard are frequently used. OWL ontologies enable composition [67], search, comparison, mapping and merging [68] of e-services and facilitate their integration, maintenance and interoperability [66-70]. These works demonstrate that OWL is a common language used for semantic knowledge representation in e-Government. However, it has been argued that the above works are more aimed at the Semantic Web audience than at the e-Government community at large [71]. Furthermore, only a few of these works provide detailed guidelines for building OWL ontologies from an e-Government service domain [72].

Knowledge is reusable by several applications across governance or business, from discovery to corporate affairs and in this work; we will make use of «domain ontologies» which represents the specific meaning of terms as interpreted in the specific domain [73-75].

2.5. Rule Based Systems (RBS)

In the AI field, within the symbolic processing based artificial learning area, a rule can be defined as a logical proposition that relates two or more objects and includes two parts, the premise and the conclusion. Each of these parts consists of a logical expression with one or more object-value statements connected by the logical operators «and», «or», or «not». A rule is usually written as «if premise, then conclusion» [76-77].

In an RBS, there are two types of elements: data (facts or evidence) and knowledge (the set of rules stored in the knowledge base). The inference engine uses both to obtain new conclusions or facts. For example, if the premise of a rule is true, then the conclusion of the rule must also be true. [77].

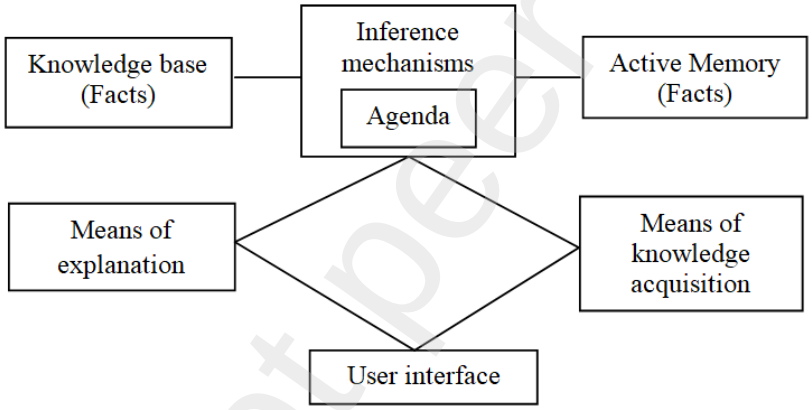

Fig. 1. Schematic diagram of a Rule-Based System [78]

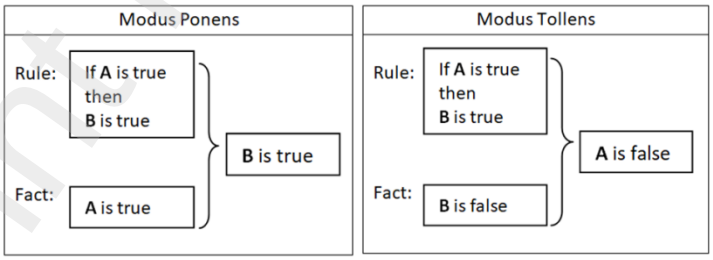

Fig. 2. Basic scheme of inferences [78]

An RBS consists of:

- A Knowledge Base (KB): It contains the rules that encode all knowledge.
- A Fact Base (FB): It contains facts established as true, both input data and inferred conclusions.

- An Inference Mechanism (IM): It selects the rules that can be applied and executes them, with the aim of obtaining some conclusion. It is also called Inference Engine.

Inference Mechanism or Inference Engine (IM):

- It is an algorithmic mechanism to obtain conclusions by applying the KB to the known facts stored in the FB.
- The conclusions are, in its turn, introduced into the FB.
- It can be seen as a Black Box:
    - Input: FB and KB.
    - Output: FB.

2.6. Theoretical background and hypotheses

ITG has been addressed in several studies but there is little research on ITG processes and relational mechanisms [2]. Furthermore, the organisations that plan and implement ITG structures are more successful than those that do not consider ITG [35, 79, 80].

It has been argued that the implementation of ITG best practices generates better degrees of business/organisational IT alignment. The reason for this is that alignment, communication and the relationship between IT and business are important aspects to consider in ITG implementation [45, 81].

In an exploratory qualitative study [82], it has been stated that the greater the ITG success, the greater the alignment of business and IT objectives. Besides, it has been suggested that the maturity of business and IT/BITA alignment is higher when organisations apply a combination of mature ITG practices (i.e., structures, processes and relational mechanisms) [39, 45].

COBIT19 framework can improve the value of enterprises using IT by maintaining a balance between achieving benefits and improving risk levels and resource usage [21, 22, 53, 83]. From this perspective, it can be determined that the better the IT governance development, the greater the capacity for alignment between the organisational objectives (business policy) to be achieved and the IT strategy. This statement allows the following hypothesis to be formulated:

H1: Addressing ITG through the COBIT has an impact on the alignment between business and IT in the public sector.

The application of a «process description model» in Spanish public administrations has demonstrated, that only when the organic-functional aspects for e-Government are solved can the technical-semantic aspects be solved as well, so that describing the management of a real process serves as an indication to solve the initial problem posed, thus offering valid results to face a second stage of action [58].

It is necessary to describe the entities of the public administrations' processes for an electronic environment because such description improves the processing of such processes, the retrieval of information, the provision of Public Services to the citizen and the interoperability between administrations [58].

One of the main advantages of the process-based approach, when compared to other approaches, lies in the management and control of the interactions between these processes and the interfaces between the functional hierarchies of the organisation. This approach is also an excellent way to organise and manage work activities to create value for the customer/user/citizen and other stakeholders. Organisations are often structured as a hierarchy of functional units that are managed vertically. The process-based approach introduces horizontal management, crossing the barriers between different functional units and unifying their approaches towards the organisation's main goals [88].

Therefore, the adoption of a process-based approach makes it possible to identify organizational aspects, such as the processes carried out and the procedures for each process. In addition, this approach can make it possible to establish what the information flows of the processes are like - the sequences, relationships and interactions - and to determine the process description, among other things [29].

Based on these reflections, the following hypothesis can be formulated:

H2: The implementation of process-based models contributes to define the business policy of the public sector on e-Government (i.e., they allow for the description of the functionalities of an organization for a specific service) while remaining aligned with IT.

An RBS can be used to identify the factors that need to be improved in order to achieve the overall goal of a project to optimize public administrations towards e-Government. In addition, several what-if scenarios can be generated, and developers and managers can get an early idea of the results.

E-Government is very complex because it involves intricate relationships between technological, organizational, institutional and contextual variables [41].
Increasing the effectiveness of AIS is a complex issue. A problem of this nature can be addressed through the development of expert systems. These systems have demonstrated their applicability in important areas of e-Government evaluation [89-91] but their application to account for the variables involved in the description of administrative processes for an electronic environment (at least in the Spanish public administration), is scarce. For this reason, the following premise is established:

H3: An RBS modelling approach allows for the capture of uncertain information to optimize the efficiency of Administrative Information Systems.

3. Methodology

The development of the research described in this work, has been carried out thought the following phases:

- Identification of the objectives to be achieved for the optimization of AIS - Spanish CA: This was achieved through current legislation and by interviewing the entities and subjects involved, so that a set of reports issued each by the coordinator of the Public Research Organizations (PROs) of each of the Departmental IT Units was obtained [17].
- Identification of the technological governance structure of the Spanish CA, for which purpose the current legislation has been consulted [9], [92-94].
- Identification of the IT strategy, achieved by analyzing the regulatory and legal sources published by the CA.
- Prioritization of management practices based on the COBIT goal cascade methodology to finally align the AIS objectives with the CA IT [20, 53].
- Definition of the fundamental entities of any administrative process of the CA. For this purpose, the recommendations of the process-based models cited in the theoretical framework were taken and, after the ones were analysed, the different entities involved in an administrative process were established.
- Creation of an implementation map of the prioritized practices (interface of actions) and their articulation into the areas of the IT Head Office, establishing a structure where the members, actions and complements were defined. A conceptualization of

such practises and organizational context was also carried out by using ontological engineering. Finally, a schema of the implementation of an RBS was defined to assist in the analysis of data and decision making.

