# A METHOD TO CREATE HYBRID MODELS

## USING A MORPHOLOGICAL MATRIX

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**Abstract**: Prescriptive management models are falling short to deal with the current and increasingly uncertain and dynamic business environment. The search for so-called hybrid models has increased among different organizations and industrial sectors. Despite the interest, there is a lack of systematic procedures to effectively adapt hybrid models to specific projects. In order to bridge this gap, we propose a method to support the creation of hybrid models, based on a morphological matrix that allows the combination of practices to the specific needs of each project. The method was developed through a systematic literature review, a theoretical proposition phase, and its evaluation in a single case study involving an information technology company. The results indicate that customization by the project is feasible, allowing professionals to be more assertive in creating customized management solutions. Finally, the study highlights the possibility of creating systematic procedures to assist organizations and professionals in choosing management practices for their projects and the consequent creation of hybrid models.

## 1. Introduction

There are two well-founded approaches in project management, known as waterfall and agile, as discussed in Boehm and Turner (2003). The waterfall is based on a sequential series of steps, where activity forecasting and constraints estimation are systematized in detailed planning at the project beginning (Shenhar and Dvir, 2007; Wysocki and Mcgary, 2007; Špundak, 2014). The plan is used throughout the project as a guide and each activity must be completed before moving on to the next, avoiding overlaps of different phases (Chandrababu, 2020). On the other hand, the agile approach has an iterative and incremental development, performing partial deliveries in short periods of time, called iterations. Agile practices provide greater flexibility, adaptability, and responsiveness as it encourages customer involvement, self-management and simplicity in terms of methods and documents (Highsmith, 2004; Leffingwell, 2010; Špundak, 2014).

However, project management is undergoing a fundamental change, where traditional management skills are no longer sufficient in the constantly changing new world (Mcgrath & Kostalova, 2020). Recently, authors who questioned the use of "pure" project management approaches have emerged. According to Batra et al., (2010) agility without structure can lead to "chaos", especially in projects involving large and complex environments, while the structure without agility can lead to rigidity, negatively affecting the project. This fact resulted in a series of research proposing theoretical models and experiences of combining agile and waterfall management practices. The strategy of combining principles and practices from different theories has been called hybrid models, as can be seen in Adelakun et al., (2017), Imani et al., (2017), and Bianchi et al., (2020).

Conforto, Rebentisch and Amaral (2014) evidenced the use of hybrid models in different companies and economic sectors around the world. According to their survey, 7% of the respondents (n=856) self-declared to use hybrid methods. The PMI's pulse of the profession survey (PMI, 2017b) found that 20% of the companies declared themselves to be using hybrid management methods in the projects completed within their organization in the past 12 months. According to Cooper, (2017), it is only a matter of time before results-oriented organizations begin to adopt and adapt hybrid project models for their own new products development.

Several hybrid models have been proposed in the last years like Binder et al., (2014), Cooper, (2014), and Sommer et al., (2015). There are also studies that present experiences of application such as Fitzgerald et al., (2013), Conforto and Amaral, (2016), and Magistretti et al., (2019). Although these models were important for advancing the theme, they present unique and structured life cycles for specific environments and projects. The authors also do not describe a systematic customization process, making it difficult to use these models for other contexts. According to Ciric et al., (2018), how to effectively tailor hybrid models to suit a specific organization or specific project is a challenge

yet to be addressed.

In order to bridge this gap, we propose a method to create hybrid models, whose differential is being able to adapt management practices to the specific needs of each project. The method adapts a technique from New Products Development (NPD) area, known as the morphological matrix. This technique allows us to systematically choose the most appropriate management practices for each project. The method was tested at a software development company. The results confirm the possibility of creating systematic procedures to assist organizations and professionals in choosing management practices for their projects and the consequent creation of hybrid models.

This paper is organized as follows. In Section 2 we discuss hybrid management models. The morphological matrix technique is presented in Section 3. In Section 4 we explore the research method. The method to customize hybrid models is presented in Section 5. In Section. 6 we discuss the application of the method in a software development company. Finally, in Section 7, we present the conclusions, limitations and future research.

## 2  HYBRID MODELS IN PROJECT MANAGEMENT

The growing search for solutions that overcome the current challenges imposed by the market and the different types and characteristics of projects in organizations have driven the demand for hybrid models (Adelakun et al., 2017; Zasa et al., 2020; Gemino et al., 2020). According to Ambler and Lines, (2018) projects are unique and need to be managed according to their needs. In sectors beyond software development, companies typically divide products into independent modules and require interactions between different departments. This process challenges the basic premises of agile management and requires the development of new work models (Zasa et al., 2020). Adopting a pure model can be risky and bring unsatisfactory results to the project or an organization (M. Bianchi et al., 2020).

Hybrid models are a possible solution to deal with this problem, balancing elements such as flexibility and control for each case (Cooper, 2016; Adelakun et al., 2017; Ciric et al., 2018).  These models combine different approaches (waterfall and agile) to find a middle ground that combines the advantages and corrects the deficiencies of both (Galal-Edeen, Riad, & Seyam, 2007).  According to Riesener et al. (2018), it is possible to find synergies and advantages in combining these approaches. The management challenge, according to Bäcklander (2019),  is to know what to structure and what not, in order to find a balance between these two worlds. Thus, it is possible to provide sufficient stimulus to experiment and adapt, together with structures and control for the organization's processes (Mcmillan, 2004).

Several authors have discussed the subject recently and different hybrid proposals have emerged. As an example, we have hybrid models for software development (Nawrocki et al., 2006; Binder et al., 2014),  regulated environments (Fitzgerald et al., 2013), new product development (Cooper & Sommer, 2016),  consulting (Magistretti et al., 2019) and technology-based companies (E. C. Conforto & Amaral, 2016). According to Azenha et al., (2020), these are prescriptive models based on theory. They have unique and structured life cycles, were developed for specific situations, do not explain how to adapt to other contexts, and do not have a systematic procedure for choosing project management practices.

In the real world, we know that organizations have different types of projects and environments, each with its own particularities, requiring distinct life cycles and solutions. Another argument in this direction is that some organizations coexist with different types of projects and often need to be managed in different ways.

None of the proposed hybrid models in the literature has a systematic and robust procedure that is useful in building or adapting to different business environments, organizational environments, teams or types of projects. Pich, Loch and Meyer (2002) discuss the lack of frameworks that help project managers understand why so many different methods exist, which one to choose, when and how to use them. Is it possible to develop methods that allow the customization of hybrid models for different projects? In this sense, an important challenge for the advancement of hybrid models is to develop solutions to assist in the customization of these models. In order to bridge this gap, we developed a method to customize hybrid models. The method is based on a morphological matrix that assists in the choice of project management practices.

## 3  MORPHOLOGICAL MATRIX

Morphological matrix is the name given to a technique in product development theory. The morphological matrix involves breaking down a complex problem into simpler parts, helping the product development team to identify a set of possible solution alternatives for each part, allowing to analyze the final configuration that the product will have (Weber and Condoor, 1998; Fargnoli et al., 2006; Pahl and Beitz, 2007).

According to Pahl and Beitz (2007), all morphological matrix follows a similar structure, as shown in **Figure 1a**. This structure consists of a two-dimensional scheme, rows that express the product functionalities, and columns that explore possible solutions and combinations in order to meet these functionalities.

