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Development of a suitable project management approach for projects with parallel planning and execution

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Abstract

In a big company, project management (PM) is always present. Traditional predictive PM approach is concerned with planning everything in advance and then controlling and adjusting if necessary, throughout the project timeline. This may work well when the requirements are well established, but for maintenance projects brings inherent uncertainty. When the subject is aircraft maintenance, it is almost impossible to plan everything at the beginning and expect that it will occur as planned because however a scheduled maintenance plan exists, according to statistics 60% of the aircraft total failure can only be found with ground inspection which means, that even if a plan is established before receiving the aircraft, it will most certainly need to be significantly changed. This requires a big effort from the planning team to plan everything right and ensure that all tools and resources are available to perform the required tasks. To solve this issue, in this paper we propose a hybrid project management approach developed to a case study company from the aircraft repair sector, to enable a faster planning while taking into account the priorities and dependencies of the inherent project tasks with the available resources.

Keywords: Aircraft Maintenance; Project Management; Agile; Scrum; Scrumban; Hybrid project management approach; Project planning

1. Introduction

Planning projects is a key for success. In the case of projects with major investments like in aircraft maintenance related projects, it is even more indispensable. It is imperative to have total control of all variables and requirements due the enormous complexity and investment associated, which can lead to huge losses if a reliable plan is not established.

This paper describes a case study developed in a multinational military aviation company within the military aircraft division. For confidentiality reasons the company name and details as well as the aircraft division will not be presented.

In a military maintenance company, where the aircraft availability is top priority for the customer, it is important to be the most effective possible in order to decrease the depot level maintenance turnaround time. Due to the aging of the aircrafts, the old times where the maintenances were linear and easily planned are not anymore valid. This is due to the number of non-conformities that are detected when the ground inspection is performed. Indeed, when the aircraft arrives to the hangar the number of non-conformities is rising, which leads to the necessity of changing the project management approach to another more dynamic to deal with this extra non planned work more efficiently.

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Due to the project's characteristics of this division, the planning and execution phases of a project need to be performed at the same time. The constant requirement changes require a fast adaptation from the team to perform the planning to be used afterwards on the execution phase. Until the beginning of this project, the traditional predictive PM approach was used. The planning used to be performed in big batches led to high inefficiency by missing the delivering of the required plans to be used on the execution phase. Therefore, the execution phase used to be performed without the required plans, leading to waste of time in solving problems whose solutions are usually stated in the plans.

After assessing what was the project improvement opportunities, some of the most well-known PM approaches in the literature were analysed to evaluate their suitability to the process under analysis and how they could fit to the division projects. During this process, the team performed a research about the application of the Hybrid approach to the Aircraft Maintenance field in the literature. The search was made in the Scopus and Web of Science electronic databases to find the relevant articles. To collect articles published the following keywords were firstly used: "aircraft maintenance" and "project management". In Scopus database 20 results were returned while in Web of Science only two results emerged. None of them included an application of agile approaches to aircraft maintenance project management. A second search was performed considering the following grouped keywords-based sets: "scrum" and "aircraft maintenance"; "agile" and "aircraft maintenance"; and "hybrid" and "aircraft maintenance" and "project management". Only one result was returned in Scopus database that was not directly linked to the project management topic. Given the level of novelty of the topic, since the agile approach emerged from the software development industry, the research team also performed a search to find applications of the agile approach in other industries as a way to collect evidences of its suitability to the case study under analysis.

After performing the literature review, the team concluded that applying and testing all of the most well-known PM approaches in the literature to this project would consume a lot of time, so it was decided to use a Suitability Assessment Radar, described in the Agile Practice Guide [1] presented by Project Management Institute in 2017, to support the decision. The output of this Radar is a recommendation of the most suitable PM approach for a specific project, which could be a Predictive, Agile or Hybrid approach, depending on the project characteristics. Regarding the methodology, the Hybrid approach was the selected option. Thus, the research question to address was how could the predictive and the agile approaches be combined to the management of aircraft maintenance projects?

This work is divided into five sections, starting by this one where a contextualization of the motivations and work developed is performed, followed by section 2 which describes the main theoretical issues needed to support the practical work. Section 3 deals with the methods used to carry out the work and section 4 presents the main results achieved through this work. Section 5 summarizes and highlights the main contributions brought by this work.