4. Case study

The object of study of this research focused on AISs. Table 1 shows the current characteristics of these (for the case of Spain) and the objectives to be achieved with their transformation.

Table 1
Administrative Information System (AIS) [96]

SERVICE DETAILS	
Attachment	Ministry of Finance and Civil Service Ministry of Economic Affairs and Digital Transformation
Description	AIS is a computer application whose basic function is to act as a catalogue of information on administrative procedures, including administrative procedures and services for citizens as well as those of the public administrations. It is a comprehensive information system that houses the set of inventories containing the list of administrative procedures and services provided, in a classified and structured manner, of levels of public administration [91].
Characteristics	All state, regional and local public administrations electronically connect their inventories with AIS.
PROBLEM	
A tendency has been detected to perceive AIS as a mere bureaucratic tool by the processing units, and therefore its meaning, scope and usefulness are not perceived. AIS does not become a powerful transparency tool not only for citizens and companies but also for the internal management of the processing units. AIS does not define what an administrative process is, i.e., it does not reflect each of the stages and steps (of procedures within an administrative process) that must be followed to reach a conclusion (administrative act) [17].	
AIS OPTIMIZATION	
Overall objectives [17]	
Increase the efficiency of AIS. Contribute to the transformation of the administration into e-Government. To make sustainable the constant process of innovation and improvement in the quality of public services. Simplify administrative burdens Develop programs for citizen attention and information and for the CA processing units. Conceive AIS as a tool for decision making.	
Specific objectives [17]	
Evidencing the management of administrative processes through a conceptual description model, i.e. providing AIS with a conceptual structure and an e-EMGDE metadata schema that serves as a source of information for the citizen and the processing units. Convert AIS into a scorecard	

4.1. Initial state: technological governance structure

Currently, in Spain the IT area of the CA basically depends on two bodies. One is the Public Governance General Directorate, which has competencies in governance and functional aspects and is part of the Ministry of Finance and Public Function. The other one is the Digital Administration General Secretariat, which assumes the competencies on technical and technological aspects under the Ministry of Economy and Digital Transformation. These bodies are coordinated. The bodies in charge of carrying out the IT strategies depend on the Ministry of Finance and Public Function and are the following: Directorate the Information and Communication Technologies, IT Strategy Commission, and the Ministerial Commissions for Digital Administration

4.2. Design factors

4.2.1. Design factor 1: initial strategy applied to all IT services, including AIS

After analyzing the legal sources, the IT strategy of the Information and Communication Technologies Directorate seeks to centralize the competencies and the means to carry them out in a single administrative body. The purpose of such strategy is that all the IT units of the CA and its public organizations are integrated. It also aims to provide shared IT services to all the units of the CA and its public organizations and to define a common strategy that will set up the action lines in IT matters [8].

Table 2
Design factor 1, COBIT 2019 strategy - CA IT strategy [53]

COBIT 2019 strategy	IT – CA strategy
Growth/ Acquisition	Increased homogeneity and simplicity through the use of common tools and services. Empowerment for the provision of shared IT services (shared means and services - reusability).
Innovation/ Differentiation	Make the constant process of innovation and improvement in service quality sustainable.
Cost leadership	Rationalize the use of IT resources in such a way as to achieve greater efficiency, providing substantial cost savings of all kinds.
Customer service/stability	Internally: common strategic planning for the entire CA and its Public Bodies. Externally: offering quality services

The objectives to achieve such strategy which are established in the COBIT model and are structured in each of the dimensions of the Balanced Scorecard (BSC), include the following elements (those in italics are found in some of the strategies included in Table 2).

Strategic business objectives according to COBIT19*:

EG01 - Competitive portfolio of products and services

EG02 - Business risk management

EG03 - Compliance with external laws and regulations

EG04 - Quality of financial information

EG05 - Customer service culture

EG06 - Business Service Continuity and Availability

EG07 - Quality of management information

EG08 - Optimization of the functionality of internal business processes

EG09 - Optimization of business process costs

EG10 - Staff skills, motivation and productivity

EG11 - Compliance with internal policies

EG12 - Management of digital transformation programs

EG13 – Innovación de productos y negocio

4.2.2. Design factor 2: prioritization of management practices based on the COBIT19 goal cascade methodology [53, 94]

Based on the functional organic model, the IT management proposal is defined with the help of the COBIT19 goals methodology, so that a structure with the recommended members, actions and complements to achieve the AIS objectives is offered and then these can be aligned with the CA IT strategy.

Table 3
IT Governance and Management Model

ROLE	RESPONSABILITIES	COBIT19 ALIGNMENT
IT Management	• Establish a coordinated IT action • Define methodologies, processes, architectures, standards and best practices common to all the IT units of the CA. • Rationalize the use of IT resources	EDM01 Setting up and maintaining the assured governance framework EDM02 Delivery of assured benefits EDM03 Assured risk optimization EDM04 Guaranteed resource optimization

* EG: Enterprise Goals or, alternatively, organizational objectives

	for greater efficiency and savings • Rationalize the contracting process Advise and keep a record of the costs that are attributable to each of the public agencies • Define IT investment priorities. • Receive monitoring reports as a measure of commitment to the I&T governance system by all parties involved.	EDM05 Assured Stakeholder Engagement APO01 Managed I&T Management Framework APO02 Managed strategy APO06 Managed budget and costs APO08 Managed relationships APO09 Managed Service Agreements APO12 Managed Risk APO12 Managed Risk BAI01 Managed Programs BAI04 Managed Availability and Capacity BAI07 Managed IT Change Acceptance and Transition
IT Strategy Committee	• Report on the status of digital transformation for its supervision Report for IT regulation • Oversee the implementation of the IT strategy • Define investment priorities	EDM01 Setting up and maintaining the guaranteed governance framework EDM02 Delivery of guaranteed benefits EDM05 Assured Stakeholder Engagement APO06 Managed budget and costs APO08 Managed relationships
General Secretariat for Digital Administration	• Elaborate the Digital Administration and Digital Public Services strategy, as well as the innovation processes for the optimization of the AIS. • Perform the technical design, implementation and management of means to evolve public services such as AIS. • Perform risk forecasting and monitoring functions in the CIS optimization process. • Oversee the Ministerial Commissions for Digital Administration • Establish the technical and technological architecture • Elaborate proposals related to IT goods and services procurement policies • Obtain transparency for key stakeholders on the adequacy of the system of internal controls and thus provide confidence in operations, confidence in the achievement of organizational objectives and adequate understanding of residual risk.	EDM01 Setting up and maintaining the guaranteed governance framework APO01 Managed I&T management framework APO02 Managed strategy APO03 Managed enterprise architecture APO04 Managed Innovation APO05 Managed Portfolio APO08 Managed Relationships APO09 Managed Service Agreements APO12 Managed Risk APO12 Managed risk APO13 Managed security APO14 Managed data BAI01 Managed Programs BAI02 Defining managed requirements BAI03 Identifying and building managed solutions BAI04 Managed availability and capacity BAI06 Managed IT changes MEA04 Managed Assurance
Ministerial Commissions on Digital Administration	• Coordinate ministerial departments (IT Units) • Analyzing the functional needs of the departmental management units • Evaluating the various alternative	EDM01 Setting up and maintaining the secured governance framework EDM02 Delivery of Assured Benefits EDM04 Assured resource optimization

