Computer Science and Information Systems 22(3):815–837 https://doi.org/10.2298/CSIS240729017M

PI2M-ITGov – Panel of Indicators for Monitoring and Maintaining the Information Technology Governance: Method and Artefacts

Altino J. Mentzingen Moraes* and Álvaro Rocha

Advance, ISEG, University of Lisbon
Rua Miguel Lupi, nº 20 (Gab. 101)
1249-078 Lisbon, Portugal
altino.moraes{@gmail.com, @gestao.gov.br}
amrrocha@gmail.com

Abstract. In today's highly competitive corporate world, effective management of Information Technology (IT) resources and the consequent need for structured management and governance are essential. Therefore, prior planning of goals, definition of effective actions, and monitoring of results (through Indicators) is the way to apply effective control. This article presents the method named as PI2M-ITGov - Panel of Indicators for Monitoring and Maintaining Information Technology Governance, which covers 12 identified IT Areas and consists of 12 key monitoring indicators (KMIs) and their 36 sub-KMIs (3 sub-KMIs for each 12 identified IT Areas). This method is the result of many years of IT Governance Models implementation expertise of the Authors besides theories presented by both in several Technical Congresses participations. The artefacts created are available at the provided links. The simulation (through a case study) demonstrated a high level of acceptance of the tools as a practical IT Governance alternative.

Keywords: IT Management; IT Governance; Areas of Management of IT; IT Strategic Alignment; MM - Maturity Models; KMI - Key Monitoring Indicators; Case Study; DSR - Design Science Research.

1. Introduction

Organizations can be classified into two distinct domains: 1) Those that utilize information technology (IT) resources for their operations; and 2) Those that serve as providers of IT resources. Figure 1 visually illustrates this division, emphasizing the differentiation between these two domains.

In both cases, even the organizations belonging to the second category (IT resources providers) have an internal administrative area that functions similarly to companies in the first category (IT resources users). This internal administrative area also needs to effectively manage its performance and actions to ensure the success of the overall business.

Consequently, both domains – without exception – make significant investments in IT, which are expected to yield tangible results for the business. Whether operating in the industrial, commercial, or financial sectors, organizations aim to maintain a competitive position in the globalized business environment.

* Corresponding author

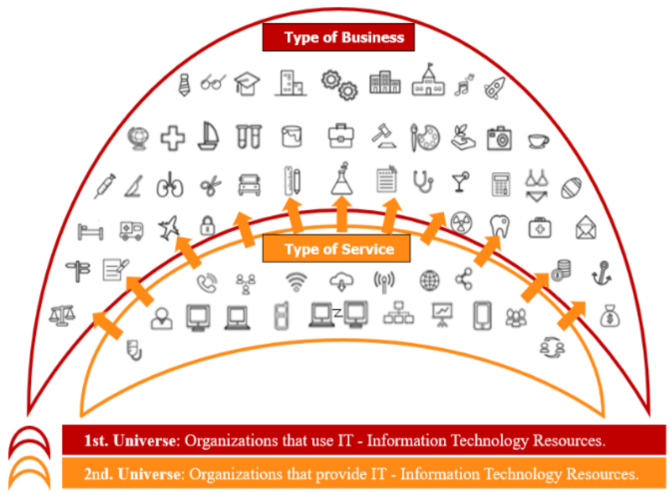


Fig. 1. Enterprise domains

To ensure effective monitoring of IT initiatives and their alignment with the organization's strategic planning, a set of guidelines known as IT governance is implemented.

Peter Weill [41] is one of the prominent authors in the field of IT governance, emphasizing the importance of IT being perceived as a sustainable area that generates results (revenues), rather than merely incurring costs (expenses). According to Weill, IT should strongly focus on 'aligning its initiatives with the business'.

In the words of Rockart [32]:

> *In sum, the load of IT on organizations is heavier than ever before and the management of it is more complex.*

In light of this reality, as highlighted by one of the authors [24] in this research, significant challenges need to be addressed to effectively implement IT governance and strive for high-quality indices. The doctoral thesis presents Figure 2, referred to as the 'puzzle' of the governance process, illustrating these challenges. Overcoming these challenges is essential to successfully implement IT governance and achieve desirable quality metrics.

Consequently, it becomes evident that monitoring IT governance activities requires an initial and meticulous planning phase (structuring), followed by effective management (administration), and rigorous governance (control) processes.

To accomplish this objective, a practical approach is to apply the plan, do, check, act (PDCA) cycle, initially formulated by the American statistician William Edwards Deming. The PDCA cycle is advocated by the author Ruks Rundle [33] and is depicted in Figure 3, adapted here to provide a more operational interpretation.

The problem at hand revolves around how management can effectively apply governance processes, particularly those recommended by IT governance techniques. It is crucial to adopt a proactive approach to administration control, rather than a reactive one, in order to anticipate and prevent misalignments between the actions of the IT de-

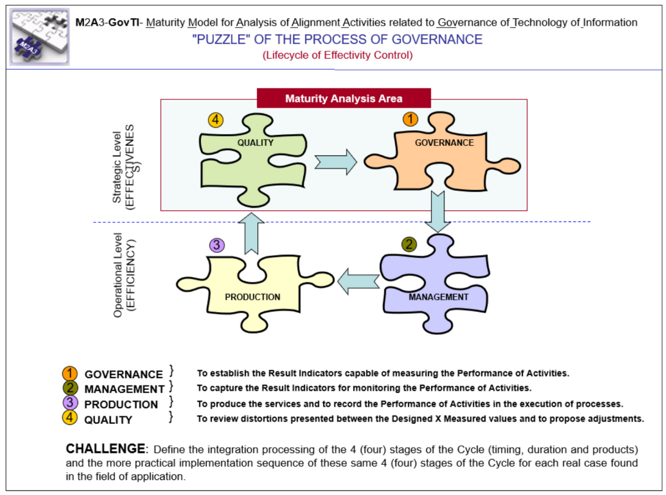


Fig. 2. Process of governance 'puzzle' [24]

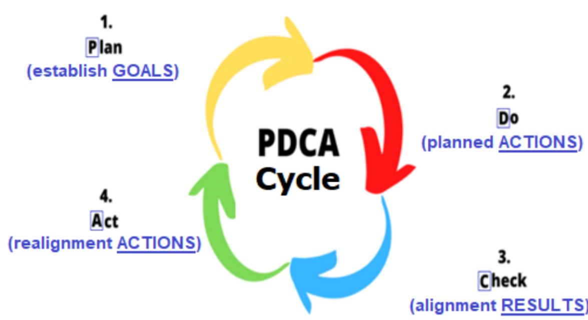


Fig. 3. Plan, do, check, act (PDCA) cycle: adapted by authors from Rundle [33]

partment and the initial planning. Failure to address these misalignments can result in non-compliance with the organization's expected outcomes.

To address this challenge, the panel of indicators for monitoring and maintaining information technology governance (PI2M-ITGov) method, developed through research and presented in this article, aims to fulfill the management's need in this field. It provides a panel of indicators that can measure the degree of alignment between the actions implemented by the IT department and the organization's strategic planning. This enables decision-makers to identify and rectify any distortions, thereby guiding the organization back to the correct course of action.

It is important to inform that this article is the result of a deep revision of one first and initial proposal presented by Moraes & Rocha [25] in a European IT Congress held in the City of Aveiro/Portugal (CISTI'23) – which revision besides other aspects – involved, as the main purpose, the build of artefacts.