2. Literature Review

A project is a "temporary endeavor undertaken to create a unique product, service or result" [2]. It will not last indefinitely, but it has time constraints and has the goal of generating something that is distinctive to the organization. Project management is at the moment a rapidly growing field and is defined as "the ability to define a goal, plan to reach it, and execute the plan with accountability and control" [3].

Traditionally, both in practice and in academy PM is assumed to start once the requirements are defined. In this paradigm, project management is a set of concepts, tools, and techniques on how to execute projects on time, within budget, and to required customer specifications within the context of an explicit company strategy [4]. However, as pointed out by several researchers (see e.g. [5]) in innovative contexts where uncertainty is prevalent, such as in large and complex projects or new markets, this approach results in poor performance since typically problems are initially ill-structured and neither technologies nor customer requirements are necessarily known at the start.

Software systems engineering was transformed by the introduction of agile methods that were developed as a reaction to the traditional software waterfall development method where software was progressively developed in serial stages [6], [7]. In the traditional approach, when issues were uncovered, the software had to revert to an earlier phase causing significant rework, schedule delays, and cost overruns [6]. To contour this, agile methods are anchored on an iterative and incremental development cycle that quickly produces functional application versions that deliver value based solutions to the customer [6]. Agile methods represent a team management approach and a productivity framework that supports continuous and incremental progress on work priorities, even in the face of changes [8].

Although originating in the software industry, the principles and methods have since spread to many other industries and to the general fiels of project management [1,9]. For example, Carlson and Turner [6] evaluate the application of agile methods in non-software industries, through several case studies, to identify lessons to implementing agile methods on aircraft systems integration. Moreover, some case studies can be found in retailing [10], transportation [11], and construction industry [12-14].

Aircraft maintenance plays an important role in the aviation industry [15]. This service aims to maintain the airworthiness and reliability previewed in civil, executive and military aircraft projects throughout their operational lives [15]. For both civil and military aircrafts, two maintenance types occur, namely, light maintenance checks and heavy maintenance. In either case the aircraft maintenance can be preventive (or scheduled) or predictive (or unscheduled). For the scheduled maintenance a detailed planning and scheduling is mandatory, consisting in resources management, forecasting, scheduling and backlog control [16]. In military aircraft maintenance specialized technical resources are required, posing an additional challenge to the activity [16].

In aircraft a maintenance project for a complex system can be regarded as a combination of disassembly (mostly access

and inspection) and re-assembly (repair and replacement) operations. Thus, the planning of a maintenance project involves re-assembly planning as well as additional functions such as disassembly of structures, generation of maintenance structures, depending on the maintenance level, networking and planning of the entire maintenance project [17].

The planning of maintenance and the maintenance operation are hard to handle since these activities are greatly affected by many turbulence factors [18]. Therefore, it is imperative that these companies seek low and predictable costs, while ensuring a competitive total maintenance time [15]. One way to increase aircraft availability and improve maintenance and support efficiency, is to speed up the turnaround time for scheduled and unscheduled maintenance [19].A project that has high rates of change, complexity and risk can present problems for a traditional predictive approach, which tries to determine the bulk of requirements upfront and to control changes [1]. In an Agile approach team expect requirements to change, thus, instead of avoiding them, the feasibility is explored in short cycles and quickly adapted based on evaluation and feedback [1].

Agile approaches cover a variety of frameworks and methods. In the context of this project, Scrum, Kanban and Scrumban frameworks were chosen as they are suitable for projects outside the software industry. Kanban and Scrum are two powerful Agile project management approaches originated in software development which objective is to optimize the development process by identifying tasks, managing time more efficiently and setting-up teams [7]. The Scrum is centered on the coordinated activity of programmers who break their work into small tasks that can be completed within fixed duration cycles or “sprints”, tracking progress and re-planning in regular meetings in order to develop products incrementally [8]. Kanban is mostly focused on accurately stating what work needs to be done and when it needs to be done [7] being operationalized through a Kanban board. Scrumban is a hybrid methodology that emerged as a way to transition from Scrum to Kanban, in which teams use Scrum as a framework and Kanban for process improvement [1]. A detailed explanation of those three methodologies can be found in [1] and [7].

