APPLICATION AND IMPROVEMENT/FINE-TUNING OF A HYBRID PM PLANNING METHOD TO A REAL PROJECT

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Dissertation presented to ISEP – School of Engineering to fulfill the requirements necessary to obtain a Master's degree in Mechanical Engineering, carried out under the guidance of Doctor Francisco José Gomes da Silva and co-supervision of Doctor Raul Duarte Salgueiral Gomes Campilho, from the Department of Mechanical Engineering, ISEP – School of Engineering, Polytechnic of Porto.

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Mechanical Engineering

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To the old friends and the new friends that were present.

And finally, and very important, I want to dedicate all this work to my parents who gave me support, patience and motivation to keep going.

KEYWORDS

Project Management; Agile; Scrum; Hybrid Project Management Approach; Project Planning

ABSTRACT

Project management is the base for all projects. As many authors say and I also say, if a project fails in planning, it will fail in execution. The aeronautic business is a very demanding work which requires a big knowledge by the persons who are working on it.

The present work is inserted into a very complex project. This project has the goal to perform Depot Level Maintenance (DLM) in a NATO fleet of 14 aircrafts. This project is characterized by performing in parallel the planning and the executing phases at the same time, which need to adopt a new approach more effective to accomplish with effectiveness all work. Within this, the team forecast to accomplish all the customers' requirements, increasing, in that way, customer satisfaction.

To address this problem, this work intent to implement and improve an approach developed before by another colleague.

Finally, the implementation process showed very satisfied from the point of view of the team which they realize the approach very useful during this work, increasing the planning and executing phases performance of the team. Moreover, improvements were already made, following the intention the be more adaptive to the team.

PALAVRAS-CHAVE

Project Management; Agile; Scrum; Hybrid Project Management Approach; Project Planning

RESUMO

Gestão de projetos é a base para todos os projetos. Como é dito por muitos autores e também dito por mim, se um projeto falhar em planear, vai falhar na execução. O negócio aeronáutico é um trabalho muito exigente, o que necessita de um grande conhecimento por parte das pessoas que estão neste tipo de área.

O presente trabalho está inserido num projeto muito complexo. Este projeto tem o objetivo de executar Depot Level Maintenace (DLM) numa frota de 14 aviões da NATO. Este projeto é caracterizado por ter a fase de execução e de planeamento ao mesmo tempo, o que precisa de adotar uma nova abordagem mais eficiente para realizar com eficiência todo o trabalho. Com isto, a equipa prevê realizar todos os requerimentos do cliente, aumentando desta maneira, a satisfação do cliente.

Para resolver este problema, este trabalho tenciona implementar e melhorar uma abordagem desenvolvida por outro colega.

Finalmente, o processo de implementação mostrou-se muito bom do ponto de vista da equipa onde encararam a abordagem muito útil ao longo deste trabalho, aumentando assim o desempenho da fase planeamento e execução da equipa. Além disso, melhoramentos já foram feitos, continuando com a intenção de ser cada vez mais apropriado para a equipa.

LIST OF SYMBOLS AND ABBREVIATIONS

List of abbreviations	
A/C	Aircraft
AEW&C	Airborne Early Warning and Control
AWACS	Airborne Warning and Control System
CPM	Critical Path Method
DLM	Depot Level Maintenance
EADS	European Aeronautic Defence and Space
MRO	Maintenance, Repair & Overhaul
PERT	Program Evaluation Review Technique
PPS	Project Planning and Scheduling
U.S.	United States

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INTRODUCTION

1   INTRODUCTION

The present master's thesis was developed during the final project of the master's degree in Mechanical Engineering and Industrial Management, in parallel with ISEP and Airbus Defence & Space Company.

1.1   Framework

The maintenance project of airplanes requires a highly detailed plan and a very successful outcome. In order to achieve that, a lot of procedures must be implemented. Due to the complexity of these kinds of projects, it is crucial to have total control of all variables and requirements inside of the project in order to prevent huge losses during the activity. Thus, the project team should follow a set of rules, processes and build the necessary documentation.

Aircraft maintenance is the key to keep a fleet flying safely complying at the same time with the evolving airworthiness directives. It is important for commercial aviation airlines to have a low maintenance turnaround time without compromising its reliability. However, in the case of military aircraft, it is more important to have a plannability of the turnaround time to ensure the availability of a fleet with a fixed number of aircrafts, which can be needed at any moment to perform defence and surveillance.

In the military sector, there are three different levels of maintenance: Organizational Level, Intermediate Level and Depot Level Maintenance (DLM). They are described in Table 1.

Table 1 - Levels of maintenance in the military sector

Organizational Level	Maintenance performed by the operational squadron, which consists of the preparation of the aircraft for flight. It includes activities like pre-flight inspection, aircraft servicing, and operation, aircraft ground handling, etc.
Intermediate Level	Maintenance performed by the maintenance squadron, including both scheduled and unscheduled maintenance. Scheduled maintenance is periodic and phase inspections carried out on mechanical systems. Unscheduled maintenance is carried out for example after special occurrences or necessity of upgrades.
Depot Level Maintenance	DLM is understood as a maintenance echelon, and it aims to restore equipment and spare parts to a serviceable condition and to support field level maintenance activities by the use of more extensive resources, in addition to those available at lower levels of maintenance (intermediate and organizational).

1.2 Main Goals

The present master thesis has as main goals the implementation and improvement of hybrid methodologies to Project Management, for example in the AWACS DLM project, which whose planning and executing phases in parallel. To accomplish these goals, detailed objectives have been defined:

- Implement and perform the methodology studied by previous Fabio's thesis;
- Research in the literature of similar works done in Project Management supported by Agile methodologies in order to have a continuous improvement;
- Analyse new implementation cases in the office in order to have a better' overall performance of the team;
- Seek for future possible improvements on the methodology to promote a good insight to the Project Management and the team members.
- Take a more systematic worldview than is typical in project management.

1.3 Thesis Methodology

The methodology utilized in this thesis was the Action Research, first used in 1964 by Lewin. This is a collaborative approach that develops solutions to real organizational problems. In essence, Action Research is an emergent and iterative process that promotes organizational learning to produce practical outcomes through identifying issues, planning action, taking action and evaluating action (Saunders et al., 2016).

This research is composed of iteration cycles, as shown in Figure 1. Each stage starts with a strategy in order to answer a research question. During the life cycle of the research, the research questions are changed as the research develops, thus providing the direction for the next stage. The stages involve a process of diagnosing, planning action, taking action and evaluating action.

The Action Research method differs from other research strategies because of its explicit focus on action related to multiple stages. It is able to explore and evaluate new solutions to the organizational issues regarding each stage.
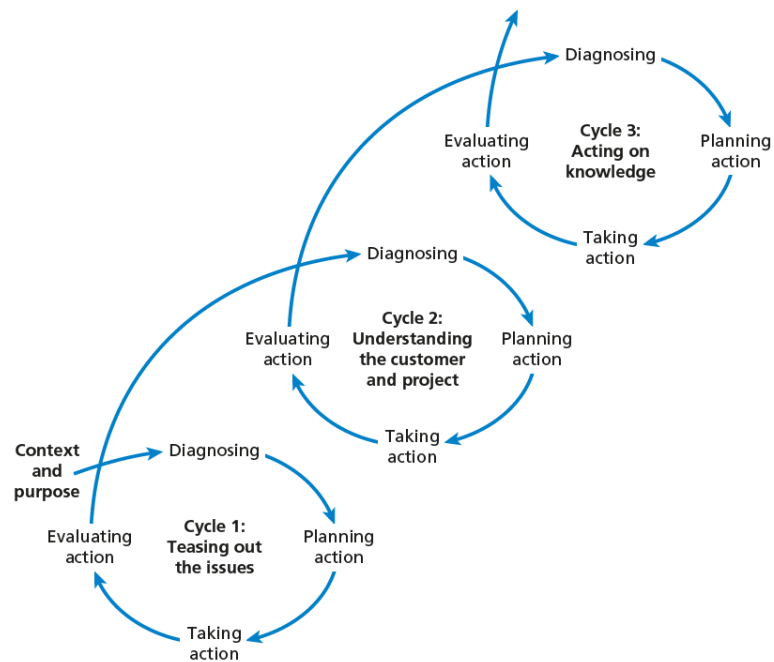
Figure 1 - The three cycles of the Action Research spiral (Adapeted from Saunders et al., 2016)

1.4   Thesis Structure

The thesis structure was developed with the intention that the reader follows a story line. Thus, the thesis is divided in four chapters.

The first chapter is the introduction. It is composed by the framework, main goals, thesis methodology, thesis structure, Airbus company presentation, Program Overview and AWACS DLM project.

The second chapter shows the literature review made related to the main topics of this work. It is showed the research to support the development of this thesis.

The third chapter does a summarization of Fábio's thesis. Here shows why it is necessary for a new methodology and the final results of Fábio's thesis.

The fourth chapter is where all the work developed takes place. The thesis development follows the main phases of the methodology, since the implementation until the current methodology performed by the team. Possible future improvements and a critical review of the methodologies used are also presented.

The fifth chapter corresponds to the main conclusions of this work.

1.5   Airbus Presentation

The Airbus Group is represented worldwide in the aerospace sector and related services. Its headquarters are in Leiden, in the Netherlands. In around 180 locations worldwide, 129.442 employees generated a total revenue of 66.8 Billion € in 2017.

Nowadays, the group consists of three divisions: Airbus Commercial Aircraft, Airbus Helicopters and Airbus Defence & Space, as shown in Figure 2.
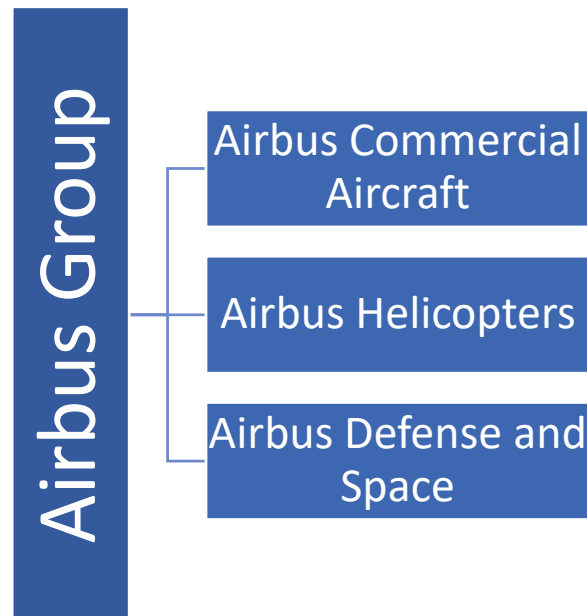
Figure 2 - Airbus group structure

Airbus Defense and Space is a division of Airbus Group, responsible for defense and aerospace products and services, and one of the top ten defence companies in the world. It was formed in January 2014 during the corporate restructuring of European Aeronautic Defense and Space Company (EADS), and comprises the former Airbus Military, Astrium, and EADS Defense & Security divisions. It has its corporate headquarters in Ottobrunn, Germany. The company has four program lines: Military Aircraft, Space Systems, Communication-Intelligence-Security, and Unmanned Aerial Systems, as shown in Figure 3.
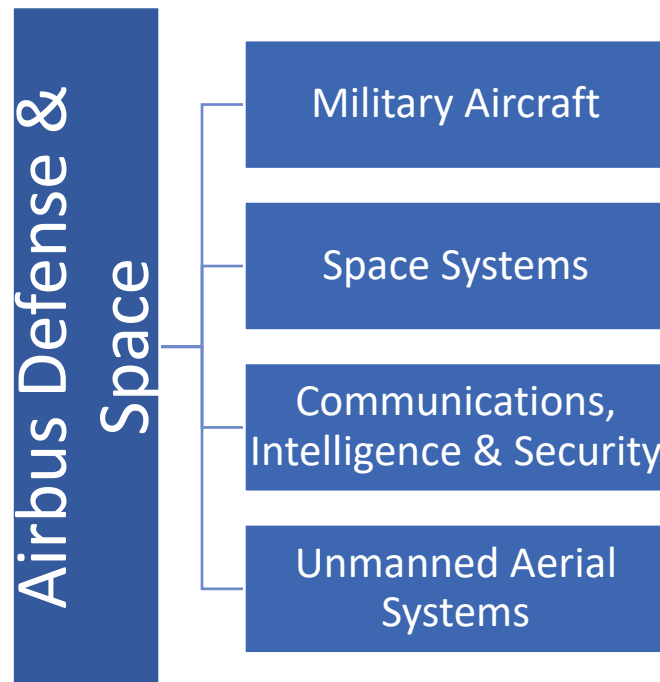
Figure 3 - Airbus Defence and Space structure

The site of Manching, as shown in Figure 4, represents the centre of competence for military air systems, where approximatively 4500 employees work. The site hosts the Eurofighter program, and all other aircrafts operated by the German Forces and NATO are serviced here. It also accomplishes Maintenance, Repair and Overhaul (MRO) activities.

This master thesis was developed at Airbus Defence and Space in Manching, Germany. It has begun with an internship of three months on the Depot Level Maintenance project of the NATO Airborne Warning And Control System (AWACS). After being comfortable inside of the project, the development of this thesis was started, taking more six months, until the end of November 2019.

Figure 4 - Aerial view of Manching site

The NATO AWACS program comprises four different projects: two modernization projects, the ongoing DLM and the NATO AWACS DLM Follow-On Contract Acquisition Project. The internship has been carried out on the last one. However, this master thesis was developed and performed in two of these projects, having in mind the possibility to expand to the other projects.

1.6   AWACS Program Overview

NATO operates a fleet of Boeing E-3A Airborne Warning & Control System aircraft, which provides the alliance with air surveillance, command and control, battle space management and communications. Figure 5 shows an example of the airplane.

Figure 5 - Boeing E-3A AWACS (NATO, 2020)

The multinational NATO E-3A (NE-3A) fleet consists of 14 NE-3A aircraft, easily identifiable from the distinctive radome mounted on the fuselage. The air vehicle is a modified Boeing 707-320 model, usually operating at an altitude of around 10 km. From this altitude, a single NE-3A can constantly monitor the airspace within a radius of more than 400 km and can exchange information – via digital data links – with ground-based, sea-based and airborne operators.

1.7   The AWACS DLM Project

The DLM for the NATO (NE-3A) fleet has been conducted based on a six-year cycle since the first aircraft entered into operation in 1982. The heavy maintenance is currently contracted through a Contracting Agency based in Luxemburg and Prime Contractor based in Mestre, Italy.

The DLM applies to the air vehicle (Boeing 707-320) with four Pratt & Whitney turbojet engines, flight essential avionics and mission avionics (surveillance radar, identification, data processing, communications, navigations and guidance, data display and control).

DLM may imply repairs/major repairs, overhaul, complete rebuild of parts, modification, testing, calibration, and engineering services.

Every six years, an aircraft comes to Manching for undergoing DLM. Some tasks are done in-house, while some of the parts are disassembled here and shipped to other MRO facilities. After the outsourced parts are shipped back to Airbus, they are re-assembled and the Aircraft (A/C) is submitted to the customer, which formally marks the end of the DLM event. Examples of maintenance tasks within one A/C DLM event in Manching are Analytical Condition Inspection, A/C Structural Integrity Program, Corrosion Prevention & Control, and Interior Refurbishing.