Those artefacts were created (such as a spreadsheet, a guideline, forms and other tools), in order to make, this first and initial proposal became from theory to practice in a real operational environment. Their links are provided and mentioned in the context of this paper.

Additionally, it is also important to note that the PI2M-ITGov method ensures the maintenance of confidentiality and privacy of personal data. The method does not handle information that possesses sensitive content or characteristics, thereby safeguarding the privacy of individuals involved.

2. Applied Methodology

This research project is guided by the design science research (DSR) methodology and its principles.

In a broader sense, scientific research involves the practical application of objective procedures by researchers to develop experiments and generate new knowledge that integrates with existing knowledge, as explained by Fontelles [11].

Within the framework of DSR, the development of artefacts plays a crucial role in producing scientific knowledge from an epistemological perspective, as described in Simon's work 'The Sciences of the Artificial' [35].

According to Peffers et al. [27], any designed entity intended to achieve a goal can be considered an artifact. However, the creation of a well-designed artifact and its investigation in a specific context are key elements in knowledge production within scientific research, as emphasized by Dresch, Lacerda & Antunes Jr. [8].

This paper adheres to the process flow of DSR as recommended by Wieringa [42], with graphical adaptations made by the authors, as depicted in Figure 4.

The DSR methodology consists of several cycles, including the design cycle (steps 1, 2, and 3) for conceiving and constructing the solution, and the engineering cycle (steps 3 and 4) for adapting the solution to real-world applicability.

In DSR, one of the objectives of research is to contribute to the knowledge base of the research area. Therefore, it is crucial for researchers to engage with existing knowledge bases to ensure their work provides an original contribution to scientific knowledge, rather than solely focusing on technological advancements [15].

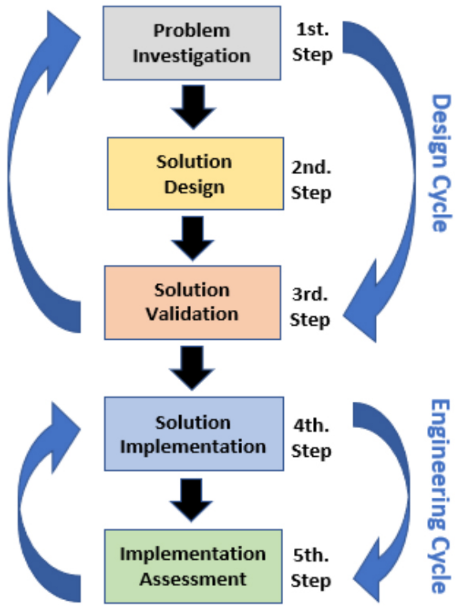


Fig. 4. The design science research flow: adapted by authors from Wieringa [42]

Following the guidelines of step 1 (problem investigation) in DSR, this research aimed to determine if there was a sufficient degree of relevance to justify its development. The investigation sought to identify whether other studies had addressed the problem that needed to be resolved and considered important. The results of this investigation are presented in the subsequent section titled 'problem investigation'.

Within the context of DSR, artefacts can be classified into four types: models (abstractions and representations), methods (algorithms and practices), instantiations (implementations and prototypes), and constructs (vocabularies and symbols).

This research focused on creating artefacts in alignment with the principles of DSR. To ensure their effectiveness in practical application, the research underwent three iterations of the engineering cycle (steps 3 and 4). These iterations aimed to refine the artefacts and adapt them to the realities of corporations.

This clarifies the rationale behind the versioning of the artefacts, which are made available in the provided link in Section 3 ('Solution Validation'). The version indicated as V.01c signifies the third revision of the artifact.

3. Problem Investigation

As mentioned in Section 1, this research aims to address the need for a tool within IT governance that can manage a dashboard to guide the alignment of IT initiatives with corporate strategic planning.

Following the guidelines of the DSR methodology, the research commenced with step 1, ‘problem investigation’. This step aimed to determine whether conducting this research and allocating effort to this task would contribute to advancing scientific knowledge.

To assess the existing literature related to the research objectives, a bibliographic search was conducted. Nine databases were searched, namely ACM, IEEE, MIT, Research Gate, Scholar Google, SciELO, Science Direct, Scopus, and Web of Science (WoS). The search keywords used were ‘IT Governance NOT Social NOT Health NOT Education AND Performance Indicator AND Spreadsheet AND Guideline’. The exclusion criteria of ‘NOT Social NOT Health NOT Education’ were applied to filter out articles not directly linked to the business domain, such as banking/financial, industry, and services.

Of course, the papers those were focused on these 3 areas (Social, Health and Education) and in their business tools, what means no in its final targets as to support Social, Health or Education problems in its main themes, were also considered because, in this interpretation, these can be sort as integrating the areas of banking/financial, industry, and services as well.

Additionally, the search was limited to the last decade (2012–2022) to ensure relevance and up-to-date information.

The initial search in the ACM database yielded only seven occurrences, which did not align with the research focus. Subsequent searches in IEEE, MIT, Research Gate, Scholar Google, and SciELO databases resulted in zero occurrences, while Science Direct yielded only two occurrences. In response to these limited results, two additional databases, Scopus and Web of Science, were searched, but no relevant articles were found.

Detailed information regarding the search results can be found in the ‘1. Problem Investigation/Investigação do Problema’ folder accessible via the following link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

Based on the analysis of these search results, which demonstrated the lack of literature on this specific topic, it became evident that the research should proceed. It was determined that there was a significant gap that could be filled by concluding this research in the planned format. The intention is to generate practical material that can effectively assist IT managers in their work and activities.

4. Solution Design

Following the principles of the DSR methodology, this research project progressed to step 2, ‘solution design’. The objective of this step was to conceptualize and construct the architecture required to address the identified research question.

4.1. The 12 IT Monitoring Areas

As a way of delimiting the scope of this study – among the various existing possibilities – the Theory of Number 12 as described by Tesla [1] [39] which highlights the significance of this ‘magic number’ in various elements of the universe, served as the inspiration for the establishment of a quantitative framework for IT work processes.

[1] Nikola Tesla was a Serbian-Croatian scientist who was known for his important discoveries in the field of electricity. His work was fundamental in improving the transmission of electrical energy.

Since Tesla was one of the most recognized scientists by the Scientific Community in studies related to electricity, and was even a direct competitor of Thomas Edison in his discoveries, the line of work applied by this research – in the composition of the quantity of IT work processes to be studied – followed his "magic number" equal to 12 (instead of being applied other value within another focus of reasoning), also because, Tesla related his "magic number" to many elements of the universe and not only to elements involved with the theme of the electricity.

Following this line of reasoning, IT work processes were organized into 12 IT management areas, which became the focal point for the creation of indicators.

To determine the 12 IT management areas, in addition to delimiting the scope of this study within 12 areas according to Tesla's Theory (as the initial idea already mentioned above), the empirical experience of the Authors (who have each worked in the IT field for almost 5 decades) was considered, as well as a criterion based on the identification of IT work processes that had published and recognized maturity level assessment models was applied.

These 12 areas, which had corresponding maturity level assessment models, were subsequently renamed as IT monitoring areas. For each of these areas, 12 key monitoring indicators (KMIs) were created, with 3 sub-KMIs for each one, resulting in a total of 36 sub-KMIs for the proposed solution (which will be the focus of the following "4.2. The Scope of the 36 Sub-KMIs - Key Monitoring Sub Indicators").

To ensure precision in the analysis, three key monitoring sub-indicators (sub-KMIs) were developed for each of the 12 IT monitoring areas, leading to a total of 36 sub-KMIs within the proposed solution. The data collected to determine the percentages for these 36 sub-KMIs were derived from aligning the results with the highest maturity levels (ranging from 3 to 5) identified in the considered maturity level assessment models.