	solutions proposed by the IT units • Elaborate the departmental IT action plans according to the IT Strategy (means, costs, needs, human resources, development times) • Issue a report outlining new organizational or operational criteria, implement new procedures or revise existing ones. • Provide a timely resolution to avoid recurring incidents. • Provide recommendations for improvements • Monitor that processes and practices are performing against agreed performance and compliance targets and metrics. • Obtain transparency to key stakeholders on the adequacy of the system of internal controls to provide confidence in operations, confidence in the achievement of the organization's objectives and an adequate understanding of residual risk.	APO02 Managed strategy APO03 Managed Enterprise Architecture APO05 Managed portfolio APO06 Managed budget and costs APO07 Managed Human Resources APO08 Managed Relationships APO09 Managed Service Agreements BAI02 Definition of managed requirements BAI03 Identification and construction of managed solutions BAI04 Managed availability and capacity. BAI04 Managed availability and capacity DSS03 Managed issues MEA01 Managed Performance and Compliance Monitoring MEA04 Managed assurance
General Directorate of Public Governance	• Analyze and evaluate CA´s organizational structures. • To elaborate provisions of an organizational nature. • Improve the rationality and efficiency of administrative structures. • Assume governance and management responsibility for AIS. • Analyze and evaluate process-based models. • Design a process description model. • Design, drive and follow up actions to reduce administrative and regulatory burdens in CA. • Simplify (optimize) administrative procedures. • Advise on organizational and procedural matters to CA's ministerial departments and public agencies. • Define and communicate quality requirements for AIS. • Ensure that AIS is managed in accordance with Decree 203/2021, of March 30, approving the Regulations for the performance and operation of the public sector by electronic means.	APO08 Managed Relationships APO09 Managed Service Agreements APO11 Managed quality APO13 Managed security APO14 Managed data BAI02 Defining managed requirements BAI03 Identifying and building managed solutions BAI04 Managed availability and capacity BAI05 Managed organizational change MEA02 Managed Internal Control System MEA04 Managed Assurance

	The objectives to be achieved are: • Improve administrative efficiency, • Increase transparency and participation, • To guarantee easily usable digital services • Improve legal certainty • Plan, achieve and execute assurance initiatives to comply with internal requirements, laws, regulations and strategic objectives.	
Departmental IT units: coordinators of the public research organizations	• Implement prototype action interface • Deliver the results of I&T operational services and products as planned. • Identify and classify problems and their root causes.	DSS01 Managed operations DSS03 Problems handled

4.2.3. Design factor 3: identification of key entities of an administrative process

In Spain, at the territorial level, the public administrations are structured in three levels, namely, Central Administration, Regional Administration and Local Administration.

Each of these administrations is organically structured in a hierarchical manner, from the general to the particular. In each of these hierarchies there is a departmental IT unit, which is in charge of executing the necessary actions for AIS optimization.

4.2.4. Design factor 4: action interface prototype

Agents or members

Table 4
Representation of hypothetical subjects of the Spanish public administration

Central Administration	Regional Administration	Local Administration
Ministry 1 Department IT Unit 1 Department IT Unit 2 Etc Ministry 2 Idem Public Organization 1 Idem	Aragón Department 1 Department IT Unit 1 Department IT Unit 2 Department 2 Etc Andalusia Idem Principality of Asturias Balearic Islands Canary Islands Cantabria	Province 1. Provincial council 1 Area Department 1 IT Unit Department 2 IT Unit Etc. Province 2. Provincial council 2 Area Department 1 IT Unit Department 2 IT Unit Etc.

	Castilla y León Castilla-La Mancha Etc.	Province 3. Province 4. Etc. Municipality 1 Area Department 1 IT Unit Department 2 IT Unit Municipality 2 Area Department 1 IT Unit Department 2 IT Unit Municipality 3. Municipality 4 Etc.

Elements involved in an administrative process for AIS [29].

A domain ontology has been built to capture the relevant concepts, activities, tasks, regulations and relationships between all constituents of the AIS e-Government service domain (OntoAIS). OntoAIS shows the key concepts of the domain (Central Administration, Regional Administration, Local Administration, Entity, Process, Procedure, etc.), the activities performed in the domain (Analyse, Identify, Assign, Attribute..., etc.) and the relationships between the domain components, as shown in Table 5. The UML syntax for knowledge representation [93] has been used because it allows modelling ontologies with instances/individuals, slots and classes, which are also used in Protégé [96] see Figure 3.

Table 5
Design details of the OntoAIS class diagram

Classes	
AIS Project, Central Administration, Ministry 1, Ministry 2, Ministry X..., Regional Administration, Aragon Region, Andalusia Region, Principality of Asturias Region, Autonomous, Region X..., Local Administration, Province 1, Province 2, Province 3, Province X…, Municipality 1, Municipality 2, Municipality 3, Municipality X..., ICT Department, Unit 1, Unit 2, Unit 3, Unit X..., Entity, Process, Procedure, Document, Agent, Relationship, Regulation, File, Type of procedure, Normal Procedure, Document management Procedure, Agent, Internal Agent, External Agent, Person, Area, Subarea, Subarea Division, Institution, File Type, Simple Documentary Unit, Composite Documentary Unit, Type, Identification, Name, Dates, Description, Functionalities, Analyse, Identify, Assign, Attribute	
Inheritance Structure	
Super Class	**Sub Classes**
Central Administration	- Ministry 1, Ministry 2, Ministry X…
Regional Administration	- Aragón Region, Andalucia Region, Principado de Asturias Region, Region X…

Local Administration	-	Province 1, Province 2, Province 3, Province X, Municipality 1, Municipality 2, Municipality 3, Municipality X…
IT Department	-	Unit 1, Unit 2, Unit 3, Unit X
Entity	-	Process, Procedure, Document, Agent, Relationship, Regulation, File
Process	-	Type, Identification, Name, Dates, Description
Procedure	-	Type, Identification, Name, Dates, Description
Document	-	Type, Identification, Name, Dates, Description
Agent	-	Type, Identification, Name, Dates, Description
Relation	-	Type, Identification, Name, Dates, Description
Regulation	-	Type, Identification, Name, Dates, Description
File	-	Type, Identification, Name, Dates, Description
Class Instances		
Class	**Instances/ Individuals**	
Type of procedure	-	Normal Procedure, Document management Procedure
Internal Agent	-	Person, Area, Subarea, Subarea Division, Institution
External Agent	-	Person, Area, Subarea, Subarea Division, Institution
File type	-	Documentary Unit, Composite Documentary Unit
Activities/ Functionalities	-	Identify, Assign, Attribute,…

This schema has been implemented into OWL language using Protégé—see Figures 3, 4 and 5 below.

