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Application of CMMI Methodology and Lean Thinking in the Improvement of a Project Management Platform

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Master Thesis

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To my parents, for all their love and support,
and for giving me this amazing opportunity.
To my two amazing sisters, whom I miss the most.
To all my friends, for always being at my side.

Abstract

This project is a single case study of a software development company, regarding the development of a project management virtual platform. The company, which utilises SCRUM agile software development method, has decided to make its processes more efficient by applying CMMI model and Lean thinking methodologies. The project took place over a five-month period and this document represents the results for it.

In the first phase, the intern conducted a round of interviews, applying the CMMI model, to identify gaps between the model and the current practices being performed by the development team. Once the gap analysis was concluded, the improvement opportunities were identified and prioritised and a few were selected to be addressed in this project.

In the second phase, a Lean 7 waste analysis was conducted to identify current and past waste generation, by the development process or by the support processes. The different types of waste were identified and categorised, and a solution for them was then proposed.

In the third phase, Lean PDCA methodology and Kanban tool were then applied to address the issues and improvement opportunities previously identified. The processes were then formalised and the documentation needed was identified.

In the fourth and final phase, a knowledge base was constructed and plans for training and audits were created. This construction was based on the Lean 5S tool, a tool designed for working environment organisation.

This project's objective is to improve the efficiency of the company's development and support processes, by tackling the waste generated and the improvement opportunities identified and by improving people's preparation in the format of training.

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List of abbreviations

CMMI: Capability Maturity Model Integration
PDCA: Plan, Do, Check, Act
Plan: Planning
MC: Monitoring and Control
Est: Estimating
RDM: Requirement Development and Management
CM: Configuration Management
PQA: Process Quality Assurance8
MPM: Managing Performance and Measurement
Gov: Governance
II: Implementation Infrastructure
PO: Product Owner
MKT: In this document, it represents the SCRAIM's Marketing Team
DEV: In this document, it represents the SCRAIM's Development Team
KPI: Key Performance Indicators
NPS: Net Promoter Score
MVC: Model View Controller

1 Introduction

This chapter will present a quick introduction of the problem researched, considering the background knowledge, motivations, contributions, objectives and research questions for a single case study of the Strongstep development team, the SCRAIM team.

1.1 Project Background, Motivations and Contributions

Since the rise of the internet in the 90s, more and more software development companies are appearing in every country, and the industry has been gaining more power year after year. According to the website IBISWorld (2022), the software development industry represents a total of 905,7 million euros in Portugal, while the general service industry for the country represents 64,75% of the gross domestic product, according to the website Statista (2023).

With this in mind, it is only logical that companies are now focusing on the service aspects of their products and investing more in software and software development to help assist their work and to improve their efficiency.

Throughout the history of humankind, the necessity for a more efficient process was always the motivation behind any new invention. From the wheel to the self-parking cars, humans have always looked for a faster way to achieve their objectives.

For this project, the focus is on three of the many ways and paths to improve efficiency in the service industry, especially in software development: The CMMI, Lean Thinking and agile software development methodologies.

Capability Maturity Model Integration, or CMMI, is a methodology developed to assist service companies to improve their processes based on a set of best practices. The model will indicate the current maturity level of the company, classifying it from 1 to 5, and what needs to be done to achieve the next level. Companies that present a higher maturity level have a higher understanding of the businesses, from production to sales to marketing, utilising statistical analysis to make high-level decisions.

Developed by Toyota, in Japan, in the 50s, the Lean principles were developed aiming to cut out every waste generated in the car manufacturing production, from timing to raw materials, to human workforce, among others. However, in the past few decades, the Lean principles were slowly transferred to other industries, arriving also in the service sector. Now,

more commonly known as Lean Thinking, it represents a broad field of studies, where it is applied not only as a methodology but also as part of a company's culture.

The search for more efficiency also arrived in the software development industry. Called Agile Software Development, the term was first introduced on the website agilemanifesto.org, being called the agile manifesto, where the aim is to deliver the product, not only fast, but with high quality and capacity for adaptability.

The motivation for this project is to help a software development company, to apply Lean methodologies to its development team and support processes. By doing so, the aim is not only to help develop a leaner development process but to also help the company with multiple of its back-end processes.