The research process involved the application of technical and professional knowledge by one of the authors, combined with the principle of empiricism, as described by Locke [22]. This approach allowed for an analysis of the data to determine whether the maturity level assessment models under investigation could be aligned with an IT management area, which in this case is referred to as IT monitoring areas.

Even when the framework which the maturity level assessment models was based could have more than just one IT area focus it was considered, to make possible the application of the idea behind this proposed study and its resulted model, its main focus (e.g.: CobiT® mentioned in the sequence of this paper).

Despite the availability of 26 maturity level assessment models, the aim was to maintain the framework within the limit of 12 IT monitoring areas. Detailed descriptions of these models can be found in the '2. Solution Design/Projeto da Solução' folder in the provided link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

These findings led to the determination of the 12 IT monitoring areas considered by the PI2M-ITGov. It is important to note that the references listed at the end of this work provide the foundational understanding for readers. However, additional literature was also researched to support the continuation of this study.

Two significant maturity models identified were ITIL® (Information Technology Infrastructure Library) by Axelos [3] and ITSCMM© (Information Technology Service Capability Maturity Model) by Clerc & Niessink [6]. Both of these models pointed towards a set of assessments that could be categorized under a services management area, which was subsequently renamed as the services monitoring area.

Furthermore, the CMMI© (Capability Maturity Model Integration) of the SEI® [34], the Software Engineering Institute, as referenced by [1], and with strong alignment with the Technical Standard 15.504 ISO/IEC [18], along with the MR MPS br© (Reference Model for Improvement of the Brazilian Software Process [*Modelo de Referência para Melhoria do Processo de Software Brasileiro*]) by SOFTEX [36], were also investigated. After conducting the research, these models were classified as relevant to the development management area, which was then renamed as the development monitoring area.

The research also investigated the CobiT® (Control Objectives for Information and Related Technology Maturity Model) from ISACA [17], referenced by Gartner [12], and found that it specifically addresses the management of IT work processes. Similarly, the TOGAF©(The Open Group Architecture Framework) from the OPEN GROUP was identified as relevant to the same area. Both models were categorized under a business management area, which will be renamed as the business monitoring area.

The exploration of the B-ITa©(Business–IT Alignment Maturity Model) by Tapia, Daneva, Eck & Wieringa [38], EAG©(Enterprise Architecture Governance) by CIOIndex [5], and ITGAP©(IT Governance Assessment Process) by Peterson [28] highlighted the need for a governance management area specifically linked to IT. This area will be renamed as the governance monitoring area in the context of this research.

The research also encompassed maturity models such as MMGP©(Project Management Maturity Model) by Prado [30], OPM3©(Organizational Project Management Maturity Model) from PMI® [29], PMMM©(Project Management Maturity Model) by Kerzner [19], and P3M3©(Portfolio, Program, and Project Management Maturity Model) by Axelos [4]. These models were associated with project management, leading to the identification of a projects management area, which will be renamed as the projects monitoring area.

The investigation revealed a maturity model called OKA©(Organizational Knowledge Assessment) presented by Fonseca [10], which mentioned the use of a software application called SysOKA©(OKA – Organizational Knowledge Assessment System). This model was classified as relevant to the knowledge management area, which will be renamed as the knowledge monitoring area for the purpose of this work.

The maturity models SIMM©(Service Integration Maturity Model) by [2] and SOAMM©(SOA©Maturity Model) by Sonic [37] were evaluated and identified as relevant to the integration management area, which will be renamed as the integration monitoring area.

During the assessment of maturity models, the research identified the requirements management area, which will be renamed as the requirements monitoring area, through the exploration of the RMM©(Requirements Management Maturity Model) by Heumann [14].

Further analysis of maturity models included the BPMM© (Business Process Maturity Model) from OMG [26] and the BPMMM©(Business Process Management Maturity Model) referenced by Tapio Hüffner [16]. These models were associated with the processes management area, which will be renamed as the processes monitoring area.

Additionally, the EFQM©[9], the European Foundation for Quality Management and the Six-Sigma©Maturity Model described by Prasad[31], were evaluated and found to be relevant to the quality management area. This area will be renamed as the quality monitoring area to align with the research terminology.

The research continued with the exploration of two more maturity models: the BSIMM© (Building Security in Maturity Model) from Synopsys [?] and the ISM3©(Information Security Management Maturity Model) from the ISM3 Consortium [7]. Both models were classified under the security management area, which will be renamed as the security monitoring area.

Furthermore, three additional maturity models were researched. The first model, MMAST©(Automated Software Testing Maturity Model) by Mitchel Krause [20], the second model, TMMi©(Test Maturity Model Integration) referenced in the TMMi – Test Maturity Model Integration Foundation [40] link, and the third model, TOM©(Test Organization Maturity Model) by Systeme Evolutif Ltd. [23], were found to be relevant to the tests management area. This area will be renamed as the tests monitoring area.

As a result of these research activities, Figure 5 was created, presenting the identified maturity models that guided the definition of the 12 IT monitoring areas considered by the PI2M-ITGov. Additionally, these 12 IT monitoring areas were categorized into 3 IT monitoring groups for ease of interpretation and application of their activities: the planning monitoring group, the execution monitoring group, and the control monitoring group.

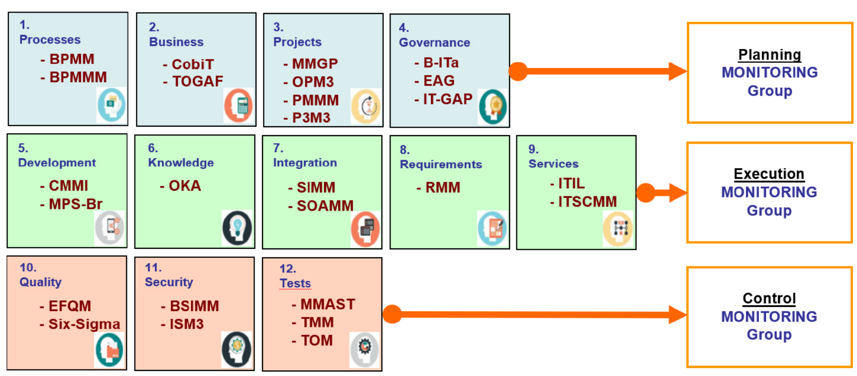


Fig. 5. The 12 monitoring areas considered by the PI2M-ITGov

After conducting the research and evaluating the requirements, it was determined that the KMIs applicable to each of the 12 IT monitoring areas would be established in order to achieve the highest maturity levels (ranging from 3 to 5) of the maturity level assessment models considered.

4.2. The Scope of the 36 Sub-KMIs - Key Monitoring Sub Indicators

The GQ(I)M framework, developed by Goethert & Hayes [13], is widely recognized in the literature as a valuable approach for constructing indicators. This framework follows a structured process consisting of four components: goal, question, indicator, and measurement. Figure 6 exemplifies the workflow of this framework, illustrating its step-by-step approach to indicator construction.