LITERATURE REVIEW

2.1 Project Management

2.2 Agile Methodology

2   LITERATURE REVIEW

This chapter weaves together the various strands of literature to support the development of the conceptual approach in chapter 4 and to give reference base to the discussion in chapter 5.

The literature review is also supported by Fábio's Thesis (Freitas, 2019). Since the beginning and knowing that this work was performed following the work of reference (Freitas, 2019), some of the literature needed to be in close agreement.

2.1   Project Management

Project management is a discipline that has evolved over the past seven decades through practice in a wide range of industries (Versuh, 2016).

A huge portion of project management practice on what is termed conventional project management heuristics (Klastorin, 2013). These heuristics are described in the Project Management Book of Knowledge (PMBOK), which is the basis for the certification of more than 80000 active project management professionals (PMP) in 210 countries.

Conventionally, project management has been the machine to deliver professional services. Project managers have been responsible for managing, directing and controlling projects. They are responsible for planning, coordinating between stakeholders, estimating cost, time and materials, and creating schedules (Dinsmore & Cabanis-Brewin, 2014).

The goals of this role are to deliver a project on time and with high customer satisfaction. The project manager has the important function to understand the client's expectations and ensure that there is clear communication between stakeholders. Also, a project manager must align all resources and ensure quality control of their own work in order to ensure optimal productivity (Rivera & Kashiwagi, 2016).

2.2 Agile Methodology

2.2.1 Why Agile?

Originated in the software industry in the early 2000s, the agile movement has taken the attention of a broad range of industries. Organizations seeking a competitive advantage in today's marketplace value the agile concepts as they strive to become quicker, more responsive and flexible – all desirable organizational traits in a fast-paced, complex environment (Agile Practice Guide, 2017).

According to the literature, new pieces of evidence reveal that Agile development methods do not apply only to software projects. Agile methods are also being integrated with traditional gating approaches to yield an Agile hybrid model that can be adapted to new manufactured products (G.Cooper & Sommer, 2016).

One of the main reasons why Agile practices are being implemented by a lot of companies all-around the world is the faster time-to-market response. The promise of short cycles of work delivery to the stakeholders increases the product value even before this final product it has done (Reddy, 2016).

New design, problem solving, and not-done-before work is exploratory. It requires subject matter experts to collaborate and solve problems to create a solution. Example of people encountering high-uncertainty work includes software systems engineers, product designers, doctors, teachers, lawyers, and many problem-solving engineering.

Figure 6 introduces the four values of the Agile Mindset.

We are revealing better ways of developing software by doing it and helping others do it. Through this work we have come to value:

Individuals and interactions over processes and tools
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan

That is, while there is value in the items at the right, we value the items at the left more.

Figure 6 - The four values of Agile manifesto (Adapted from Agile Practice Guide, 2017)

As more definable work is automated, project teams are undertaking more high-uncertainty work projects that require new techniques.

According to Linda (Kerzner, 2017), most of the principles of agile Project Management practices have shown beneficial results when applied not only to software projects.

The following twelve principles are behind the Agile Manifesto for Agile Software Development:

1. The highest priority is to satisfy the customer through early and continuous delivery of valuable software;
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage;
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale;
4. Business people and developers must work together daily throughout the project;
5. Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done;
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation;
7. Working software is the primary measure of progress;
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely;
9. Continuous attention to technical excellence and good design enhance agility;
10. Simplicity – the art of maximizing the amount of work not done – is essential;
11. The best architectures, requirements, and designs emerge from self-organizing teams;
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.

Traditional Approach (Predictive) VS Agile Approach (Adaptive)

High-uncertainty projects have high rates of change, complexity, and risk. These characteristics cause problems in traditional predictive approaches that aim to determine the bulk of the requirements upfront and control changes through a change request process. Instead, agile approaches were created to explore feasibility in short cycles and quickly adapt based on evaluation and feedback (Agile Practice Guide, 2017).

Approaches

Predictive approach: A more traditional approach, with the bulk of planning occurring upfront, followed by execution in a single pass;
Iterative approach: An approach that allows feedback for unfinished work to improve and modify that work;
Incremental approach: An approach that provides finished deliverables that the customer may be able to use immediately;
Agile approach: An approach that is both iterative and incremental to refine work items and deliver frequently.

Hybrid Approach

Different projects use different approaches which are more convenient for the project. It is possible to use a combination of predictive, iterative, incremental, and/or agile approaches. This mix is called a Hybrid approach, and it needs to be specially developed for the project.
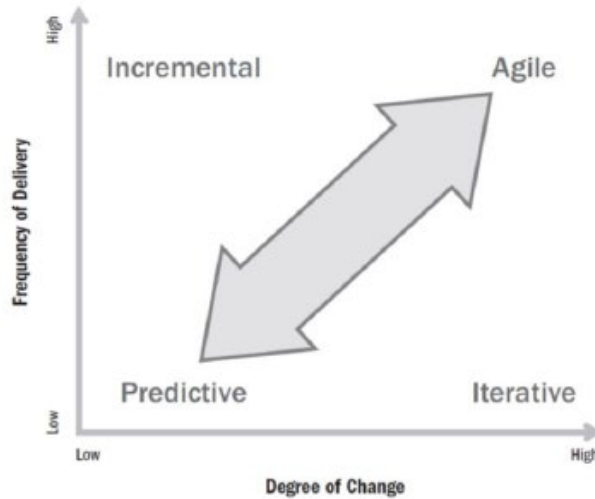
Figure 7 - The Continuum of Approaches (Agile Practice Guide, 2017)

Figure 7 shows that the approach for the project should be chosen depending of the frequency of delivery and degree of change.

Figure 8 shows examples of Hybrid approaches.

Figure 8 - Agile Development Followed by a Predictive Rollout (Agile Practice Guide, 2017)

This hybrid approach utilizes an agile development cycle, which is then followed by a predictive rollout phase. This approach can be used when there is uncertainty, complexity, and risk in the development portion of the project, which would benefit from an agile approach, followed by a defined, repeatable rollout, phase which is appropriate to be undertaken in a predictive way, perhaps by a different team (Agile Practice Guide, 2017).

Figure 9 - A Combined Agile and Predictive Approach Used Simultaneously (Agile Practice Guide, 2017)

In Figure 9, the project uses a combination of both predictive and agile approaches. Here the team is incrementally transitioning to agile and using some approaches like short iterations, daily stand up and retrospective, but other aspects of the project,

such as upfront estimation, work assignment, and progress tracking, are still following predictive approaches.

Thus, addressing this methodology as an agile approach does not fully embody the agile mindset, values, and principles. And at the same time, it is also incorrect to consider it as predictive.

Figure 10 shows a small agile element inside a mainly predictive project. In this case, a portion of the project with uncertainty and complexity is being undertaken in an agile way and, on the other hand, the project is being managed using predictive approaches.
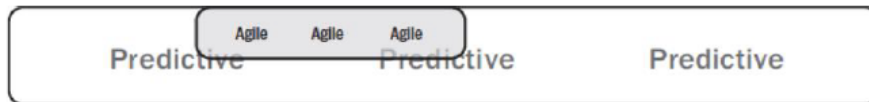
Figure 10 - A largely predictive approach with Agile components (Agile Practice Guide 2017)

In Figure 11, a large portion of the project has an agile approach with a predictive component. This approach might be used when a particular element is non-negotiable.

Figure 11 - A Largely Agile Approach with a Predictive Component (Agile Practice Guide, 2017)

However, all these approaches are used depending on each project and could be different than the ones described before. The goal of hybrid approaches is to increase the business value in the best possible way. It does not matter if that way is agile or predictive.

2.2.1.1 Study Cases

This chapter shows, in Table 2, a few examples of studies about Agile and Project Management. These studies discuss the performance of Agile techniques on Project Management, showing in this way better confidence from the project manager who wants to work Agile in his office.

Table 2 - Studies' compilation

Reference	Work description
(Aljaž Stare et al, 2014)	The goal of this article was to demonstrate the applicability of agile project management in the context of product development. This work was developed in five Slovenian enterprises, involving 21 product development projects. The authors highlighted the difference between the agile and traditional approaches, dividing it into four groups: requirements & specifications, project scheduling, teamwork and client's collaboration. After the research, the authors

	proved that inside of each group, they were using agile practices with good outcomes.
(Pedro Serrador, 2015)	This paper uses a data sample of 1002 projects across multiple industries and countries. The use of Agile was tested in organizations considering two dimensions of project success: efficiency and overall stakeholder satisfaction. The aim of this paper was to investigate the evidence that Agile methods work better than traditional approaches for achieving project success. Furthermore, the results of this study showed that 6% of the projects are completely or nearly completely Agile. Moreover, more than 65% of them reported having some Agile or iterative component. They found that the greater the Agile/iterative approach reported, the higher the reported project success.
(Klara Antlova, 2014)	This paper aimed at finding ways how to solve failures in project management. This, one of the possibilities is to use an Agile approach. The paper also brings the results of a survey which has been conducted in 40 Czech companies during 2013. In total, 20 companies were using Agile methods, where most project managers agree that the critical factors to be successful are: organizational and procedural on the approach to the customer.
(Günther Schuh et al, 2017)	In this work, the goal was the creation of an adaptive engineering change management (ECM) for rapid engineering changes which are identified as central enablers for the agile product development of physical products. To do this framework, the authors considered the challenges in the field of ECM and the requirements of the dynamic prototyping processes, as investigated in the case study. As a conclusion, the authors argued that agile product development is promising for limiting the time-to-market and resources used for development projects.
(Deanne Larson et al, 2016)	This paper shows how business intelligence has evolved with Agile methodologies. The intent of this article is to provide practitioners an understanding of how Agile principles can be applied to business intelligence delivery, fast analytics, and data science. An Agile business intelligence delivery framework was proposed. The results of the paper are that Agile ideas fit well into the business intelligence world and Agile addresses many of the common problems found in business intelligence projects by promoting interaction and collaboration between stakeholders.
(Alfredo Rivera et al, 2016)	This work aims to show that approximately 60% of construction projects are over budget, over schedule and have low customer satisfaction. Within this scope, the research was performed in order to demonstrate Project Management methodologies worldwide. Agile is presented as adaptive management approaches which

	increase the flexibility, relevance and business value, concluding that the Agile approach attacks the complexity of the problem by increasing communication, collaboration, and decision-making.
(Sohi et al., 2015)	This paper investigates whether lean and Agile project management helps to cope a complex project in the construction sector. This research was done by means of correlation analysis on data gathered from a structured questionnaire. After this research, the authors of this article found out that the usage of lean and Agile elements can help to cope with complex projects.

2.2.2   Scrum

Scrum is relevant within the scope of project management because more organizations are managing changes with incremental delivery, and not just software projects (Versuh, 2016).

2.2.2.1   Scrum Theory

Scrum methodology is a framework that was introduced in 1995 when Schwaber and Sutherland presented out the first paper about this subject (Rouse, 2015). (Rola, Kuchta, & Kopczyk, 2016) Regarding that, he assumed that scrum is an enhancement of the commonly iterative/incremental object-oriented development cycle (Schwaber, 1997).

This process is a lightweight project management framework that quickly fosters an iterative advancement of the solution. Thus, continuous improvement is used to support higher quality, higher productivity and better outcomes (scaledagileframework, 2018).

Additionally, scrum is based on an empirical process control theory with the aim of controlling risk and optimizing the predictability of a project. Transparency, inspection, and adaption are three important factors in the Scrum process (Schwaber & Sutherland, 2017):

Transparency: everyone should have an overview of the project;

Inspection: all users of the methodology must check the Scrum artefacts frequently to detect problems in early stages;

Adaptation: If an inspector determines that some aspects of the project are unacceptable, the process or the material being processed might be adjusted. Moreover, it must be made as soon as possible to minimize upfront situation.

The first application was at Easel Corporation in 1993 by Schwaber and Sutherland. They applied the technique to a software development team with small talks development environment (Sutherland, 2004). In that context, this methodology was

mainly incorporated because the waterfall approach was presenting failures. Peter DeGrace and Leslie Hulet (1990) reviewed those reasons (DeGrace & Stahl, 1990):

- Requirements are not fully understood before the project begins;
- Users know what they want only after they see an initial version of the software;
- Requirements change often during the software construction process;
- New tools and technologies make implementation strategies unpredictable.

This framework was raised up also with a lot of ideas adopted from a Harvard business review paper written in 1986 Takeuchi and Nonaka, (Takeuchi & Nonaka, 1986). This paper does an analogy with rugby and cited Scrum as an example of a holistic or all-at-once team, thus, rugby scrum tried to push to destination without discrete roles but as a self-organized team.

Scrum methodology is blended to rules and meetings that need to be performed with rigor and accountability by the whole team.

Table 3 consist of a research made about Scrum. This research present articles which the subject is Scrum.

Table 3 - Scrum research

Reference	Work description
(Rola et al., 2016)	The main goal of this paper is to propose a conceptual model of office space arrangement for the needs of IT project teams working according to the Scrum method, which will have a positive effect on the efficiency in the executing of Scrum projects. The authors of this article persuaded that the layout proposed will have a positive effect on the management and everyday execution of all Agile IT projects.
(Galvan et al., 2015)	This paper seeks a methodology for software projects. In this research, the particular issue of compliance of Agile Software Development Methodologies (Scrum) and the new ISO/IEC 29110 standard is studied. The ISO/IEC 29110 standard contains two processes: Project Management and Software Implementation. This study is centred on the first process. The main findings indicate that the Scrum presents a high compliance level with the ISO/IEC 29110 Project Management process.
(Steghöfer et al, 2017)	In this paper, it was done workshop experiences where they had taught Scrum to students with the goal to build up a Lego city. After the exercise, the data indicated the student's engagement and had shown the student's confidence rises directly after the workshop. Furthermore, the analysis sheds a light on how students apply the knowledge and skills they picked up in the workshops in an actual project setting.
(Hidalgo,	This paper explores the adoption of agile methods for the

2019)	management of projects. The use of the Scrum framework, a specific set of agile principles and practices for self-organizing cross-functional teams in software development projects, is currently being expanded to other types of organizations and knowledge management processes. This paper concludes that the adoption of agile methods in research collaboration is suited to organisations embedded in complex and changing settings, with some capacity for self-organization, flexibility, and adaptivity to new management approaches.

The presented papers have shown that Scrum methodology is very promising in a wide set of projects. It is proved that Scrum increased the satisfaction of teams such as in IT projects, project management process, students' workshops as software development projects.