The project will contribute to the Service sector by utilising different Lean methodologies and tools to improve a software development team combined with a CMMI gap analysis. Both of the analyses being done simultaneously will help the business to be more efficient, adding in this way more value to the customer.

1.2 Company presentation and problem description

Strongstep - Innovation in Software Quality, Lda, is a consultancy company in Porto, Portugal, focused on assisting other companies to improve their workflow, cyber security and management. Among its services, it can be listed CMMI consultancy, ITMark consultancy and SCRAIM, a project and process management platform, that assist third companies to achieve faster and more efficient implementation.

Although built to assist at a high management level, there are a few improvement opportunities presented in the current version of SCRAIM. It is clear to some of its users and developers that the platform presents some features that are not user-friendly or that do not add value to the customer.

Moreover, the current responsible for the SCRAIM team and its development decided to improve their efficiency, from a back-end perspective, regarding their processes and their team.

Currently, the processes are not formalised and not all the documentation needed is being used properly. This creates a less standardised workflow, which may cause errors and mistakes during the procedures. The missing of formalised processes affects other aspects, such as training and people preparation, leading to even more errors being made by the

employees. Finally, the lack of proper documentation makes it difficult for audits to be done more often.

1.3 Objectives and research questions

This project development was done over a five-month period, where the intern conducted a single case study research of the company's case related to the SCRAIM platform, adding some aspects of qualitative research.

In the beginning, a roadmap was defined with the milestones to be achieved throughout the duration of the internship. Two research questions were then proposed:

RQ1: What are the improvement opportunities for the SCRAIM team at Strongstep?

RQ2: What are the actions needed to address the improvement opportunities in RQ1 and how to develop them?

The initial objectives for this work were to discover the improvement opportunities based on a CMMI and Lean analysis, to address the problems described in the section prior.

To answer *RQ1*, the first action was to conduct a CMMI gap analysis, showcasing the improvement opportunities to achieve a maturity level 2 considering the set of best practices determined by the model. This analysis was done with a round of semi-structured interviews with all the members of the SCRAIM team, comparing their answers with the best practices of the model.

Following up, the second action was to conduct a 7 waste analysis in the SCRAIM software development. Once again, a second set of semi-structured interviews were done with all the members of the SCRAIM team. This aimed to discover and classify all the different sources of waste that currently exist or are being created considering their current processes.

With the results of both analyses, a Lean methodology called PDCA (plan, do, check and act) was applied to answer the first part of *RQ2*. This aims to plan the actions necessary to correct the problems, to apply those actions and finally check and improve them until the procedures are coming naturally to the employees (act). To answer its second part, two lean tools were then applied, the 5S and Kanban, where the first is regarding the cleanliness of the work environment while the second is a visual aspect that facilitates the overall understanding of the project situation.

The final objectives for this project were:

- To define the SCRAIM processes formalisation as they are currently being done.
- To construct a knowledge base, to ensure a source of information and a training program for the employees.
- The definition of standardised documentation is needed, in order to assist audits to happen more frequently.

1.4 Report Outline

Six different sections compose this dissertation. The first section, the introduction, presents the scope of this dissertation in a more succinct way. It starts with a small explanation of the project background and the motivation behind this work, followed by a quick presentation of the company, the problems that the company is facing, the main initial and final objectives for the work in addition to the two research questions and how to answer them.

The second section is a knowledge background, where theoretical information that serves as a base for this project is presented. This section covers the topics of CMMI, agile methodologies and SCRUM, Lean principles and Lean in services, Lean in software development and finally different Lean methodologies and tools.

The third section is a problem characterization, where the problems of the company that this project is addressing are discussed further.

The fourth section represents the methodologies applied to conduct the dissertation project. It first presented a comparison between quantitative and qualitative research, a quick definition of a single case study, and the workflow followed by the intern throughout the duration of this project.

The fifth section is where the results found by the intern are presented. It discussed all four phases of the Lean PDCA methodology and explained how the CMMI gap analysis and the Lean 7 waste analysis were done, the results found and a definition of which ones will be addressed. In addition, it shows the solutions proposed to address the problems and to fulfil the objectives previously determined.

The sixth and final section summarises the results found in the fifth section, and how they contribute to the literature, in addition to informing the possibilities for future research in this field.