For example, a function of a motorcycle is to generate propulsion so that it can move. Different solution principles for this function can be combustion engine, electric motor
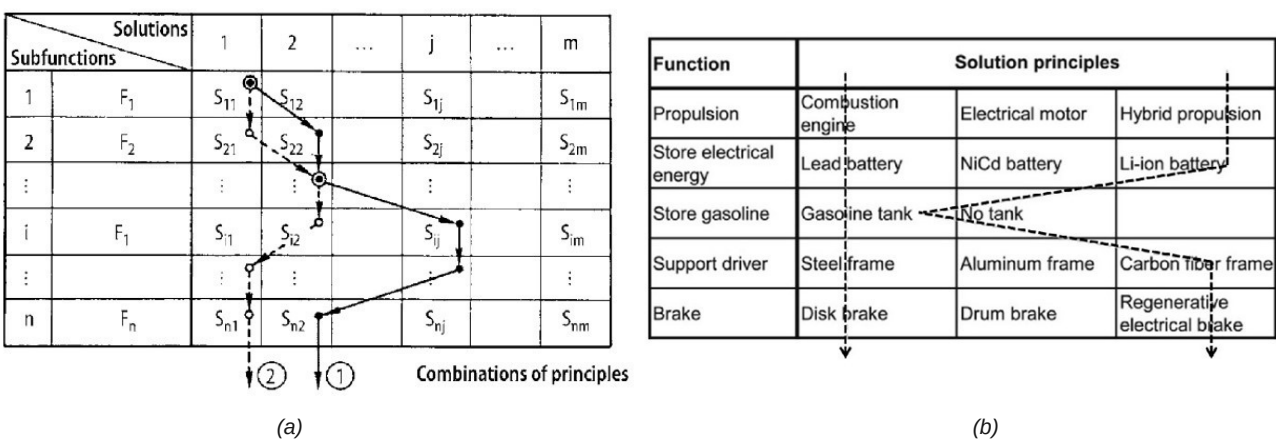


*(a)*

*(b)*

*Figure 1: (a) Theoretical proposition of morphological matrix. Source: Pahl and Beitz (2007); (b)   Combining solution principles for a motorcycle. Source: Ölvander et al., (2009).*

and hybrid propulsion, as shown in **Figure 1b**. According to the example, two solutions were proposed, one more conventional, the other with a more sustainable concept (Ölvander et al., 2009).

The concept guiding this technique has already been used in other areas such as the study of anti-aircraft shelters (Ritchey, 1998), in product/service-system development (Tan & McAloone, 2006) and in product design tests (Duhovnik & Tavčar, 2005). In the present article, the technique will be used to create a catalog of different possibilities of practices that can be used in a project, referring to the solution principles of the original theory.

## 4  RESEARCH METHOD

The research method was divided into four phases (see **Figure 2**). Phase 1 - Dimension definitions. A systematic

literature review was carried out to identify and define the latent constructs that support the method to customize hybrid models. The objectives were two: a) identify dimensions capable of allowing the categorization of project management practices in order to create a morphological matrix to allow future combinations of practices, and b) identify dimensions to assess the characteristics and environment of the project in order to relate its needs with different possibilities of management practices.

Due to the significant size of the theory and the existence of many project management processes, only the scope and time management were considered in this study. These processes present the main points of divergence between the waterfall and agile approaches. Other processes can be added to create hybrid models (e.g., Cost, Communication and Risk), depending on the needs of each organization, as we will see in the next sections.
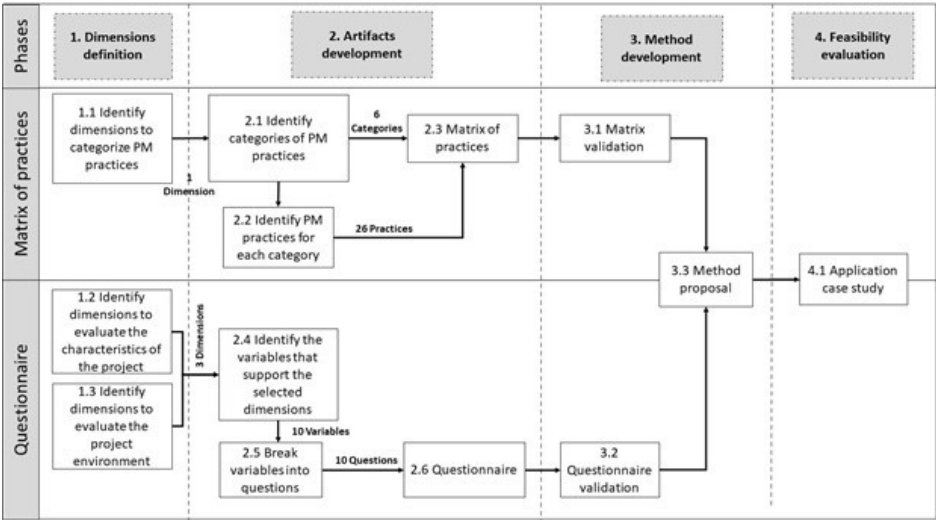


*Figure 2: Research development phases.*

Phase 2 – Artifacts Development. The dimensions defined in the previous step were broken down into variables in order to operationalize the method's artifacts. For the morphological matrix, six categories of practices were defined to guide the construction of hybrid models. These categories represent groups of actions related to the scope and time management of a project. Through a literature review, different possibilities of project management practices were identified for each of these categories. Following the questionnaire development, the dimensions were transformed into ten questions to analyze the characteristics and environment of the project, and assist in the customization process of the hybrid models.

Phase 3 – Method Development. Both artifacts were validated internally by a project management expert, and the method, using the artifacts, was designed considering the objectives and results.

Phase 4 – Feasibility evaluation. The method was evaluated using a single in-depth case study. Single cases may be used to confirm or challenge a theory, or to represent a unique or extreme case (Yin, 2009). The application was carried out in an information technology (IT) organization. We selected the company for three main reasons: a) the company has successfully used different project management approaches in parallel in the development of its projects (agile and waterfall); b) for some projects, the company wanted to combine practices from different approaches to extract the best possible results for the case; and c) the selected business unit comprises the development pole of the company, developing customized software, in addition to managed services and IT projects.

## 5 A METHOD TO CUSTOMIZE HYBRID MODELS

In this section, we present in detail the artifacts of the method, and the application process to create hybrid models.

### 5.1. PROJECT DIAGNOSTIC QUESTIONNAIRE

One of the challenges in the development of hybrid models is to diagnose and understand the main characteristics of the organization, project and team, in order to define the "ideal point" for the combination of practices (E. C. Conforto & Amaral, 2016). This information is essential to create a suitable solution for each case since it will be the driver for choosing practices. The questionnaire dimensions were based on the diagnostic methods found in the project management area (**Table 1**). The models were identified from a systematic literature review (SLR).

From these methods, we selected the dimensions to compose the questionnaire. To guide the choice, we define two criteria: 1) the dimension should analyze the general characteristics of the project that are independent of its execution (that can be measured before the project starts), and 2) the dimension should have an influence on the project management practice, technique or tool, assisting the configuration of hybrid models.

The selected dimensions can be seen in **Table 2**. In order to operationalize the questionnaire, the variables of each dimension were deployed in questions. The complete questionnaire can be checked in Appendix A.

