# Reference Framework for the Enterprise Architecture for National Organizations for Official Statistics: Literature Review

***Abstract*** - Enterprise Architecture Frameworks (EAF) play a crucial role in organizations by providing a means to ensure that the standards for creating the information environment exist and they are properly integrated, thus enabling the creation of Enterprise Architectures (EA) that represent the structure of components, their relationships, principles and guidelines with the main purpose of supporting business. The increase in the variety and number of Information Technology Systems (ITS) in organizations, increasing their complexity and cost, while decreasing the chances of obtaining real value from these systems, makes the need for an EA even greater. This issue is very critical in organizations whose final product is information, such as the National Organizations for Official Statistics (NOOS), whose mission is to produce and disseminate official statistical information of the respective countries. Historically, NOOS have individually developed business processes and similar products using ITS that are not similar, thus making it difficult to produce consistent statistics in all areas of information. In addition, over the years, the NOOS adopted a business and technological structure and model that entails high maintenance costs that are becoming increasingly impractical and the delivery model inexcusable, and the current EAFs are not properly optimized to deal with these problems. NOOS are being increasingly challenged to respond quickly to these emerging information needs. We carried out this research through a literature review and a body of information pertinent on the topic was collected, which allowed us to demonstrate that, in order to respond to these challenges, it is necessary to have a holistic view of ITS through the definition of an EA using a reference EAF among the current ones or a new one, built from scratch.

***Keywords* -** Enterprise Architecture; IS Architecture; IT Systems; Official Statisticas.

## I. INTRODUCTION

Undoubtedly, the cost and complexity of ITS have increased exponentially in recent times, while the chances of getting real value from these systems have drastically decreased, requiring EA (also more complex) to satisfy the information needs of organizations. This situation introduces an additional degree of complexity in the practice of managing and maintaining ITS to ensure its alignment with the organizations' business, a factor that continues to be seen as of vital importance by IT professionals and business managers in maximizing the contribution of Information Systems (IS) investments. The NOOS, the governing bodies of national statistical systems, are not immune to this problem. Over the years, through many iterations and technological changes, they built their organizational structure and production processes, and consequently their statistical and technological infrastructure. Meanwhile, the cost of maintaining this business model and associated asset bases (process, statistics, technology) is becoming insurmountable and the delivery model unsustainable [1]. For most NOOSs, the underlying model for statistical production is based on sample surveys, but increasingly, organizations need to use administrative data or data from alternative sources to deliver efficiencies, reduce provider burden, and make richer use of existing information sources [1]. This requires significant new EA features that are not available on the vast majority of NOOSs. The absence of these resources makes it difficult to produce consistent statistics in all domains of information. NOOS are being increasingly challenged to respond quickly to these emerging information needs. The advent of EAFs over the past few decades has given rise to a view that business value and agility can best be realized through a holistic approach to EA that explicitly examines every important issue from every important perspective [2]. Similarly, Zachman, early in the EA field, stated that the costs involved and the success of the business, which increasingly depend on its IS, require a disciplined approach to managing these systems [3]. The need for an architectural vision for the IS of the NOOS, which allows a holistic conceptualization of their reality and which allows dealing with each situation in particular regardless of the IS solutions implemented in it, is thus justified by the need for tools that allow not only the representation of its reality, in order to understand the whole, as well as to examine how its constituent parts interact to form this whole. It is from this evidence of the facts that the need for a new EAF for the NOOSs can be understood.

## II. THE OFFICIAL STATISTICAL INFORMATION

Official statistical information (or official statistics) provides the quantitative basis for the development and monitoring of government social and economic policies [4]. This information is essential for economic, demographic, social and environmental development and for mutual knowledge and trade between states and peoples of the world [5]. For this purpose, official statistics that pass the practical utility test must be compiled and made available impartially by NOOS to honor citizens' right to public information [6]. There are many examples where good quality data are essential for decision making, such as participation and performance in education, health statistics (morbidity, mortality rates, etc.), crime and incarceration rates, tax information, etc. Statistical data are almost invariably representative at the national level, because it is obtained from complete censuses or large-scale national sample surveys, and generally seek to present definitive information in accordance with international definitions and classifications or other well-established conventions [6].