2 Knowledge Background

For this project to be developed, it was important to comprehend the theoretical background of the processes applied at Strongstep, as well as of those processes and methods chosen to answer the research questions.

When it comes to the processes applied at Strongstep, in this case, more specifically the processes utilised for the development of the SCRAIM platform, the two theories revised in this section refer to the CMMI and the agile methodology applied for the SCRAIM's development, the method Scrum.

As per the chosen methods to help answer the research questions, a literature review regarding LEAN, its tools and techniques and its applicability in the service sector, focusing on software development, has been conducted.

2.1 CMMI

By definition, business performance is "the ability of a business to implement a strategy to achieve organisational objectives and is considered as an important tool for businesses to analyse how effective management is at achieving business goals", (Yıldız at. al. 2014 and Harper 2019) as cited in StudySmarter (2023). However, how to measure the business performance of a given company?

According to ISACA (2023), CMMI is a model built with the purpose to evaluate business performance and to help and assist businesses to improve their key processes performance through an evaluation process and the application of a group of best practices.

The initial analysis will compare the current practices being done by the company with those determined by the CMMI model. The gap between those two should provide the company with enough information to determine the best course of action to tackle problems found, searching for the most optimal solution. SCRIBD (2023) showcases the four different best practices categories, being divided into doing, managing, enabling and improving. Each of these categories is divided into subcategories, called capabilities areas, and each of these subcategories has a set of different best practices, as presented in Figure 01.

Having the initial gap analysis being conducted, the CMMI is then implemented in five different stages: project planning, training, workshops and follow-ups, process revising and certification.

This certification will state which is the company's maturity level based on the CMMI model. Watts (2020) explains the five different maturity levels:

Initial: Processes are seen as unpredictable, poorly controlled, and reactive. Businesses in this stage have an unpredictable environment that leads to increased risks and inefficiency. Managed: Processes are characterised by projects and are frequently reactive. Defined: Processes are well-characterised and well-understood. The organisation is more proactive than reactive, and there are organisation-wide standards that provide guidance. Quantitatively Managed: Processes are measured and controlled. The organisation is using quantitative data to implement predictable processes that meet organisational goals. Optimising: Processes are stable and flexible. Organisational focus is on continued improvement and change response.