2.2.2.2 Scrum Summarization

In order to have an overview of the methodology, the main steps to start a scrum process will be explained in five topics (Kniberg & Skarin, 2010):

- Split your organization into small, cross-functional, self-organization teams;
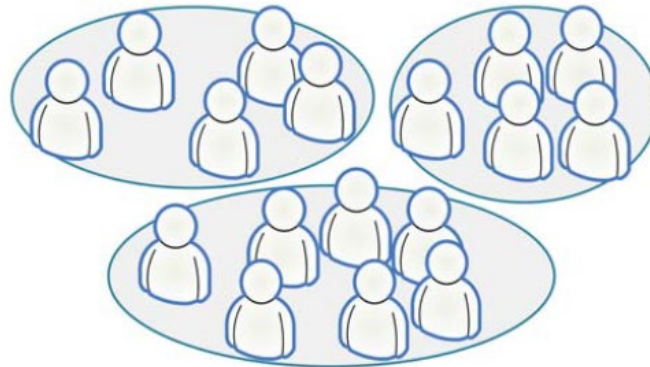
Figure 12 - Splitting Teams (Kniberg & Skarin, 2010)

- Split your work into small, specific deliverables;
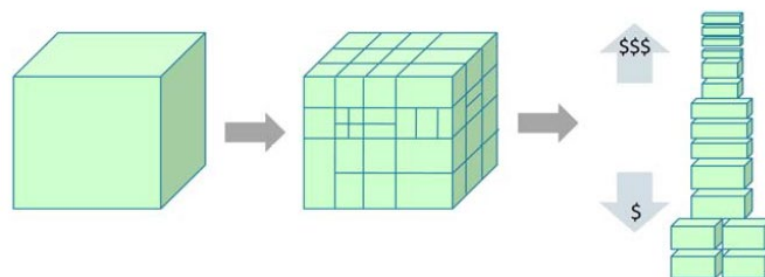
Figure 13 - Splitting work (Kniberg & Skarin, 2010)

- Split time into short fixed-length sprints (1-4 weeks);
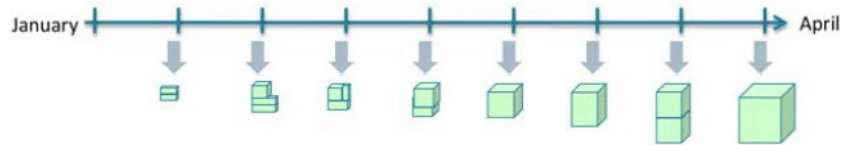
Figure 14 - Splitting time (Kniberg & Skarin, 2010)

- Optimize the release plan and update priorities in collaboration with the customer;
- Optimize the process by having a retrospective after each sprint.

The Scrum Team consists of the Product Owner, the Scrum Master and the Development Team. The roles will be detailed in section 2.2.2.5.

2.2.2.3   Scrum Values

Scrum values were defined in 2001 by a group of seventeen independent software thinkers (Alliance, s.d.). During a journey in Utah, they worked to join a set of compatible values based on trust and respect for each other in order to promote organizational models focussed on people, collaboration and teams where they want to work.

These values are the foundation of the Scrum team's processes and interactions. They emphasize on fostering agility, teamwork, and continuous improvement. Scrum's score set of values are team-centric (Reddy, 2016), as shown in Figure 15:

Figure 15 - Scrum Values (Scrum.org, 2019)

Despite these values have been created some time ago, they are still in continuous development and constant modification (in a true Agile fashion).

2.2.2.4   Scrum Artifacts

Scrum Artifacts are defined by the work or value and provide transparency and opportunities for inspection and adaptation (Schwaber & Sutherland, The Scrum Guide, 2017). The main artifact is, of course, the product itself. It is expected that the team brings the product or system to a potentially shippable state at the end of each Sprint (Mountain Goat Software, 2019).

❖   User Stories

A user story is an individual feature that the business wants in order to achieve customers' expectations. In Scrum, the effort is to understand the customer viewpoint above anything else. To do this, each user story is made in a form that it explains who will use it, which functionalities who expect it to have and why it is valuable to that user. The following template is an example of one user story (Cohn, 2010):

As [WHO]
I would like to, need to, want to, am able to, can [WHAT]
in order to [WHY].

Figure 16 - User story layout example (Academy, 2016)

Additionally, a user story is only a start point for a discussion and it does not have all the information that the team might need to complete the job.

Several functionalities described in such user stories build up one product.

❖   Process of *Grooming*

The process of *grooming* is the transition from a user story to a sharply defined set of tasks. Grooming refines the initial description step by step until the user stories are well defined into tasks and have enough information to be performed in one sprint.

Grooming takes around 10% of the team resources, being the major methodology task in the team (Cohn, 2010).

The grooming process could be led by one person or split up among several team members. While this process is occurring, the team members should carefully split up the user stories with responsibility. A poor grooming process could result in poor performance of the team. Whether a story is improperly prepared, i.e., without

enough details, it causes turnbacks during the sprint. In that way, poor grooming compromises the efficiency of the team (Ellis, 2016).

❖ Product Backlog

The Product Backlog is a list which describes the final output expected and needed for the product. The Product Backlog is the heart of Scrum, is where all start (Kniberg, 2015) and is continuously updated.

The day-by-day Product Backlog is constantly changing because it is dynamic. Thus, each sprint has its own reprioritizing in order to be competitive and achieve the goals of the customer. As the product gains value and the stakeholders provide feedback, the Product Backlog is in continuous modification. Thus, it can be concluded that the Product Backlog is a living artifact (Schwaber & Sutherland, 2017).

This scrum artifact is basically a reprioritized list of user stories that customer wants at the beginning of each sprint.

The following topics show how the Product Backlog should be designed (James & Walter, 2017):

- Force-ranked (prioritized) list of desired items as described in the user stories;
- Visible to all stakeholders;
- Any stakeholder (including the team) can propose items;
- Constantly re-prioritized by the product owner;
- The scrum team constantly provides inputs to the product owner.

❖ Sprint Backlog

At the start of each sprint, the sprint acklog holds all known tasks to be performed by the team, as well as a plan for finished tasks in order to realize the sprint goal (Schwaber & Sutherland, 2017). It means that the team is responsible to forecast the work needed to deliver the tasks.

During the sprint progress, the Development Team modifies the Sprint Backlog as they work on the tasks. More detailed tasks enable the Development Team to understand the real efforts to accomplish the objectives.

❖ Burndown Chart

The burndown chart is a Scrum methodology tool, which is used by the scrum team to realise the progress of the current Sprint. This enables the Product Owner, the Scrum Master and the Development Team to visualize the amount of work remaining along the timeline (Schwaber, 2004) and how the team is reducing this work.

Following the agile methodology, the Burndown Chart and Burnup Chart, could have more than one configuration as show in Figure 17 and Figure 18 (Agile Practice Guide, 2017).
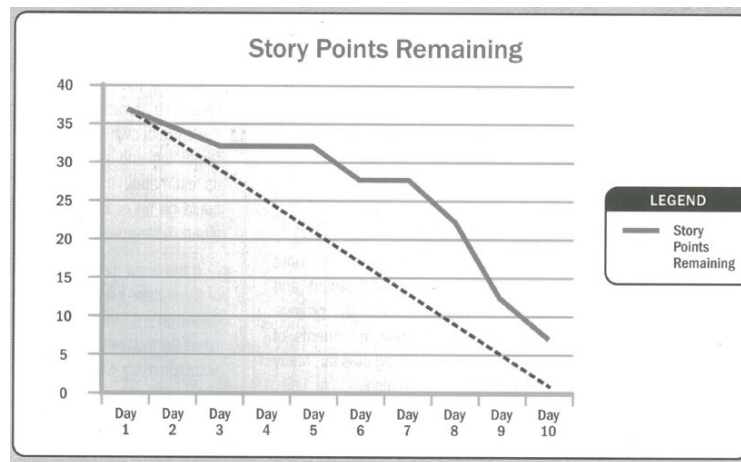
Figure 17 - Burndown chart (Agile Practice Guide, 2017)
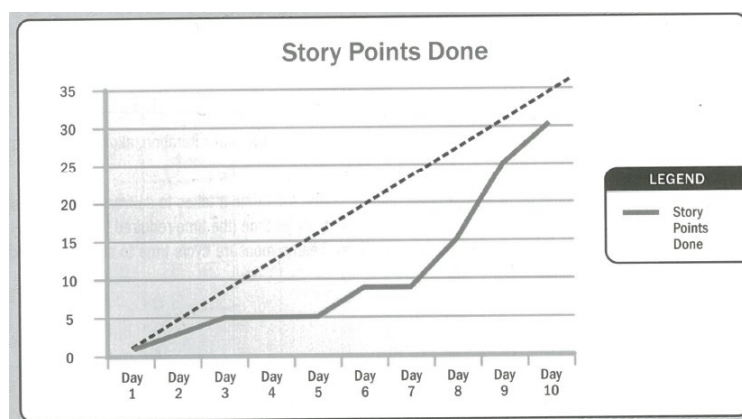
Figure 18 - Burnup chart (Agile Practice Guide, 2017)

As it can be seen, both charts are composed by time on X axis and story points on Y axis.

2.2.2.5   Scrum Roles

In the Scrum methodology, three roles remain: Product Owner, Development team and Scrum Master, as shown in Figure 19. Each stakeholder of these has its specific rules for the correct implementation and improvement. As mentioned before, Scrum teams must be self-organizing and cross functional, which aim to choose the best way to accomplish their work (Schwaber & Sutherland, 2019).

Figure 19 - Scrum Team

❖ Product Owner

The Product Owner is one person instead of a committee. His function is to be accountable for maximizing the value of the product and the work team. The product backlog is managed only by this person. His duties include:

- Clear communicating of the Product Backlog items;
- Ordering the items in the product backlog to best achieve goals and missions;
- Optimizing the value of the work that the Team performs;
- Ensuring that the Product backlog is transparent and clear to all team, and demonstrate in what the scrum team will work next;
- Ensure the Team understands the items needed in required detail.

To successfully fulfil that roles, the entire organisation must respect the product owner's decisions.

❖ Development Team

The team is built of professionals who deliver the agreed items at the end of each sprint. Only members of the team generate the increment.

Teams are self-organising and empowered by the organisation. The resulting synergy optimizes the team's overall efficiency and effectiveness. The teams must follow the following characteristics (Academy, 2016):

- They are self-organising. No one (not even the Scrum Master) tells the development Team how to turn Product Backlog into Increments of potential releasable functionality;
- Development teams are cross-functional, with all the skills that a team needs to create a product Increment;
- Scrum recognizes no titles for Team members, regardless of the work being performed by each individual;
- Scrum recognizes no sub-teams in the Team, regardless of the domains that need to be addressed, like testing or business analysis; there are no exceptions to this rule;

- Individual Team members may have specialized skills and areas of focus, but accountability belongs to the Team as a whole.

❖ Scrum Master

The Scrum Master is responsible to ensure that Scrum is understood. The Scrum Master accomplishes this work by helping everyone understanding Scrum theory, practice, rules and values (Academy, 2016).

As shown in Figure 20, the Scrum Master is a servant-leader for the Scrum Team. The Scrum Master helps those outside the Scrum Team to understand which of their interactions with the Scrum Team are helpful and which are not. The Scrum Master helps everyone to change in order to maximize the value created by the Scrum Team.

Figure 20 - Scrum Master Accountabilities (Scrum.org, 2019)

Most of the Scrum Master time is spent in removing obstacles for the team and ensuring they have a suitable work environment. The "master" in the term is intended to show that this person masters the Scrum methodology (Rouse, 2015).

The Scrum Master serves the product owner in several ways, including:

- Finding techniques for effective Product Backlog management;
- Helping the Scrum Team to understand the need for clear and concise Product Backlog items;
- Understanding product planning in an empirical environment;
- Ensuring the product Owner knows how to arrange the product Backlog to maximize value;
- Understanding and practicing agility;
- Facilitating Scrum events as requested or needed by the Product Owner.

The Scrum Master serves the Development Team in several ways, including:

- Coaching the Development Team in self-organization and cross-functionality;
- Helping the Team to create high-value products;
- Removing obstacles to the Teams progress;

- Facilitating Scrum events as requested or needed by the Development Team;
- Coaching the Development Team in organizational environments in which Scrum is not yet full adopted and understood.

The Scrum Master serves the organization in several ways, including:

- Leading and coaching the organization in its Scrum adoption;
- Planning Scrum implementations within the organization;
- Helping employees and stakeholders understand and enact Scrum and empirical product development;
- Initiating the change that increases the productivity of the Scrum Team;
- Working with other Scrum Masters to increase the effectiveness of the application of Scrum inside the organization.

2.2.2.6   Definition of "Done" DoD

This topic is important when the team decides to attribute a task as "Done". For that, the product owner and the team need to have a clear definition of "Done" (Kniberg, 2015). This is used to assess when work is completed on the product increment (Schwaber & Sutherland, 2017).

Done is also defined as a team checklist of all the criteria required to be met so that a deliverable can be considered ready for customer use (Agile Practice Guide, 2017).

2.2.2.7   Scrum Events

The scrum has five events which help the teams to work effectively and encourages to work closely together. These events are:

❖ Sprint

Sprint is the most used word in the Scrum methodology (Schwaber & Sutherland, 2017). Sprint is described as a timeboxed[1] iteration in Scrum (Agile Practice Guide, 2017).

The formal events of Scrum are specified as four team meetings: Sprint Planning, Daily Scrum, Sprint Review and Sprint Retrospective. Each event is done by its rules accordingly mentored by the Scrum Master.

The Scrum Framework, as shown in Figure 21, represents the correlation of the Scrum Events.

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[1] A fixed period of time, for example, 1 week, 1 fortnight, 3 weeks, or 1 month.
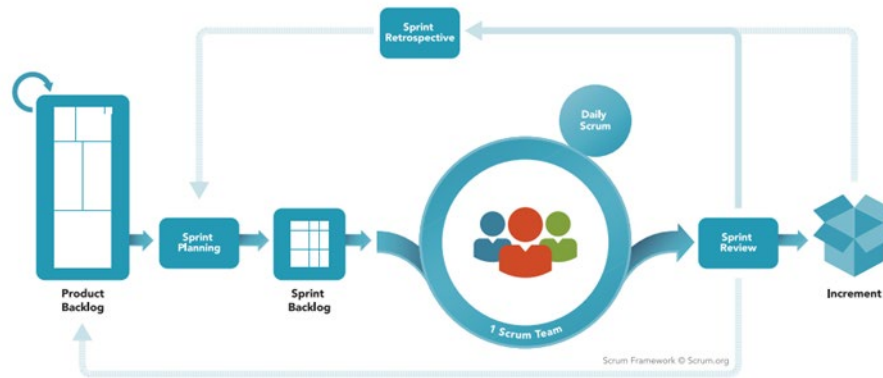
Figure 21 - Scrum Framework (Scrum.org, 2019)

During the sprint (Schwaber & Sutherland, 2017):

- No changes are made that would endanger the Sprint Goal;
- Quality goals do not decrease;
- Scope may be clarified and re-negotiated between the Product Owner and Development Team.

According to the Scrum rules, a new Sprint begins immediately after the conclusion of the previous Sprint.

❖ Sprint Planning

This event marks the start of a Scrum cycle. It means that in this meeting the Product Owner, the Scrum Master and the Development Team negotiate which Product Backlog Items they will perform during the next Sprint (James & Walter, 2017). This occurs one time per cycle.

During the Sprint Planning meeting, the team works in order to forecast the work that will be developed on the next Sprint in order to achieve the Sprint goal. The tasks are carefully chosen and discussed by the Development Team. The Product Owner should clarify the details of the tasks to the Development Team if they do not understand how to accomplish them. The Scrum Master ensures that the event takes place and that attendants understand its purpose.