However, building a capacity to systematically produce relevant, current, reliable, comprehensive and internationally comparable statistics is a challenge for all countries. In this context, institutions involved in the production of statistics must rely on the use of international standards, without which the comparability of data produced by different NOOS, within a country and between countries, would be impossible. Its practical implementation is strongly aligned and supported by the Generic Statistical Business Process Model (GSBPM – Generic Statistical Business Process Model) [7].

## III. STANDARDS FOR SUPPORTING THE OFFICIAL STATISTICS PRODUCTION

During the last decades, official statistical production has been undergoing a process of modernization and industrialization conducted internationally. In this regard, the most distinctive initiative is the activities of the High-Level Group for the Modernization of Official Statistics (HLG-MOS) of the United Nations Economic Commission for Europe [8]; being responsible for the development of the following reference models: GSBPM [9], Generic Statistical Information Model (GSIM) [10] and the Common Statistical Production Architecture (CSPA) [11]. To these models is also added the Generic Activity Model for Statistical Organizations (GAMSO) [12]. The GSBPM describes and defines the set of business processes required to produce official statistics and provides a standard framework and harmonized terminology to help statistical organizations modernize their production processes as well as share methods and components [9]. Figure 1 shows the phases of the GSBPM.

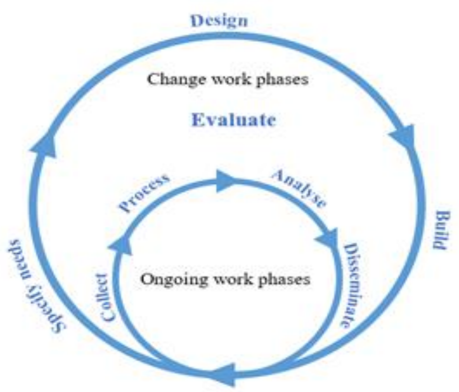


Figure 1: Phases of the GSBPM

In addition to the processes, we also have the information that flows between them (data, metadata, rules, parameters, etc.). The GSIM aims to define and describe these information objects in a harmonized way [13]. GSIM and GSBPM are complementary models for the production and management of statistical information. The GSBPM models statistical business processes and identifies the activities carried out by the producers of official statistics resulting in information outputs [10]. These activities are divided into sub-processes, such as “edit and impute” and “calculate aggregates”. As shown in Figure 2, GSIM helps to describe the GSBPM sub-processes by defining the information objects that flow between them, that are created in them, and that are used by them to produce official statistics [10].

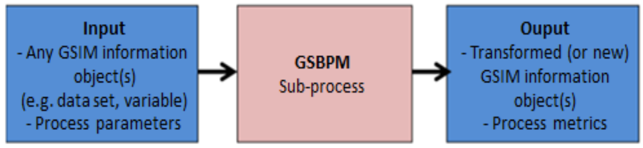


Figure 2: Relationship between GSIM and GSBPM [10]

The CSPA is a set of design principles that allow NOOS to develop components and services for the statistical production process, in a way that allows these components and services to be easily combined and shared between organizations, regardless of the underlying technology platforms [14]. In this way, CSPA aims to provide “industry architecture” for official statistics. In addition to the achievements made with the GSBPM, GSIM and CSPA standards, to support greater collaboration between NOOS, it is equally important to cover all typical activities of a statistical organization to improve communication within and between these organizations, introducing a common and standard terminology. This is the task of GAMSO [15]. The following diagram shows the position of GAMSO in relation to other standards for international collaboration.

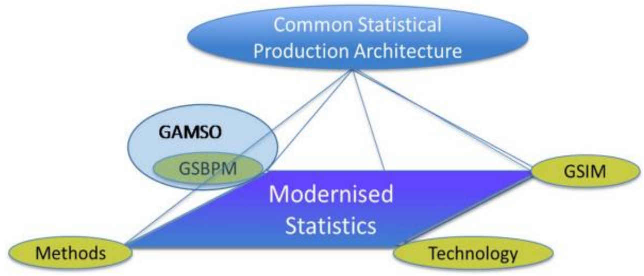


Figure 3: Relationship between GAMSO, GSBPM, GSIM and CSPA [15]

All of these are measures to industrialize the statistical production process by proposing standard tools for the many aspects of this process. In general, they all follow a top-down approach, through which generic proposals are made that do not take into account specific methodological details of production [16]. As an immediate positive consequence, NOOS can find a direct adaptation of these standards to their particular processes and the statistical production is more easily comparable in the international domain and, therefore, susceptible of standardization to a certain extent. However, NOOS have been developing their own business processes and ITS to create statistical products [1]. While products and processes are conceptually very similar, individual solutions are not; each technical solution was built for a very specific purpose, with little regard for the ability to share information with other adjacent applications in the statistical cycle, and with limited ability to handle similar but slightly different processes and tasks [1]. To this, Gjaltema [1], considers "accidental architecture", as the process and solutions were not conceived from a holistic view (Figure 4).