These dimensions affect how project management should be conducted. For example, organizations characterized by being informal, decentralized and with few levels of authority correspond well to the uncertainties inherent in dynamic business environments. In contrast, centralized, specialized and bureaucratic organizations are likely to perform better in predictable environments. Closer team members contribute to better communication and consequently to greater interaction. The smaller the teams, the greater the levels of communication, integration and alignment between team members. Regarding the skills of the team members, the greater the range of skills (knowledge), the lesser the uncertainties, risks and challenges throughout the project, since it can integrate different areas and departments of an organization. We also assumed that the greater the experience of members in the development of similar products, the greater the facility to respond to changes throughout the project, contributing to the achievement of greater agility. In addition, the greater the experience of associates in the development of similar products, the greater the ease of responding to changes throughout the project, contributing to the achievement of greater agility.

The novelty and technology dimensions are closely linked to the difficulty in terms of technology to develop the project. Innovative projects have a high level of uncertainty. The more the organization has the technological skills for development, the less the uncertainties and challenges to be faced throughout the project. Regarding complexity, the more complex the project is, the more difficult it will be to manage it, and the organization may have to adapt its management procedures. Finally, Time Availability affects the team's level of autonomy. All of this information will assist in choosing the appropriate management practices for the projects, and consequently in the configuration of the management models. To this end, the information collected through the questionnaire will be the inputs to use the morphological matrix of practices, presented in the following section.

| Name | Description |
|---|---|
| Risk Approach, (Boehm and Turner, 2003) | Risk-based approach for structuring projects, incorporating agile and waterfall practices, depending on project needs. At the time, the authors already envisioned the possibility of combining practices with the aim of balancing the benefits of both approaches. The Risk Approach has five dimensions: Personnel (skills to manage projects), Dynamism (percentage variation of requirements per month), Culture (rules and procedures), Size (number of people involved) and Criticality (loss due to impact of defects). |
| SDPM, (Wysocki, 2007) | The authors present a scheme involving two dimensions: Complexity and Uncertainty. The diagnosis helps in the definition of specific strategies for the project management, according to some approaches suggested by the author: Linear, Incremental, Iterative, Adaptive and Extreme. |
| Diamond Approach, (Shenhar & Dvir, 2007) | It addresses that each project is unique, therefore, must take into account the project characteristics in order to adapt the project management. It has four dimensions: Novelty, Technology, Complexity and Pace. Each of the dimensions contribute to determine the project type and can affect the choice of certain practices, techniques and tools. |
| Methodology selection framework, (Barlow et al., 2011) | The author presents a framework for diagnosing the management method according to the Team size, which can be large or small; Project volatility, which refers to team instability or turnover, and which may be high or low; and the Nature of project interdependencies, which can range from sequential to reciprocal. Based on the relationship of these dimensions, the framework indicates the best approach, which may be traditional, agile or hybrid, and identifies the coordination strategies to support the project team. |
| Health Check Tool for Projects, (Kennedy & Philbin, 2014) | A diagnostic proposal consisting of an integrated view of processes, technology, resources, impact, knowledge and culture. These factors are classified into three dimensions: Project infrastructure (resources and technology), Project organization (process and knowledge) and Project environment (culture and impact). These dimensions can be useful in choosing the practices and tools that can contribute to the best project performance. |
| Agility Diagnostic Tool, (Bianchi, Conforto, & Amaral, 2021) | Project diagnosis tool whose objective is to identify dysfunctions or inadequacies between context and practices used in order to explain aspects of improvement. The diagnosis is based on three dimensions: Agility CriticalFactors (ACF); Agility characteristics (AC); and Agility Performance (AP). The tool allows identifying discrepancies in agility performance in relation to the adopted practices and organizational environment of the project. In addition, it can be used for other types of projects, as well as software. |

*Table 1: Project diagnostic methods from literature.*

### 5.2. THE MORPHOLOGICAL MATRIX OF PROJECT MANAGEMENT PRACTICES

The matrix represented here is based on the same concept of product development but adapted to the project management area. The matrix is composed of six rows that represent groups of actions that need to be carried out to ensure the planning and control of a project. The columns present alternative solutions (practices) to meet each one. The matrix serves as a practice catalog during the process of creating hybrid models. In principle, it allows quicker and more oriented access to a range of solutions for project management.

#### 5.2.1. Matrix Rows (Group of Actions)

The research team carried out a previous work of agile and plan-driven practices comparison, published in Eder et al., (2015).

In this study a search for practices (actions, techniques and tools) was carried out in a set of books and articles from project management area. The search resulted in a total of 23 actions, 54 techniques and 21 tools, which have been described in detail through case studies.

This previous work allowed the identification of six main groups of actions that must be carried out during the project to ensure the management of time and scope. These groups also address the main topics of divergence in relation to the application of agile and plan-driven practices

| Dimension | Source | Variable | Question | Measure |
|---|---|---|---|---|
| Organizational structure | (Boehm and Turner, 2003; Kennedy and Philbin, 2014) | How activities and authority are developed in order to achieve organizational objectives | 1- In relation to the organizational structure of the company, this: | Nominal range |
| Project team experience | (Bianchi, Conforto, & Amaral, 2021) | Experience time of project manager | 2 - What is the average experience time of project manager (acting in leadership positions) in the development of projects (products / software) in the organization? | Interval scale |
| | (Bianchi, Conforto, & Amaral, 2021) | Experience time of project team members | 3- What is the average experience time of project team members in the development of projects (products / software) in the organization? | Interval scale |
| Project team size | (Boehm and Turner, 2003; Barlow et al., 2011; Bianchi, Conforto, & Amaral, 2021) | Number of project team members | 4- Regarding the size of the project team (number of people), this consists of: | Interval scale |
| Diversity of team members' competencies | (Boehm and Turner, 2003;Bianchi, Conforto, & Amaral, 2021) | Competencies of project team members | 5- With respect to the project team, this consists of: | Nominal range |
| Proximity of project team members | (Bianchi, Conforto, & Amaral, 2021) | Geographical location of project team members | 6- Check the option that best represents the reality in the project in relation to the project team location (manager + executing members): | Nominal range |
| Technological innovation | (Shenhar and Dvir, 2007; Bianchi, Conforto, & Amaral, 2021) | Project product novelty degree | 7 - Regarding the project result (product / software / service), the main innovation is: | Nominal range |
| Project complexity | (Wysocki, 2007; Shenhar and Dvir, 2007) | Level of project complexity | 8 - In relation to the project complexity, this involves | Nominal range |
| Technology availability | (Shenhar and Dvir, 2007; Kennedy and Philbin, 2014; Bianchi, Conforto, & Amaral, 2021) | Technological competence of the project team | 9 - Skills in the technologies needed to develop the product / software or service: | Nominal range |
| Time availability | (Shenhar & Dvir, 2007) | Level of project urgency | 10 - In relation to the urgency to complete the project, it is necessary to | Nominal range |

*Table 2: Questionnaire development.*

in project management. These elements represent the matrix rows (see **Table 3**). Initially, we present solutions for time and scope management, but they can be extended later to other groups of processes, such as cost, communication, risk and quality.

### 5.2.2. Matrix Column's (Project Management Practices)

The column is the main part of the matrix and contains different possibilities of practices for each row. To fulfill the columns with practices, we analyzed the main hybrid models, books and publications in the project management area (waterfall and agile). For example, the Project Plan Structure varies from using a single project plan that covers the total project time, containing phases, milestones, products, deliverables, work packages, and activities (PMI, 2017a), going through hybrid practices such as a macro plan (schedule) together with a short-term plan (iteration) involving the main products to be delivered at the moment, until practices derived from the agile approach such as Product Vision with a Product Backlog and Sprint Backlog (Schwaber, 2004), as well as the use of a Kanban board (Leffingwell, 2010).

