

# RESEARCH ON THE AGILE AND WATERFALL APPROACHES IN IMPROVEMENT PROJECTS

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**Abstract:** In the Romanian economy, there is a clear need for improvement, optimization, and efficiency, not only in the private sector but also in the public sector. The economic success of industry firms depends on their ability to identify customer needs and quickly produce the products people require at minimal costs. To achieve these objectives, which involve multiple departments, product and system development is necessary. Designing and developing systems require intensive work to gather information, knowledge, and their practical application. However, despite significant efforts, it often happens that the results of a project do not meet expectations. One of the causes can be an inappropriate approach to the project. Different types of projects require different procedural models for successful execution. A procedural model organizes project management methods and tools into standardized project phases or processes. Procedural models for improvement projects can be divided into plan-driven methods, following a classical waterfall-type process, and agile methods (such as Scrum and Kanban), following an iterative, test-driven approach.

**Keywords:** agile, waterfall, improvement, project

## 1 INTRODUCTION

In the books based on the study of project management, the following ideas have been identified as definitions and basic principles of project management:

Clarity of objectives: The project must have clear and well-defined objectives, ensuring a common understanding among all stakeholders. Objectives should be measurable, relevant, and achievable.

**Adequate planning:** It is essential to develop a detailed plan that includes activities, necessary resources, deadlines, and responsibilities of the project team. Proper planning helps in organizing and coordinating efforts efficiently within the project.

**Effective communication:** Clear and open communication among project team members, stakeholders, and other departments is crucial for project success. Regular communication, progress updates, and prompt issue resolution help maintain everyone involved on the same page.

**Risk management:** Identifying and evaluating risks associated with the project is important to develop appropriate risk management strategies. Timely monitoring and addressing risks help minimize their negative impact on the project.

**Efficient resource allocation:** Ensuring proper allocation of resources, including personnel, budget, and equipment, is important to accomplish project tasks and objectives efficiently and cost-effectively.

**Monitoring and evaluation:** The project needs to be periodically monitored and evaluated to ensure it is progressing according to the plan. Running evaluation and recognition of any changes help in using corrective actions and permanent improvement of the task.

**Tractability and adaptability:** The project should be flexible and allow adjustments based on changing environmental factors, customer conditions, or surprising conditions that may arise thru the mission.

These philosophy provide a grounds for forming and managing successful projects. Nevertheless, it is important to adapt and adjust these values based on the individual nature of the project and the demands of the corporation or industry required.

## 2 WATERFALL VS AGILE

### 2.1 *Waterfall Methodology*

The Waterfall methodology is a progressive and straight project management approach. It is described by a step-by-step succession through distinct stages, where every single phase must be finished before going on to the next one. The stages typically involve requirements assuming, system design, execution, testing, setting out, and maintenance. The Waterfall methodology tracks a structured and decided plan, with a formidable emphasis on straight planning and documents. It is regularly used in jobs with well-defined and constant requirements, where modifications are expected to be smallest once the project begins. The Waterfall approximate provides a clear and complete vision of the project timeline, goals, and deliverables. Conversely, it can be fewer flexible in adjusting changes or feedback during the progress process. It is an tactic to mission management that highlights a linear progression from the introduction to the end of a project, established on a distinctly defined target at the start of the project and standing each step of the progress. This usual method, regularly referred to as the waterfall model, contains of several phases, each advancing one after the previous in a logical approach. The pattern upon which every project begins contains the following stages:

**Rations gathering and examination:** This is the primary phase of the project and means identification the project necessities and creating a conditions document.

**Design:** In this phase, the system design is created. This contains designing the style, user interface, and routine data flow.

**Implementation:** The project from the preceding phase is realized in this stage. It involves recording the code, forming the system, and testing it.

Testing: The system is tested to ensure it meets the requirements and is of high quality. There are various types of testing, including unit testing, integration testing, and acceptance testing.

Review: After the system is implemented, it is important to maintain it by addressing errors, adding new features, and improving it.

Product release: The final product is launched.