Two important questions should be answered during this event (Schwaber & Sutherland, 2017):

- What can be done in this Sprint?
- How the work will be chosen to be done during the nest Sprint?

To finish the Sprint Planning, the Development Team should be able to explain to the Product Owner and to the Scrum Master how they will perform the tasks with the intent to accomplish the Sprint Goal.

❖ Daily Scrum

This event is the smallest of all Scrum events. It is a brief, daily collaboration meeting in which the team reviews the progress day-by-day, arguing each other about the progress of the tasks. Usually, this meeting has a fixed time of 15 minutes (Schwaber & Sutherland, 2017) and is held at the same schedule and place.

The Scrum Master is accountable to lead the meeting, removing barriers and asking the main questions of this meeting and keeping the team engaged, as shown in Figure 22.

Figure 22 - Daily Scrum questions

This meeting consists of a physical stand up around a board where only committed people can express their ideas. It should start and end on time and distractions such as phones, laptops and coffee must be avoided.

❖ Sprint Review

The Sprint Review is held once near the end of each Sprint. Here the team shows the output of the sprint to the Product Owner and interested stakeholders. In these meetings, which normally have a duration of four hours, one time per Sprint, the Scrum Team and the stakeholders can collaborate and discuss what was done during the Sprint. The Scrum Master ensures that the event takes place and makes sure that everyone is in the same row, understanding the purpose of the Sprint Review (Schwaber & Sutherland, 2017).

❖ Sprint Retrospective

This is the final step of Sprint cycle. For this meeting, the Scrum Team has the opportunity to discuss what disturbed the work of the Development Team and their efficiency. They also discuss what needs to be improved. The Sprint Retrospective is the primary means for continuous improvement (Ellis, 2016).

The function of the Scrum Master is to encourage the Scrum Team to improve the developing process and practices to make it more effective and confident for the next Sprint.

The aims of the Sprint Retrospective are to (Schwaber & Sutherland, 2017):

- Inspect how the last Sprint regarding the people, the relationships, the processes and the tools;
- Identify the major items that performed well and potential improvements;
- Create a plan for implementing improvements.

2.2.3 Kanban

Kanban is a powerful tool developed by Mr. Taiichi Ohno, Vice-President of Toyota Motor Company (Y. Sugimori, 2007). Kanban provides a simple approach to deliver high-quality value to the customers, on time and budget (Brechner, 2015). This robust method in lean manufacturing is a system for scheduling inventory control and replenishment (Agile Practice Guide, 2017). The word Kanban itself is a Japanese word, which translated means "visual sign" or "card".

The Kanban method provides four principles that should be followed by the users of this tool, which are (Reddy, 2016):

- Start with what you do know;
- Respect the current process, roles, responsibilities, and titles;
- Agree in continuous improvement, evolutionary change as opportunities are discovered;
- Encourage acts of leadership at all levels of the organization.

Kanban should be used when a team or an organization needs the following conditions (Agile Practice Guide, 2017):

- Flexibility – teams are not limited by sprints and will work on the highest priority item in the backlog;
- Focus on continuous delivery – teams are focused on flowing work through the system to completion and not beginning new work until the work in progress is completed;
- Increased productivity and quality – productivity and quality are increased by limiting work in progress.

Table 4 shows relevant studies in the scope of Kanban.

Table 4 - Kanban research

References	Work description
(Rahmana et al., 2013)	This article aims to determine how the Kanban systems work effectively in multinational organization and identifies factors hindering Malaysian small and medium enterprises (SME) from implementing Kanban. After the study was done, it was concluded that the Kanban system has a lot of benefits in manufacturing companies. Mainly, the operational costs, wastes, scraps and losses were minimized and over production stocks were controlled with flexible workstations.
(Krishnaiyera et al., 2018)	This paper proposes a cloud Kanban framework that enables deployment of excellent process. This study addresses two research questions: How can a robust cloud-based Kanban decision support framework work for a service industry, particularly in operations?; how can an evolutionary algorithm, specifically Ant Colony Optimization (ACO), augment a cloud-based Kanban decision support framework?. This research had shown that a cloud-based Kanban performs much better and faster than the traditional systems.
(Aguilar-Escobara et al., 2014)	This study aims to measure nurse's satisfaction with Kanban systems in logistics in medical consumables and assesses possible advantages and differences among users' groups through an anonymous survey at Hospital Universitario Virgen Macarena of Seville, Spain. The obtained results showed a high level of satisfaction for each aspect of the Kanban system. The exploratory factor analysis revealed that two factors underlie the collected assessments: the inherent advantages of a Kanban system and the logistics system performance. Thus, hospital managers should promote the implementation of Kanban systems.
(Matta et al., 2005)	This paper deals with an issue of evaluating the performance of assembly systems managed with Kanban. In particular, two different Kanban policies, differing in the way in which kanbans are released, have been considered: independent and simultaneous systems. Both systems have been assessed and compared with approximate analytical methods. Results reported in the paper demonstrate the accurateness of the developed technique in some defined cases where the service levels of the system assume large values close to 100%.

These papers showed the work efficiency of the Kanban methodology in a wide set of projects. Since small and medium enterprises, where it showed the increase of the profit on the company, until a hospital to manage medical consumables, Kanban have shown very useful and very satisfactory by the teams.

2.2.3.1 WIP Limit & Pull System

The work in progress should be conditioned by a limited number of tasks running in the shop-floor. Thus, Kanban can assume an important role in the limitation of the number of active tasks being performed.

The introduction of Kanban changes the "push" work way to the "pull" work way, which means that the tasks do not start until the current tasks are not done (Anderson & Carmichael, 2016).

The pull system enables the teams to pull tasks into their workstream when they have the capacity to handle it (Reddy, 2016). This system aims for optimal usage of the team's capacity.

2.2.3.2 Kanban Board

Kanban is a low-tech but very efficient and easy to handle tool. The main meaning of this tool is to enable the team to have a visual overview of the workflow (Stellman & Greene, 2014). Figure 23 (Hansen, 2019) shows an example of a Kanban board.
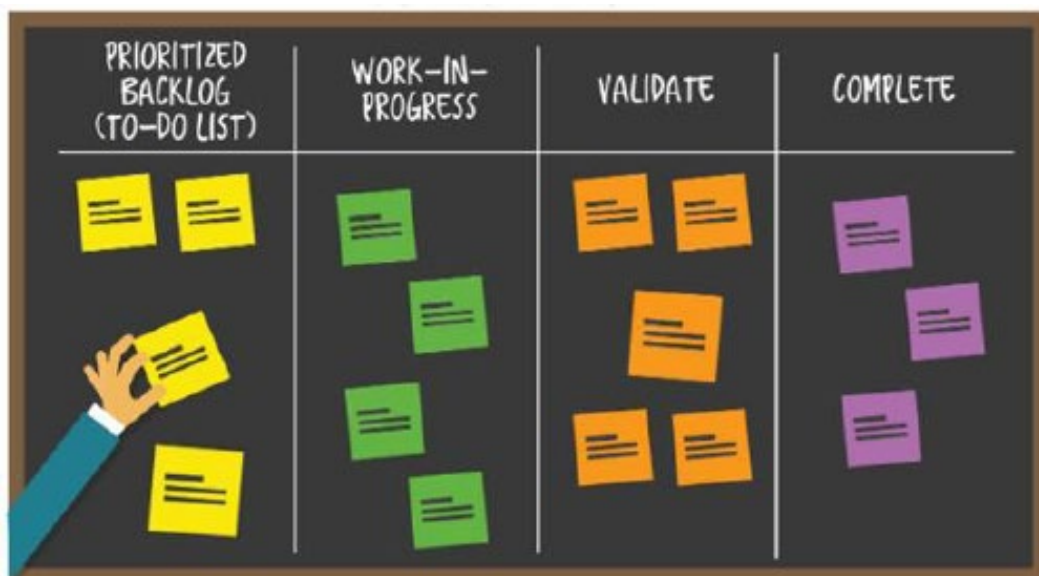

Figure 23 - Example of a Kanban board (Hansen, 2019)

Table 5 is a resume of study cases about Kanban board which shows the efficient of this tool in another contexts.

Table 5 - Kanban boards research

Bibliography References	Work Description
(Diebold et al., 2018)	This work aims to evaluate if an evolutionary transition to agile is suitable for small companies. The transition was based on assessments of improvements. A positives experiences reported by all the employees during the agile transition means that it is suitable for small companies. In this work, the adoption of Agile practices was done step-by-step. They had introduced first the Definition of Done and the User Stories. Subsequently, after a positive response of the team, they introduced the Kanban board along with the WIP limit and the pull principle, which brought further cultural changes along with the process changes. The authors ended this paper saying that a true agile transition never end because it has every time place to improvement.
(Powell, 2018)	This paper reviews two cases studies from the Maritime sector where Kanban boards and cards have been introduced for the executing phase of shop orders in manufacturing. The goal of this paper was to investigate whether Kanban in its most primitive form - a sign board – can serve as an effective means to manage the production control task in high-mix, low-volume environments. After this process tool has been implemented, the team figure out immediately 50% reduction of lead-time in both cases.

These researches have shown that the visual Kanban boards are used a wide of activities. In the first article, the authors present it as an Agile tool suitable for small companies. Then, the second article is in the Maritime sector where they have reduced the lead-time immediately by 50%.

2.2.4   Scrum & Kanban

Following the literature, Scrum & Kanban are both Agile process tools with the goal to accomplish a task or purpose (Consulting, 2019). Table 6 shows the differences between the Scrum and Kanban.

Table 6 - Difference between Scrum and Kanban (Ellis, 2016)

Scrum		Kanban
More perspective		More adaptive
More rules to follow		Fewer rules to follow
Three roles	VS	Does not prescribe roles
Timeboxed iterations		Timeboxes are not prescribed
Tracks Velocity		Tracks Flow
Scrum Master owns the process		Team owns the process

Table 7 shows the advantages of each process.

Table 7 - Advantages of each process (Ellis, 2016)

Scrum	Kanban
Transparency	Flexibility
Improve credibility with clients	Focus on continuous delivery
High product quality	Increased productivity & quality
Product stability	Increased efficiency
Team reaches sustainable rhythm	Team has ability to focus
Allows clients to change priorities & requirements	Reduction of wasted work and time

To conclude this topic, the application of these tools truly depends on the context in which those are inserted. It can be used in many ways and it could be only the Scrum or only the Kanban or a Kanban with some roles of Scrum, and so on. The application really depends on the context of the team.

2.2.5   Scrumban

Scrumban is a hybrid framework that combines Scrum and Kanban methodologies. It was originally designed as a way to perform the transition from Scrum to Kanban (Agile Practice Guide, 2017). As shown before, the Scrum framework organizes the work into small "sprints" and leverages the use of Kanban boards to visualize and monitor work.

Scrumban is not using just a few elements of both Scrum and Kanban. Rather, it empathizes applying Kanban systems within a Scrum context and layering the Kanban method alongside Scrum as a vehicle for evolutionary change (Reddy, 2016).

This tool is a hybrid framework keeping the Daily Scrum meeting and the Kanban board, but eliminating the planning activities and velocity measurement. The focus is to smooth the flow and minimize the WIP (Ellis, 2016).

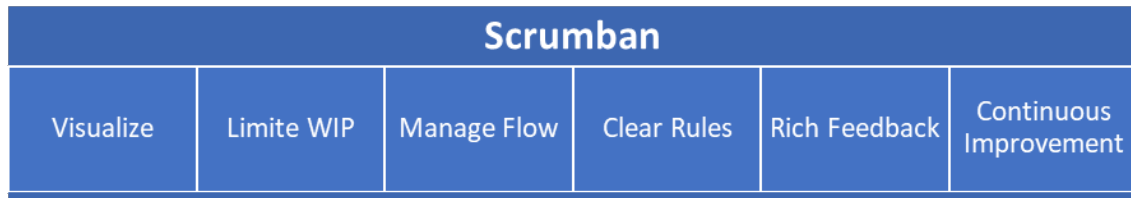David Anderson suggested six keys practices of Scrumban (Deep, 2013), as follows in Figure 24.

Scrumban					
Visualize	Limite WIP	Manage Flow	Clear Rules	Rich Feedback	Continuous Improvement

Figure 24 - Pillars of Scrumban (Deep, 2013)

The definition of each pillar is following explained.

Visualize

This pillar makes sure that the Kanban board is visible at all time. It also recommends avoiding an electronic board or someone's PC (Anderson & Carmichael, 2016).

WIP Limit

This pillar limits the WIP as a function of Kanban. The Kanban board reveals WIP and provides a simple way to limit it: the team cannot advance a task into a Kanban column when the column is at its limit (Deep, 2013).

Manage Flow

This pillar shows that the flows should be visual which allows the team to see if a task is stuck (Anderson & Carmichael, 2016).

Clear Rules

This pillar explains that the team should write down the Kanban rules (Deep, 2013).

- What are the WIP constrains?
- How will tasks be added to the backlog and how will they be pulled out of the backlog to be processed?
- If an experienced team member has advanced a task improperly, how will this be reversed? Does someone on the team have authority?
- Is there a small group that can override team member decisions?

Scrumban does not have defined roles like Product Owner or Scrum Master, so the team must decide how to manage interactions.

Rich Feedback

The Kanban board should be visible across the company and invite feedback from every corner. The focus is to increase value and reduce waste (Ellis, 2016).

Continuous Improvement

This pillar lays down in typical of lean thinking. Scrumban starts simple and brings little benefit in the beginning. Scrumban brings value through evolution powered by collective ideas of the team (Deep, 2013).

2.2.5.1 Agile Scrum vs Scrumban

Table 8 shows some topics which differentiate the Scum methodology from the Scrumban methodology (Ellis, 2016):

Table 8 - Scrum vs Scrumban (Ellis, 2016)

Scrum	Scrumban
Tasks are planned in 2-4 weeks sprints.	Tasks single-piece flow.
Tasks in backlog have effort estimated in story points.	Tasks effort is not estimated.
Focus on story point velocity.	Focus on task flow and minimal WIP.
Requires a large effort to start.	Requires little effort to start.
Targeted at teams with deep collaboration.	Targeted at teams with lots of interrupts and simple projects.
Team size 5-9.	Any team sizes.

PREVIEWS WORK AND PARTICULAR TERMINOLOGY

3.1 Summarization of Fábio's Thesis

3.2 Fábios's Developed Approach

3 PREVIEWS WORK AND PARTICULAR TERMINOLOGY

3.1 Summarization of Fábio's Thesis

Fábio's thesis was performed to achieve the necessities that the DLM project was looking for.