To relate the rows (group of actions) and columns (management practices), we created a scale that ranges from practices that contribute to greater anticipation, predictability and standardization, to practices that contribute to greater adaptability, flexibility and responsiveness. This makes it possible to structure the matrix in a more organized way. **Figure 3** illustrates the matrix of project management practices. We call it a

reference matrix, since it is based on evidence from the literature, and as we will see in the next section, it can be adapted to each organization. The matrix presented here contains only four columns of practices for each row. However, according to the organization's needs, the number of columns can be expanded to support a greater number of management practices.

## 5.3. THE PROCESS TO CREATE HYBRID MODELS

Each project has different life cycles, levels of complexity, innovation and strategies, requiring different management styles. The **Figure 4** presents the set of steps and tools to create hybrid models using the proposed method. The target audience of the method contemplates companies and professionals involved in the development of a project. Project Management Officers (PMOs), Project managers, and leaders can use it to define management models appropriate to their projects. Consultants can use it to design project management models before implementing them in an organization.

**Step 1**. Adapt the matrix: Probably the organization uses specific practices, techniques and tools that are not included in the reference matrix, or the matrix may present practices that do not fit the company's needs. So, we need to adapt the reference matrix (Figure 3) for the company that will use it. This adaptation consists of identifying the project management practices used by the company and inserting them into the basic structure of the matrix (rows and columns). We present in Appendix B a guide to identify the organization's project management practices.

**Step 2**. Define the unit of analysis: The unit of analysis for the hybrid model development is a specific project of the organization or a set of projects that share similar characteristics between them.

**Step 3**. Apply the questionnaire: The questionnaire is applied to analyze the characteristics and context of the project, such as organizational structure, novelty, level of complexity, technology, and time available for execution. This step can be done by using a paper form containing the questions, or by electronic means.

**Step 4**. Analyze data and select project management practices: Based on the information collected in the previous step, we use the matrix to choose the practices (columns) for each of the groups of actions (rows) that best meet the particularities of the case. At least one practice must be chosen for each row. These practices must be systematically grouped, resulting in the specific project management model.

| Group of actions | Description |
|---|---|
| 1- Project plan structure | Identifies how project planning is described, encompassing the planning horizon level, if there is a single project plan or not, if the plan covers the total project completion time or short-term intervals, whether the plan encompasses the products, deliveries, work packages and activities, etc. |
| 2- Project scope description | Identifies how is developed the project scope and how it is communicated to project stakeholders. It analyses if the project content is described in a formal and detailed way, or in a challenging and motivating way, if it involves contractual norms or not, etc. |
| 3- Activity breakdown | Identifies the form with the activities are detailed, whether these are described in a standardized and organized way or not, the control level used, if it uses classification codes, user stories, tasks, and if there is an attempt to prioritize these activities. |
| 4- Project monitoring and control | Identifies how is carried out the project monitoring and control. Identifies whether project progress based on cost, time, completion percentage, partial deliveries, and/or prototypes. It also evaluates the documentation used, if there is use of performance reports, written documents and visual devices. It also assesses the formality level employed and how often the project team meets. |
| 5- Customer involvement | Identifies the client's participation in the project, its role in prioritizing deliveries, level of formality in the change process, and closeness to the team, including the times it is present in the project. |
| 6- Resources and duration estimation | Identifies how the duration and resource estimates are performed, identifying which standard is used by the company. |

*Table 3: Understanding the Matrix rows.*

**+ Anticipation, Predictability and Standardization** ⟵⟶ **+ Adaptability, Flexibility and Responsiveness**

| Group of actions / Practices | A | B | C | D |
|---|---|---|---|---|
| **Project Plan Structure** — Types of plan | 1- Schedule (Gantt) | 1 – Schedule (Gantt) 2- Product Backlog 3- Sprint Backlog | 1- Vision 2- Product Backlog 3- Sprint Backlog | 1- Kanban |
| **Project Scope Description** — Format | Project Scope Statement | Scope Statement and project vision | Project Canvas | Project vision |
| **Project Scope Description** — Content | - All project information in detail - May involve contractual rules | - Project information that the team judges to be important - Project vision | - Logical and visual components organized in question blocks | - Metaphoric and ambiguous description using artifacts and visual techniques |
| **Activity Breakdown** — Format | Work Breakdown Structure | Tasks | User Stories | Epics |
| **Activity Breakdown** — Content | -Activities have codes and are classified into work packages, deliveries and products | Activities needed to complete a User Story. Tend to be carried out by a time person | Brief statements to specify something the product needs to do / deliver to the user | A high-level description of what the client wants, and accordingly, it has some value attached to it. |
| **Project Monitoring and Control** — Indicators | Cost, time and % of progress | Cost, time, and Partial deliveries | % of completed stories | Partial deliveries, prototypes, demonstrations, drawings |
| **Project Monitoring and Control** — Reports | Reports with performance indicators, written documents, audits and phase transition analysis | Reports with performance indicators, written documents, and visual artifacts (posters, pictures, self-adhesive notes, etc.) | Visual boards that indicate the project progress | Does not use reports, only visual artifacts that indicate the project progress |
| **Project Monitoring and Control** — Ceremonies | -Formal -Non-frequent meetings | -Formal e informal -Frequent meetings | -Informal -Scrum Ceremonies | -Informal -Scrum Ceremonies |
| **Customer Involvement** — Frequency | At contract signing and final delivery of the project | At contract signing, milestones and final delivery | Weekly basis | Daily basis |
| **Customer Involvement** — Interaction | -Minimum -The project manager adds and changes project activities to conform to the project scope | -Minimum - Clients evaluate the progress of the project in the milestones | - High -The team evaluates the client's proposals and changes the activities to ensure project quality and customer satisfaction | -Very High -The customer evaluates, prioritizes, adds or changes the product -The team changes activities to get the results expected by the client |
| **Resources and Duration Estimation** — Form | Amount of activities and men / hours | | | Amount of people to reach certain speed to meet the story points |
| **Resources and Duration Estimation** — Technique | Parametric estimation, analogous, three points | | | Specialized opinion |