In the context of aircraft maintenance some alternative approaches to project management can be found in the literature. As an example, [17] use critical path method, materials requirements planning and production activity control techniques to the management of aircraft maintenance activities. [19] use critical chain project management method, derived from the theory of constraints, to aircraft maintenance checks. Furthermore, [9] used in an integrated way the critical path and the critical chain project management methods. Hao et al. [20] consider the resource-constrained multi-project scheduling problem, a problem arising in aircraft inspection and maintenance, linked to the development of a schedule of maintenance services. The authors tackle the problem using a dynamic project scheduling algorithm based on partial task network heuristics. Ahmadi et al. [21] present a critical review of existing aircraft scheduled maintenance program development methodologies. To our best knowledge, the literature tackling the application of agile methods in aircraft maintenance is almost inexistent.

3. Methods

In this section the methods used to assess which PM approach could fit better the case study maintenance repair system will be presented, namely a SWOT analysis comparing the predictive approach with the agile approach and a Suitability Assessment Radar. Furthermore, the hybrid PM approach developed to the case study is also explained. We note that this research is applied to military preventive heavy maintenance.

3.1. SWOT analysis

To have a clear view of the strengths, weaknesses, opportunities and threats regarding the predictive and the agile approaches a SWOT analysis was performed. Its results enabled to determine the points that can be improved in case of the necessity of developing a new or adapted approach. Fig. 1 shows the SWOT analysis regarding the predictive approach while Fig. 2 presents the SWOT analysis for the agile approach.

Fig. 1. Predictive approach SWOT analysis.

Fig. 2. Agile approach SWOT analysis.

3.2. Suitability Assessment Radar

Among the several suitability assessment tools, the one developed by PMI and Agile Alliance [1] was the one chosen since it is quite complete, because it assesses not only important aspects about the team, culture and project, but also includes the Hybrid layer that is really important for projects that come from a traditional approach. Furthermore, the radar also makes the distinction of the different project management approaches like the predictive, or agile. The military aircraft division project suitability has been assessed using this tool by answering a set of questions presented in [1]. The interested

reader can find more information about the answers to the set of questions in [22,23]. In Fig. 3, the obtained results are plotted in the radar. The more the results are in a specific circle, the more the associated PM approach is suitable to the type of projects under analysis. At first glance, it is possible to see that six of the subcategories fit on the Agile zone, which means that the approach that was been used, the predictive approach, is not the most recommended one. Moreover, some subcategories are in the hybrid zone. This indicates that a pure Agile approach is not the most recommended. Inside the Agile approaches exists a lot of methodologies, from which the most known are Scrum, Kanban and Scrumban. Thus, it was decided to use these methodologies as a basis for the new project management approach and tailor them with some predictive elements to be used in the areas that are outside the Agile zone circle.

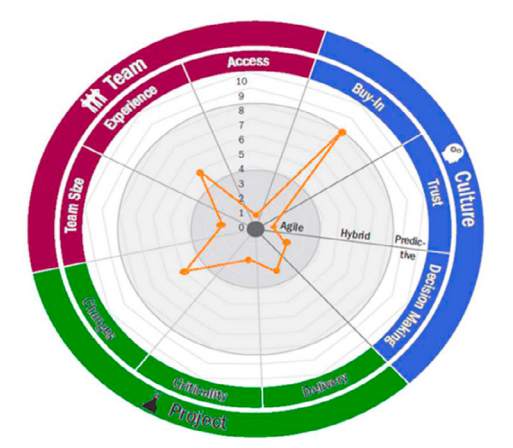

Fig. 3. Suitability assessment radar results.

3.3. Project Management approach proposal

Grounded on the results of the Suitability Assessment Radar, the next step was to create the approach to be implemented in the case study company, by using the most known Agile methodologies like Scrum, Kanban and Scrumban, and tailoring them to create the "perfect" approach to fit to the projects of the case study.

The most known Agile methodologies were assessed on where they could work and where they would not in the project under study. This allowed know where the methodology could fail. This failure is expected to happen, because like it was said before, they are pure agile methodologies and for this project a hybrid one is the most suitable. The goal is to tailor a methodology to fit to the project or complete it with elements from others.