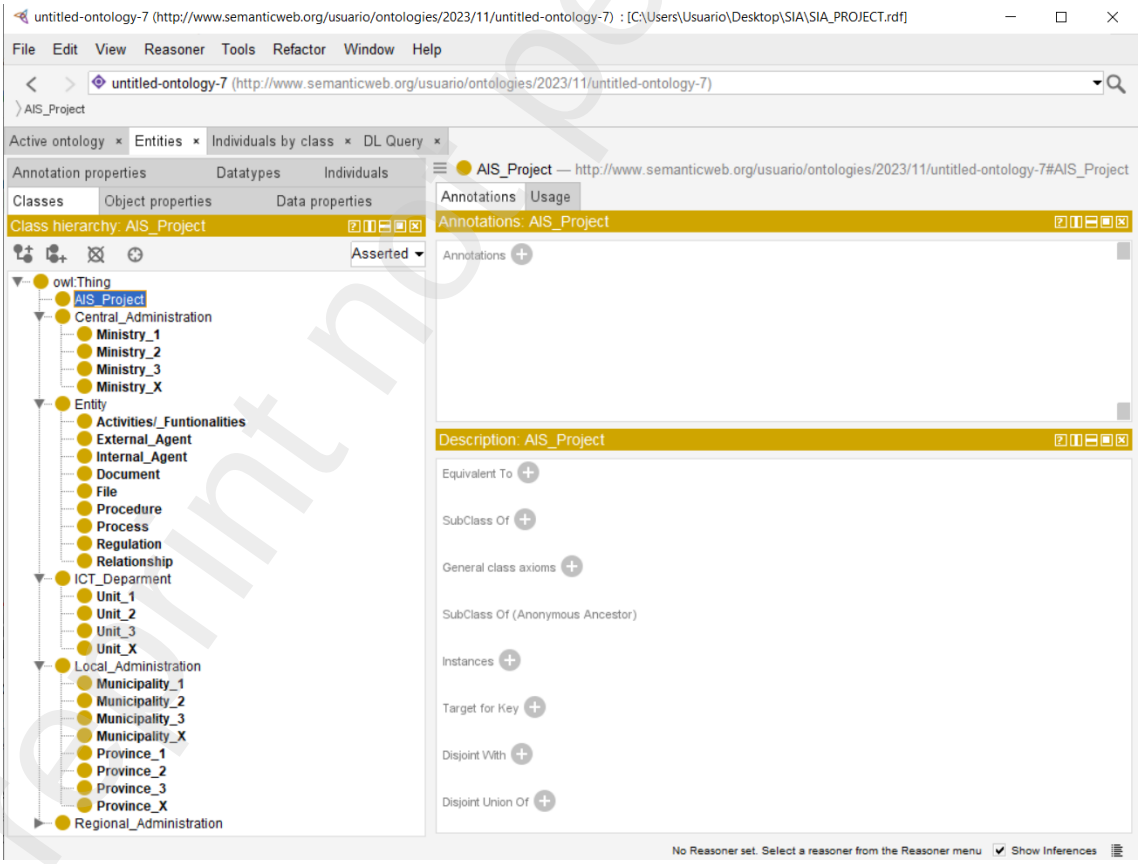

Fig. 3. Protégé Version of the OntoAIS: class and subclass

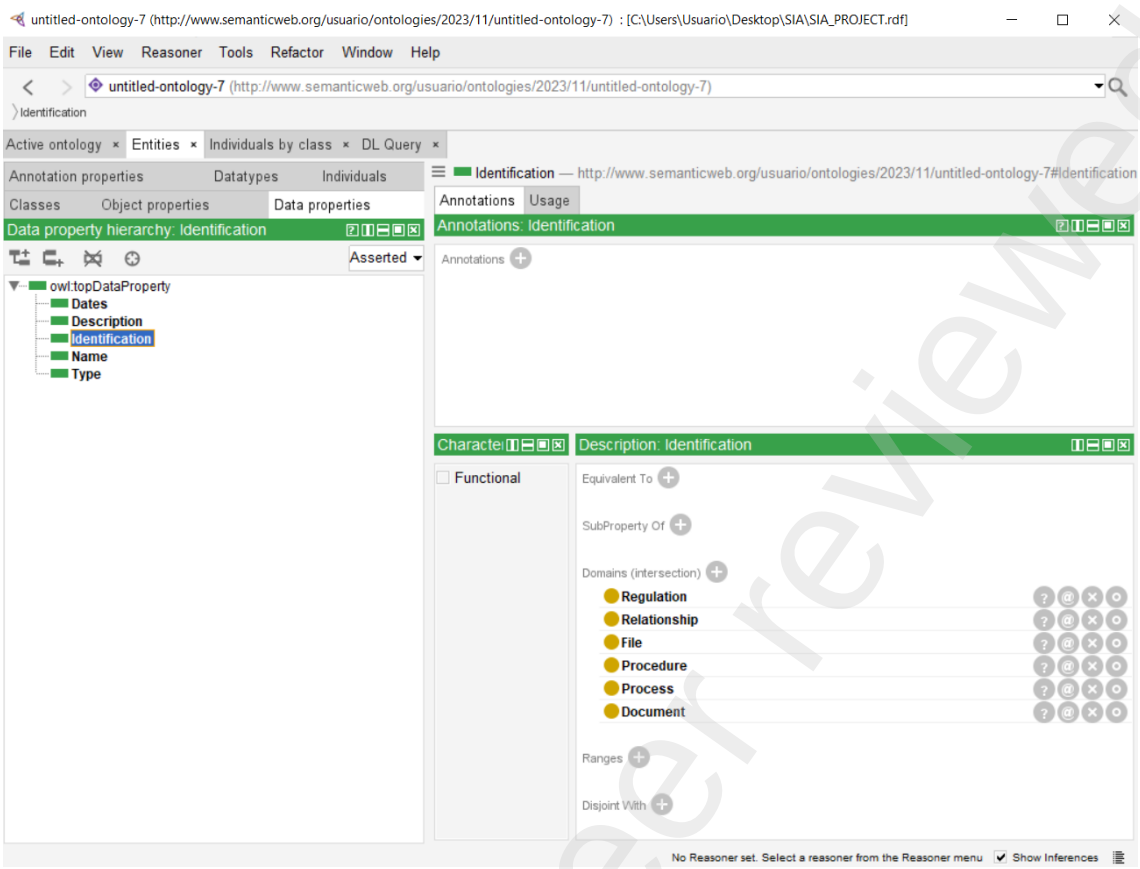

Fig.4. Protégé Version of the OntoAIS: data properties

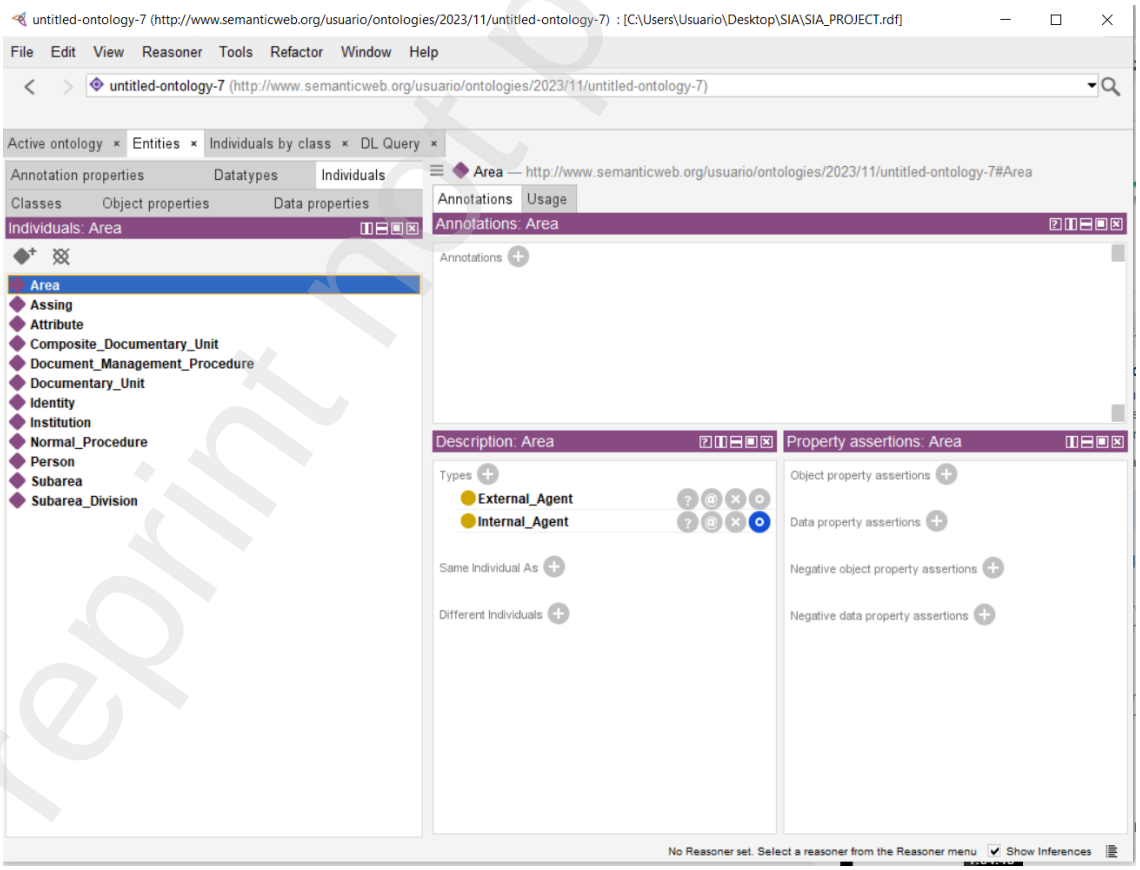

Fig.5. Protégé Version of the OntoAIS: instances/individuals

4.2.5. Design factor 5: action interface prototype

Each IT departmental Unit must take into account that an administrative process is made up of a number of sequential procedures that are executed until the administrative process is completed. For e-Government, these procedures can be defined as normal processing procedures (i.e., procedures referred to immaterial functions) and electronic document management procedures that affect simple electronic documents (i.e., simple documentary units) and files (i.e., compound documentary units) that must be evidenced.

In an electronic environment, each document is linked to a series of procedures, which allow to assign it a name, to determine all the agents involved, the regulations that apply, and the relationships it maintains with other entities in the process (i.e., other processes, procedures, agents, documents, regulations...).

It has been assumed that by analyzing the minimum unit, the documents of a process, more collective and contextual data can be extracted to describe an administrative process for e-Government and for AIS optimization.

The following is an example of a command scheme to be followed by the IT Departmental Units for AIS optimization:

Rule 1.
If composite documentary unit(s) = analysis
Then process = identification
Rule 2.
If process = identification
Then process = naming
Rule 3.
If process = identification
Then process target = assignment
Rule 4.
If simple document unit(s) = analysis
Then procedure = identification
Rule 5.
If procedure/s = identification
Then type of procedure/s = denomination
Rule 6.
If procedure/s = identification
Then sequence of procedures= establishment
Rule 7.
If procedure/s = identification
Then procedure agent = assignment
Rule 8.
If procedure agent = identification
Then agent name = designation
Rule 9.
If procedure = identification
Then regulation = application
Rule 10.
If process = identification

Then processing time = implementation
Rule 11.
If process = identification
Then document = binding
Rule 12.
If process = identification
Then file = linked
Rule 13.
If process = identified
Then relationships between the elements of the process = identification
Rule 14.
If process = identified
Then related processes = linkage

5. Results Analysis

IT governance models are based on knowledge to align organisational policy and IT in the public sector, as has been demonstrated by practice.

This paper provides the necessary steps for the AIS optimization. To this end, the objectives of AIS have been aligned with the CA IT strategy through an IT Governance schema, which provides a conceptual structure after adopting process-based models and an ontology based on the AIS service domain has been created for e-Administration, allowing the description of the organization's functionalities and interpreting a specific domain as represented by concepts.

Finally, an example of an RBS-Based scorecard has been described that responds adequately in terms of guiding officials amongst administrative processes by attending to different inputs referring to all legal, functional and structural concepts and processes handled by such public administrations. Therefore, part of the third hypothesis can be confirmed, namely, an RBS makes it possible to capture uncertain information to optimise the effectiveness of AIS.

6. Discussion and conclusions

The smooth progress of technological innovation in public administrations has sometimes been truncated by the predominant managerial models in place in such a kind of organizations, including clientelist and bureaucratic organizational models. With this type of models, public administrations fail to professionalise their public management tasks while such administrations have increasingly made use of private subcontracting and service outsourcing tools to solve their managerial problems. Given this phenomenon, we believe that public administrations should develop and consolidate

a smart public governance model that solves some of the problems arising from the predominant old organizational models.