*Figure 3: Morphological matrix of project management practices.*
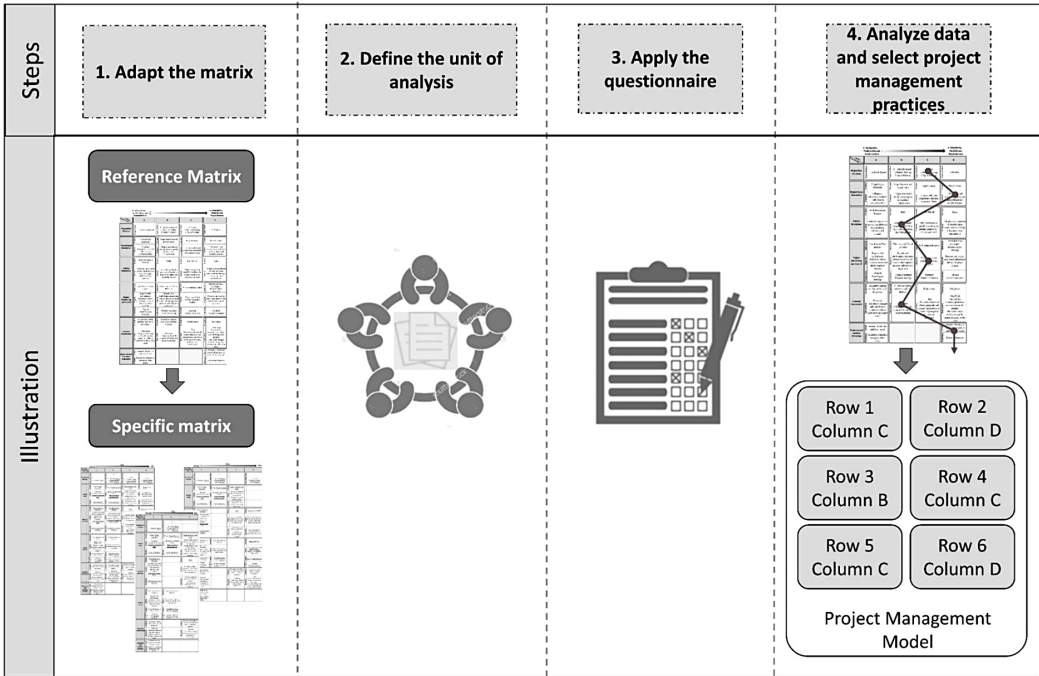


*Figure 4: The process to create hybrid models.*

## 6 A CASE EXAMPLE FROM A SOFTWARE COMPANY

The purpose of the case study was to confirm the feasibility of applying the method to configure hybrid models in a real company. The case was conducted at an information technology (IT) company, which works with custom software development, managed services and IT projects. The company has over 20 years of experience and currently has offices in six cities in Brazil. The selected business unit comprises the development pole of the company. Waterfall and agile approaches were already used in parallel in the organization. However, they demonstrated the need to combine these two approaches to address specific projects.

The first step according to the proposed method, was to adapt the matrix of practices according to the company's reality. To accomplish this step, we conducted a diagnosis of the organization's project management (using Appendix B) in order to collect data related to the way projects are managed (practices, techniques and tools). This information ensures a better understanding of the current project management process in the organization, including the identification of the main problems. It is important to interview different people from different teams and areas to collect information from different perspectives. We interviewed four project teams. Each of them uses different ways to manage their projects, which includes waterfall and agile management.

The raw data was ordered and grouped according to project management processes and matrix rows. Then, we eliminate similar practices to avoid redundancies. The structure used in the data analysis is shown in **Table 4**. After this process, the practices were standardized and included in the matrix structure (rows and columns). The company's matrix is illustrated in **Figure 5**.

In the second step, we define the unit of analysis. In this case, two projects with different characteristics were selected: Project A) development of a complete management system platform integrating various modules (stock, budgets, sales, notes). This project involved a high degree of complexity, requiring many people and with a deadline of 18 months for completion, being a critical factor for the project success; and Project B) development of a corporate cost control software for a start-up, which automates and manages all real-time corporate repayments. The project involved collaborative and innovative technologies and functionalities, with a stipulated time of 6 months for completion.

Ten professionals from the organization participated in the application, involving project leaders and members of the development teams. Participants were separated into three teams. Teams 1 and 2 received project A (management system platform) and team 3 received project B (corporate cost control software). This division was made to evaluate the following hypotheses: I) Different teams can develop different solutions for the same project; II) Different teams can develop different solutions for different projects.

At this point (Step 3), each team answered the questionnaire according to their project. The diagnosis of the characteristics of the project and the environment directly influence the choice of practices. For example, projects with a high level of innovation tend to respond better to the use of a high-level scope. In these cases, the problem is not clear, making it difficult to establish a detailed scope. On the other hand, projects that involve low innovation describe the scope in detail, in order to guarantee the inclusion of all necessary work, avoiding ambiguities and misinterpretation. In the fourth step, based on the data from the previous step and using the company's matrix, the teams chose the practices that best met the particularities of the analyzed projects (see **Figure 5**).

The teams developed proposals with different combinations of practices. This result confirms the two hypotheses mentioned earlier. Between teams 1 and 2 (Project A - management system platform), only two practices were similar (Gantt /Scrum and estimation based on historical data). Team 1 chose to use the project scope statement claiming that according to the case, the project would already be clear to the client, presenting a fixed scope. Team 2, however, chose the Service Model Canvas. According to the participants, this artifact guides the objectives and purposes of the project, allowing scope adjustments without deviating from the expected results.

Regarding client involvement, Team 1 chose frequent involvement, with meetings to align the project progress, while Team 2 selected daily involvement. Since the project under analysis had a large delivery period (18 months), Team 2 was asked about their choice. According to the team, the practice was chosen by the culture of all members of the group in using agile management practices and principles. The members of this team used the Scrum method in their projects. They made the choice according to the practices they already used in their projects, which may not necessarily be the best options for this project. This may be an indication that some practices or techniques are adopted "by the book" simply because they are described in this way in books or methods, and there is no reflection on how to adapt these practices to the project reality, as is intended with the proposed method in this paper.

Team 3, which received project B (a corporate cost control software) presented four practices that were the same as those chosen by Team 1, with different practices related to project control and duration estimation. In relation to Team 2, only one of the practices was the same (Gantt/Scrum). The result of Team 3 was unexpected, since project B involved a software development containing several characteristics that directed it to purely agile management. They justified the choice due to members' lack of experience with agile practices (they work with well-defined scope projects in the organization). They drew on their own experience as the main aspect to make the choice. This fact demonstrated, together with the discussion among researchers and project managers, that the culture and knowledge of the organization's professionals had a significant influence on practices choice. Some significant statements have been collected in this sense, such as:

*"We take as a basis the practices that we already know";*

*"Most of the projects we have today are like this, following the line we are accustomed to", and*

*"Usually we do not reflect on other existing practices in project management".*

There is a trend in the company: the team members do not stop to reflect and analyse deeply the other possible options, which may be even more beneficial for that particular project. A possible solution to this scenario may be the implementation of training in project management methods and practices, together with a procedure to encourage team members to reflect on the best solution to manage the project. Thus, teams can increase their range of options and knowledge of practices.