The first methodology to be assessed was Scrum. It uses sprints which will account the available resources and necessities throughout a project and it uses ceremonies that help to organize the whole project. There are some points where it was not able to be used in the case study such as:

- Scrum states that it exists a Product Owner, a Scrum Master and a Development team. In this project, the Product Owner and Scrum Master have to be the same person and he/she will work with the development team, something that is not allowed to happen in a pure Scrum methodology.
- The daily Scrum meeting is not enough for the case study and it should be tailored with some predictive elements to address the lack of team experience.

The next methodology to be evaluated was Kanban. Regarding this one, it has no prescribed goals, which means that the team from the project can be used without the necessity of learning how to perform a specific role. It helps to visualize the work, measure and manage flow, use feedback loops to improve quality and continuous development. Some elements of this methodology cannot be used in the case study such as:

- Kanban limits work in progress, which means that a maximum amount of work in progress at any stage of the workflow exists. This does not apply to the case study because its tasks are not linear, meaning that some may have much longer durations than expected and others the opposite, making it difficult to predict the limit of work in progress that should be assigned.
- The pure pull principle cannot be applied to the case study because the team experience is not high enough and they don't have the "big picture" overview to know which tasks have higher priority.

Scrumban was the last methodology to be analysed. It mixes techniques of Scrum and Kanban. It follows six core principles that are like the ones from Kanban and for that reason they were not analysed because it was already done before. The bigger difference between Kanban and Scrumban is that Scrumban uses time boxes like the Scrum methodology. It could not be purely used because this one as the same roots from Scrum and Kanban, which means that the points where they fail, this one fails as well.

After this analysis the team responsible for this project decided to create an own approach for the current case study. This first analysis to check where the methodologies failed gave valuable information to know where to modify/add new elements. Among the different ones, Scrum was the one that showed more promising suitability; therefore, it has been used as a basis. Basis elements were tailored, and new predictive elements were added to create the "perfect" methodology for the current case study. This new methodology is a hybrid one, in a first approach, but tending to become more Agile in order to be even more effective. Some adjustments were necessary to address the weaknesses previously presented from the Scrum methodology and the areas which are outside the Agile zone found on the Suitability Assessment Radar presented in Fig. 3.

The first adjustment was the duration of each sprint which has been set to one month due to the frequency of changes inherent to the project, and the low team experience, which may require a longer period to perform the sprint tasks. Adding to this, the team experience will also trigger a change on the original scrum roles (as will be later explained). The projects also require a big awareness of the project status. To achieve that, a Kanban Board has been added to the proposed approach (Fig. 4). This extra tool will provide a clear vision of the

workflow, becoming the work more organized, which will consequently reduce the team confusion and the risk of overlooking. Furthermore, a new event was added to the approach, because the ones implemented on Scrum were not enough to comply with the project characteristics and to provide a total awareness because of the low team experience. To address that, a new event was added between the daily scrum and the sprint review (to be presented afterwards).

Due to the complexity of the proposed PM approach a flow chart has been developed to become it easier to see how the process flows (Fig. 5).

In the text below some details about the approach are explained.

Product Backlog	Groomed Backlog	Sprint Backlog	Doing	Stand-By	Approval	Done

Fig. 4. Kanban board of the proposed PM approach.

3.3.1. Scrum roles

The new approach has a person that does the job of Scrum Master and Product Owner at the same time. This is possible in the case study because this person has a long experience within the projects of the military aircraft division. As Scrum Master he/she will solve all the issues that the team may have throughout each sprint and as Product Owner he will be the interface between the stakeholders and development team by getting the requirements from the customer and delivering them to the team. After the work is performed, he is also the responsible person to obtain customer approval if required. Due to the lack of experience of some team members, and the small team size, he will also be a member of the development team, which means that he is able to perform work along with the others, something that would not be possible in a pure Agile methodology.

3.3.2. Product Backlog

This element belongs to the Scrum methodology. It contains the high-level tasks that need to be developed. It is a constant evolving artefact, which means that new tasks can be added, deleted or revised according to the project requirements/ constraints in a specific time of the project. Changes can only be made by the Product Owner. This element is implemented on the Kanban Board (Fig. 4).