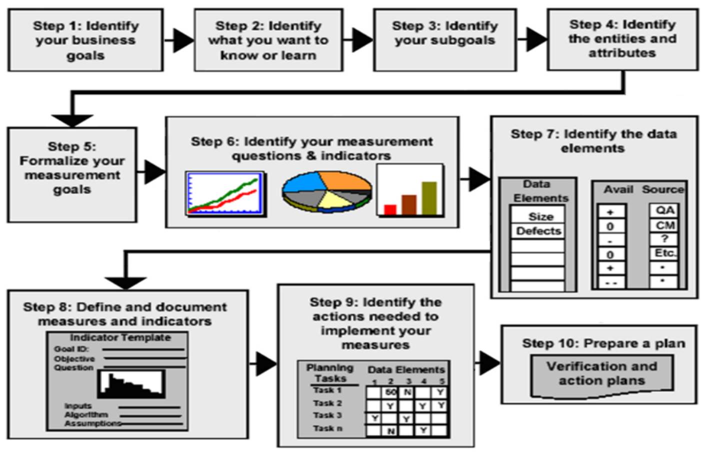


Fig. 6. GQ(I)M – Goal, question, indicator, and measurement [13]

During the synthesis process following the research, it was observed that three requirements were common and essential for attributing the highest maturity levels (ranging from 3 to 5) of the maturity level assessment models considered. These requirements were related to achieving satisfactory performance of activities, complying with schedule and budget, and meeting quality requirements.

These three evaluation criteria also aligned with the proposal put forward by one of the authors [3, p. 180–189] of this research in their doctoral thesis. They suggested reducing the Likert [21] scale, which typically has five levels of evaluation, to just three levels (referred to as the AJMM table) for greater precision in assessment. The three levels of evaluation in the AJMM table were defined as: 1st = Ok, 2nd = Ok with Restriction, and 3rd = Not Ok.

In accordance with the previously mentioned indicator construction technique and the planned approach, the assembly of the three sub-KMIs for each of the 12 IT monitoring areas was carried out as follows: one sub-KMI for the assessment of work results, one sub-KMI for the assessment of delivery commitment, and one sub-KMI for the assessment of customer satisfaction.

The following section presents the content of the three sub-KMIs, which are replicated for each of the 12 identified IT monitoring areas. The placeholder '???' will be replaced by the monitoring area code ranging from 1 to 12:

It is apparent that sub-indicator 1, WR, has the least demanding requirements among the three sub-indicators. Sub-indicator 2, DC, has moderate requirements, as it establishes that the volume of sub-indicator 1, WR, has fulfilled its restriction. On the other hand, sub-

KMI ?? – 1. WR (work result)	=	Percentage of work concluded.
KMI ?? – 2. DC (delivery commitment)	=	Percentage of work concluded and delivered on schedule planned and within the estimated cost.
KMI ?? – 3. CS (customer satisfaction)	=	Percentage of work concluded and delivered on schedule planned and within the estimated cost, which in addition, received the definitive acceptance (and not provisional).

indicator 3, CS, is the most demanding, as it requires the cumulative fulfillment of both the volumes of sub-indicator 1, WR, and sub-indicator 2, DC.

5. Solution Validation

Following the principles of DSR, the next step, step 3, involves 'solution validation'. This step focuses on planning the implementation of the solution designed in step 2.

To calculate the sub-KMI, which represents the resulting data as a percentage for the KMI $\%$, the following equation can be utilized.

$$\left\{\sum \text{inspected numbers} - m\left(\frac{\text{maximum goal} - \text{minimum goal}}{2}\right)\right\} = \times \frac{100\%}{m}$$

where: $\sum = Summationm =$ Average

The '$\sum$ inspected numbers' data implies that it may be necessary to aggregate individual values for the same area/sector or across multiple areas/sectors if the time unit of the maximum goal and minimum goal differs from the volume being inspected for these data.

The maximum goal can be a smaller value than the total of an existing value in practical reality, which will be considered as the expected achievement for the KMI, or it can even be a larger value than the existing total in the real world.

Conversely, the minimum goal can be a greater value than the total of an existing value in practical reality, which will be considered as the accepted achievement for the KMI, or it can even be a smaller value than the existing total in the real world.

It is important to note that both the maximum goal and the minimum goal should be provided as quantitative numerical values rather than percentages. This approach is more feasible and simpler for obtaining this data.

If there are changes in the maximum goal and/or the minimum goal for certain KMIs, these changes should be considered simultaneously within the same time period. This ensures an equal assessment and allows for comparisons across different scenarios.

The balance for all KMIs is determined by the arithmetic average of the maximum goal and the minimum goal, also known as the maximum–minimum average. This average is compared with the 'inspected numbers' data, which enables evaluation of the KMI against this criterion for the entire PI2M-ITGov framework. Based on this comparison, there are two interpretations: A KMI greater than 0 indicates a positive percentage calculated above the maximum–minimum Average, while a KMI smaller than 0 indicates a negative percentage calculated below the maximum–minimum average.

The interpretation of the KMI calculated as 0% would be that the data ‘inspected numbers’ remained exactly at the maximum–minimum average, and therefore, there was no positive or negative result. As a sample of a hypothetical example, we can say that for a maximum goal established as 8 and a minimum goal established as 4, which would result in a maximum–minimum average equal to 6: 1) if the data ‘inspected numbers’ were 6 the KMI would be 0%; 2) if the data ‘inspected numbers’ were 3 the KMI would be –50% which demonstrates a negative result, falling halfway below the maximum–minimum average; 3) if the data ‘inspected numbers’ were 9 the KMI would be 50% which demonstrates a positive result, exceeding the maximum–minimum average by half.

According to this logic, in the case described in the previous paragraph, the percentage of 100% of the KMI would only be calculated when the value of the data ‘inspected numbers’ was equal to 12, which is the sum of the maximum goal and the minimum goal. Under this same logic, positive percentages greater than 100% can be calculated when the value of the data ‘Inspected Numbers’ is greater than 12.

When the value of the data ‘inspected numbers’ is equal to 0, the KMI percentage will be negative and equal to –100%. It is not common or normal for the data ‘inspected numbers’ to have a negative value. However, in certain cases where it is necessary to account for previous poor results or ‘debit’ them in the current evaluation, this scenario could be plausible. In such cases, the KMI will be negative and lower than just 100%.

In some companies that operate in different industries or sectors, the evaluation and score of a specific IT Monitoring Area among the 12 treated areas may be considered more important than the values calculated for the other areas. This prioritization can vary depending on the nature of the business and the specific needs and goals of the company.

For instance, a company in the communication sector (such as a newspaper or magazine) may place greater emphasis on the sub-KMIs focused on knowledge management (IT monitoring area code = KMI 6). Conversely, a company in the financial sector (such as banks or loan institutions) may prioritize the sub-KMIs focused on security management (IT monitoring area code = KMI 11). Similarly, a company in the manufacturing sector (such as a factory or assembly plant) may attach more significance to the sub-KMIs focused on project management (IT monitoring area code = KMI 3).

To account for the varying significance of different KMIs in distinct scenarios, significance weights can be assigned to highlight the importance of one KMI over another during the comparison process. Therefore, the final formula used by PI2M-ITGov for calculating the KMI percentage will be modified to include the application of significance weights (represented as the letter ‘W’ in the equation):

$$\left\{\sum \text{inspected numbers} - m\left(\frac{\text{maximum goal} - \text{minimum goal}}{2}\right)\right\} = \times \frac{100\%}{m} \times W^2$$

or: W^3]

It is important to note that the KMI (final) and its sub-indicators are calculated with one decimal place. This precision is necessary because in decision-making processes, the decimal place can hold significant information that differentiates similar values.

A small spreadsheet has been created to simulate this formula and can be accessed in the folder '3. Solution Validation/Validação da Solução' in the link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

This spreadsheet allows for the exercise of the hypothetical example mentioned earlier, with a maximum goal of 8, a minimum goal of 4, and data 'inspected numbers' of 6, 3, and 9, resulting in KMI percentages of 0%, –50%, and 50%, respectively.