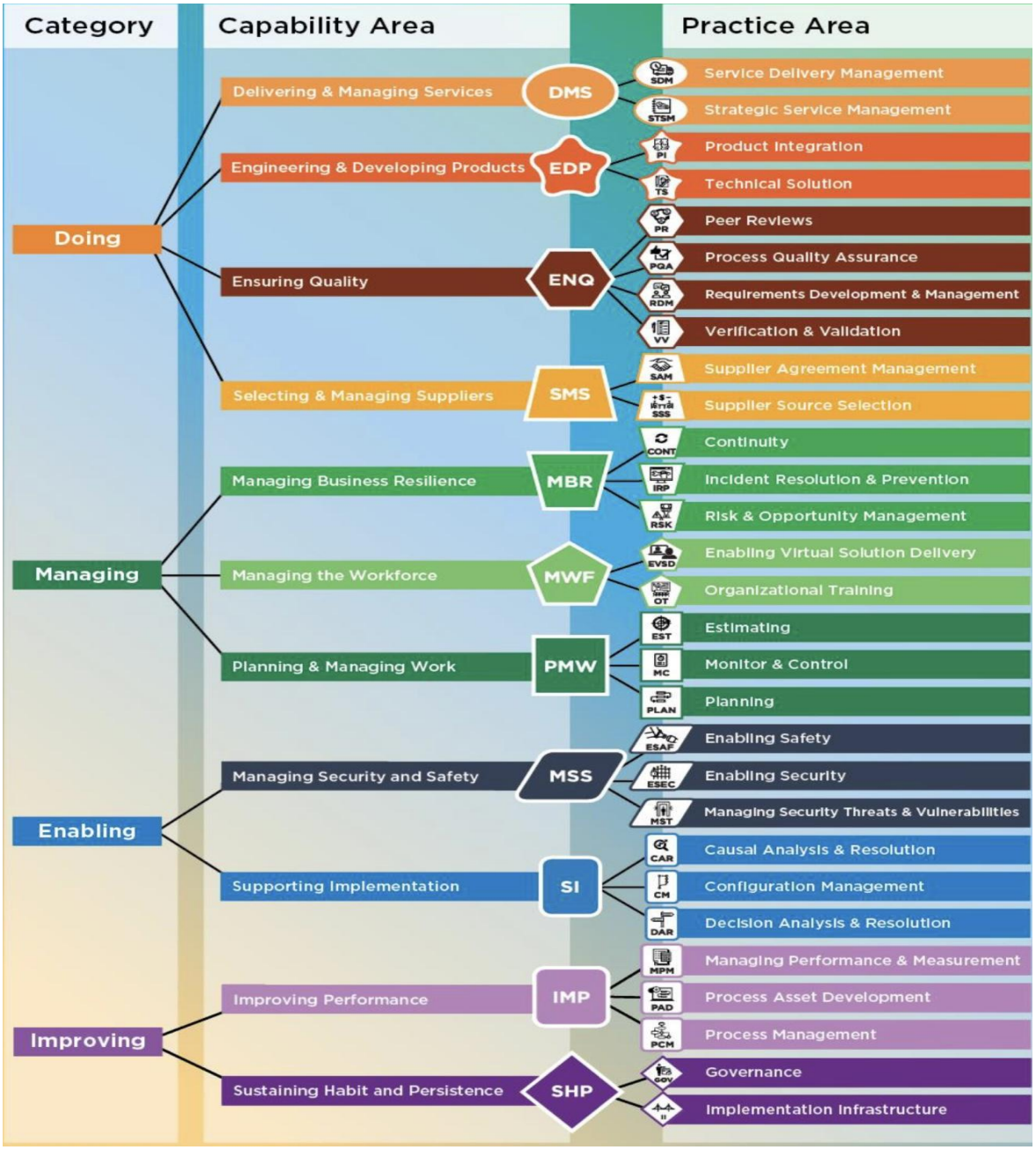


Figure 01: CMMI Model Content Relationship, CMMI Institute (2018), as showed in SCRIBD (2023)

2.2 Agile Methodology and Scrum

The Agile Methods came to light when a group of software professionals (practitioners and consultants) published a manifesto back in 2001, named "Agile Software Development Manifesto"[1], Abrahamsson et al. (2017). On their manifest, the authors stated the values for their methodology, presenting them in four different points:

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

According to Al-Saqqua et al. (2020), the first value is meant to express the importance of teamwork, focusing on communication among team members, human interaction with each other and the work quality of the human developers. It is wrong to give more importance to processes, tools, protocols, etc than to your human resources.

Second, the comprehensive documentation of the processes is important, however, it should not be the priority. Document what is important for the software development but do not spend time with unnecessary up-to-date synchronisation. All documentation created must add value to the process.

Third, the Agile Methodology is designed to cope with any requirement changes, at any point in the development processes, that the customer brings to the development team. The methodology is highly focused on feedback, negotiation and collaboration between the customer and the development team.

Finally, the fourth value shows that the methodology is designed to make the process more adaptable to changes, and not follow a strict previously defined plan, considering that customer satisfaction is the ultimate goal for the software development process.

Cohen et al. (2003) highlight that the main goal of the Agile methodologies is to not only deliver the product fast but to do so with high levels of interaction, focusing on interactive development and having a quick capability to adapt to requirement changes imposed by the customer. "True agility is more than a collection of practices; it's a frame of mind" Cohen et al. (p 11, 2003).

Abrahamsson et al. (2017) present ten different types of agile methods:

1. Extreme Programming

[1] agilemanifesto.org

2. Scrum
3. Crystal methodologies
4. Feature Driven Development
5. Rational Unified Process
6. Dynamic Systems Development Method
7. Adaptive Software Development
8. Open-source Software Development
9. Agile Modeling
10. Pragmatic Programming

In addition to the ten previously cited above, Cohen et al. (2003) also make the addition of Lean Development as one of the agile methods. For this dissertation, Scrum and Lean Development will be the ones studied.