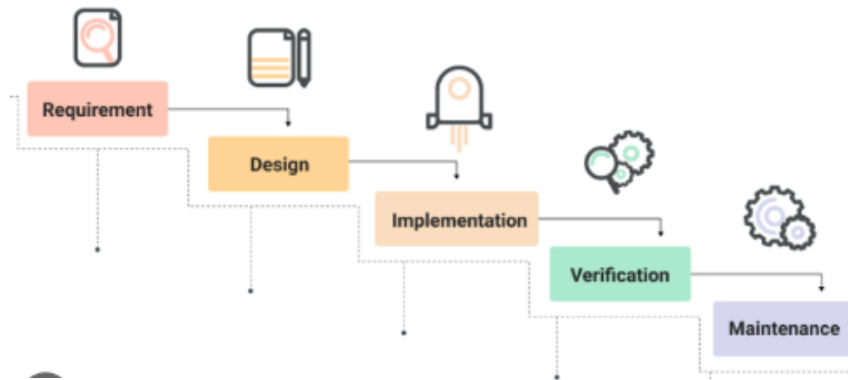


Figure 1. Waterfall structure

The waterfall methodology follows a sequential approach, where each phase is completed before moving on to the next one. It provides a structured framework for project management but may have limited flexibility in accommodating changes or feedback during the development process.

## 2.2 Agile Methodology

The well-known Agile methodology is a relatively recent approach compared to other methods, specifically developed in 2001 as a response by the software industry to the Waterfall method, aiming to address its disadvantages. Over time, various Agile variants have emerged, such as Scrum, which is likely the most widely used method, especially in software teams. Four key values in creating an efficient customer-oriented development methodology have been defined for Agile:

Individuals and interactions over processes and tools: The project manager should prioritize collaboration and the contribution of clients, rather than sticking to rigid rules that may become outdated.

Working software over comprehensive documentation: Although this principle is software-oriented, it can be applied in any other field. Essentially, it means that the project team should focus on delivering a functional product that the client can use (even if it may be incomplete), rather than trying to build the "perfect" solution that may never be delivered because it proves to be too complicated.

Customer collaboration over contract negotiation: Instead of solely focusing on the details specified in a contract, try to find a solution together with the client.

Responding to change over following a plan: Project managers should adapt to changes rather than sticking to an outdated plan.

This type of Agile project does not have a well-defined structure, as adjustments can be made after each phase, allowing for flexibility and adaptation. Often, a project activity can look like this:

- Design
- Development
- Testing
- Design

- Development
- Repeat.