6. Solution Implementation

Step 4 of the DSR, referred to as 'solution implementation', requires exercising the solution theory and implementing the constructed models (from the prior step 3). This involves applying and evaluating the created artefacts (spreadsheet and guidelines) in a real operational environment.

To facilitate the assessment of IT governance in a given situation using the PI2M-ITGov assessment, two artefacts have been developed and are available for use in the folder '4. Solution Implementation/Implementação da Solução' in the link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

These artefacts include the MS® Excel spreadsheet entitled 'PI2M-ITGov - Spreadsheet {V.01c}' Edition=____________+Scenario=____________' and the accompanying guidelines 'PI2M-ITGov - Guidelines {V.01c}'. The guidelines provide instructions on how to complete the spreadsheet and interpret its results.

In the same link, you will also find the form for each KMI, which consists of two frames. The first frame is used to record the goals established during the evaluation planning phase in collaboration with the strategic management department. The second frame is used to record the actual data captured in the field during the execution phase of the PI2M-ITGov evaluation.

To facilitate identification, it is suggested to copy the fields 'Edition' and 'Scenario' from the spreadsheet's header to the file name, which will help in organizing and identifying the content of the spreadsheet in the directory or archive folder.

The layout of the cells in the MS®-Excel spreadsheet follows the predefined order of the 12 IT monitoring areas, divided into the three IT monitoring groups: planning monitoring group, execution monitoring group, and control monitoring group.

The current version of these artefacts, at the time of publication of this article, is V.01c, representing the third revision (letter 'c') of the first version (number '01'). Further updates and improvements may be made available in the same link following subsequent revisions.

The previous revisions (letters 'a' and 'b') were identified during the execution of the fifth and final stage of the DSR, which will be presented in the next topic. This stage involved a case study conducted over three rounds until reaching the current version in the third and final round.

Appendix A of this article presents the four main tabs of the MS® Excel spreadsheet. The first tab displays the data entry cells, while the other three tabs contain graphs for interpreting the results. The 'INSTRUCTIONS' tabs, which provide guidance on data entry and analysis of status icons, are not displayed.

It is important to note that the instructions provided in the 'PI2M-ITGov - Guidelines V.01c' document are based on the results obtained from simulating the implementation of this method in a real corporate environment, as described in Section 7, 'Implementation Assessment'.

Appendix B of this paper showcases the Chronogram (created in MS® Project) used to coordinate the execution of step 4 of the DSR. This chronogram is available in the same link under the folder '4. Solution Implementation/Implementação da Solução'. Although it is already filled, it can be copied and reused, as it provides average duration data for the tasks that can be replicated.

7. Implementation Assessment

In the final step of the DSR, step 5, known as 'implementation assessment', the results obtained from the previous step 4 were interpreted and examined to determine the utility and applicability of the proposed solution from step 3.

To assess the effectiveness of the solution, a simulation was conducted in a Brazilian Government Agency, consisting of three rounds. The outcomes of this simulation were utilized in the development of the guidelines, as mentioned earlier, which can be accessed through the provided link.

The results obtained from the simulation are presented in the spreadsheet titled 'PIM2-GovTI - Spreadsheet V.01c Edition=2021 2nd.Quarter+Scenario=Organizational Restructuring' available in the folder '5. Implementation Assessment/Avaliação da Implementação' in the link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

Additionally, in the same link, a form for each KMI (KMI Form) with two frames is available where the first frame captures the goals defined during the evaluation planning phase in collaboration with the Strategic Management Department, as part of the application of the PI2M-ITGov method. The second frame records the actual data collected in the field from the business areas during the execution phase of the PI2M-ITGov evaluation.

The 3rd. and final round of this simulation, was to evaluate the 2nd. Quarter of the assessment year and, in this quarter, this assessment was performed at a time when the Company was undergoing Organizational Restructuring.

There are comments, in the above Spreadsheet, where this scenario was described and where is possible to be understood that even with this issue the Method could be implemented and retrieve extra-results those were applied to support decision about this Organizational Restructuring in progress.

Following the Chronogram (created in MS® Project) used to coordinate the execution of step 4 of the DSR (which is available in the same link under the folder '4. Solution Implementation/Implementação da Solução' and presented in the Appendix B) this simulation handles the numbers exposed in the Figure 7 when was applied the KMI Form.

Many interpretations, which led the need of immediate corrective actions, could be found analyzing the results in the spreadsheet titled 'PIM2-GovTI - Spreadsheet V.01c

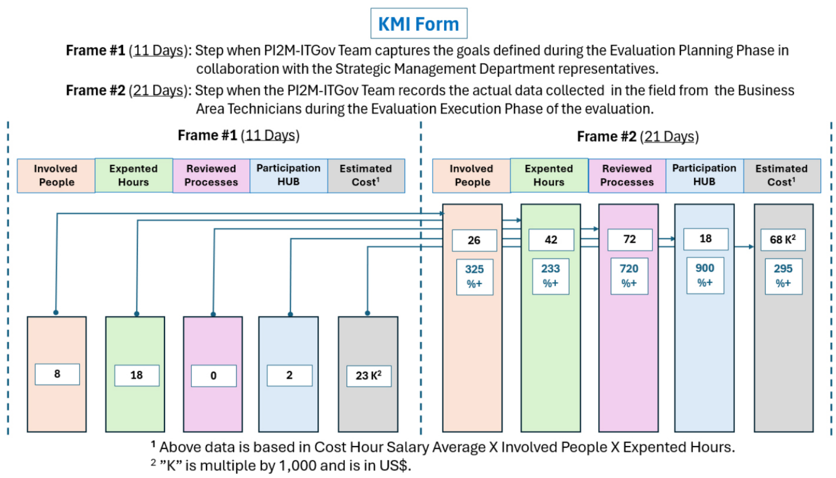


Fig. 7. Numbers retrieved from Final Simulation

Edition=2021 2nd.Quarter+Scenario=Organizational Restructuring' available in the folder '5. Implementation Assessment/Avaliação da Implementação' in the link `https://drive.google.com/drive/folders/1sFa5845Wcxr7KXQlH9hePXxN0WdRKchV?usp=sharing`.

Those corrective actions were discussed with the Board of Directors of the Brazilian Government Agency, where this simulation and assessment were applied, during the 4th. Phase = Evaluation of the Chronogram (created in MS® Project which is available in the same link under the folder '4. Solution Implementation/Implementação da Solução' and presented in the Appendix B)

One of the interpretations about the KMI 1 - Processes is that this Processes had a high level of Production with 100% in the Sub-KMI 1. WR (work result) but with many difficulties to get the values for the Sub-KMI 2. DC (delivery commitment) and 3. CS (customer satisfaction), what of course, impacted indeed the analysis that could be made by the Strategic Area.

Other of them is according to KMI 6 - Knowledge which the evaluation shown that this Processes had no procedures implemented in this theme, what can be interpreted that the Organization in assessment is losing the monitoring of its successful actions to register these and reuse as practical and useful feedback.

Also, could be found that the KMI 11 - Security, even this Process having a very high importance for a effective IT Governance, was impossible to be defined and the explanation for that was: "All 3 Subindicators of this KMI will be evaluated only in the next Time Period as this Security Area is in the process of reviewing the Internal Processes." (as is in the comments in the Spreadsheet).