The AWACS DLM project was characterized by using a predictive approach to develop the required documentation to support project management. In this way, each document was done after another document is finished. Then, when a document is done, it can't be updated. This was an issue for the project because all documents are connected as showed in Figure 25. Thus, by the predictive approach, the content of the documents could be not aligned.
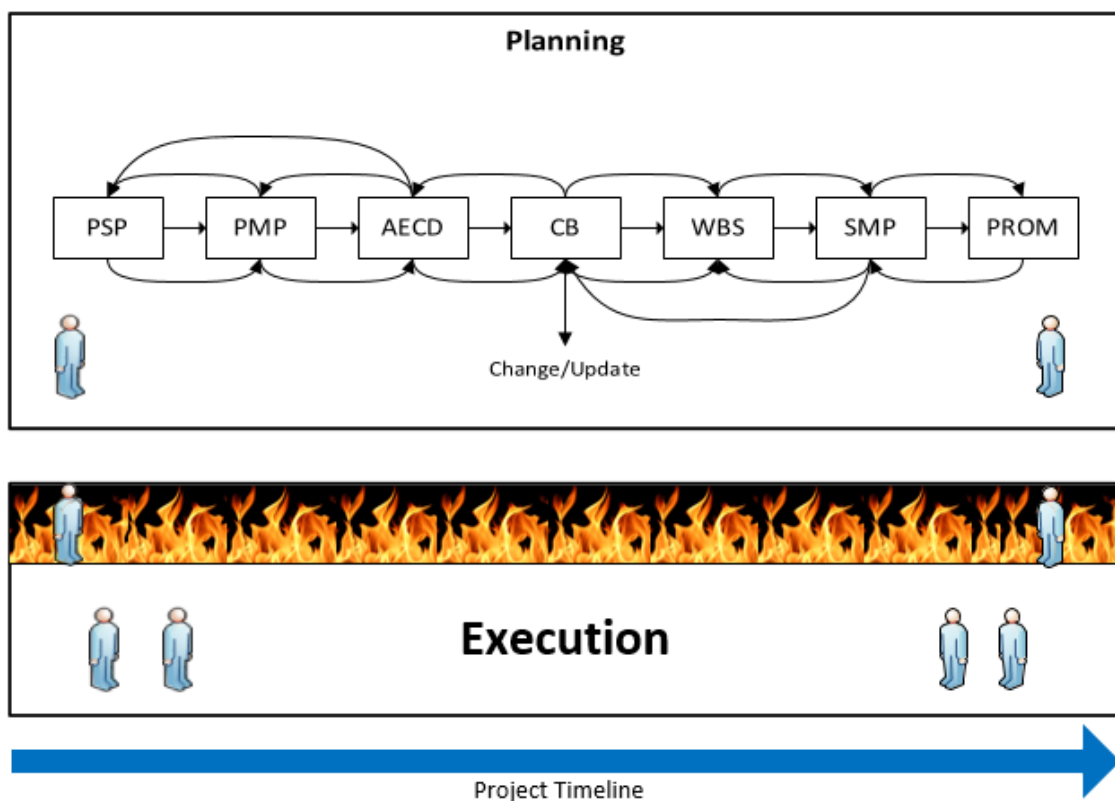

Figure 25 - Scheme of the current approach (Freitas, 2019)

Following Fábio's thesis, both phases of planning and execution are important for the success of the project and therefore, they need to carefully perform. The planning needs to be carried out quickly enough to be followed by the execution phase, otherwise, the execution phase could be performed without a plan. If this happens, a big effort will be required in the execution phase to solve related issues by performing firefighting, further limiting the resources available for planning.

New ways of work needed to be investigated which could support all documents edition and updates. Thus, his first work started for seeking methodologies that fitted well and could be adapted to the project. His work had begun to assess by SWOT

analyses which approach suits better to the project and verify if it is necessary to develop a new approach.

3.2   Fábios's Developed Approach

Fábio found out that pure Agile methodology did not fit in the project. Thus, Scrum methodology was the one that showed to be the most promising but tailored with well-known predictive elements as well as totally new predictive elements. Figure 26 shows a Kanban Board resulting from Fabio's work.
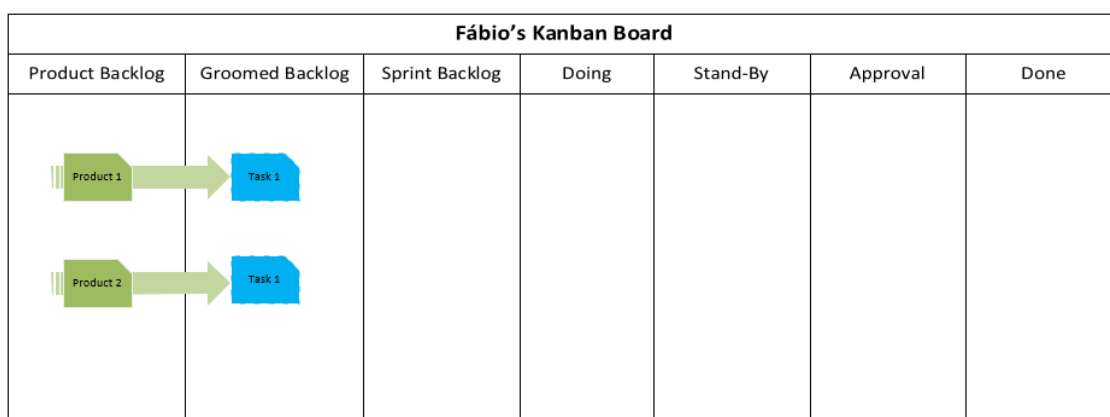

Figure 26 - Fábio's Kanban Board (Freitas, 2019)

Table 9 shows the meaning of each Fábio's Kanban Board column.

Table 9 - Fábio's Kanban Board Columns Meanings

Columns	Meaning
Product Backlog	This column is the only one fulfilled with products.
Groomed Backlog	The products are a breakdown in tasks and then the tasks are put in this column. Here is the first step of the tasks.
Sprint Backlog	The column is composed of the tasks that will be worked in the next sprint.
Doing	The column shows that a team member is working on those tasks.
Stand-By	This column is composed of tasks that were already performed by a team member, however, it needs to wait for inputs of the stakeholders to be completely performed.
Approval	This column is composed of tasks that are waiting for internal stakeholder or customer approval. The product owner is the one accountable to bring the answer to the team.
Done	This column shows that the tasks were already performed.

THESIS DEVELOPMENT

4 THESIS DEVELOPMENT

This section presents the development of this master thesis. It should be noted that all improvements were done based on the literature and the experience of the team with Fábio's approach, since the implementation until the current days.

4.1 Implementation

The implementation phase was promoted and guided by the project manager, who is the Product Owner and the Scrum Master as well. The beginning of the methodology implementation was done step-by-step. The project manager had the concern that all team members have been in line with the new approach, being conscious that all team members were understanding the new approach.

The real begin started with the board designed by Fábio, which was divided into two boards because of the original size of the boards and the disposition of the walls. The first board was composed of the Product Backlog column, Sprint Backlog column, Doing column, Stand-By column, Approval column and Done column, as shown in Figure 27. The second board was composed of the Product Backlog column and Groomed Backlog column, as shown in Figure 28.
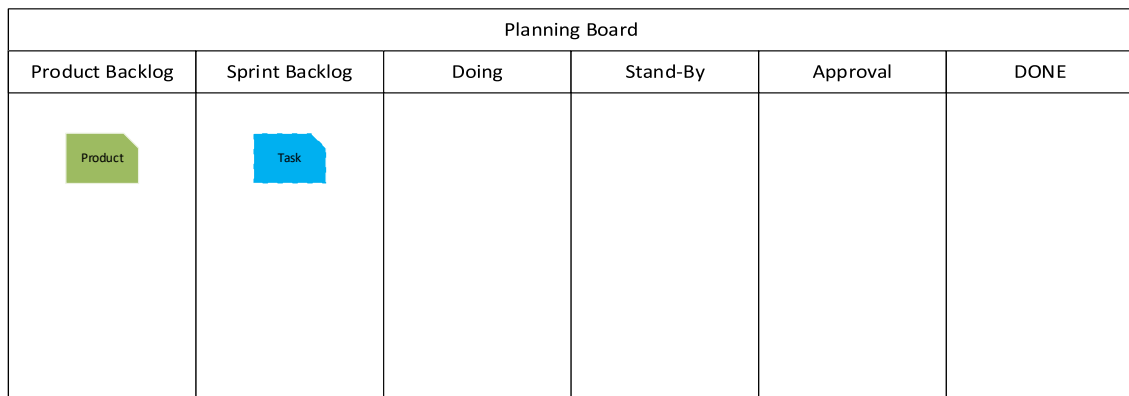

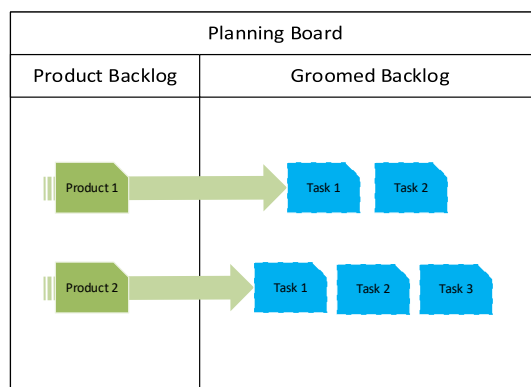Figure 27 - Implementation of the first Fábio's Board

Figure 28 - Implementation of the second Fábio's Board

The implementation continued with the placement of the boards on the wall and the drawing of the columns, as described in Fabio's thesis. During the formation of the

board, the team had careful with the dimensions of the columns, paying attention to the maximum number of tasks able to be inserted in the columns and lines, and if they fit in well. In this regard, the team was preventing future time lost reconfiguring the board columns.

As described in Fabio's thesis, the project manager explains the Scrum events, Daily Scrum, Weekly Scrum, and Sprint Review, to the team. This explanation consisted of giving instructions to the team on how they should perform during the events and explain the roles of each team member. Additionally, the project manager was conscious of showing the artifacts of the methodology applied to the team members to give them a deep understanding of their functions and utilizations.

Sprint Planning

The Sprint Planning event was introduced to plan the work for each Sprint. To do so, the product backlog and the groomed backlog was filled with products and tasks. It was assumed that the product backlog could not be changed during the sprint. The tasks which did not fulfill the prerequisites to be performed would stay in the "Stand-by" column.

Sprint Executing

The Sprint Executing, as a Scrum event, was defined to start immediately after the Sprint Planning and lasting 1 month, and it is at that point that the team is responsible to perform the tasks fitted in the doing column.

Daily Scrum

The Daily Scrum was very well driven by the Team's coach. The Scrum Team was composed of three individuals at that time. Only the project manager was familiarized with the methodology while for the other two members, it was the first contact with this methodology. Regarding that, the first event required more than 15 minutes, as described in Fabio's thesis, in order to explain all rules and responsibilities. The main focus of the project manager, mentoring as Scrum Master, was to explain the main questions of this event and show that the team should not conduct the meeting for another sort out of subject than answer the questions in an assertive manner.

After a few events, the team members already knew the rules of this event and the time duration decreased to around 7 minutes per event.

Weekly Review

The Weekly Review is done every Friday morning with all the team members involved in the project. This event was a new feature introduced by Fabio's thesis as a predictive element in order to help the team at the beginning, expecting difficulties that could appear during the Sprint Execution. One more time, the project manager explained the rules of this event. This meeting was programmed with a duration of one

hour for the product owner to have enough time to give directions to the right path to increase the chance of getting stakeholder approval at the end when the tasks are finished.

Sprint Review

The Sprint Review is an event that belongs to the Scrum methodology. It was mentioned that the event takes place at the end of each sprint with the purpose of reviewing the tasks that were performed in that sprint by the stakeholders.

Sprint Retrospective

The Sprint Retrospective was established as an event that the team must assess the sprint process and workflow in order to create a plan for related improvements for the next sprint. The meeting is characterized by the questions described in Fabio's thesis. This Sprint was driven under the "Continuous Improvement" mindset. The Sprint Retrospective meeting is driven by the Scrum Master and includes in this meeting the Product Owner and Team members.

4.2   Investigation

The investigation was one of the most important duties of this work. The evolution of this thesis started with all the research needed to accomplish the goals of this work. During the development of this thesis, the research was permanently performed looking for new solutions.

All the changes and updates done throughout the life cycle of this work were based on investigations based on the literature review.

4.3   Improvements

The improvements to the approach were made and are made in order to get the best of the methodologies and tools, promoting to the team the best work way possible.

Thus, all team members needed to be comfortable, having effective communication with each other in order to express their opinion about the work methodology and the tools applied. All requirements and possible features presented by the team are evaluated and questioned whether they make sense to apply to the new methodology in order to have a successful performance.

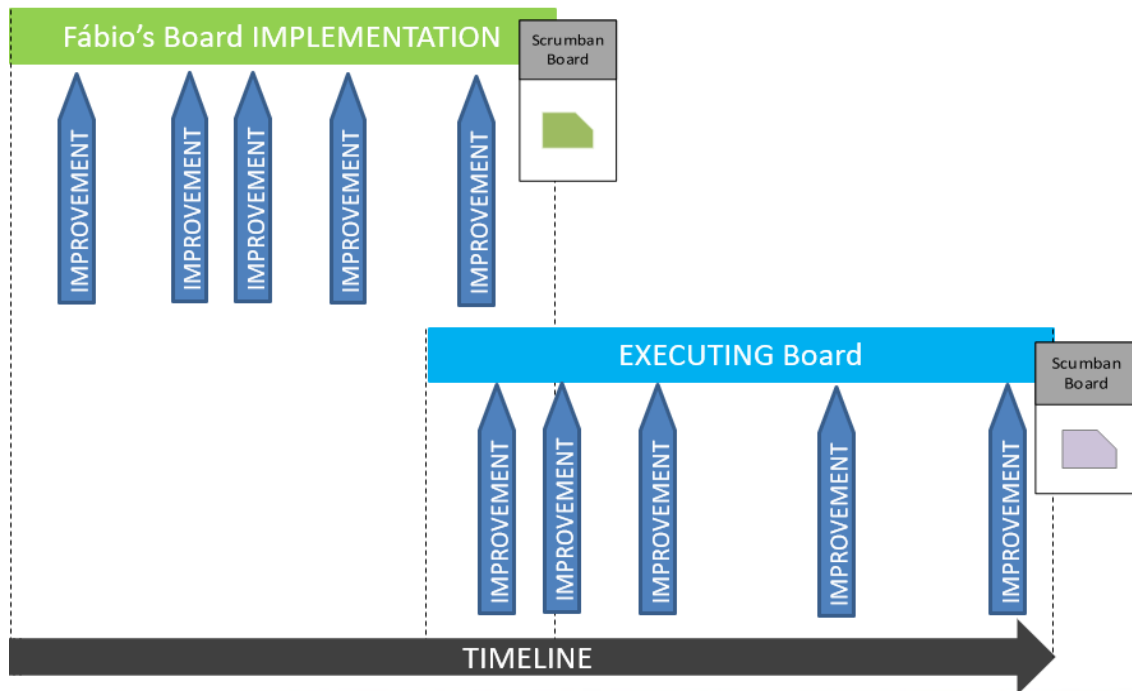Figure 29 shows the improvements timeline done on the methodology.

Figure 29 - Improvements Timeline

4.3.1   First Improvements

During two weeks of implementation, the team have noticed very good results on daily working and have felt very comfortable with the methodology. However, they thought that some of the approach characteristics must be re-thought in order to be a better fit for the team requirements.