In the last years, the EU has paved its way to become one of the most important AI ecosystems in the world, focusing its efforts on sectors such as health and transport, as AI technologies have developed substantially in these areas [86]. However, it would be convenient to strengthen and consolidate efforts in public administrations and consider to what extent AI can help in the development of public policies or what benefits it could bring in the design of collaborative governance and open innovation models to create public value.

There is wide consensus in considering that real technological transformation can be achieved with the use of AI-based systems, but all the changes that are desired in the implementation of AI and governance with algorithms are in a preparatory phase, more like a mere declaration of intent. For this reason, in the National Artificial Intelligence Strategies published by the different EU Member States and in the case of public administrations, more details on the necessary actions for this type of technological transformation are necessary. Thus, some of the following issues should be addressed and detailed:

- the intelligent governance model;
- the key agents and drivers;
- the parameters for evaluating the progress of the actions;
- the execution times;
- the objectives and expected results;
- how the intergovernmental interactions between governments at different levels of the administration are carried out;
- what the review and evaluation tools are;
- the necessary funding sources for projects addressing such issues.

The research presented in this work aimed to articulate an adequate process management system for public administrations through the application of a governance model. This contributes to fill in the gap of the lack of transversality required by the actors involved in such process, so that these play a meta-governance role with the help of governments. The research offers a self-regulatory process in which pre-adoption and post-adoption functions are extended by measuring operational capacities, providing

insight for decision-makers to understand long-term process patterns for e-systems on an ongoing basis.

Given above stated current managerial issues in public administrations, we believe that these should adopt a process-based approach. In other words, description of administrative process entities should be established as one of the priority goals for alignment with the Central Administrations information technology strategy. In addition, in this work a framework for generating (ontological) knowledge representation models from a government service viewpoint has been presented, so that government's services may be analysed attending to structural, functional, or legal features defining the concepts included in such models.

Several activities have been planned as future research. Firstly, ensuring the viability of administrative practices requires for prior abstraction through conceptual modelling to create more complete information representation systems, as demonstrated in this research. Such modelling involves the specification of conceptual attributes, which must be described through information representation standards to ensure those ones applicability in real settings. Secondly, it is necessary to carry out a proof of concept of the system through its implementation at a software prototype level. This will be carried out as soon as some public administration agrees in granting access to the necessary data and procedures.

References

[1] Tanriverdi, H., Rai, A. & Venkatraman, N., 2010. Reframing the Dominant Quests of Information Systems Strategy Research for Complex Adaptive Business Systems. Information Systems Research, 21 (1), 822-834. DOI: https://doi.org/10.1287/isre.1100.0317.

[2] Caluwe, L. & De Haes, S., 2019. Board Level IT Governance: A Scoping Review to Set the Research Agenda. Information Systems Management, 36 (3), 262-283. DOI: https://doi.org/10.1080/10580530.2019.1620505.

[3] Cervone, H.F., 2017. Implementing IT governance: a primer for informaticians. Digital Library Perspectives, 33 (4), 282-287. DOI: https://doi.org/10.1108/DLP-07-2017-0023.

[4] Kude, T., Lazic, M., Heinzl, A. & Neff, A., 2018. Achieving IT-based synergies through regulation-oriented and consensus-oriented IT governance capabilities. Information Systems Journal, 28 (5), 765-795. DOI: https://doi.org/10.1111/isj.12159.

[5] Gerow, J.E., Grover, V., Thatcher, J. & Roth, P.L., 2014. Looking Toward the Future of It–Business Strategic Alignment Through the Past: A Meta-Analysis. MIS Quarterly, 38 (4), 1159-1186.