The participants explained the matrix helped to create the management models, allowing them to see a range of options and reflect that there are several ways to meet the needs of the project. In addition, they pointed out the importance of the matrix for collaboration and discussion among team members about which practices would be most appropriate for the case.
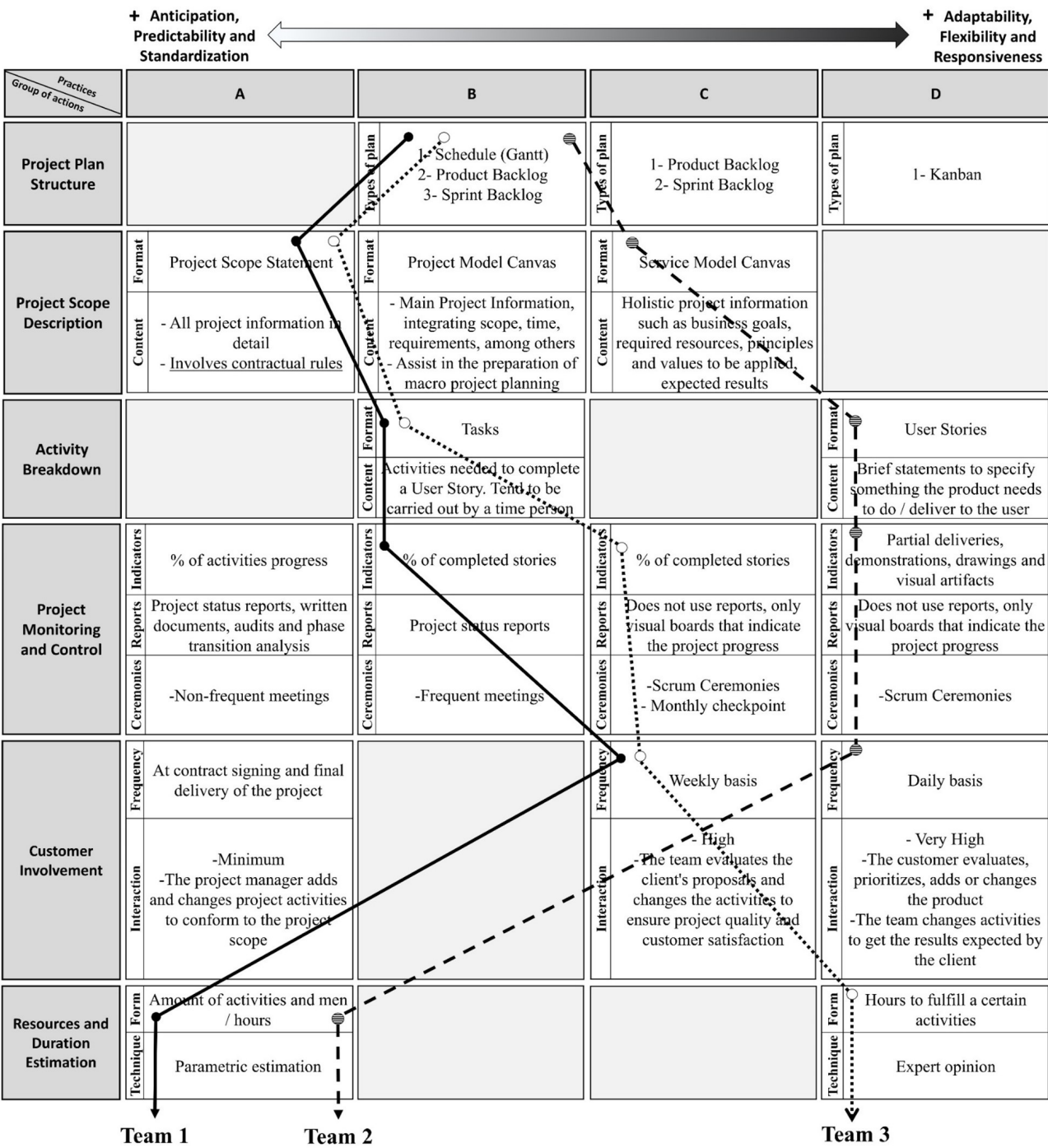
| ID | Description | Practice | | | Related Process | Matrix row | Similarity |
|---|---|---|---|---|---|---|---|
| | | Action | Technique | Tool | | | |
| E3.6 | They have a customer schedule that involves the macro responsibilities of the company and the customer, and an internal schedule based on sprints. | Schedule develop-ment | Product Backlog/Sprint Backlog/Gantt | Project Management Software | Planning | Structure of the plan | E.4.5 e E.2.4 |

*Table 4: Understanding the Matrix rows.*



*Figure 5: Company's matrix and application results.*

The management models created reflect the reality of each team, inserted in the context of the organization. If the method were used by another team or in a different context, with different organizational factors, the final models would probably be different. Some lessons learned from this case study can assist other organizations and professionals in building their hybrid models. The first lesson is not to restrict the team to just the practices they already use. The team's knowledge and experience are important, but we must explore new practice opportunities, aiming to improve the organization's project management process. The second lesson is to encourage integration between different teams and project management professionals, sharing their experiences regarding the use of a particular practice. The organization can create a database of the experiences of its management practices (historical basis), in order to assist in the development of its management models.

## 7　CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

This study represents the first effort to solve the challenge of customizing hybrid models for specific projects. The method relates the project characteristics with management practices, in order to create an appropriate solution. Instead of predefined models for an organization, it is encouraged to create instruments that allow the personalization of specific management models for each project.

The results indicate that the method was able to help the participants in the customization of management models. However, the experience and/or previous knowledge of the professionals, besides the personal preferences of each one, impacted the choices during the customization process. This fact reflects the lack of an alignment between what the company is performing and what the company really needs since the members showed a preference to remain in their comfort zone.

The hypothesis that arises is that teams did not reflect and analyze the possible options, even with the use of the proposed questionnaire. This reinforces the importance of the research problem. If previous experience in using a method and the "habit in employing it" has a greater significance to the point of using it in an inappropriate situation, as observed from these results, an important gap needs to be filled. This means that the efforts of project management specialists in recent years to elucidate the relationship between project context, practice and performance may not have an effect in the practice field.

This problem, however, does not rule out the use of the matrix. As noted in the customization results, the matrix made sense to the organization and project managers. For the organization, the matrix allows a way to balance standardization with flexibility, as managers are free to choose different practices, but they are limited to a set that is defined by the PMO when preparing the organization's matrix.

The PMO can, therefore, limit the techniques of a set that has been verified empirically and that can generate results for the organization.

In future research, the idea of customizing practices by project can be an alternative and an important research theme in this area. It would be especially interesting to verify: a) the construction of mechanisms for assisting professionals to adopt project management practices that enhance agility; b) the possibility to use recommendation algorithms that could adapt management practices for a specific project; c) identify intelligent algorithms for data extraction in project management information systems to help professionals to improve management process.

Among the study limitations, the research scope was limited to the planning and control of project scope and time, not involving other areas of knowledge, such as risk, quality and costs. Future studies may focus on the morphological matrix evolution. The second limitation involves the use of the questionnaire responses as inputs to the morphological matrix, in a qualitative way to encourage users to think about important aspects of the project that affect its management. New studies can investigate mechanisms capable of automatically relating the questionnaire to the matrix, in order to generate a management model. The third limitation refers to the number of cases and companies studied. The method test was performed through a single case study in a software development company. We recommend applying the method in a larger number of projects and organizations, in different contexts and types of industries.

## REFERENCES

Adelakun, O., Garcia, R., Tabaka, T., & Garcia, R. (2017). Hybrid Project Management: Agile with Discipline. In: International Conference on Information Resources Management (CONF-IRM). Association For Information Systems.

Ambler, S., & Lines, M. (2018). Choose Your WoW! A Disciplined Agile Delivery Handbook for Optimizing Your Way of Working (Disciplined Agile Consortium, Ed.). Disciplined Agile, Inc.

Augustine, S. (2005). Managing Agile Projects. Prentice Hall PTR.

Azenha, F. C., Reis, D. A., & Fleury, A. L. (2020). The Role and Characteristics of Hybrid Approaches to Project Management in the Development of Technology-Based Products and Services. Project Management Journal. https://doi.org/10.1177/8756972820956884

Bäcklander, G. (2019). Doing complexity leadership theory: How agile coaches at Spotify practise enabling leadership. Creativity and Innovation Management, 28(1), 42–60. https://doi.org/10.1111/caim.12303

Barlow, J. B., Giboney, J. S., Keith, M. J., Wilson, D. W., Schuetzler, R. M., Lowry, P. B., & Vance, A. (2011). Overview and Guidance on Agile Development in Large Organizations. Communications of the Association for Information Systems, 29(July 2011), 25–44.