Scrum is a methodology created by Schwaber and Sutherland (Schwaber & Beedle, 2002, as cited in Cho, 2010), designed to fit small development teams, with less than 10 components ideally, where all the members collectively possess the knowledge necessary to complete the job, having values of compromise, focus, opening, respect and courage. With no hierarchy, the team works together to implement new features and requirements within a Sprint, a period of a month usually.

Schwaber (2004), as cited in Cho (2010), showcases that as part of the Scrum methodology, three different empirical pillars were defined to support the work: Transparency, Inspection and Adaptability. The first expresses the importance of giving transparency to the job being done, not only for those developing it but also for those who will receive the final product, to add value and diminish risks. The second enhances the necessity of making inspections throughout the process, aiming the defined objectives, for early potential issues detection and discovery. The third and final one informs about the need for quick adaptability to unforeseen changes, variations and problems, with the minimum new deviations. For this, self-management and individual involvement are core characteristics of the Scrum team.

According to Schwaber (2004), as cited in Cho (2010), the Scrum team is composed of three different types of members. The developers (the team), those who are responsible for developing the product, focus on each feature that adds value to each Sprint. The Product Owner (PO), is responsible for managing the Product backlog and its full items content. Among his responsibilities, he must develop and explicitly communicate the Product Goal. The Scrum Master is the team member responsible for the Scrum methodology

implementation, responsible for its efficiency and for helping all members to comprehend the theory behind it. Among his responsibilities, could be cited the team member's training in self-management, management of every Scrum event and the Scrum implementation at an organisation level (Schwaber and Beedle, 2002, as cited in Cho 2010).

Sprint is a conjunction of events that has a defined period to be completed, usually within a month or less. As explained by Falls (2004), cited by Permana (20015), the events start with the Sprint Planning, a meeting where the work to be done will be defined, answering the question "Why is this Sprint valuable?", "What can be done in this Sprint?" and "How will the chosen work be done?". Afterwards, a Daily Scrum takes place, a short meeting done every day to keep track of the progress done to achieve the Sprint Goal, answering the questions "What was done yesterday?", "what will you do today?" and "Are there any problems that need attention?". Those meetings are important since they help to identify issues and promote fast decision-making. At the end of the Sprint, the Sprint Review and the Sprint Retrospective take place, the first aiming to inspect the results and the second to identify possible changes and plans that might induce quality and efficiency improvement.

2.3 Lean Principles and Lean in Project Management

The LEAN principle has its origin in the industrial sector, where they were first developed by the Toyota Company in the mid 1950s. After World War II, Japan was going through a financial crisis, leading to high difficulty to find investors for the different economic sectors. The company then realised that the best approach to achieve its goals was to eliminate, from the production line, value chain and supply chain, all the unnecessary aspects of it, in other words, to reduce all the different types of waste. According to Kilpatrick (2003), there are mainly eight wastes: overproduction, producing more than the market needs; waiting, from raw materials to internal information; transportation, where materials should be delivered to where they are necessary to be used; non-value-added-processing; excess inventory, having more raw material and components than those needed to meet market demand; defects, which causes material and other losses; excess motion; underutilised people, where the mental and creative skills are ignored, focusing only on the physical aspect of the workforce.

After the success of Toyota, and especially in the past two decades or so, the Lean principles were largely implemented in the manufacturing industries around the world to improve production. Ansah et al. (2016) and Panwar et al. (2015) have identified the five main LEAN principles:

I. Value Specification: considering the customer's point of view, correctly identify what generates value.
II. Value Stream: to identify the waste that is generated in the value stream and to focus only on what adds value to the customer, it is necessary to identify and detail all the steps in the full scope of the value stream.
III. Value Flow: take actions and do implementations to ensure a continuous value flow.
IV. Pull: Focus on Just in Time (JIT), which means, producing only what is needed by your customer in the time needed.
V. Seek perfection: always seek perfection, to deliver what the customer needs and wants and to avoid all different types of waste in the process.

Ansah et al. (2016) state that "lean is as much a philosophy and culture as a set of principles or methodologies and therefore could be applied to any industry".