Regarding the KMI 3 - Projects must be highlighted that its 3 Sub-KMIs, what means 1. WR (work result), the Sub-KMI 2. DC (delivery commitment) and 3. CS (customer satisfaction), had these 3 ones done under the expectations and can be considered as a successful Process all concluded.

These above interpretations were consistent with the evaluation obtained in the KMI 4 - Governance where the Sub-KMI 3. CS (customer satisfaction) had a negative value even with the follow explanation which can justify this grade but drive to reinterpret this result: “The Division Manager justified the very low value of the 3. SC above due to the large number of his Customers on vacation or on leave that still could not assess the Degree of Satisfaction of the reports delivered.” (as is in the comments in the Spreadsheet).

The guidelines provided in the link serve as a practical resource for understanding how the simulation was conducted, in addition to being a tool for applying the PI2M-ITGov method.

As mentioned in the initial summary of this research work, the PI2M-ITGov method can be utilized to (1) assess the performance status of an IT area. Furthermore, it can also be used to (2) compare the results of suppliers as a means of supporting decision-making, particularly in the context of proof of concept (POC) evaluations for contracting or renewing commercial agreements.

The MS® Excel spreadsheet discussed earlier primarily focuses on objective (1) mentioned above. However, to address objective (2) and provide an immediate assessment of a POC, the PI2M-ITGov KMIs can be applied in the manner depicted in Figure 8 (for evaluating service provider enterprises in the field of systems development, specifically as a software factory [FSW]) and Figure 9 (for evaluating service provider enterprises in the field of project management, particularly as a project management office [PMO]).

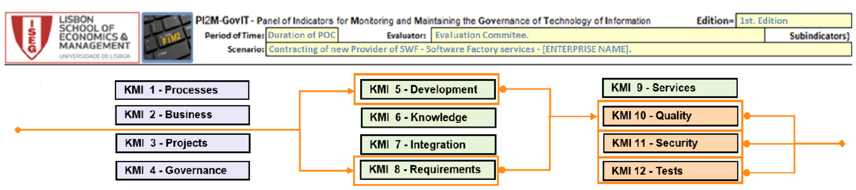


Fig. 8. Example of proof of concept (POC) to build a comparative framework in system development

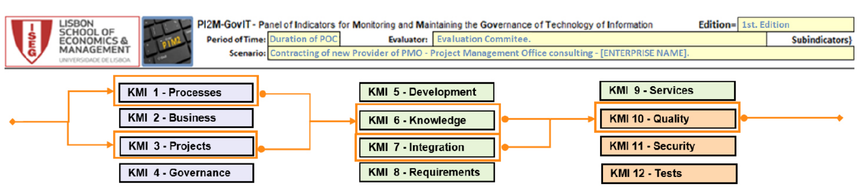


Fig. 9. Example of POC - Proof of Concept to build a Comparative Framework in Project Management

In both examples, the assessment of sub-indicator 2. DC should focus solely on the deadline criterion, excluding the cost criterion. In a POC evaluation, cost evaluation is not typically a common factor.

Furthermore, in both examples, regarding sub-indicator 3. CS, the term ‘customer’ represents the evaluation committee responsible for applying the final acceptance criteria for the POC presented by the assessed supplier.

For these examples, the maximum goal and minimum goal for the KMIs should be the same. Since the POC has a short duration and aims to achieve a specific outcome, the maximum goal and minimum goal reflect the singular target value that the evaluated supplier must meet.

8. Future Work

This article limited its approach in retrieve data and analyzes results from how the IT Governance, in a specific Organization, are being conducted – with the target – to gain able time to realign deliveries and expectation, based in the status obtained with a precise monitoring, before a massive control and auditing are not yet necessary in fact.

Nevertheless, we can expand this approach to compare the result obtained by a specific Organization with another to sort its ranking, what means, transforming PI2M-ITGov Method into a real MM - Maturity Model itself acting in distinct Organizations.

As a first step, we can think (as an initial idea) of creating a ranking with Gold, Silver and Bronze levels, what will drive us to need to define the maximum and minimum range grade for each Level according to each 36 sub-KMIs results.

In the sequence of this new approach implementation, it is necessary to establish criteria (such as: Capital Amount, Employes Number, Type of Business Finance; Industry; Services, Capillarization (Local; National; Intl), and other points) for sorting the Organizations in Small, Medium and Big sizes, so it will be possible compare different scenarios and apply an ”Adjustment Weight” in order to equalize the grades obtained and attributes the correct Gold, Silver and Bronze level.

If this idea will be put in practice, of course, a new article will be built and explaining how it was done in details and how to use the new approach of PI2M-ITGov Method as a MM - Maturity Model between different Organizations to obtain a unique Pannel of Statistics.”

9. Conclusion

This research adhered to the principles of a scientific method by following the steps of DSR, including the application of a case study consisting of three simulation rounds to validate the constructs and artefacts created (guidelines and spreadsheet).

Based on the evaluation, it can be concluded that the PI2M-ITGov, which is a panel of indicators for monitoring and maintaining IT governance, effectively serves as a practical tool for executing the necessary procedures in IT management.

While the PI2M-ITGov was constructed in a structured manner, its continued use and feedback from users will likely lead to new versions with added functionalities and improvements.

The author welcomes and appreciates users who provide feedback and share their experiences in using the PI2M-ITGov. This feedback will contribute to enhancing the quality of the method.

It is recommended to periodically check the provided link for any new updates or revisions that can be downloaded.

Furthermore, the author encourages future contacts and assures that any inquiries will be handled with care and attention. The author is dedicated to guiding interested individuals in implementing the PI2M-ITGov in their organizations and providing necessary support to ensure the success of this initiative.

Acknowledgments. Partial financial support was received from ITMA - Information and Technology Management Association for sponsoring the proofreading revision costs.