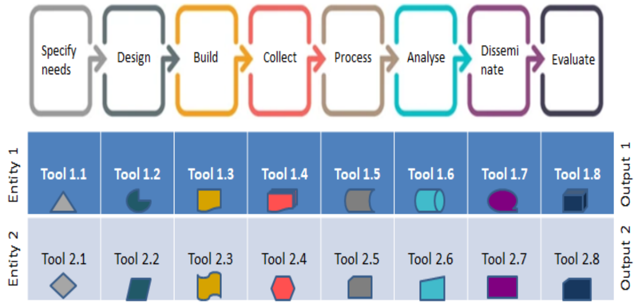


Figure 4: NOOS *status quo*

In Figure 5, two entities producing official statistics (NOOSs, local delegations or delegated bodies) have totally different technological concepts in the same stages of the statistical production process (e.g., using the GSBPM). As a result, outputs 1 and 2 will never be comparable, which jeopardizes the quality of the information produced and, consequently, the decisions taken, not only nationally, but also internationally. In terms of cost, columnist Bob Lewis has shown that in these situations, during initial IT implementations, the managed architecture is slightly more expensive than the rugged one, but over time, the cost of this one increases exponentially compared to the first one [17] (see Figure 5). This same idea is shared by Sjöström et al. [18] (see Figure 6).

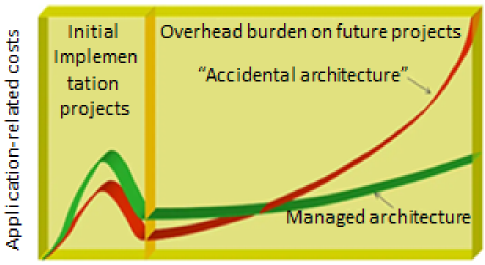


Figure 5: Total IT functionality delivered to enterprise [17]

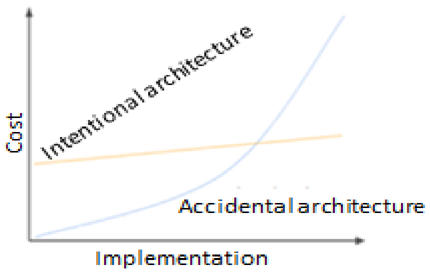


Figure 6: Architecture cost [18]

This means that NOOSs find it difficult to produce and share data across systems in line with modern standards (e.g. Data Documentation Initiative (DDI) and Statistical Data and Metadata eXchange (SDMX)), even with new production support standards (GSBPM, GSIM, CSPA and GAMSO). In short, the *status quo* of NOOSs is characterized by:

- complex and costly systems;
- difficult to keep those increasingly expensive systems aligned with NOOS's needs;
- rigid processes and methods; and
- inflexible aging technology environments.

## IV. ENTERPRISE ARCHITECTURE FRAMEWORKS

EAF define how to organize the structure and perspective associated with EA [19]. EA, in turn, represents the architecture in which the system in question is the entire company, especially the company's business processes, technologies and IS [20]. These components are EA artifacts that can be defined as specific documents, reports, analyses, models or other tangible items that contribute to an architectural description [20], i.e., providing a holistic view for developing solutions. Thus, an EAF collects tools, techniques, artifact descriptions, process models, reference models and guidance used in the production of specific artifacts. This includes innovations in an organization's structure, the centralization of business processes, the quality and timeliness of business information, or ensuring that the money spent on IT investments can be justified [19]. Over the past three decades, many EAFs have emerged (and others have disappeared) to deal with two major problems: the increasing complexity of IT systems and the increasing difficulty in getting real value out of these systems [20]. As we can imagine, these problems are related. The more complex a system the less likely it is to deliver the expected value to the business. By better managing complexity, it increases the chances of adding real value to the business. Current literature highlights the following EAFs: Zachman's Framework, The Open Group Architecture Framework (TOGAF), Federal Enterprise Architecture (FEA), Value Realization Framework (VRF) along with Simple Iterative Partitions (SIP) or VRF/SIP, Department of Defense Architecture Framework (DoDAF), Integrated Architecture Framework (IAF), and two techniques developed in the academic context, which are Enterprise Knowledge Development (EKD) and Resources, Events and Agents (REA) [20][21]. Nowadays, the criteria for the selection of the main EAFs is based on two perspectives:

- widely used and highly rated EAFs; and
- EAFs that support mobile IT/cloud computing and web service elements, which are crucial requirements of current IS.