Due to this, the team decided to start the modification of the methodology both in terms of theory as in practical terms. This process was carried out by the author of this thesis and was initiated and driven under special attention in order to do the correct improvements. The project manager, as responsible for the methodology, is the one who validates the final word for the new improvements.

During the research, Figure 30 and Figure 31, it was found that "Doing" and "WIP" terms were used for the same purpose. Although the implementation has been started under with "Doing" term, the author of this thesis proposed to change this term to "WIP". The team was already more familiarized with this one in another work context. For that reason, the term was changed.
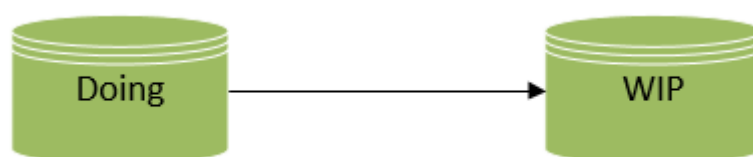

Figure 30 - Column name changed from Doing to WIP

Planning Board					
Product Backlog	Sprint Backlog	WIP	Stand-By	Approval	DONE
Product	Task				

Figure 31 - First change in the Planning Board

The first aspect proposed to improve the methodology was to change the tasks flow. As in the original implementation, the tasks waited for the Daily Scrum to be repositioned, which means, moving the tasks from the "WIP" column to the "Approval" column. The new flow way is made when the tasks are done, i.e., when a team member has the task done, he promotes the repositioning of the task. This modification was based on the Scrumban literature mention the Manage Flow pillar. In this vein, the project manager has constant visualization of the workflow.

The second change was proposed in order to combine two events: the Weekly Review and the Scrum Review. This joint intended to combine the best properties of each event. After some Weekly Reviews, it was possible to have the stakeholders' weekly approval. Thus, the team did not need at all to wait for the Sprint Review for the stakeholders' approval. For that reason, the two events were combined in order to reduce the time wasted on events. Thus, the Weekly Review additionally assumed the purpose of the Sprint Review. Furthermore, it turned out that it was easier for the team to obtain the stakeholders' approval weekly in comparison to waiting some weeks before presenting the results and maybe cannot recall correctly what was done.

The third concern identified by the author of this thesis was the "Stand-By" Column, which should be erased, Figure 32 and Figure 33. Once this column was never filled with the tasks, it was purposed to remove this column. As now the team does not have Sprint Review and has feedback from the stakeholders every day, the main goal of this column was never accomplished. This action has promoted more space on the boards for other columns.

Figure 32 - Second change in the Planning Board

Planning Board				
Product Backlog	Sprint Backlog	WIP	Approval	DONE
Product	Task			

Figure 33 - Columns' progress

It was also suggested to change the name of the "DONE" column to "History", Figure 34. That change emerged because this column was working more like a place where each "DONE" task is stored and maintained here. Additionally, it was suggested to re-name the "Approval" column into the "DONE" column (Figure 35), as the original intent to have tasks waiting for approval was no longer required due to changed content of the Weekly Review.

Since, after deletion of the "Stand-by" column, one board of the boards was free, it was suggested to move the "History" column to the free board. This gave the opportunity to widen the "WIP" column and gave at the same time more space for the "History" column.
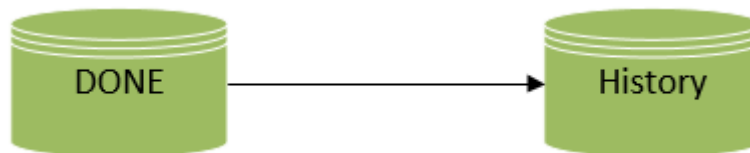

Figure 34 - Column name changed from DONE to History

Planning Board				
Product Backlog	Sprint Backlog	WIP	DONE	History
Product	Task			

Figure 35 - Third change in the Planning Board

As presented by Fábio's thesis, the old Groomed Backlog (Figure 28) was filled with tasks chosen in a predictive way. This means that tasks of the product were broken down in all possible tasks to be done on that product. Thus, since the first beginning, the tasks were put into the Groomed Backlog, they remain with the same definition until the product is done. The New Groomed Backlog (Figure 36) is a more agile version. This means that, when the products are broken down into tasks, these tasks are chosen to be performed as soon as possible, and they have the possibility to be changed at any moment according to the stakeholders' interests.

Figure 36 - New approach behind Groomed Backlog

4.3.2   Improvements after First Sprint Retrospective

The first Sprint Retrospective was performed. During this meeting, the team members spoke about the methodology and the performance of the new tool. They recognized at this point that the methodology improved the performance of the team and the attention of the stakeholders, and did not suggest any additional improvement.

4.3.3   Fire-Fighting Board

After a few months of the methodology implementation and verification of its successful results in the project planning, it was proposed to apply this methodology to the executing phase (Fire-Fighting Board) of the project.

Regarding the project executing side, the methodology was adopted, according to the needs of this work.

For that reason, the project execution was featured with the Scrumban board based on the pull task system in parallel with scrum events.

The first difference between the planning board and the executing board remained on the tasks. As stated before, the planning board was featured with Products that are next split in tasks. In this case, only tasks fill the board. These tasks flow through the board, starting in the first column until the last one.

4.3.3.1   First Board

The first board of the executing phase was the one showed in Figure 37. Initially, the board began with four columns. Regarding the Scrum events, they start with Daily Scrum, Weekly Review and Sprint Retrospective, the same events as the planning phase.

The board had 4 columns: Product Backlog, Sprint Backlog, WIP and DONE. Because this phase is fulfilled only with tasks, they start the flow on the first left column, on the Backlog, and then they flow until the DONE column. Conversely to the planning phase, here, the colors of the post-it are every time the same because it is only tasks applicable.
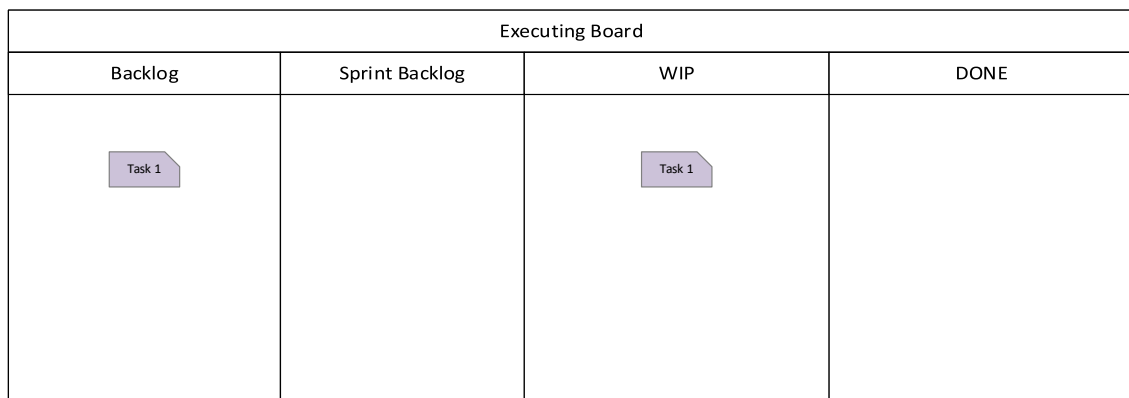

Figure 37 - First board configuration

4.3.3.2   Second Board

The second configuration of the board is shown in Figure 38. These improvements were promoted by the author and then developed together with all team members of the office.

This team has several sorts of tasks that need an answer from different kinds of people outside of the office team, such as people inside of the company, as well as people outside of the company. Because of that, the board was changed in order to organize all tasks per each source of the answer.

As an improvement, a new column WFI, Wait For Input, has been added which is split into two blocks, External and Internal. This new column was needed because it will provide a better understanding to the team of what they are waiting for. This column is the one showed in Figure 38, at the right of the WIP column. The tasks that fulfill the WFI column are tasks for those the team needs information from outside Stakeholders. The External block refers to Stakeholders outside of the company and the Internal block refers to stakeholders inside of the company, but outside of the team.

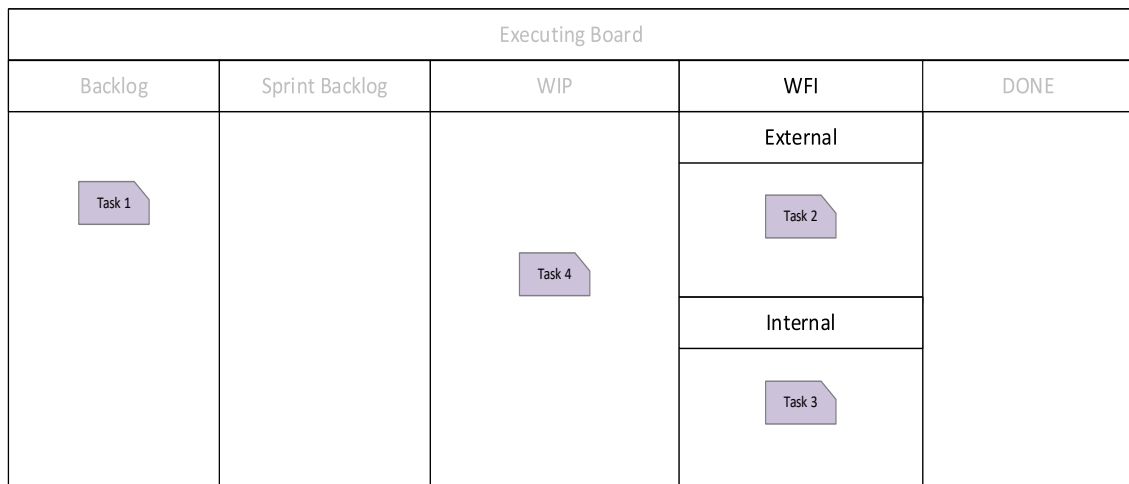The events remain the same as in the first board.

Executing Board				
Backlog	Sprint Backlog	WIP	WFI	DONE
Task 1		Task 4	External Task 2 Internal Task 3	

Figure 38 - Second board configuration

4.3.4   MindManager Application

Due to the small size of the History column, it was impossible to move all the tasks performed by the team there and store them until the next utilization. Keeping that in mind, the investigation about software able to be used as a support for this methodology was discussed and proposed thinking in record every work performed on the History column. The software selected and checked MindManager. This software is very popular in project management due to its capacity for easy and powerful management.

The team experienced this tool during three weeks in order to feel the team's comfort in using it. This software enables the team to record every task performed with the person's name accountable for it, as well as starting and ending dates. Since the beginning, the team noticed that this software was not useful for them. Indeed, dealing with the software is a time-consuming task which had downsized the team's performance. Moreover, the initial goal of recording tasks as a "History", does not make sense at this point because the products were not performed anymore following the same way. Regarding that the tasks were performed every time following the same way, it does not enable the team to think outside of the box and find out new and better ways to perform the tasks.

Following the literature, the first pillar of the Scrumban methodology Visualize, emphasises that the boards should be visible all the time to all team members and should not be used as an electronic board.

Thus, the initial vision of the team to use this software was very well accepted by all team members but the goal of its utilization was not accomplished. As a result, the team stopped using this tool.

4.3.5   Final Improvements

This subsection will show the final results of the methodology applied on both sides of the project. Moreover, it will demonstrate the last boards configuration and how the approach works through the flow chart.

4.3.5.1   Current State Planning Phase

In this sub section is presented the current methodology applied to the Planning Phase of the projects presented.

The final boards, as shown in Figure 39 and Figure 40, have four columns plus two columns. The boards are splitted as they are implemented in the office. The columns of one of the boars are Product Backlog which is filled with Products, while Sprint Backlog is filled with tasks which flow throughout the board, passing by the WIP column and ending up in the DONE column.

The explanation of the process will be done afterward using Figure 41.

The last improvement implemented in the planning phase was reprioritizing the work, which belongs to the Scrum methodology and is one of the characteristics of the Product Backlog artifact. This purpose was developed for the team members to establish which work should be done first to achieve the stakeholder's goals. This process is very simple, just needing different magnets with two colors, in which the red color corresponds to the most urgent work and the white color to the remaining work. The magnets are placed as shown in Figure 39.
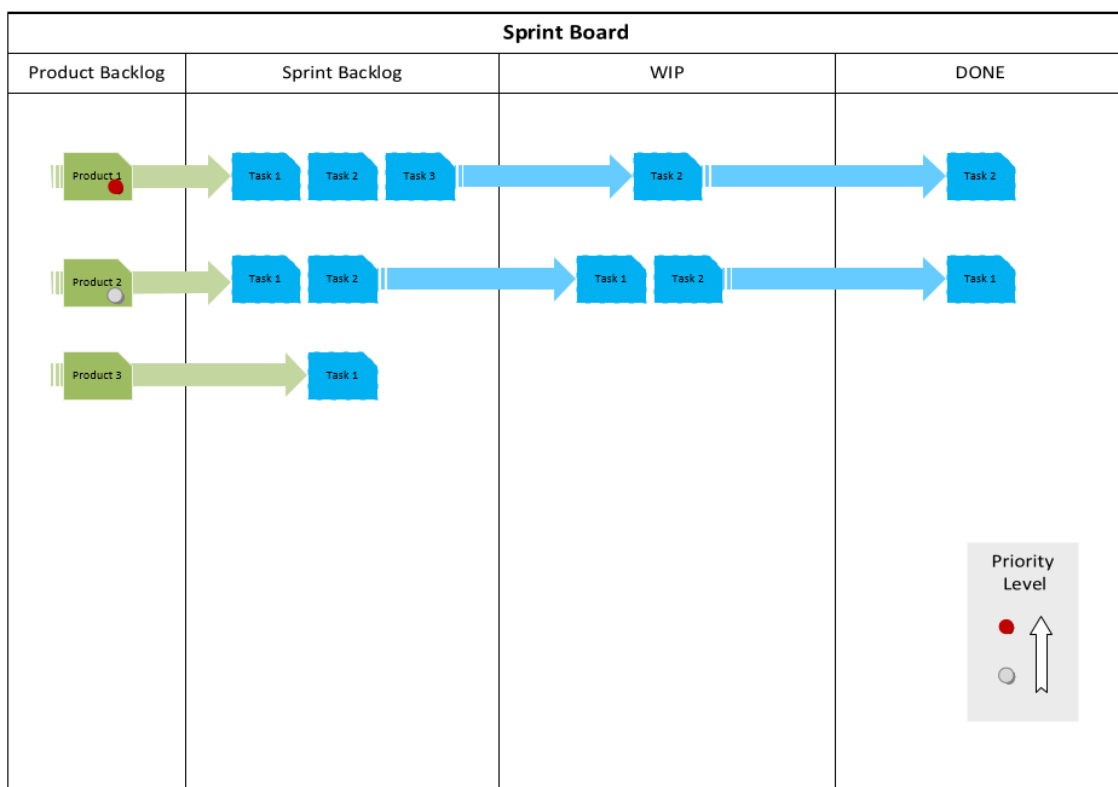