Batra, D., Xia, W., van der Meer, D., & Dutta, K. (2010). Balancing agile and structured development approaches to successfully manage large distributed software projects: A case study from the cruise line industry. Communications of the Association for Information Systems, 27(1), 379–394. https://doi.org/10.1.1.186.7346

Bianchi, M. J., Conforto, E. C., & Amaral, D. C. (2021). Beyond the agile methods: a diagnostic tool to support the development of hybrid models. International Journal of Managing Projects in Business. https://doi.org/10.1108/IJMPB-04-2020-0119

Bianchi, M., Marzi, G., & Guerini, M. (2020). Agile , Stage-Gate and their combination : Exploring how they relate to performance in software development. Journal of Business Research, 110(May 2017), 538–553. https://doi.org/10.1016/j.jbusres.2018.05.003

Binder, J., Aillaud, L. I., & Schilli, L. (2014). The Project Management Cocktail Model: An Approach for Balancing Agile and ISO 21500. Procedia - Social and Behavioral Sciences, 119(119), 182–191. https://doi.org/10.1016/j.sbspro.2014.03.022

Boehm, B., & Turner, R. (2003). Using risk to balance agile and plan-driven methods. Computer, 36(6), 57–66. https://doi.org/10.1109/MC.2003.1204376

Chandrababu, A. (2020). Adoption of Hybrid Methodology in projects.

Ciric, D., Lalic, B., Gracanin, D., Palcic, I., & Zivlak, N. (2018). Agile Project Management in New Product Development and Innovation Processes : Challenges and Benefits Beyond Software Domain. In: 2018 IEEE International Symposium on Innovation and Entrepreneurship (TEMS-ISIE)., 1–9.

Conforto, E. C., & Amaral, D. C. (2016). Agile project management and stage-gate model—A hybrid framework for technology-based companies. Journal of Engineering and Technology Management, 40, 1–14. https://doi.org/10.1016/j.jengtecman.2016.02.003

Conforto, Edivandro Carlos. (2013). Modelo e ferramenta para avaliação da agilidade no gerenciamento de projetos. In Tese (Doutorado) - Escola de Engenharia de São Carlos, Universidade de São Paulo.

Conforto, Edivandro Carlos, Rebentisch, E., & Amaral, D. C. (2014). The Building Blocks of Agility as a Team ' s Competence. Project Management Agility Global Survey.

Cooper, R. G. (2014). What's Next?: After Stage-Gate. Research-Technology Management, 57(1), 20–31. https://doi.org/10.5437/08956308X5606963

Cooper, R. G. (2016). Agile-Stage-Gate Hybrids. Research Technology Management, 59(1), 21–29. https://doi.org/10.1080/08956308.2016.1117317

Cooper, R. G. (2017). Idea-to-Launch Gating Systems : Better , Faster , and More Agile Idea-to-Launch Gating Systems. Research-Technology Management, 60(1), 48–52. https://doi.org/10.1080/08956308.2017.1255057

Cooper, R. G., & Sommer, A. F. (2016). The Agile–Stage-Gate Hybrid Model: A Promising New Approach and a New Research Opportunity. Journal of Product Innovation Management, 00(00), n/a-n/a. https://doi.org/10.1111/jpim.12314

Duhovnik, J., & Tavčar, J. (2005). Product design test using the matrix of functions and functionality. DS 40: Proceedings of AEDS 2005 Workshop, (November).

Eder, S., Conforto, E., Amaral, D., & Silva, S. da. (2015). Diferenciando as abordagens tradicional e ágil de gerenciamento de projetos. Production Journal, 25(3), 482–497. https://doi.org/10.1590/S0103-65132014005000021

Fargnoli, M., Rovida, E., & Troisi, R. (2006). The morphological matrix: Tool for the development of innovative design solutions. Proc. ICAD, 1–7. Retrieved from http://www.axiod.com/technology/icad/icad2006/icad2006_21.pdf

Fitzgerald, B., Stol, K., Sullivan, R. O., & Brien, D. O. (2013). Scaling Agile Methods to Regulated Environments : An Industry Case Study. In: 2013 35th International Conference on Software Engineering (ICSE). IEEE.

Galal-Edeen, G. H., Riad, a. M., & Seyam, M. S. (2007). Agility versus discipline: Is reconciliation possible? ICCES'07 - 2007 International Conference on Computer Engineering and Systems, 331–337. IEEE. https://doi.org/10.1109/ICCES.2007.4447068

Gemino, A., Horner Reich, B., & Serrador, P. M. (2020). Agile, Traditional, and Hybrid Approaches to Project Success: Is Hybrid a Poor Second Choice? Project Management Journal. https://doi.org/10.1177/8756972820973082

Highsmith, J. (2004). Agile Project Management: Creating Innovative Products. Boston, MA: Addison-Wesley.

Imani, T., Nakano, M., & Anantatmula, V. (2017). Does a Hybrid Approach of Agile and Plan-Driven Methods Work Better for IT System Development Projects ? Int. Journal of Engineering Research and Application, 7(3), 39–46. https://doi.org/10.9790/9622-

Kennedy, D., & Philbin, S. (2014). Diagnostic Framework and Health Check Tool for Engineering and Technology Projects Simon. Journal of Industrial Engineering and Management.

Leffingwell, D. (2010). Agile software requirements : lean requirements practices for teams, programs, and the enterprise. Addison-Wesley Professional.

Magistretti, S., Trabucchi, D., Era, C. D., & Buganza, T. (2019). A New Path Toward a Hybrid Model: Insights from PwC's Italian Experience Centre. Research-Technology Management, 62(5), 30–37. https://doi.org/10.1080/08956308.2019.1638223

Mcgrath, J., & Kostalova, J. (2020). Project Management Trends and New Challenges. https://doi.org/10.36689/uhk/hed/2020-01-061

Mcmillan, E. (2004). Complexity, organizations and change. London: Routledge.

Nawrocki, J., Olek, L., Jasinski, M., Paliświat, B., Walter, B., Pietrzak, B., & Godek, P. (2006). Balancing agility and discipline with XPrince. Lecture Notes in Computer Science, 266–277. https://doi.org/10.1007/11751113_19

Ölvander, J., Lundén, B., & Gavel, H. (2009). A computerized optimization framework for the morphological matrix applied to aircraft conceptual design. CAD Computer-Aided Design, 41(3), 187–196. https://doi.org/10.1016/j.cad.2008.06.005

Pahl, G., & Beitz, W. (2007). Engineering design: A systematic approach (3rd ed.). Springer. https://doi.org/10.1073/pnas.0703993104

Pich, M. T., Loch, C. H., & Meyer, A. De. (2002). On uncertainty, ambiguity, and complexity in project management. Management Science, 48(8), 1008–1023. https://doi.org/10.1287/mnsc.48.8.1008.163

PMI. (2017a). A guide to the project management body of knowledge (PMBOK guide) (6th ed.). Newtown Square, Pa: Project Management Institute.

PMI. (2017b). Success Rates Rise: Transforming the high cost of low performance. PMI's Pulse of the Profession, (9th Global Project Management Survey), 32. Retrieved from http://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/pulse/pulse-of-the-profession-2017.pdf

Riesener, M., Dölle, C., Ays, J., & Ays, J. L. (2018). Hybridization of Development Projects Through Process-related Combination of Agile and Plan-driven Approaches. 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 602–606. IEEE.