As a principle, the structure can be modified until the client is satisfied

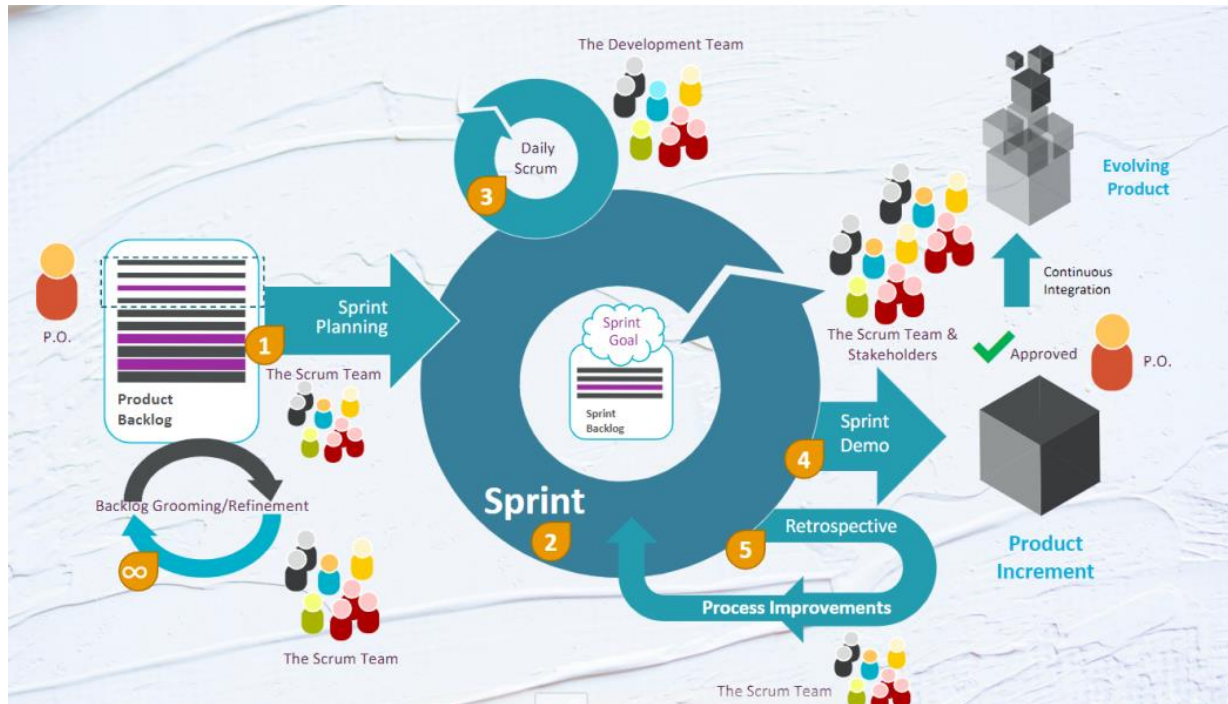


Figure 2. Agile structure

### 2.3 The differences between Waterfall and Agile:

- Approach:

Waterfall: Waterfall follows a sequential and linear approach, where each phase of the project is completed before moving on to the next phase. It is a plan-driven methodology with a focus on upfront planning and documentation.

Agile: Agile follows an iterative and incremental approach, where work is divided into smaller iterations or sprints. It is a flexible and adaptive methodology that encourages collaboration and continuous improvement.

- Flexibility:

Waterfall: Waterfall is less flexible and allows limited changes once the project starts. Changes or adjustments are difficult to incorporate once a phase is completed.

Agile: Agile is highly flexible and embraces changes throughout the project. It encourages adaptive planning and welcomes feedback and modifications to deliver the best possible outcome.

- Delivery:

Waterfall: Waterfall delivers the final product at the end of the project. It focuses on delivering a fully developed and tested product in one go.

Agile: Agile delivers the product incrementally, with each iteration delivering a working product or component. This allows for faster feedback, early value delivery, and the ability to adapt to evolving requirements.

- Customer involvement:

Waterfall: Waterfall involves less customer involvement during the development process. Customer feedback is typically gathered at the beginning and end of the project.

Agile: Agile encourages close collaboration with customers throughout the project. Customers are involved in providing feedback, prioritizing features, and validating deliverables during each iteration.

➤ Documentation:

Waterfall: Waterfall emphasizes extensive documentation, including detailed requirements, design specifications, and project plans. Documentation is created upfront and serves as a reference throughout the project.

Agile: Agile focuses on lightweight documentation. It values working software over comprehensive documentation but still ensures essential information is captured and shared.

➤ Risk management:

Waterfall: Waterfall attends risks and issues as they arise but may not prioritize continuous risk assessment. Risks are typically managed in later stages of the project.

Agile: Agile incorporates continuous risk management. Risks are identified, assessed, and addressed throughout the project, with a focus on mitigating potential impacts.

### 3 THEORETICAL STUDY ON THE SELECTION CRITERIA FOR PROJECT METHODOLOGY

The objective of this study is to deepen the knowledge in the field and to demonstrate the selection criteria when deciding which methodology to apply to an improvement project, as well as to identify which Lean Management methods can be easily implemented based on the type of approach.

In order to achieve the objective, the following steps were followed: identifying the source of information, conducting a literature review, selecting and evaluating the information, organizing the information, analyzing and interpreting it, revising and editing it, and finally, presenting and communicating the results.

### 3.1 Comparison between general criteria

Waterfall is a sequential linear model of a project life cycle, while Agile is a continuous improvement process for development and testing. Looking at the table below, we can see which methodology is more suitable for the same project management criteria.

- Complexity: Agile is more suitable for complex projects, as it allows for easier changes and adjustments as the project progresses. Waterfall is more suitable for less complex projects, as it is more structured and predictable.
- Requirements and nature of the project: Agile is more suitable for projects with requirements that are still under development or that can change as the project progresses. Waterfall is more suitable for projects with well-defined requirements that are unlikely to change.
- Team and resources available: Agile is more suitable for small, agile teams. Waterfall is more suitable for large, structured teams.
- Delivery time and priorities: Agile is more suitable for projects with a short delivery time and priorities that can change as the project progresses. Waterfall is more suitable for projects with a longer delivery time and priorities that are less likely to change.
- Risks and regulations: Agile is more appropriate for projects through extraordinary risks, as it accepts for more efficient risk management.

Overall, agile is more than right for complex projects with conditions that can alteration as the project evolutions, with small, agile players, with a sharp distribution time and importance that can adjust as the project progresses. Waterfall is further appropriate for less complex projects with well-defined conditions, with large,

formed teams, with a slower delivery time and primacies that are less likely to adjust.