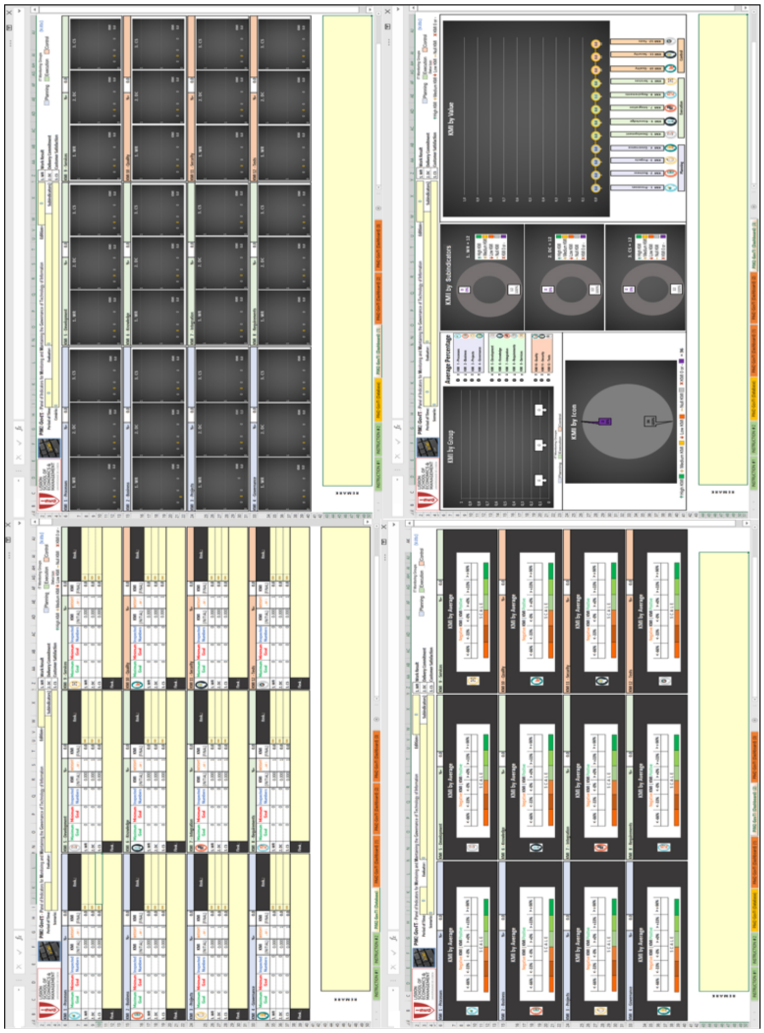
References

1. Ahern, D.M., Clouse, A., Turner, R.: CMMI Distilled – A Practical Introduction to Integrated Process Improvement. 2nd ed. Pearson Education Inc., Boston, Massachusetts, USA (2002)
2. Arsanjani, A., Holley, K.: The Service Integration Maturity Model: Achieving Flexibility in the Transformation to SOA©, Services Computing, IEEE International Conference on, p.515, IEEE International Conference on Services Computing (SCC'06), ISBN: 0-7695-2670-5. Chicago, Illinois, USA, Sep 18–22 (2006)
3. Axelos: ITIL® Foundation: ITIL 4 Edition. Axelos Ltd. (2022), `https://www.axelos.com/best-practice-solutions/itil`
4. Axelos: P3M3 – Portfolio, Programme and Project Management Maturity Model. Axelos Ltd. (2022), `https://www.axelos.com/best-practice-solutions/p3m3`
5. CIOIndex: EAG© – Enterprise Architecture Governance. CIOIndex – Global Community For Chief Information Officers (2022), `https://cio-wiki.org/wiki/Enterprise_Architecture_Governance`
6. Clerc, V., Niessink, F.: IT Service CMM, A Pocket Guide. Van Haren Publishing, Holland (2005)
7. Consortium, I.: Information Security Management Maturity Model., chap. ISM3 Consortium - Creative Commons Attribution. ISM3 Consortium - Creative Commons Attribution, ISBN: 978-54-611-9825-2. San Francisco, California, USA (2007)
8. Dresch, A., Lacerda, D.P., Antunes Jr., J.A.V.: Design Science Research: Research Method for Advancing Science and Technology (Método de Pesquisa para Avanço da Ciência e Tecnologia). Bookman, Porto Alegre, RS, Brazil (2015)
9. EFQM©: The Fundamental Concepts of Excellence. European Foundation for Quality Management (2022), `https://www.onecaribbean.org/wp-content/uploads/Fundamental-Concepts-of-EFQM.pdf`
10. Fonseca, A.F.: Organizational Knowledge Assessment Methodology. World Bank Institute, Washington, DC, USA (2006)
11. Fontelles, M.J., Simões, M.G., Farias, S.H., Simões, R.G.: Scientific Research Methodology – Guidelines for Elaboration of a Research Protocol. Cercomp, Brazil (2009)
12. Gartner, G.: CobiT® – Control Objectives for Information and Related Technology. Gartner Group (2022), `https://www.gartner.com/en/information-technology/glossary/cobit-control-objectives-for-information-and-related-technology`
13. Goethert, W., Hayes, W.: Experiences in implementing measurement programs. Technical note, Software Engineering Measurement and Analysis Initiative, SEI® – Software Engineering Institute (2001), CMU/SEI-2001-TN-026, NOV

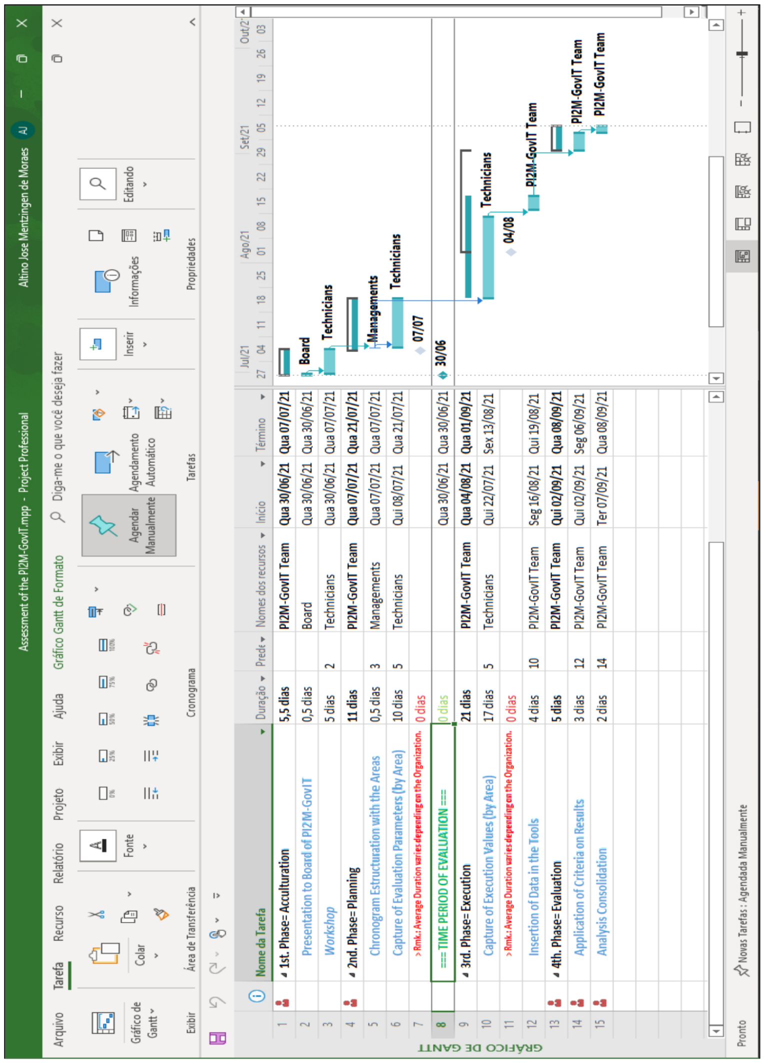
14. Heumann, J.: The Five Levels of Requirements Management Maturity – Rational Software (2022), https://pt.slideshare.net/ibmrational/the-five-levels-of-requirements-management-maturity
15. Hevner, A.: A Three Cycle View of Design Science Research. Scandinavian Journal of Information Systems 19(2), 4 (2007)
16. Hüffner, T.: The BPM® Maturity Model – Towards A Framework for Assessing the Business Process Management Maturity of Organizations. GRIN Verlag, Munich, Germany (2007)
17. ISACA: CobiT® – Control Objectives for Information and Related Technology. Information Systems Audit and Control Association (2022), https://www.isaca.org/resources/cobit
18. ISO/IEC: 15.504 – Process assessment – Part 5: An Exemplar Software Life Cycle Process Assessment Model. International Organization for Standardization (2022), https://www.iso.org/standard/60555.html
19. Kerzner, H.: Using the Project Management Maturity Model: Strategic Planning for Project Management, 2nd ed. John Wiley & Sons Inc, New York, NY, USA (2004)
20. Krause, H.M.: A maturity model for automated software testing. Medical Device & Diagnostic Industry Magazine (1994), mDDI Article Index
21. Likert, R.: A technique for the measurement of attitudes. Archives of Psychology 140, 1–55 (1932)
22. Locke, J.: The Works of John Locke: An Essay Concerning Human Understanding. Halcyon Classics – Kindle Edition, Jun-23 (2009)
23. Ltd., S.E.: Test Organization Maturity Questionnaire V2.0. Systeme Evolutif Ltd, Gloucester House, 57/59 – Gloucester Place, London, England (2000)
24. Moraes, A.J.M.: M2A3-GovTI Proposal – Maturity Model for Analysis of the Alignment of Activities Related to Governance of Technology of Information in Accordance with the Outcome Expectations Planned by the Organization (Proposta do M2A3-GovTI – Modelo de Maturidade para Análise do Alinhamento das Atividades relacionadas à Governança da Tecnologia da Informação em conformidade com as expectativas de resultado planejadas pela Organização). Doctoral thesis, Stricto-Sensu Postgraduate Program in Production Engineering Doctorate. UNIP – Paulist University, São Paulo, SP, Brazil (2010)
25. Moraes, A.J.M., Rocha, M.R.: IT Management: Proposal of the PI2M-ITGov - Panel of Indicators for Monitoring and Maintaining IT Governance: Research and Model (2023), https://ieeexplore.ieee.org/document/10211818
26. OMG: BPMM® – Business Process Maturity Model. Object Management Group (2022), http://www.omg.org/spec/BPMM/1.0/PDF
27. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A design science research methodology for information systems research. Journal of Management Information Systems 24(3), 45–77 (2007)
28. Peterson, R.: Crafting Information Technology Governance. Taylor & Francis Online (2022), https://www.tandfonline.com/doi/abs/10.1201/1078/44705.21.4.20040901/84183.2
29. PMI®: OPM3® – Organizational Project Management Maturity Model. Project Management Institute (2022), https://www.gartner.com/en/information-technology/glossary/cobit-control-objectives-for-information-and-related-technology
30. Prado, D.: MMGP – A Brazilian Model of Project Management Maturity (Um Modelo Brasileiro de Maturidade em Gerenciamento de Projetos). Ponto GP (2005), http://pontogp.wordpress.com/2006/05/06/mmgp
31. Prasad, R.: Maturity Model Describes Stages of Six-Sigma® Evolution. iSixSigma (2010), https://www.isixsigma.com/basics/maturity-model-describes-stages-six-sigma-evolution/