According to research in the Journal of Enterprise Architecture, Cameron and McMillan [22], from the perspective of the "widely used" criteria, TOGAF, Zachman, Gartner, FEA, and DoDAF are the most widely used, and it was decided that TOGAF, FEA, and DoDAF are "highly rated". Sessions [2] also, in his study, states that Zachman, TOGAF, FEA and Gartner are the most commonly used EAF. From this last list, Mora et al. [23], replace Gartner with DoDAF for the same perspective (widely used). In the second criterion for the selection of the EAF, “integration with the basic structure of mobile IT/cloud computing and services”, Gill et al. [24] argued that FEA, TOGAF, Zachman, and the Adaptive Enterprise Architecture Framework are adequate. Given these facts, we found that only the frameworks of Zachman, TOGAF and FEA stand out in the two perspectives considered. For this reason, they are of interest to our study. The Zachman

Framework provides a means of ensuring that the standards for creating the information environment exist and are properly integrated [25]. It is a taxonomy for organizing architectural artifacts that takes into account both who the artifact is aimed at and the specific problem being addressed [20]. These two dimensions allow the classification of the resulting artifacts, allowing any organization to obtain all types of possible artifacts. However, Zachman alone is not a complete solution. There are many issues that will be critical to the company's success that Zachman doesn't address. For example, Zachman doesn't give us a step-by-step process for creating a new architecture, and it doesn't even help us decide if the future architecture we're creating is the best possible one [20]. Furher, Zachman doesn't give us an approach to show the need for a future architecture [20]. For these and other questions, we'll need to look at other frameworks. TOGAF describes itself as a “framework”, but its most important part is the Architecture Development Model (ADM) which is a process to create an architecture [20]. Since ADM is the most visible part of TOGAF, we categorized it as an architectural process rather than an architectural framework like Zachman. Viewed as an architectural process, TOGAF complements Zachman, which is taxonomy. It should be noted, however, that TOGAF is not linked to government organizations [26][27]. As for the FEA, it was developed specifically for the federal government and offers a comprehensive approach to the development and use of architectural endeavors in federal government agencies [28] and is recognized as a standard for state institutions [29], unlike Zachman and TOGAF which are generic. FEA is the most complete of the three frameworks under discussion, i.e., it has a comprehensive taxonomy, like Zachman, and it also allows for the development of these artifacts, providing a process for doing so, like TOGAF [20]. There is, however, an important criticism of the FEA. In 2010, the Federal Council of CIO (Chief Information Officers) raised some problems in relation to FEA, such as [30]:

- lack of a common and shared understanding;
- confusion about what EA is; and
- issues associated with FEA compliance reports.

Participants recognized that it was time for a change. And, in general, a series of constraints in the implementation of EA are pointed out, such as the lack of clarity of its functions, ineffective communication, low maturity and commitment of EA and its tools [31]. These challenges were attributed to three root causes: the ambiguity of the EA concept, the difficult terminology, and the complexity of EA frameworks.