### 3.2 Agile and Waterfall systems opposed to Lean management instruments

Greatest projects start from a requirement for upgrading, which is why a contrast between

continuous improvement tackles and their pertinency. in both approaches is another reason that does not facilitate in the executive-making process, judging the specific nature of the business.

Table 1. Lean Tools vs Agile, Waterfall

Lean Management and Kaizen Tools	Fit with Agile Approach	Fit with Waterfall Approach
5S	Suitable	Less suitable
Visual Management	Suitable	Less suitable
Value Stream Mapping (VSM)	Suitable	Less suitable
Poka-Yoke (Error Prevention)	Suitable	Less suitable
Kanban	Suitable	Less suitable
Jidoka (Human-controlled automation)	Less suitable	Suitable
Value Stream	Suitable	Less suitable
JIT (Just-in-Time)	Suitable	Less suitable
SMED (Single-minute exchange of dies)	Suitable	Less suitable
Kaizen Blitz (Rapid improvement events)	Suitable	Less suitable
Gemba (On-the-job)	Suitable	Less suitable
A3 Thinking (Problem-solving )	Suitable	Suitable
SIPOC (Supplier, Input, Process, Output, Customer)	Suitable	Suitable
360-degree feedback	Suitable	Suitable

The suitability of Lean Kaizen tools can differ based on the particular implementation and project context. Evaluating the appropriateness of each methodology and Lean

Kaizen tool is essential, taking into account the distinct requirements and characteristics of the improvement projects.

### 3.3 Agile and Waterfall approaches opposed to industry or discipline

The pertinence of Agile and Waterfall differs depending on the distinctive project or organization, but we can say that the Waterfall approach is more valid in some areas and Agile

is similarly applicable. There are also circumstances where equally can be used within an company.

In the end, the greatest project management method is the one that top fits the given project or group.

Industry or field	Agile	Waterfall
Software development	Suitable	Slightly suitable
Web development	Suitable	Slightly suitable
Mobile app development	Suitable	Slightly suitable
Hardware development	Slightly suitable	Suitable
Product development	Suitable	Slightly suitable
Marketing	Slightly suitable	Suitable
Sales	Slightly suitable	Suitable
Customer service	Slightly suitable	Suitable
IT support	Slightly suitable	Suitable
Finance	Slightly suitable	Suitable
Accounting	Slightly suitable	Suitable
Human resources	Slightly suitable	Suitable
Legal	Slightly suitable	Suitable
Regulatory compliance	Slightly suitable	Suitable
Manufacturing	Suitable	Slightly suitable
Transportation	Suitable	Slightly suitable
Logistics	Suitable	Slightly suitable
Healthcare	Suitable	Slightly suitable
Pharmaceutical industry	Suitable	Slightly suitable
Automotive industry	Slightly suitable	Suitable
Distribution	Suitable	Slightly suitable
Public institutions	Suitable	Slightly suitable

### 3.4 Conclusion

In summary, the mixture of the proper project management approach must be based on the detail project requirements, team organization, industry, and other background factors.

There is no one-size-fits-all approach, and the decision should be made based on careful consideration of the unique circumstances of each project.

In general, Agile is more suitable for complex projects with changing requirements, while Waterfall is more suitable for less complex projects with well-defined requirements.

Lean management tools can be used with both Agile and Waterfall methodologies. The specific tools that are most suitable will depend on the project's characteristics and the organization's culture.

The best way to choose a methodology is to assess the specific project's characteristics and then select the methodology that is most likely to be successful.

*What do we do when we observe, taking into account the criteria and features presented, that we need something from each approach?*

## 4 HYBRID AGILE AND WATERFALL APPROACH

The Agile-Waterfall hybrid model, as it is known in documents and literature, incorporates the best of both approaches. As defined by Erick Bergmann and Andy Hamilton, (Team, n.d.), the mixed method allows development teams to work with the Agile method, while the core team and product managers use the Waterfall method. The two methods can work harmoniously together because Agile is more of a mindset and an approach than a method, so it is possible to use the Agile philosophy with the rigid Waterfall methodology.

When considering a hybrid approach consisting of Agile, Lean, and Kaizen, there are a number of project dimensions that need to be considered. These include:

**Project complexity:** Complex projects can be more difficult to manage with a single framework and may require a hybrid approach.

**Requirements level:** Projects with unclear or changing requirements can benefit from a hybrid approach, as it allows for greater flexibility and adaptability.