[6] Wagner, H.-T., Beimborn, D. & Weitzel, T., 2014. How social capital among information technology and business units drives operational alignment and it business value. Journal of Management Information Systems, 31 (1), 241-272. DOI: https://doi.org/10.2753/MIS0742-1222310110.

[7] Yayla, A.A. & Hu, Q., 2012. The impact of IT-business strategic alignment on firm performance in a developing country setting: exploring moderating roles of environmental uncertainty and strategic orientation. European Journal of Information Systems, 21 (4), 373-387. DOI: https://doi.org/10.1057/ejis.2011.52.

[8] Coltman, T., Tallon, P., Sharma, R. & Queiroz, M., 2015. Strategic IT alignment: twenty-five years on. Journal of Information Technology, 30 (2), 91-100. DOI: https://doi.org/10.1057/jit.2014.35.

[9] España. Decreto 806/2014, de 19 de septiembre, de organización e instrumentos operativos de las tecnologías de la información y la comunicación en la Administración General del Estado y sus Organismos Públicos.

[10] European Commission. A Digital Single Market Strategy for Europe [COM (2015) 192 until the end]. https://eur-lex.europa.eu. (Accessed 22 April 2023).

[11] García-González, M.S., Paniagua-Arís, E., Martínez-Béjar, R. & López-Caballero, J.A.; Gasparetto, A., 2023. An Artificial Intelligence-Based Model for Knowledge Evaluation and Integration in Public Organizations. Appl. Sci. 13 (21), 11796. DOI: https://doi.org/10.3390/app132111796.

[12] Muñoz García, A.; Lamolle, M.; Martinez-Béjar, R.; Espinal Santana, A., 2019. Learning Ecosystem Ontology with Knowledge Management as a Service. In: *Computational Collective Intelligence. ICCCI 2019*; Nguyen, N., Chbeir, R., Exposito, E., Aniorté, P., Trawiński, B., Eds.; Lecture Notes in Computer Science; Springer: Berlin/Heidelberg, Germany 11684.

[13] Carlile, P.R., 2004. Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. Organ. Sci. 15, 555–568.

[14] European Commission. E-Government Action Plan 2016-2020 Accelerating the digital transformation of government [COM/ 2016/0179 until the end]. https://eur-lex.europa.eu. (Accessed 22 April 2023).

[15] Directorate of Information and Communication Technology. Digital Transformation Plan for the General State Administration and its public bodies (ICT Strategy 2015-2020). https://administracionelectronica.gob.es/pae_Home . (Accessed 24 April 2023).

[16] Spain. Ministry of Economic Affairs and Digital Transformation. Plan for the Digitalisation of Public Administrations 2021-2025. https://administracionelectronica.gob.es/pae_Home. (Accessed 29 March 2023).

[17] Spain. Ministry of Science and Innovation. Subdirectorate General for Personnel and Inspection of Services 2022. Coordinator of Public Research Bodies and Organisations (OPIS). SIA Report by Emilio Souto. https://administracion.gob.es/pag_Home/espanaAdmon/SIA.html. (Accessed 15 March 2022).

[18] ISACA., 2023. Cobit 19. https://www.isaca.org/resources/cobit. (Accessed 4 March 2023).

[19] ISACA., 2018a. COBIT 2019 Framework: Introduction and Methodology, Information Systems Audit and Control Association.

[20] ISACA., 2018b. COBIT 2019 Implementation Guide: Implementing and Optimizing an Information and Technology Governance Solution, Information Systems Audit and Control Association.

[21] ISACA., 2018c. COBIT 2019 Design Guide: Designing an Information and Technology Governance Solution, Information Systems Audit and Control Association.

[22] Robert, R. M., 2013. *Executive Guide to IT Governance: Improving Systems Processes with Service Management*, *COBIT and ITIL.* Wiley.

[23] Lanto Ningrayati Amali, M. Mahmuddin, M. A., 2014. Information Technology Governance Framework in the Public Sector Organizations. Telkomnika, 12 (2), 429-436. DOI: http://doi.org/10.12928/telkomnika.v12i2.51.

[24] Caluwe, L. & De Haes, S., 2019. Board Level IT Governance: A Scoping Review to Set the Research Agenda. Information Systems Management, 36 (3), 262-283. DOI: http://doi.org/10.1080/10580530.2019.1620505.

[25] Lunardi, G.L., Gastaud Maçada, A.C., Becker, J. o L. & Van Grembergen, W., 2017. Antecedents of IT Governance Effectiveness: An Empirical Examination in Brazilian Firms. Journal of Information Systems, 31 (1), 41-57. DOI: http://doi.org/10.2308/isys-51626.

[26] De Haes, S., Van Grembergen, W. & Debreceny, R.S., 2013. COBIT 5 and Enterprise Governance of Information Technology: Building Blocks and Research Opportunities. J. Inf. Syst, 27 (1), 307–324.

[27] ISACA., 2012. COBIT 5: A Business Framework for the Governance and Management of Enterprise IT, Information Systems Audit and Control Association.

[28] Conde, J. M., 2015. Propuesta metodológica para la gestión documental de los procesos de la Administración pública [Tesis Doctoral]. Universidad Nacional de Educación a Distancia (UNED), España.

[29] García-González, M.S., 2018. E-Administración: realidad encontrada tras la aplicación de un método descriptivo de gestión de procesos administrativos en entidades locales españolas. España: Congreso de los Diputados, Dirección de Estudios, Análisis y Publicaciones. Departamento de Publicaciones.

[30] Zhang, Yi. & Kimathi, F.A., 2022. Exploring the stages of e-Government development from public value. Technology in Society, 69, DOI: https://doi.org/10.1016/j.techsoc.2022.101942.

[31] DeLone, W. H. & McLean, E. R., 2003. The DeLone and McLean Model of Information Systems Success: a Ten-Year Update. Journal of Management Information Systems, 19 (4), 9-30. DOI: https://doi.org/10.1080/07421222.2003.11045748.

[32] Tan, C. W., Benbasat, I. & Cenfetelli, R., 2013. IT-Mediated Customer Service Content and Delivery in Electronic Governments: An Empirical Investigation of the Antecedents of Service Quality. MIS Quarterly, 37 (1), 77-109.

[33] Bhattacherjee, A., 2001. Understanding Information Systems Continuance: An Expectation-Confirmation Model. MIS Quarterly, 25 (3), 351-370.

[34] Alruwaiea, M., El-Haddadehb, R. & Weerakkody, V., (2020). Citizens´ continuous use of e-Government services: the role of self-efficacy, outcome expectations and satisfaction. Government Information Quarterly, 37 (3). DOI: https://doi.org/10.1016/j.giq.2020.101485

[35] Weill, P. & Ross, J., 2004. IT Governance: How Top Performers Manage IT Decision Rights for Superior Results. Boston, MA: Harvard Business Review Press.

[36] Van Grembergen, W., 2004. Estrategias para la gobernanza de la tecnología de la información. Hershey, Pensilvania: Idea Group Inc (IGI).

[37] Peterson, R., 2006. Crafting Information Technology Governance. Information Systems Management, 21 (4), 7-22. DOI: https://doi.org/10.1201/1078/44705.21.4.20040901/84183.2

[38] De Haes, S., 2007. The impact of IT governance practices on business/ IT Alignment in the Belgian financial services sector [Doctoral Thesis]. University of Antwerpen, Belgium.

[39] De Haes, S. & Van Grembergen, W., 2008. Relationship between IT Governance and Business/IT Alignment Maturity. In: *Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008),* Waikoloa, HI, USA 428-437.