3.3.3. Sprint Planning

On this event the next sprint is planned. To do this, the tasks from the product backlog are groomed to lower-level tasks adding them to the new column from the Kanban board called *Groomed Backlog* which will be then chosen to be performed on the next sprint by the whole team. These chosen tasks constitute the sprint backlog. Some tasks may be groomed and do not be performed in the next sprints, but they are foreseen to be performed in the future. Tasks that do not fulfill the prerequisites to be performed will be moved to the *Stand-by* column, which is a new column added to the Kanban Board, thought as useful to better manage visually the projects. This column provides a great view of what the team is able to perform and any input which is still missing.

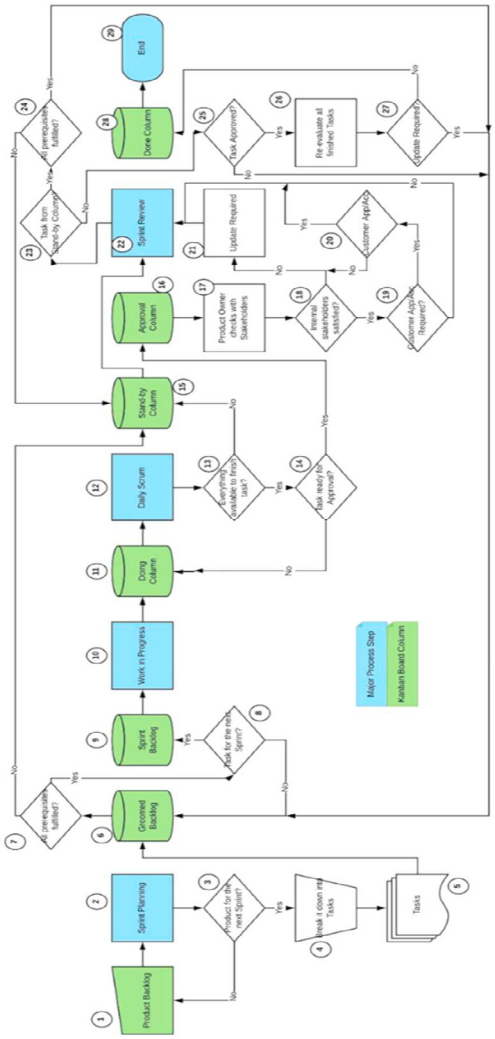

Fig. 5. Flow chart of the proposed PM approach.

3.3.4. Sprint execution

In this event the development team performs the *Sprint Backlog* tasks chosen on the previous event.

3.3.5. Daily Scrum

This meeting has the purpose of solving roadblocks but also to address the team experience problem by solving possible obstacles. If during the sprint it is found that a task from the

Sprint Backlog cannot be done, it will be moved to the *Stand-by* column, as explained before. Tasks that have been finished are decided by the whole team if they are ready to get approval, being moved in that case to the *Approval* column, which is a new column that has been also added to the *Kanban Board* because it has been decided to leave the already default *Done* column to tasks that have been already approved internally or externally. These tasks which arrive to the *Approval* column will be then checked by the stakeholders, getting their corresponding approval internally or externally.

3.3.6. Weekly review

This is a new event that was added to the approach because the sprints will have one month of duration, therefore, it would be a long time since the beginning of the sprint until the sprint retrospective to review the tasks. Thus, this event will allow have a small, but effective review, to ensure that the low experienced team is constantly aligned with the customer requirements and allowing steer the team/tasks when is still time, instead at the end when the task is complete.

3.3.7. Sprint Review

This event happens at the end of the sprint and has the purpose of reviewing the tasks that were performed during the sprint, and which have been completed during the sprint, being later presented to the responsible stakeholders to get approval. The result is now presented to the team in this event. If the task is approved, it will be moved to the *Done* column. Otherwise, if it is not approved, the task will be moved back to the *Groomed Backlog* column because the development team will need to rework it, but now they have the feedback from the customer together with extra information which will be helpful to ensure that only one more iteration is needed.

Tasks which are waiting for input in the *Stand-by* column are also assessed. If they have already the prerequisites to be performed, they are moved to the *Groomed Backlog*.

Due to the constantly changing project requirements, some tasks that were already performed and approved may need to be updated, so tasks that are in the *Done* column may have to be moved back to *Groomed Backlog* to be performed again.