## V. FRAMEWORK FOR NOOS

As soon as we have briefly described the three most important frameworks, and presented their limitations, we will now discuss the essential characteristics of the solution proposed for NOOS. From the description of the EAFs above, we concluded that with any of the three frameworks (Zachman, TOGAF and FEA) it is possible to define how to create and implement an EA, providing the principles and practices for its description. Recognition of this reality is important because it allows any organization, public or private, including NOOS, to be aware of the specific needs that EAs must support, as well as to alert to the need for a sustained development of ITS. However, for NOOS, special attention must be considered, taking into account their public nature, which at the same time requires a lot of rigor in the execution of statistical surveys, respecting all phases of the GSBPM. For this type of organizations, it is crucial to define a global EA, integrating all the entities involved in the statistical processes and, for that, it is necessary to adopt an EAF that supports this business model, which includes the implementation of ITS solutions in multiple statistical cycles while the process is performed by multiple entities. As we saw earlier, Zachman and TOGAF have some limitations to build an EA (although they can be used together in a blended approach) especially in NOOS (they are not linked to government organizations). In a comparative study carried out by Sessions and DeVadoss [20] between Zachman, TOGAF, FEA and VRF/SIP, considered the most important in that study, and using criteria such as information availability, business focus, governance orientation, reference model orientation, prescriptive catalogue, maturity model, among others, and in particular the criterion of the maturity model, FEA was considered the best [20]. The maturity model refers to how much guidance the framework provides to assess the effectiveness and maturity of different organizations in the use of EA [20]. This feature is important for NOOS since different entities are involved in the statistical production process and it is interesting to assess their effectiveness and maturity in the use of EA [32]. Furthermore, FEA is the most complete of the three most important EAFs (it has mechanisms not only to classify artifacts, but also to develop them), as we saw earlier. It was also seen that FEA is a standard framework for state organizations, which NOOS fall under. By presenting all these characteristics, which are favorable to NOOS, FEA seems suitable for NOOS, despite being tainted by the problems raised by the Federal Council of CIO [30]. Therefore, to take advantage of these potentials, we recommend, as the first option, the creation of a reference EAF based on FEA, with better approaches in the following fields: common and shared understanding of the EA, compliance reports, clarity of the EA concept, and simplification of terminology and structures of EA. This approach, for official statistics, is also supported by Alturas, Isabel and Nhabomba [32]. The second option that we propose is the creation of a new EAF, from scratch, and specific to the official statistics industry. This option would somewhat use a blended approach, consisting of fragments of each of the EAFs that provide the most value in their specific areas. These fragments would be obtained by rating the EAFs taking into account the criteria considered important on a case-by-case basis. This approach can be explained in the following table:

Table 1: Criteria and ratings for each framework

| | Rating | | | |
|---|---|---|---|---|
| **Criteria** | Zachman | TOGAF | FEA | Others |
| Criteria 1: maturity model | Z1 | T1 | F1 | O1 |
| Criteria 2 | Z2 | T2 | F2 | O2 |
| Criteria 3 | Z3 | T3 | F3 | O3 |
| Criteria 4 | Z4 | T4 | F4 | O4 |
| Criteria 5 | Z5 | T5 | F5 | O5 |
| Criteria N | ZN | TN | FN | ON |

Here, it is recommended that the criterion “maturity model” and the three frameworks (Zachman, TOGAF and FEA) are always present in the evaluation; the maturity model for being characteristic of NOOS and the three frameworks for being the most important. At the end of this exercise, the result will be a new EAF that consists of fragments from each of the top rated frameworks. This will be the most suitable framework for NOOS and its implementation will require a broad perspective on all selected frameworks and expertise in helping companies create a framework that works better, given the specific needs and political realities of that company.

## VI. CONCLUSIONS

In this article, we demonstrated the need for a new framework for enterprise architecture for NOOS as these organizations have historically developed technical solutions without any holistic perspective, i.e., solutions developed individually for very specific purposes, with little consideration for the ability to share information, resulting in an accidental architectures, which propitiates complex and costly expensive systems, difficult to keep those systems aligned with NOOS's needs, rigid processes and methods, and inflexible aging technology environments. To address these problems, two possible solutions were proposed. Before conceiving these solutions, we first selected the best frameworks, based on two criteria, which are “widely used and highly rated EAFs” and EAFs that support mobile IT/cloud computing and web service element”, and three of them (Zachman, TOGAF and FEA) proved to be the best. Then we presented the first solution that is a reference framework based on FEA to take advantage of its potential related to the fact that it is more complete than the other two frameworks, it is a standard for state organizations, and it works better with the maturity model, an important feature for NOOS. We recommended that this first option should have better approaches in the fields related to common and shared understanding of AE, compliance reporting, clarity of AE concept, simplification of terminology and structures of EA. The second solution is a new EAF, resulting from a blended approach, consisting of fragments of each of the EAFs that provide the most value in their specific areas. In this second option, we recommended that the criterion “maturity model” and the three most important frameworks must always be present in the evaluation; the first for being peculiar to NOOS and the three frameworks for being the most important. In the future, we will continue this research, providing a concrete proposal for a new EAF for NOOS, following one of the suggested solutions.

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