**Risk level:** Projects with a high level of risk can benefit from a hybrid approach, as it allows for better risk management.

**Team experience level:** Teams with experience in Agile may be more able to implement a hybrid approach, as they will better understand the concepts and principles of both frameworks.

**Organization maturity level:** Organizations with a high level of maturity in project management may be more able to implement a hybrid approach, as they will have the ability to integrate the two frameworks in an efficient way.

A case study of two companies showed that teams underestimate or fail to implement critical elements of the Scrum framework. Water-Scrum-Fall is considered the reality in most agile organizations today. This leads to the failure to realize the business benefits of Agile: shorter time to market, greater business value, and better flexibility and responsiveness. Water defines the upfront work that is required according to governance rules. This includes project planning and budgeting. Requirements are specified. Teams use Scrum to develop software, which requires frequent software releases to get feedback. "However, most organizations do not have the architecture in place to support dynamic and flexible releases; instead, they make inefficient releases supported by processes and governance." This is the Fall part; using agile processes will not change the enterprise architecture.



#### 4.1 *Practical example of hybrid approach in an energy distribution company for the maintenance process*

The need for this project arose from the following reasons: the organization wants to implement a major change, which requires a project to make it possible.

The company's goal was to digitize as much of the informational part of the maintenance process as possible by moving from collecting and analyzing data on paper to a digital system. Of course, the main goal was to increase efficiency and eliminate waste from the process.

The project was started following the organization's need to digitize the maintenance process by: Automatically planning activities in accordance with existing technical standards and current procedures (improved), so that those who compete to complete the databases (defect database / network element database) can no longer enter incomplete information, and in the event of events, the company can prove that we were present in the field.

We are referring to a project that follows the *Waterfall project management method*, with a linear approach to project management, in which progress is made in a sequential manner from one phase to the next, without returning to a previous phase. For almost a year, this was the way in which the project was carried out and it had the goal of analyzing the process through Lean methods and highlighting the potential for improvement in order to achieve the company's vision / mission towards the digitalization of the process. The approach was a procedural one by appointing a project manager to track and plan the entire activity, with the planning of progress review meetings. The project manager discussed with the client, in our case being management and department director, discussing together the project criteria and indicators that are desired to be improved.

After detailed planning, we have concluded that we have 21 steps to follow:

- Identifying stakeholders, their needs, and relevant legal requirements.
- Conducting field observations of the process.
- Identifying IT applications used in the processes.
- Understanding the interfaces between departments.
- Identifying risks and measures to avoid them (internal operations and procedures).
- Identifying root causes for deviations from internal procedures.
- Linking risks to process/company objectives.
- Studying and applying best practices (internally and externally).
- Identifying and resolving process bottlenecks.
- Identifying other improvement needs - effectiveness and efficiency.
- Understanding issues from previous audits and using Pareto analysis.
- Defining SMART indicators.
- Identifying the impact on process owner: technologies, equipment, budget, benefits vs costs.
- Implementing data management controls.
- Implementing improvement measures (with immediate impact focus).
- Implementing budgeting, monitoring, and reporting controls.
- Clearly structuring process stages and aligning them with IT systems.
- Updating written procedures to align with current operations and organizational structure.
- Generating clear, simple, and visual work procedures.
- Triggers for revisiting steps 1 to 20.

The correlation of these steps with the stages we have established in the project can be observed as follows:

- Customer Perspective (empathy map, SIPOC).
- Interfaces (Swimlane).
- Activity observation.
- Current State Mapping (AS IS).
- Addressing blockages (issues/blockages/risks)
- Future State Mapping (TO BE).
- Actual vs. Future Analysis.
- Defining implementation plan.
- Standardization.
- Documentation for sustainability.
- Monitoring.

Following the analysis of improvement opportunities identified through process analysis and step-by-step monitoring, a total of 43 issues were identified. A significant portion of actions were closed during the process analysis (which were easily implementable with low costs and internal resources), while another portion were progressed to the stages where they could be addressed within the project's scope. However, the most critical ones towards achieving the *goal have not yet been resolved*.

The end of the traditional project represents the transition into the Agile project approach. Why was another approach added? It was added because after a long period of analysis and attempts, we did not achieve the desired result and realized that the need is much broader and more complex than initially thought. In order to achieve the goal/objective of digitizing the process, our need is a *Lean Agile* improvement methodology so that the results meet the client's requirements.