[40] Taylor P. W., 2009. ¿Deslizándose? Los CIO todavía están en terreno firme, pero por cuánto tiempo. CIO: 44. https://www.ciospain.es/home. (Accessed 28 June 2023)

[41] Helbig N., Hrdinová, J. & Canestraro D. 2009. Enterprise IT governance at the state level: An emerging picture. In: *Proceedings of the 10th Annual International Conference on Digital Government Research: Social Networks: Making Connections between Citizens, Data and* Government, 172-179.

[42] Campbell, J., McDonald, C. & Sethibe, T. 2009. Public & Private Sector IT Governance: Identifying Contextual Differences. Australasian Journal of Information Systems, 16, 5-18.

[43] Gheorghe, M., 2010. Audit Methodology for IT Governance. Informatica Economica, 14 (1), 32–42.

[44] Iliescu, F.M., 2010. Auditing IT Governance. Informatica Economica, 14 (1), 93-102.

[45] Santos, W., 2021. Impact of Information technology (TI) Governance on Business-TI Alignment. Management Letters, 21 (2), 83-96. DOI: http://doi.org/10.5295/cdg.180995Ws.

[46] Jia, Y., Wang, N. & Ge, S., 2018. Business-IT Alignment Literature Review: A Bibliometric Analysis. Information Resources Management Journal, 31 (3), 1-16. DOI: http://doi.org/10.4018/IRMJ.2018070103.

[47] Sabherwal, R., Hirschheim, R. y Goles, T., 2001. La dinámica de la alineación: perspectivas de un modelo de equilibrio puntuado. Ciencia de la Organización, 12 (2), 179-197.

[48] Yayla, A.A. y Hu, Q., 2012. El impacto de la alineación estratégica del negocio de TI en el desempeño de la empresa en un entorno de país en desarrollo: exploración de los roles moderadores de la incertidumbre ambiental y la orientación estratégica. Revista Europea de Sistemas de Información, 21 (4), 373-387. DOI: http://doi.org/10.1057/ejis.2011.52.

[49] Gerow, J.E., Thatcher, J.B. y Grover, V., 2015. Seis tipos de alineación estratégica de negocios de TI: una investigación de los constructos y su medición. Revista Europea de Sistemas de Información, 24 (5), 465-491. DOI: http://doi.org/10.1057/ejis.2014.6.

[50] Gerow, J.E., Grover, V., Thatcher, J. y Roth, P.L., 2014. Mir&o hacia el futuro de la alineación estratégica de TI y negocios a través del pasado: un metaánalisis. MIS Quarterly, 38 (4), 1159-1186.

[51] Henderson, J.C. y Venkatraman, N., 1993. Alineación estratégica: aprovechamiento de TI para transformar organizaciones. Revista de sistemas de IBM, 32 (1), 472-484.

[52] Chan, Y.E. & Reich, B.H., 2007. IT Alignment: what have we learned?. Journal of Information Technology, 22 (4), 297-315. DOI: http://doi.org/10.1057/palgrave.jit.2000109.

[53] ISACA., 2023. COBIT 19 Framework: Governance & Management Objectives. https://www.isaca.org/resources/cobit. (Accessed 4 March 2023).

[54] Huygh, T., De Haes, S., Joshi, A., & Grembergen, V., 2018. Answering Key Global IT Management Concerns Through IT Governance & Management Processes: A COBIT 5 View. In: *Proceedings of the 51st Hawaii International Conference on System Sciences*, 5335-5344

[55] Fernández, A., Carbonell, S., Pérez, Y., y Villalón, T., 2009. Las Ontologías. Nuevos retos. En: *Trabajo presentado en IX Congreso ISKO-España, Valencia*, 355 - 379

[56] Moyano, J., 2013. La Descripción Archivística. De los instrumentos de descripción hacia la Web Semántica. Anales de Documentación, 16 (2). DOI: https://doi.org/10.6018/analesdoc.16.2.171841.

[57] Hurley, C., 2004. Relationships in Records. In: *Monash University. Information Technology. Research. Groups. Rcrg. Publications*

[58] García-González, M.S., 2016. Administración electrónica: por qué implantar una política de gestión de procesos institucionales en las administraciones públicas. Profesional De La información, 25 (3), 473–484. DOI: https://doi.org/10.3145/epi.2016.may.17.

[59] Adreu, J. y Nolla, S., 2009. El sistema de gestión documental de la Universidad de Barcelona en el marco de la Administración electrónica: Un elemento más para fomentar la mejora continua. Bid: Textos Universitaris de biblioteconomia i documentació (23).

[60] Lee, T., Hon, C.T. & Cheung, D., 2009. XML Schema Design & Management for E-government Data Interoperability. Electronic Journal of E-government, 7 (4), 381-390.

[61] Choudrie, J. & Weerrakody, V., 2007. Horrizontal Process Integration in E-government: The perspective of UK Local Authority. International Journal of Electronic Government Research, 3 (3), 22-39.

[62] Muthaiyah, S. & Kerschberg, L., 2008. Achieving Interoperability in E-government Services with two Modes of Semantic Bridging: SRS & SWRL. Journal of Theoritical & Applied Electronic Commerce Research, 3, (3), 52-63.

[63] Saekow, A. & Boonmee, C., 2009. A Practical Approach to Interoperability Practical Implementation Support (IPIS) for E-government Interoperability. Electronic Journal of E-government, 7, (4), 403-414.

[64] Wimmer, M. A. 2002. Integrated Service Modelling for Online One-Stop Government. Electronic Markets, 12 (3), 149-156.

[65] Salhofer, P., Stadlhofer, B. & Tretter, G. 2009. Ontology Driven E-government. Electronic Journal of E-government, 7 (4), 415-424.

[66] Sabucedo, L.M.A., Rifon, L.E.A., Corradini, F., Polzonetti, A. & Re, B. 2010. Knowledge-based Platform for E-government Agents: A Web-based Solution Using Semantic Technologies. Journal of Expert Systems with Applications, Elsevier Inc., 2010 (37), 3647-3656.

[67] Apostolou, D., Stojanovic, L., Lobo, TP., Miro, J.C. & Papadakis, A. Configuring E-government Services Using Ontologies. IFIP International Federation for Information Processing, Springer Boston, 2005 (189), 1571-5736.

[68] Sanati, F. & Lu, J., 2009. Multilevel Life-event Abstraction Framework for E-government Service Integration. In: *Proceedings of the 9th European Conference on E-government (ECEG 2009)*, London, UK, 550- 558.

[69] Xiao, Y., Xioa, M. & Zhao, H., 2007. An Ontology for E-government Knowledge Modelling & Interoperability. In: *Proceedings of IEEE International Conference on Wireless Communications, Networking & Mobile Computing, (WiCOM 2007)*, Shanghai, 3600-3603, 21-25 September, 2007.

[70] Gómez-Pérez, A. & Benjamins, V.R., 1999. Overview of knowledge Sharing & Reuse Components: Ontology & Problem-Solving Methods. In: *Proceedings of the IJCAI-99 workshop on Ontologies & ProblemSolving Methods (KRR5)*, Stockholm, Sweden, 1-15, 2 August, 1999.

[71] Uschold, M., 1996. Building Ontologies: Towards a Unified Methodology. In: *Proceedings of Expert Systems 96, the 16th Annual Conference of British Computer Society Specialist Group Expert Systems*, Cambridge, UK, 1-18, 16-18 December.

[72] Horridge, M., Knublauch, H., Rector, A., Stevens, R. & Wroe, C., 2004. *A Practical Guide to Building OWL Ontoloies Using the Proteg´ e-OWL ´ Plugin & CO-ODE Tools Edition 1.0*. Research Report, University of Manchester, UK.

[73] Ceccaroni. L. & Kendall, E., 2003. A Semantically-Rich, Graphical Environment for Collaborative Ontology Development en Agentcities. In: *iD3*, Barcelona, Spain, 1-6.