Figure 39 - An example of the Sprint Board

Figure 40 has two columns, Product Backlog, and Groomed Backlog. The Product Backlog is filled with products. It was suggested to order products on the board by their priority. The Groomed backlog is filled with tasks.
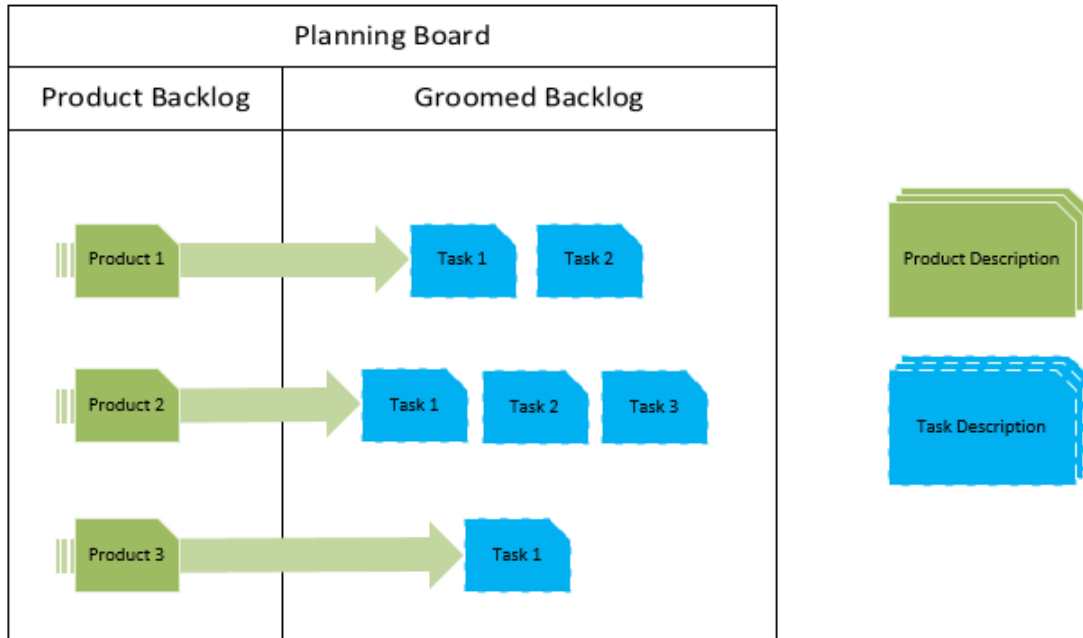

Figure 40 - An example of the Groom Board

The History column does not fit anymore in the methodology. As described before in the MindManager Application, the column was considered as obsolete by the team.
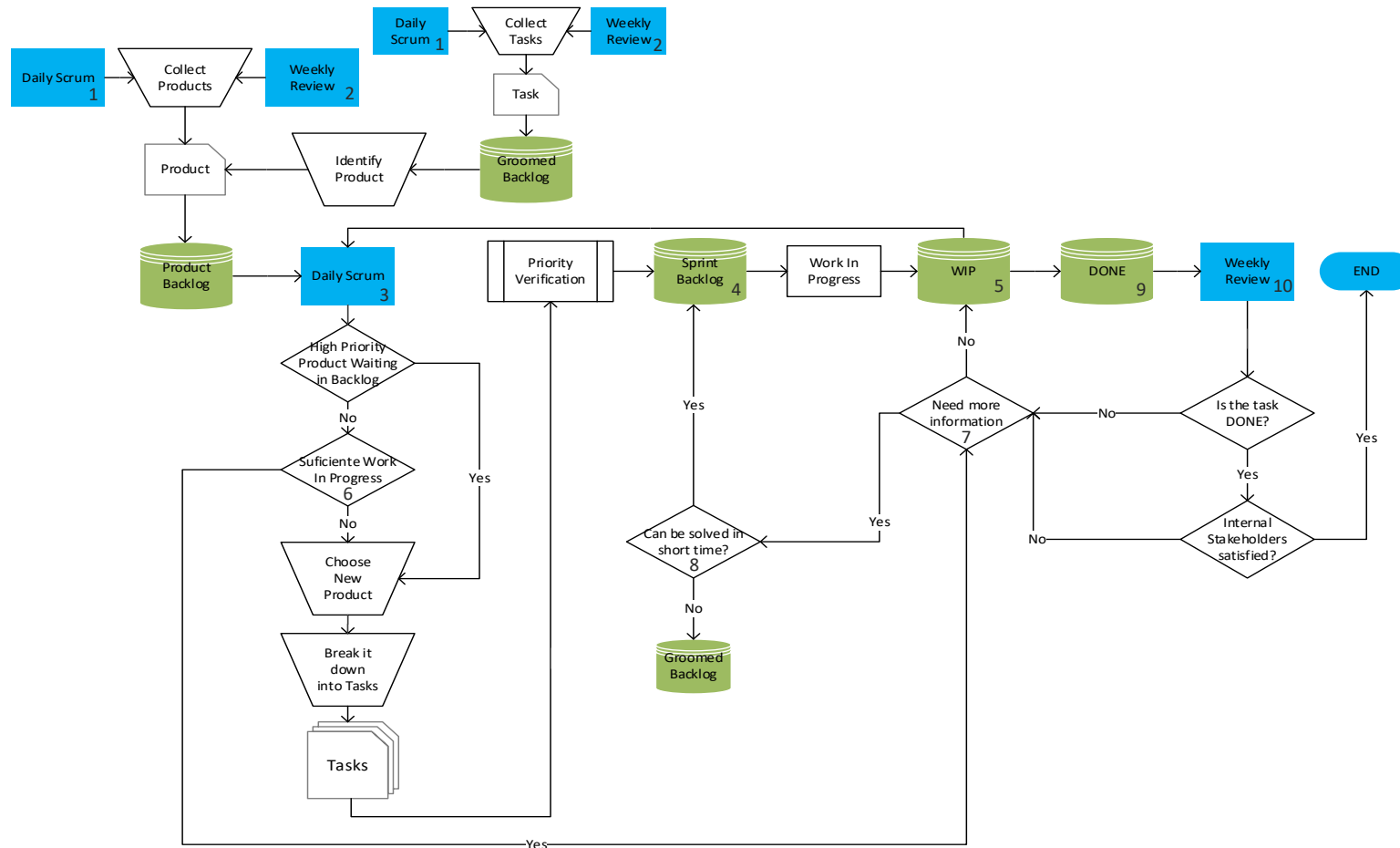
Figure 41 - Flow chart of the Planning Phase

Figure 41 presents a flow chart that explains the ongoing of the planning phase process. Conversely to Fábio's work, some elements were changed and some elements were introduced in order to achieve the goals of the team.

The flow chart begins from the left side top to the right side. This team is composed of the project manager, who assumes the role of Scrum Master and Product owner, plus the Development Team. As it is possible to see above, the methodology starts with Daily Scrum, Weekly Review, collecting products and collecting tasks. Because the team needs to be flexible every time in the project, they do not do any Sprint Execution. Instead, they maintain a constant workload with the work in progress.

The Daily Scrum (1) is done every day, five times per week. On this event, the team defines the products which will be performed, filling by this way the Product Backlog with Products. Also, it is discussed the tasks necessary to be done per each product and these tasks are put into the Groomed Backolog Column. This process is also made on the Weekly Review (2).

During the Daily Scrum (1)/(2), the questions showed in ANNEX1 are also answered.

In order to answer the questions "What will you do today?", the team moves the work through the board (from Sprint backlog to WIP). On the Daily Scrum (3), the team checks which products are more important to do at that moment. The products with high priority go ahead and they are broken down into tasks. After the priority verification is done, the products are introduced in the Sprint Backlog (4) and the tasks are put into the WIP (5). If there are no High Priority Products waiting in the backlog, the team looks for whether it has sufficient work (6) to do in the WIP. If not, the team adds more work to Sprint Backlog and to the WIP with the proper priority verification. If yes, the team ask themselves whether they need more information (7) to accomplish the tasks. If not the tasks stay in the WIP column. Otherwise, the team looks if they can solve that in a short time (8). If they cannot solve in a short time, the tasks are moved to the Groomed Backlog Column.

As the team is doing the work, they move by themselves the work to the DONE column (9).

During the Weekly Review (10), the product owner provides stakeholders approval. If the approval is given, the tasks are completed and removed from the board. If the approval is not provided, the tasks continue to step (7).

4.3.5.2   Current State Executing Phase

In this sub section the current methodology applied to the Executing Phase of the project is showed.

As show in Figure 42, the board has now another column: the Escalation column. (Stare & CSPM, 2014; Serrador & Pinto, 2015; Antlova, 2014)
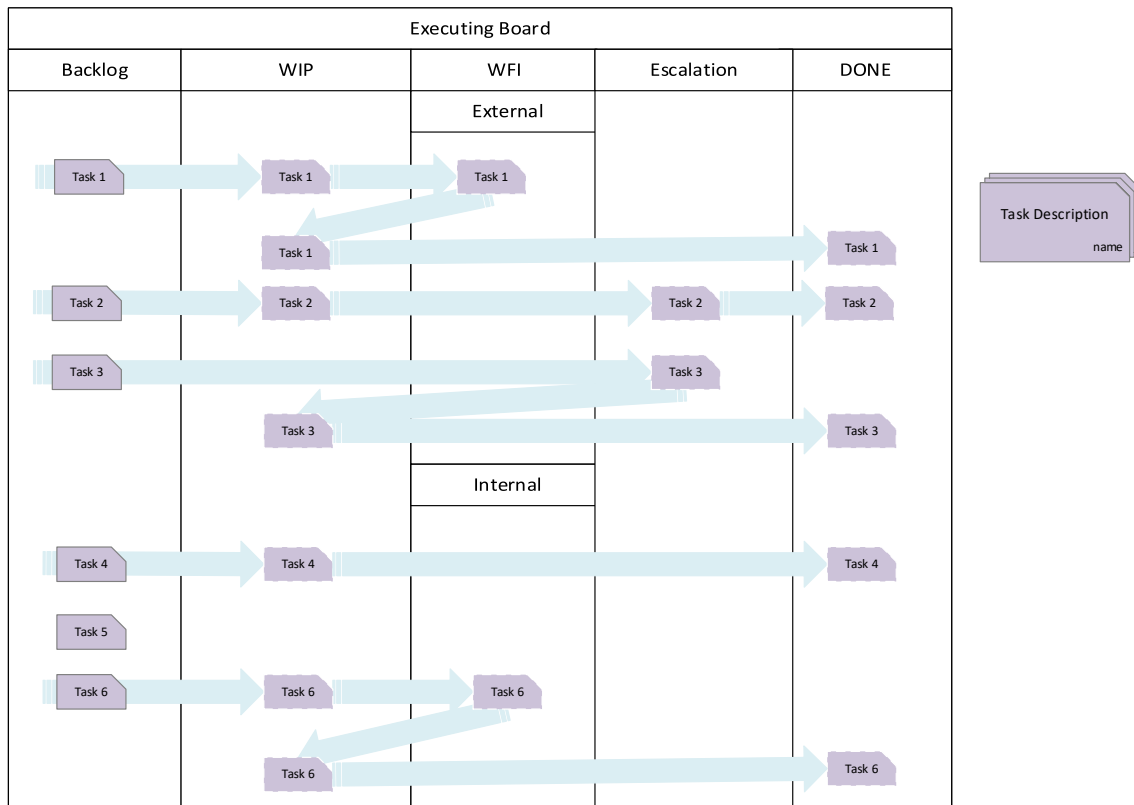

Figure 42 - Overview of the Executing Board

As shown in Figure 42, the board has six columns each, one with its function. From the left to the right side, the executing board starts with the Backlog column, followed by WIP, WFI (Wait For Input), Escalation and DONE.

On the right side of Figure 42, a template of the tasks is presented where it is described the "Task Description" and the name of the responsible for work on it.

Regarding the board, it starts with the Backlog column. Here is where all tasks have them first step on the work process.

The second column is the WIP column. This column shows which tasks are being worked at the moment by the team members.

The third column is the WFI column. This column is divided into two parts: the external and internal Input. These columns mean that the team is waiting for inputs from

stakeholders, such as internal or external approval to perform the tasks. Once the inputs arrive at the team, the tasks come back to the WIP column to be performed by the team. Figure 42 shows two examples, task 1 and task 6, of this work progress.

The task 2 and task 3 in Figure 42 are examples of what is mention in the paragraph before. Task 2 is performed by the team, thus, in the WIP column, and then flows to the Escalation column waiting for an answer from the escalation level. Afterward the task is done, it is moved to the DONE column. Task 3 is like task 2 but after the tasks are supported by the escalation level, they need to still be worked by the team, thus they are moved back to the WIP column, and then, moved to the DONE column.

Scrum Events

The events applied here have been Daily Scrum, the Weekly Review and the Sprint Retrospective. They are scheduled with the same timeframe as the planning phase and they are driven in the same way.
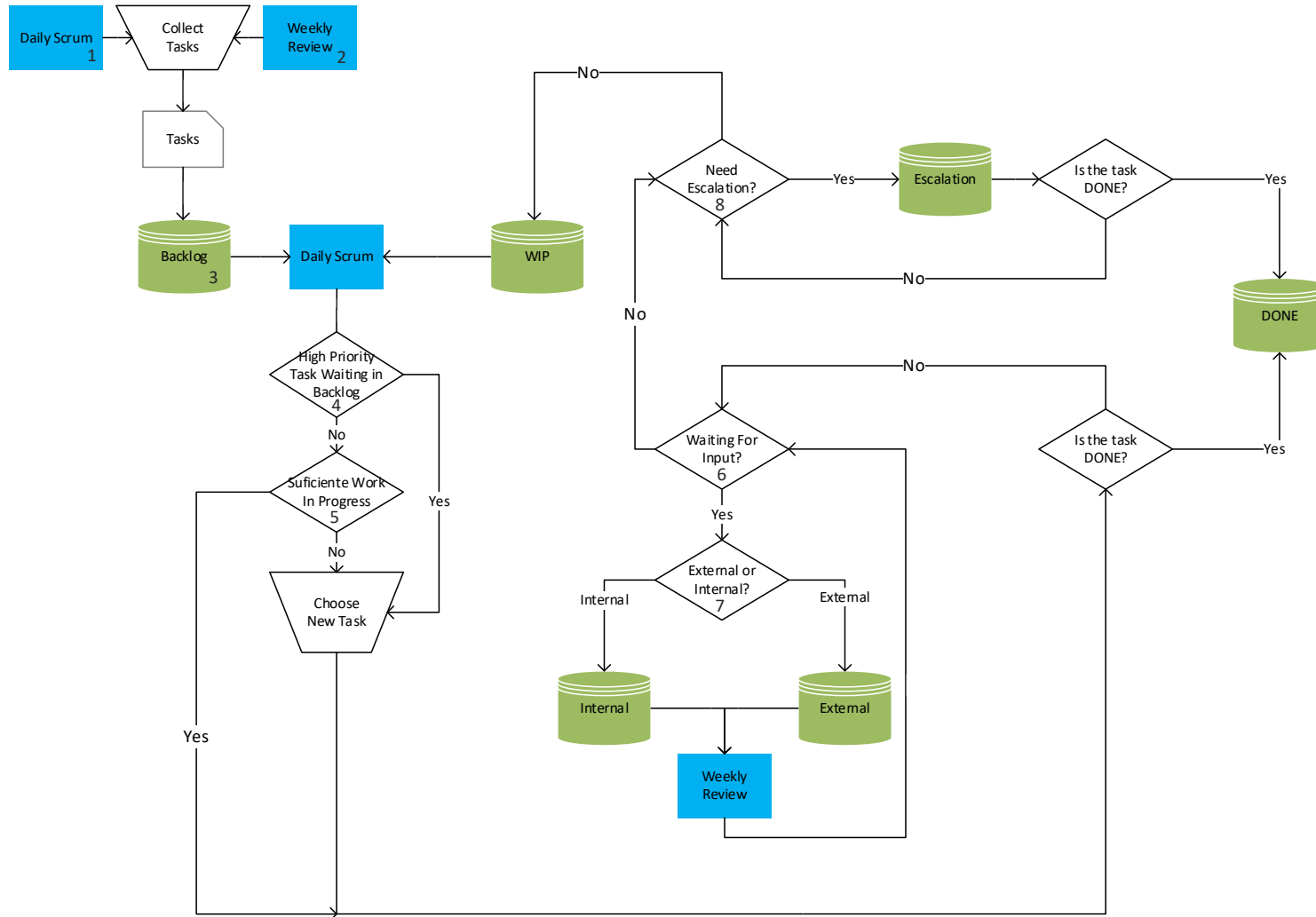
Figure 43 - Flow chart of the Executing Phase

Figure 43 presents a flow chart regarding the executing phase of the previously mentioned project. The flow chart begins on the top with the Daily Scrum and the Weekly Scrum, as in the developed approach.