32. Rockart, J.F., Earl, M.J., Ross, J.W.: Eight imperatives for the new it organization. Sloan Management Review 38(1), 43–55 (Fall 1996)
33. Rundle, R.: Deming Cycle PDCA – Plan Do Check Act Journal in Daily Life Toyota Way. Independently Published (2019)
34. SEI®: CMMI® – Capability Maturity Model Integration. Software Engineering Institute (2022), https://resources.sei.cmu.edu/asset_files/TechnicalReport/2010_005_001_15287.pdf
35. Simon, H.A.: The Sciences of the Artificial. 3rd ed. MIT Press, Cambridge, Massachusetts, MA, USA (1996)
36. SOFTEX: MR MPS br®: Reference Model for Brazilian Software Process Improvement (Modelo de Referência para Melhoria do Processo de Software Brasileiro). Softex (2022), http://www.softex.br/mpsbr/_guias/default.asp/
37. Sonic: The New SOA® Maturity Model. Sonic Software Corporation, AmberPoint Inc., BearingPoint Inc., Systinet Corporation. All rights reserved (2005)
38. Tapi, R.S., Daneva, M., Eck, P., Wieringa, R.J.: B-ITa – Business-IT Alignment Maturity Model. University of Twente (2022), https://research.utwente.nl/en/publications/towards-a-business-it-alignment-maturity-model-for-collaborative
39. Tesla, N.: Map of Multiplication. Unicentro, Paraná, PR, Brazil (2021), https://www3.unicentro.br/petfisica/2017/05/18/o-mapa-da-multiplicacao-de-tesla/
40. TMMi: Test Maturity Model Integration. TMMi Foundation (2023), https://www.tmmi.org/tmmi-documents/
41. Weill, P.: The relationship between investment in information technology and firm performance: A study of the valve manufacturing sector. Information Systems Research 3(4), 307–333 (Dec 1992)
42. Wieringa, R.J.: Design Science Methodology for Information Systems and Software Engineering. Springer-Verlag Berlin Heidelberg, Berlin, Germany (2014)

Appendix A: MS® Excel Spreadsheet of PI2M-ITGov



Appendix B: MS® Project 'Assessment of the PI2M-ITGov'



Altino Moraes holds the title of Ph.D. in Production Engineering (with emphasis in Information Systems), M.Sc. in Information Management, and BCs in Information Technology. He also developed Post Doctoral Research with an IT Governance focus. Additionally, he has two lato-sensu courses: one MBA in Project Financial Management and one Specialization in System Analysis. He is certified in five Technical Certifications applied to the IT Area (CobiT, ITIL, PMI, ISTQB, and ABPMP). He is a Researcher at the ADVANCE (the ISEG Centre for Advanced Research in Management at the University of

Lisbon). He is a member of Scientific Committees in congresses sponsored by IIIS - International Institute of Informatics and Systemics, ITMA - Information and Technology Management Association and AISTI - Iberian Association of Information Systems and Technologies. He often participates in Conferences related to the IT Area and publishes in its Proceedings. Besides, he has been participating in books (as coeditor/coauthors) distributed by IGI Global. He is also a Brazilian Government Employee currently allocated to MGI - Ministério da Gestão e Inovação (Management and Innovation Ministry).

Álvaro Rocha holds the title of Honorary Professor, and holds a D.Sc. in Information Science, Ph.D. in Information Systems and Technologies, M.Sc. in Information Management, and BCs in Computer Science. He is a Professor of Information Systems at the University of Lisbon - ISEG, researcher at the ADVANCE (the ISEG Centre for Advanced Research in Management), and a collaborator researcher at both LIACC (Laboratory of Artificial Intelligence and Computer Science) and CINTESIS (Center for Research in Health Technologies and Information Systems). His main research interests are maturity models, information systems quality, online service quality, requirements engineering, intelligent information systems, e-Government, e-Health, and information technology in education. He is also Vice-Chair of the IEEE Portugal Section Systems, Man, and Cybernetics Society Chapter, and Founder and Editor-in-Chief of two Scopus and SCIMago journals: JISEM - Journal of Information Systems Engineering & Management; and RISTI - Revista Ibérica de Sistemas e Tecnologias de Informação / Iberian Journal of Information Systems and Technologies. Moreover, he has served as Vice-Chair of Experts for the European Commission's Horizon 2020 Program, and as an Expert at the COST - intergovernmental framework for European Cooperation in Science and Technology, at the European Commission's Horizon Europe Program, at the Government of Italy's Ministry of Universities and Research, at the Government of Latvia's Ministry of Finance, at the Government of Mexico's National Council of Science and Technology, at the Government of Polish's National Science Centre, and at the Government of Cyprus's Research and Innovation Foundation.World's Top 0.05% Scientist, according to ScholarGPS. World's Top 1% Scientist, according to Stanford University and Elsevier. World's Top 1% Scientist, according to ResearchGate. ISEM's Book Series Scientific Manager at Springer Nature: https://www.springer.com/series/17396. Chair of ITMA - Information and Technology Management Association: http://itmas.org. Founder and Vice-Chair of IEEE SMC Portugal Chapter. Invited Full Professor at University of Calabria, Italy. Honorary Professor at Amity University, India. Professor of Information Systems, ISEG, University of Lisbon, Portugal.

Received: July 29, 2024; Accepted: January 12, 2025.