3.3.8. Sprint Retrospective

This event is an opportunity to improve the processes and create a plan for improvements for the next sprint. It is a feedback session to be aware about the team difficulties and apply changes, if necessary. In order to get collaboration of the team, three questions will be answered as follows [23]:

What do we want to continue?
What do we want to stop?
What do we want to start?

The answer to these questions will provide a great insight about the team opinion regarding the used methodology.

3.3.9. Done

In order to make policies explicit, it is important to give a definition of *Done*. In this new methodology a task is only considered *Done* when the approval of the internal stakeholders or customer is given. When this happens, the tasks can be then moved to the *Done* column and the sprint ends.

4. Results

To test and validate the PM approach in practice it is being applied to a pilot project of the case study company and so far, the feedback from the team involved is good and the results are starting to appear. Though, there are some issues that may require some adaptations in the future with the increasing experience of the team. In Fig. 6 an illustrative example of the adapted Kanban Board, applied to the pilot project, is presented to show the different ways of possible task flow. The arrows mean the possible tasks movement in accordance with the rules that have been set.

The roles for this methodology were tailored and now instead of having one person with the responsibilities of Scrum Master and another with the responsibilities of Product Owner, only one person takes care of the two jobs. This may imply a conflict of interests or too much work for only one person which means that in the future it may be necessary to hire another person to take care of one of the roles.

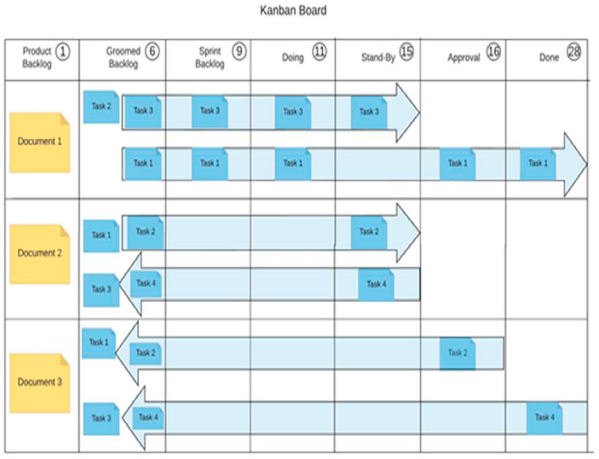

Fig. 6. Adapted *kanban* board tasks management.

During the sprint planning, the product backlog is totally broken down into asks. This activity requires a lot of time and effort, especially when the product is not well known. In future, it may be enough to break down only the tasks of the product that are foreseen for the next sprint.

When the team finishes a task, the product owner has the responsibility to get the approval from the internal or external stakeholders. The acceptance result is provided to the team at the end of the sprint. If a task is finished close to the deadline of the sprint, the product owner may not have yet the result from the stakeholders regarding the acceptance to present to the development team which can be a blocking point.

This new approach turned the planning phase much more effective, which allowed to use less resources than before to perform it without interfering on the execution phase. Moreover, this increased the planning performance, that provided updated plans to the execution phase, ensuring by that way the compliance with project requirements.

5. Conclusions

This paper main contribution is the development of a hybrid PM approach that resulted from the integration of some elements of the Scrum PM methodology with the PM predictive approach. Another contribution of this work is the application of this approach to a case study from the military aircraft sector through a pilot project. A third contribution is the study and application of the Agile PM approach outside its natural context.

The results obtained so far, show that this improved solution to PM applied to the case study company lead to a much more efficient management of the process and an increase of the quality of the project management processes. The use of an Agile approach, with the incorporation of some elements of the traditional approach, proved to be the best solution for this project, something that may be required for a lot of projects in other companies and in different areas of business. It is important to stop and think what might be wrong when projects are not delivering as expected. The solution may be changing the project management approach. Through this article we could show how the PM of a company could be improved, by combining elements of the predictive project management approach with elements of the agile approach, and give an overview of how the process can be performed and at the same time encourage other project managers to get out of the box and be open to new ways of working because they may be very benefic for their projects.

Besides the contributions of this research, some limitations are identified, to be addressed as future research, such as the continuity of the deployment of the hybrid approach in the case study company as well as testing the proposed methodology through an in-depth multiple case study to make both the conclusions more robust and to perform benchmarking analyses between the multiple case studies. To generalise the findings of this research it would also be useful to research other sectors in the aviation industry since this research is focused only on the aircraft maintenance.

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