Ritchey, T. (1998). General morphological analysis. 16th Euro Conference on Operational Analysis. https://doi.org/10.1007/978-3-642-19653-9_2

Shenhar, A., & Dvir, D. (2007). Reinventing Project Management: the diamond approach to successful growth and innovation. Boston: Harvard Business School Press. https://doi.org/10.1016/j.techfore.2007.12.001

Sommer, A. F., Hedegaard, C., Dukovska-Popovska, I., & Steger-Jensen, K. (2015). Improved Product Development Performance through Agile/Stage-Gate Hybrids. Research Technology Management, 58(1), 34–44. https://doi.org/10.5437/08956308X5801236

Špundak, M. (2014). Mixed Agile/Traditional Project Management Methodology – Reality or Illusion? Procedia - Social and Behavioral Sciences, 119(1), 939–948. https://doi.org/10.1016/j.sbspro.2014.03.105

Tan, A. R., & McAloone, T. C. (2006). Characteristics of strategies in product/service-system development. 9th International Design Conference, DESIGN 2006, 1435–1442.

Weber, R. G., & Condoor, S. S. (1998). Conceptual design using a synergistically compatible morphological matrix. Proceedings - Frontiers in Education Conference, 1, 171–176. https://doi.org/10.1109/fie.1998.736828

Wysocki, R. ., & Mcgary, R. (2007). Effective Project Management: traditional, adaptative, extreme. Indiana: Wiley Publishing, Inc. https://doi.org/10.1017/CBO9781107415324.004

Wysocki, R. K. (2007). Effective Software Project Management. In Statistics. Wiley Publishing, Inc.

Zasa, F. P., Patrucco, A., & Pellizzoni, E. (2020). Managing the Hybrid Organization: How Can Agile and Traditional Project Management Coexist? Research Technology Management, 64(1), 54–63. https://doi.org/10.1080/08956308.2021.1843331

## Appendix A - Project Characteristics Questionnaire

**Instructions**:
• Each question should have only one answer
• All questions should be answered
• Consider only one project at a time
• Consider the project team as the one formed by the project manager and the professionals who will work on the project.

**1. In relation to the organizational structure of the company, this:**
☐ It is characterized as being centralized, specialized and bureaucratic. It is based on the hierarchy and centralization of decision-making power (1)
☐ (2)
☐ (3)
☐ (4)
☐ (5)
☐ It is characterized as informal, decentralized and with few levels of authority. It is based on knowledge and interaction between members (6)

**2. What is the average experience time of the project manager in the development of projects (products / software) in the organization:**
☐ Do not have previous experience (1)
☐ Below 1 year (2)
☐ Between 1 and 3 years (3)
☐ Between 4 and 6 years (4)
☐ Between 7 and 9 years (5)
☐ 10 years or above (6)

**3. What is the average experience time of project team members in the development of projects (products / software) in the organization?**
☐ Do not have previous experience (1)
☐ Below 1 year (2)
☐ Between 1 and 3 years (3)
☐ Between 4 and 6 years (4)
☐ Between 7 and 9 years (5)
☐ 10 years or above (6)

**4. Regarding the size of the project team, this consists of:**
☐ More than 30 people (1)
☐ 25 to 30 people (2)
☐ 19 to 24 people (3)
☐ 13 to 18 people (4)
☐ 7 to 12 people (5)
☐ Up to 6 people (6)

**5. With respect to the project team, this consists of:**
☐ Professionals from the same department, with the same skills and experience (1)
☐ (2)
☐ (3)
☐ (4)
☐ (5)
☐ (6)
☐ Professionals from different departments, with different skills and experiences, complementary to the project execution (7)

**6. Check the option that best represents the reality in the project in relation to the project team location:**
☐ The team is located in different countries or geographically far away (1)
☐ The team is located in the same country but distant geographically (2)
☐ The team is located in the same space (room, floor, building), or very close geographically (3)

**7. Regarding the project result (product / software / service), the main innovation is:**
☐ On some components or parts of the product and was new to the company (1)
☐ On some components or parts of the product and was new to the market (2)
☐ In architecture and was new to the company (3)
☐ In architecture and was new to the market (4)
☐ Total, new product or software for the company (5)
☐ Total, new product or software for the market (6)

**8. In relation to the project complexity, this involves:**
☐ The creation of elements, components and modules in a single unit, involving communication between team members (1)
☐ (2)
☐ (3)
☐ (4)
☐ (5)
☐ (6)
☐ Several systems that work together to achieve a common purpose (7)

**9. Skills in the technologies needed to develop the product / software or service:**
☐ Are the domain of the project team (1)
☐ (2)
☐ (3)
☐ (4)
☐ (5)
☐ (6)
☐ They are totally unknown to the project team. There is one or more gaps in one of the technologies (7)

**10. In relation to the urgency to complete the project, it is necessary to:**
☐ Delays do not affect project success (1)
☐ The shorter the completion time, the greater the competitive advantage (time-to-market prioritization) (2)
☐ The time to completion is critical (due to an event or opportunity window) (3)
☐ Urgent, they have time as the most critical factor and must be completed as soon as possible (4).

## Appendix B - Guide for identifying project management practices

**1. Initiation**
1.1. Describe how a new project starts.
1.2. How are project team members defined?
1.3. Is there a kick-off meeting? Is the project start documented in any way? Who are involved?
1.4. Is a project charter used? If there is no official document, is there a brief description of the product scope (product view) and project scope?
1.5. Are any other techniques or procedures used?

**2. Planning**
2.1. How is the project planning?
o Does planning start from any document?
o Who participates in the planning (team, stakeholders, customer, etc.)
o What is the team's role in project planning?
o How does the identification of customer requirements occur? (Interviews, discussion groups, creativity techniques, questionnaires, observations, prototypes, etc.)
o How do you identify the customer's core value?
o Is the planning detailed? What is the time horizon of the project plan?
o How are activities defined? Are they sequenced and / or prioritized?
o What tools and techniques are used? (meeting, WBS, tables, spreadsheets, etc.)
o How do time, cost and resource estimates occur?
o Is there a project schedule? How is it developed?
2.2. Does the company use information from past projects?
2.3. What documents are prepared?
2.4. How the project plan is communicated to those involved in the project (team, stakeholders, customer, etc.)

**3. Execution**
3.1. How does the company know that it is meeting the client's requirements during project execution?
3.2. There are evaluation and feedback meetings with the client; tests; verification, etc.?
3.3. How does the company evaluate the quality of the project?
3.4. How do you verify and control the scope, schedule and changes of the project?
3.5. Does the organization use different types of prototypes?
3.6. How does communication between stakeholders occur?
3.7. How often and how do you contact the customer?

**4. Monitoring and control**
4.1. How is the project monitored and controlled?
o Do project teams use any progress indicators? Which are? Is it based on costs, time,% progress, partial deliveries, prototypes, visual artifacts?
o Do they use satisfaction, team and customer indicators? and financial performance indicators?
o Who participates in this process? Client, stakeholders, etc. What is the frequency of interaction?
o How does interaction with the PMO occur?
o What techniques and tools are used? (Sprint review, Sprint retrospective, Softwares, Charts, Spreadsheets, Ckecklist, etc.)
o Is there a document repository and version control?
4.2. What documents are used in this process? Who is responsible for updating these documents?

**5. Closing**
5.1. How is the project closed?
o How are lessons learned treated?
o Who participates in this process?
o What tools are used in this process?