The Daily Scrum event has the same procedure as the executing phase of the project. During this event (1), the team collects the Tasks and they fill the Backlog (3) with them. The same is done in the Weekly Scrum (2). After that, the team verifies the prioritisation of the work (4), or in other words, the tasks that should be done first. If there is task priorisation, these tasks should go ahead before the others. If there is no prioritisation, the team verifies the amount of work on WIP (5).

During the ongoing day, some tasks are not done because inputs from the outside of the team are required (6). Regarding that, depending on the sort of source, the tasks are moved to the (Airbus) External or Internal (7). These tasks are reviewed weekly by the project manager and the team. Coming back to the point (6), and if there are no tasks waiting for input, the team goes to point (8) and looks if the tasks needing to be escalated. If yes, the team moves the tasks to the Escalation column and informs the next hierarchic level that support is needed. If an escalation is not or is no longer required, the tasks are moved to or stay in the WIP column and the team performs the work.

Once the tasks are reviewed and the assessment is complete, they are moved into the DONE column.

4.3.6   Summarization

This sub-section was included for the reader to have a better understanding of how the methodology works daily in the project.

For the summarization of the approaches currently implemented, Figure 44 shows an overview of the currently used methodology.

Figure 44 starts on the left side with Scrumban board filled with products and tasks. Flying from the left side to the right side, the project manager fits in the middle of the planning phase and the executing phase accountable for the firefighting present in the project. The project manager, as said before, has the function to be the Scrum Master and the Product Owner in both phases. The Daily Scrums are at almost the same time, one after the other. The figure shows the one-week cycle with five Daily Scrums and the Weekly Scrum at the end of the week. The planning phase starts with a standard document template and finishes when the corresponding tasks are done with an approved and published document. The executing phase starts with several tasks to do and ends with most of the tasks done. The executing phase shows the information that needs to be provided by internal and external stakeholders. Figure 44 ends with a Sprint Retrospective, explained before, which is done monthly.
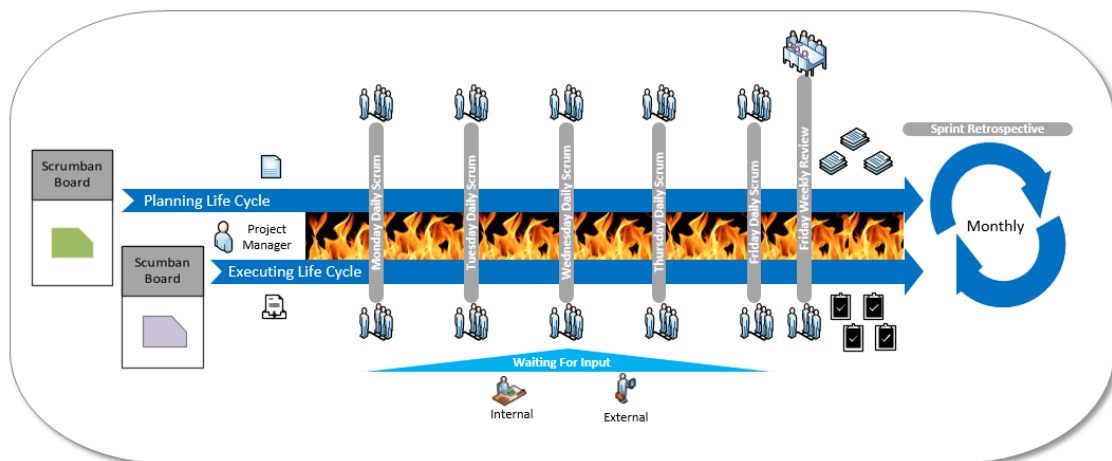

Figure 44 - Project Life Cycle

4.3.7 Sustainability Assessment Radar

Following Fabio's thesis, the sustainability assessment radar was one of the tools that were used to assess if different project management approaches can be used in the same project.

After the implementation and several improvements to the methodology, it was recognized by the senior sponsor, who has now a better understanding and support of the Agile approaches for the project, who before only was familiarized with traditional approaches that now the team has more knowledge about Agile methodology. This means that regarding the question "Buy-In to approach", the score has been improved to 5, as shown in Figure 45 & Figure 46.
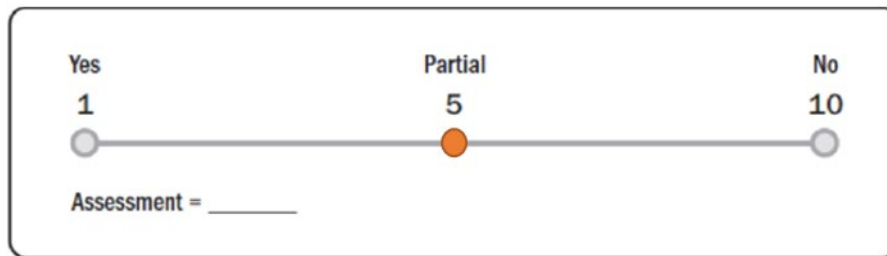

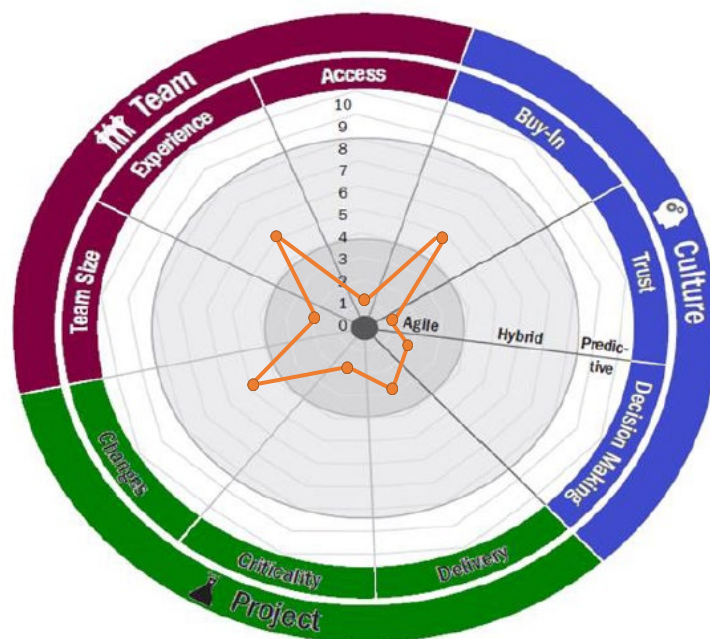Figure 45 - Buy-In to approach assessment (Agile Practice Guide, 2017)

Figure 46 - Results plotted in the Suitability Assessment Radar

4.4   Future Improvements

4.4.1   User Stories and Products

The first improvement forecast is to demonstrate the difference between Products and User Stories based on the literature. Figure 47 shows an overview of the differences between these two elements. When the team is using Products instead of User Stories, the product backlog is filled with products and, in this case, these elements are the documents themselves and the tasks are the updated features of these documents. Comparing with User Stories, the Product Backlog is filled with User Stories, which explains the reason for the update(s) and

Figure 47 - Products & User Stories

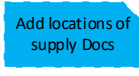functionalities to be implemented. Related tasks can comprise several documents. Starting with User Stories, it is easier to assess all required changes in all documents. Starting with Products (documents) it is easier to have a comprehensive view of all required updates in one document. Therefore, the team can decide based on the situation to start with the Product or User Stories.

4.4.2   SAFe

Scrum and Scrumban are only for small teams up to eight people (Scaled Agile, 2018). Therefore, if Agile or Hybrid methodologies should be used in larger projects, for example, DLM with approximately 240 people, the approach needs to be scalded, meaning Scrum of Scrum, or comparable needs to be implemented. Inside Airbus SAFe is the framework to be applied in such cases.

The Agile Scaling Strategy framework has been used to provide guidance to the project managers, who aim to run large and complex projects. By applying the framework's principles, uncertainty is strategically decreased in different sub teams of the project. (Schuh, et al., 2018).

The utilization of this framework has been proved business outcomes for companies of all sizes across the world. The time-to-market employ engagement and higher customer satisfaction are the main elements that increase with this framework (Knaster & Leffingwell, 2017).

Concluding, SAFe is an approach that intends to show to the companies the urgency to move and adapt faster by changing their way of working.

4.5   Critical Review

In this chapter, an evaluation of the work developed is done. The main goal is to assess and explain what could be done better. After the implementation and the improvements, the methodology applied to the project, a hybrid approach, is filling all the aims of the team.

The following points reflect areas where different approaches might have been more effective:

- The application of software during this work is one of the points to be criticized. As said before, the main reason for the software used was to support the methodology. However, the literature review demonstrates that this principle should not be done. This means that, during the development of this work, a large effort was made on this topic which was not and will not be used by the team on the project.
- In the beginning, the team had taught to check through an Agile methodology if the work was done was performed within the time initially scheduled to do it. The tool planned for this job was the burndown chart, which is an important artifact of the Agile methodologies. During this internship, a starting point could not be found to implement this tool due to scarce team knowledge about the external information needed, usually provided by external stakeholders. Thus, the team had no chances to plan the work.
- The team did not achieve the goal to draw Clear Rules for the team, as described in one of the Scrumban pillars. For example, a correct and accurate definition of "done" adjusted to the team needs was not established, as well as how the tasks should be managed in terms of WIP constrains.

4.6 Final assessment to the team

After the implementation and improvement of the new work methodology, it was critical to know what the opinion of the team is. For that, the author of this work did a questioner to the team members which was composed of the following questions:

1. How do you feel familiar with the new implemented Agile methodology?
2. Do you feel the new work support method useful and suitable for the team?
3. Regarding the meetings, do you feel better work communication with the team?
4. During the meetings, do you think that the Scrum Master is worth it in terms of driving and getting the team focuses on the main goal of the meetings?
5. Have you noticed any work improvement, in terms of delivery tasks done by the team?
6. Do you think the improvements done on the methodology mainly on the boards are the best?
7. Do you feel that having the tasks on a visual board and every time visible helps you in to know which work needs to be performed?

The questioner was composed of questions in which the answer was replied with levels, between zero and five, in which the zero is very unsatisfied and five is very satisfied.

Figure 48 - Final assessment results
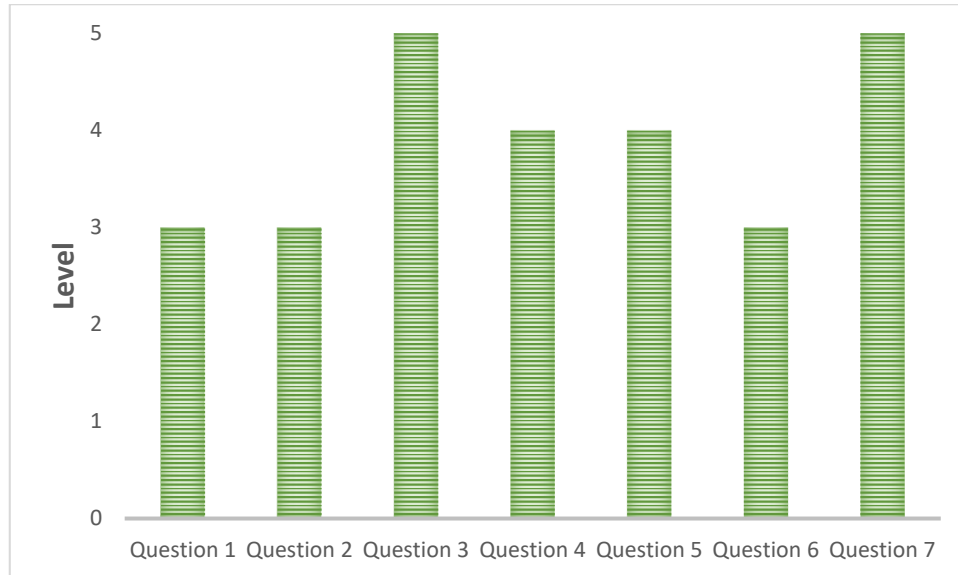
Figure 48 are the results of the assessment. It shows what is the thought of the team members regarding the questions. After analyzing the results in accordance with the questions it is possible to say that the team very satisfied with the methodology. The results show that the team in two questions is really happy and, in the others, the team is up of the middle level.

CONCLUSIONS

5 CONCLUSIONS

Since the early beginning until the implementation, the methodology has deserved special attention and interest by the team, being as well very promising to achieve the goals of the project. The documents management plans are never an easy work to perform, especially in a complex project like this, with many departments and people involved.

The literature review is scarce for this sort of application. Thus, it was needed to develop a new approach for this case, which required a big effort.

The implementation of the Fábio's methodology had a good reception by the team. Every point developed by him was thought carefully in order to improve the performance of the team in the best way.

All work developed and described here was done based on the literature and real the needs of the team. The Agile methodologies evolved from Scrum and Kanban to Scrumban. At this moment, the team is supported by Kanban boards and the Scrum framework adapted for each phase of the project. These phases are Planning phase and Executing phase. The board of the executing phase was entirely developed in this thesis.

For such a complex project, it is described in the literature that the best way is to manage the majority of the elements under a predictive approach. Nevertheless, Fábio's thesis and this thesis proved that there are areas of the project which could be improved by using a Hybrid project management approach.

Concluding, this team had recognized that Agile methodologies are worthwhile in the project. After a few months of implementation, improvements, development, and effort, the team is now very comfortable with the methodology. The work progress verified during the last months has been deeply appreciated by the stakeholders.

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SOURCES OF INFORMATION

6 REFERENCES AND OTHER SOURCES OF INFORMATION

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ANNEXES

7 ANNEXES

7.1 ANNEX1