It is no surprise that with the success found in the manufacturing industry, academics and professionals applied the Lean Principles in other sectors as well, such as the service sector, also known as Lean Service. To have a good implementation, first, an analysis of service waste must be conducted. Qu et al.,(2011) identified five different main types of waste in the service industry:

I. Service Design Waste: the failure of attending to the customers' needs, which might lead to poorly designed and non-useful features and characteristics.
II. Service Item Waste: non-optimal and defective processes while presenting the service.
III. Service Ability Waste: the failure to match the complete service capacity.
IV. Service Process Waste: inefficient work, workflow or workforce.
V. Service Delay Waste: the situation where the workers or customers wait for the processes/services to be completed.

When it comes to Lean service, there are three main pillars to focus on: the elimination of waste, the total quality of the process and most importantly the people's preparation. As explained before, you want to eliminate your waste by tackling the eight main waste sources: overproduction, waiting, transport, over-processing, excess inventory, defects, motion and underutilised people.

When focusing on total quality, it is important to have good management leadership, integration of effort, problem prevention, worker's ownership of the process, a clear way to detect problems and continuously improve by seeking perfection.

People's preparation will ensure that your staff is capable and ready to work and to handle all different situations and scenarios, taking into account that services are largely influenced not only by the staff but also by other customers. It is important to enforce discipline, flexibility, autonomy, equality, development of personnel, quality of working life and individual creativity.

According to the Project Management Institute (PMI), as cited in Dinsmore and Cabanis-Brewin (2006, p. 2), project management can be defined as "A temporary endeavour undertaken to create a unique product, service or result". However, according to Dinsmore and Cabanis-Brewin (2006, p. 2),

> This definition, while useful to project managers, may not be sufficient for others to distinguish projects from other undertakings. Understanding some of the characteristics of projects and comparing projects to other types of undertakings may give a clearer perspective.

When it comes to project management, three different methodologies can be used, as cited by Cruz and Alves (2020). First, we have the traditional method, where each new phase of the project starts after its previous one has been concluded, in a linear life cycle model, such as the waterfall model, in which there is no feedback done to the previous phase.

Secondly, we have agile methodologies. According to Cruz and Alves (2020), they were developed to accept, adjust and embrace changes that might come on the way, being implemented mostly in dynamic environments, and used more commonly in software development projects and companies.

Finally, "Lean Project Management is the application of Lean Thinking principles to Project Management", Cruz and Alvez (2020). Focusing on reducing time-consuming to conclude the project, by eliminating all different types of waste found along the way.

2.4 Lean in Software Development

As explained previously, Lean Software Development belongs also to the group of different methodologies also known as Agile Development. To have Lean principles applied to software development, there are a few adjustments that need to be addressed to the original Lean thinking and principles. The Lean principles are applied to reduce the time consumed to develop a new software utilising the JIT approach. In Figures 2 and 3, Poppendieck (2011) presents us with her adjustments regarding the Seven Wastes of Software Development, in contrast with the waste in manufacturing, and how Extreme Programming, a methodology used in rapid software development, is used to tackle the wastes, respectively.

The Seven Wastes of Software Development
Overproduction = Extra Features
Inventory = Requirements
Extra Processing Steps = Extra Steps
Motion = Finding Information
Defects = Defects Not Caught by Tests
Waiting = Waiting, Including Customers
Transportation = Handoffs

Figure 02: The Seven Wastes of Software Development

Waste in Software Development	How Extreme Programming Addresses Waste
Extra Features	Develop only for today's stories
Requirements	Story cards are detailed only for the current iteration
Extra Steps	Code directly from stories; get verbal clarification directly from customers
Finding Information	Have everyone in the same room; customer included
Defects Not Caught by Tests	Test first; both developer tests and customer tests
Waiting, Including Customers	Deliver in small increments
Handoffs	Developers work directly with customers

Figure 03: Extreme Programming

In his book, Schipper and Sweets (2012) present us with his six principles for Innovative Lean Development:

I. Identify and fill user gaps: extensive research to identify the user's needs, in a way that allows the development team to not only understand them but also to apply as straightforward as possible to the project.

II. Use multiple learning cycles: once the user needs and user gaps are properly identified, the multiple learning cycles allow the development team to navigate through each of them in a systematic way, largely reducing the total project time frame, which drastically improves the results. When applied correctly, this method allows the team to achieve an optimal solution.

III. Stabilise the development process: "support the process of development by stabilising and streamlining the entire development process."