[74] Usero, J.A.M. & Orenes, M.P.B., 2005. Ontologies in the Context of Knowledge Organization & Interoperability in E-Government Services. In: *IRFD World Forum 2005 - Conference on Digital Divide, Global Development & the Information Society*, Tunis, Tunisia, 1-8, 14-16 November.

[75] Calero, C., Ruiz, F. & Piattini, M., 2006. *Ontologies for Software Engineering & Software Technology*. Calero.Ruiz.Piattini (Eds.), Springer-Verlag, Berlin Heidelberg.

[76] Castillo, E., Gutíerrez, J.M. & Hadi, H., 1997. *Expert Systems & Probabilistic Network Models.* Springer, New York.

[77] Durkin, J., 1994. *Expert Systems: Design & Development*. Maxwell Macmillan, New York.

[78] Santos, F. & Work, W., 2019. Sistemas Basados en Reglas. http://www.cs.us.es/~fsancho/?e=103. (Accessed 24 June 2023)

[79] Van, W. & De Haes, S., 2008. *Implementing Information Technology Governance: Models, Practices & Cases*. PA: IGI Global, 270.

[80] Weill, P., Subramani, M. & Broadbent, M., 2002. Building IT Infrastructure for Strategic Agility. MIT Sloan Management Review, 44 (1), 57-65.

[81] Alreemy, Z., Chang, V., Walters, R. & Wills, G., 2016. Critical success factors (CSFs) for information technology governance (ITG). International Journal of Information Management, 36 (6, Part A), 907-916. DOI: https://doi.org/10.1016/j.ijinfomgt.2016.05.017.

[82] Buchwald, A., Urbach, N. & Ahlemann, F., 2014. Business value through controlled IT: toward an integrated model of IT governance success & its impact. Journal of Information Technology, 29 (2), 128-147. DOI: https://doi.org/10.1057/jit.2014.3.

[83] Thabit H., 2021. The Impact of Implementing COBIT 2019 Framework on Reducing of e-Audit. Buhuth Mustaqbaliya Scientific Periodical Journal (49), 1 -23.

[84] Fernández, A., Carbonell, S., Pérez, Y. & Villalón, T., 2009. Las Ontologías. Nuevos retos. En *Trabajo presentado en IX Congreso ISKO-España Valencia*, 355-379.

[85] Iribarren, M., Concha, G., Valdés, G., Solar, M., Villarroel, M. & Gutiérrez, P., 2008. Capability maturity framework for e-Government: A multi-dimensional model & assessing tool. In Wimmer, M.A., Scholl, H. J., & Ferro, E. (Eds), *EGOV 2008, Lecture notes in computer science*. Springer-Verlag, 136-147.

[86] European Commission., 2018. *Artificial Intelligence for Europe*. https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence

[87] Software Engineering Institute (SEI). 2006. *Capability Maturity Model Integration development.* https://www.sei.cmu.edu/

[88] ISO., 2008. *Conjunto de documentos para la introducción y el soporte de la serie de normas ISO 9000: Orientación sobre el concepto de enfoque basado en procesos para los sistemas de gestión (ISO/TC 176/SC 2/N 544R3)*. AENOR, Madrid.

[89] Magoutas, B. & Mentzas, G., 2010. SALT: A semantic adaptive framework for monitoring citizen satisfaction from e-Government services. Expert Systems with Applications, 37(6), 4292– 4300. DOI: https://doi.org/10.1016/j.eswa.2009.11.071.

[90] Yang, H., Liu, J., Chang, M. & Yang, J., 2012. Improving the government service process through a grey relationship broker mechanism. Expert Systems with Applications, 39 (10), 9755–9763. DOI: https://doi.org/10.1016/j.eswa.2012.02.180.

[91] Ministerio de política territorial y Función Pública., 2020. Sistema de Información Administrativa, guía de contenidos. https://administracion.gob.es/pag_Home/espanaAdmon/SIA.html. (Accessed 6 July 2023).

[92] España. Real Decreto 403/2020, de 25 de febrero, por el que se desarrolla la estructura orgánica básica del Ministerio de Asuntos Económicos y Transformación Digital.

[93] Real Decreto 682/2021, de 3 de agosto, por el que se desarrolla la estructura orgánica básica del Ministerio de Hacienda y Función Pública y se modifica el Real Decreto 139/2020, de 28 de enero, por el que se establece la estructura orgánica básica de los departamentos ministeriales.

[94] España. Orden HFP/862/2021, de 29 de julio, por la que se regula la composición y funciones de la Comisión Ministerial de Administración Digital del Ministerio de Hacienda y Función Pública.

[95] Wilson, C. & Van der Velden, M., 2022. Sustainable AI: An integrated model to guide public sector decision-making. Technology in Society, 68, DOI: https://doi.org/10.1016/j.techsoc.2022.101926

[96] Ministerio de política territorial y Función Pública (2020). Sistema de Información Administrativa, guía de contenidos. https://administracion.gob.es/pag_Home/espanaAdmon/SIA.html.

[97] Muñoz García, A., Lamolle, M., Martinez-Béjar, R. & Espinal Santana, A., 2019. Learning Ecosystem Ontology with Knowledge Management as a Service. In *Computational Collective Intelligence. ICCCI 2019*; Nguyen, N., Chbeir, R., Exposito, E., Aniorté, P., Trawiński, B., Eds.; Lecture Notes in Computer Science; Springer: Berlin/Heidelberg, Germany, 2019; p. 11684.

[98] García-González, M.S., Paniagua-Arís, E., Martínez-Béjar, R., López-Caballero, J.A. & Gasparetto, A., 2023. An Artificial Intelligence-Based Model for Knowledge Evaluation & Integration in Public Organizations. Appl. Sci., 13, 11796. https://doi.org/10.3390/app132111796.

[99] Australian Government Information Management Office (AGIMO)., 2006. *Delivering Australian Government Services: Service delivery capability model.* https://catalogue.nla.gov.au/catalog/3752142.

[100] Government of Canada, 2000. *E-Government capacity checkdiagnostic tool*. https://www.tbs-sct.canada.ca/emf-cag/risk-risques/tools-outils-eng.asp.

[101] Cresswell, A., Pardo, T. & Canestraro, D., 2006. Digital capability assessment fore-Government: A multi.dimensional approach. In Wimmer, M.A. et al., (Eds), *Lecture notes in computer science*, Vol. 4084, 293

[102] Makolm, J., 2006. A holistic reference framework for e-Government: The practical proof of a scientific concept. In *Proceedins of the 39th annual Hawaii international conference on system sciences*. Washington: DC IEEE Computer Society, 77-85.

[103] Cresswell, A.M., Pardo, T.A., & Hassan, S., 2007. Assessing capability for justice information sharing. In *Proceedings of the 8th annual international conference on digital government research.* Philadelphia, PA: Digital Government Society of North America, 122- 130.

[104] United Nations, & American Society for Public Adminsitratiton (UN & ASPA)., 2002. *Benchmarking e-Government: A global perspective*. New York: United Nation.

[105] &ersen, K.V. & Henriksen, H.Z., 2006. E-Government maturity models: Extension of the Layne & Lee model. In *Government information quarterly*. 23 (2), 236-248. https://doi.org/10.1016/j.giq.2005.11.008.

[106] Gottschal, P., 2009. Maturity levels for interoperability in digital government. *Government information quarterly*. 26 (1), 75 – 81 http://org/10.1016/j.giq.2008.03.003.

[107] Klievink, B., & Janssen, M., 2009. Realizing joined-up government – dynamic capabilities & stage models for transformation. *Government information quarterly*, 26 (2), 275-284. https://.org/10.1016/j.giq.2008.12.007