In the first part of this example we had a well-defined period/goal/duration and knew from the beginning what the steps were, in this second stage, we are going to implement and find solutions that do not necessarily depend on us (for example, IT solutions), where we could estimate a time frame, but the probability of the

supplier having the same prioritization system as us internally is zero.

The approach will be changed from Part 1, with agility being about continuous improvement, more of a mindset rather than treating it as a process. This process is a two-way process that continuously experiments and improves performance.

In the Agile project, the project structure and roles have been changed, consisting of:

- Process Owner (PO) who manages the process being conducted
- Process Team (PT) who performs quality activities
- Scrum Master (SM) who manages the pilot process.

We started at the beginning of 2022 with 43 initiatives - which were exemplified in the table above (Figure 13). They were manually entered into Excel. With the change in project approach and methodology, these initiatives were transferred to Azure DevOps (monitoring software) where we built the project Gantt chart from sprint to sprint.

Tracking initiatives/progress and assigning deliverables for sprints and other ceremonies was done using the same monitoring tool, which helped us with time orientation, maintaining traceability, and documenting all initiatives. All project team members can view the activity status at any time without the need for a meeting, providing great flexibility for the project.

At the end of 2022, following the initiatives from the beginning (the initial 43), an additional 468 iterations were entered into the system through ceremonies and work throughout the year. The project team grew from 8 to 23 people along the way.

From sprint to sprint, we see that we are getting closer to completing the project. However, when mapping out the activities/solutions that still need to be implemented in March 2023, we found that the project will take approximately 6-8 more months.

The conclusions of the hybrid approach are as follows:

- Although the project initially had loosely defined requirements (not as SMART as in a traditional project), it has proven to have a significant impact, both in terms of value and scope, encompassing multiple departments and key processes.
- With a traditional project approach, we would not have been able to implement many IT solutions, develop algorithms, and digitize processes. Due to the involvement of both internal and external teams and the unpredictable nature of the requirements, especially since we didn't know them upfront and they emerged during the project, we couldn't set a fixed timeline for their implementation.
- The project sponsors are delighted and continue to support the project. This project has a much larger impact than a traditional project, but it also incurs higher costs.
- Manual processes have already decreased by 45%, and after the implementation of the solutions, they are expected to decrease by up to 70%. This translates into the following benefits:
  - Data accuracy
  - Real-time data in the system
  - Process efficiency
  - Work standardization
  - Resource optimization
  - Creation of a digital flow

The *goal of the project is 90% solved*, and in 6-8 calendar month when the ultimate IT solution will be accessible the objective will be finished.

## 5 CONCLUSION

This article investigates the theories of project management and relates the Waterfall and Agile approaches. It highlights the magnitude of clarity of goals, adequate organization, effective statement, risk organization, effective resource allocation, and monitoring and estimation as fundamental theories of project management.

The Waterfall approach is described as a successive and linear approach, highlighting upfront planning and papers. It is suitable for projects with well-defined and stable needs but may need flexibility in adapting changes during increase.

On the other hand, the Agile methodology is described as an iterative and incremental style that promotes teamwork, adaptability, and continuous improvement. It is more appropriate for complicated projects with developing requirements and pushes customer involvement during the project.

The paper also discusses the pertinency of Lean management instruments in both Agile and Waterfall approaches. It suggests that the variety of Lean instruments have to consider the specific project perspective and demands.

Moreover, the article explores the changes between Agile and Waterfall methodologies grounded on factors such as approach, tractability, delivery, customer involvement, documents, and risk organization.

The magnitude of considering manufacturing or field-specific requirements when choosing a project management method is highlighted. Agile and Waterfall are considered fitting for different industries, but the group depends on the project's difficulty, requirements, team constitution, and risk intensity.

Finally, the article proposes that a hybrid style combining Agile, Waterfall, Lean, and Kaizen approaches can be favorable in certain circumstances. It allows for tractability, adaptability, and effective project management by leveraging the powers of each methodology.

The applied example of a hybrid method in an power distribution company's maintenance procedure demonstrates the winning realization of a project that initially trailed the Waterfall methodology and afterward transitioned to an Agile approach. It display case the benefits of relating different approaches to achieve the mission's goals.

In summary, the range of a project management method should be built on careful concern of project requirements, team organization, industry, and other background circumstances. Here is no one-size-fits-all approach, and businesses should adapt and adjust the principles and systems to fit their specific requirements. The mix approach can submit a flexible and effective answer when the conditions call for a sequence of Agile and Waterfall methodologies.

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