IV. Capture knowledge: catalogue and share the gained knowledge through each project, to learn from past mistakes and saving time with each new discovery.
V. Use rapid prototyping
VI. Apply Lean Management Principles: to mould and change the current company culture, or to implement a new one, the Lean Management Principles must be used by the leaders to seek perfection and avoid all the different types of waste throughout the development of each project.

2.5 Lean Methodology and Tools

2.5.1 Lean PDCA

According to Liker (2004), Lean PDCA, also known as Deming Cycle, is a problem-solving methodology designed for continual improvement of processes that can be applied at different levels of the company. Liker (2004) also states that the PDCA method "Teaches individuals skills for working effectively in small groups, solving problems, documenting and improving processes, collecting and analysing data and self-managing within a peer group. It pushes decision-making down to the workers and requires open discussion and group consensus before implementing any decision".

Liker (2004) explains the four different stages:

- Plan: the planning phase where you identify and decide the improvements to be done, considering who is doing it, through which method, focusing on which target, in a determined period of time.
- Do: a set of actions and tasks to do the plan previously established for each item, doing measures and countermeasures.
- Check: the stage where the company evaluates the results, checking for improvements, which method was applied and if the objectives were achieved and in what amount of time.
- Act: after standardising the process and eliminating the waste, this step will allow a more cohesive flow, where the workers will do the processes more automatically, focusing on time, quality, cost and innovation.

2.5.2 Lean 5S

One of the many tools that Lean has to offer is the 5S. Kilpatrick (2003) expresses that this tool is used to focus on organising and standardising the work environment in a

systematic way. Gupta and Jain (2013) point out that, among the benefits provided by this tool, you can count an "increase in safety levels, cleaning of workspace, enhanced productivity and preventive maintenance".

The 5S has its name based on the Japanese language according to ACCEPT Simplifying Quality (2019):

- Seiri: Sort, having in your workplace only what is necessary.
- Seiton: Set in order, defining a place for everything, and everything in its own place.
- Seiso: Shiny, having a sense of cleanliness and organisation.
- Seiketsu: Standardise, defining rules and procedures to ensure everything is recorded and without ambiguity.
- Shitsuke: Sustain, evaluating how the processes are being properly followed.

2.5.3 Lean Kanban: Visual Controls

Another tool utilised in the Lean methodologies is different forms of visual controls. Kilpatrick (2003) explains that, from a manufacturing point of view, these visual controls are used to simplify the overall understanding of a current situation, condition or process in a short period. Anyone could have a general perspective on the production schedule, workflow, quality, and inventory, among others, just by reading the different visual controls available.

One of the different types of visual controls is Kanban. From a software development point of view, Kanban, in Japanese means “visual cards”, it is used to “show the current status of all tasks” (Ahmad et al. 2017). Anderson (2010), as explained in Ahmad et al. (2017) also tells about the 5 core principles of Kanban:

1. Visualise workflow.
2. Limit work in progress.
3. Measure and manage the flow.
4. make process policies explicit
5. use models to recognize improvement and opportunities.

3 Problem Characterization

In this chapter, a short presentation of the company is made, focusing on its history, mission, vision and objectives, as well as its products. Then, a short description of the problems identified within the company takes place. For this chapter, all the information was retrieved from the company's website, strongstep.pt, and the SCRAIM website, scraim.com.

3.1 Company presentation

Strongstep - Innovation in Software Quality, Lda, is a spin-off of the Engineering Faculty of the University of Porto (FEUP). The company located in Porto, Portugal, was created in 2009 by its current CEO Pedro Castro Henrique and a few of his colleagues at the time. Their focus is on helping different companies and organisations to adopt and implement a set of best practices related to international management in software development and information security.

For its mission, Strongstep states that "We are committed to promoting the improvement of software development processes and information security through the implementation of practices that concern the company's main tools: people, processes and technologies". As for its vision, the company says "We want to leave our mark and our contribution in the world of software quality and information security. Our goal is to work not only for, but also with our clients, aligning their processes and business goals efficiently and effectively. As drivers of change management, we are dedicated to making our partners' workforces more mature, motivated and productive, enabling more agile and competitive organisations".

When it comes to the company's culture, Strongstep believes in the balance and conciliation between work and personal life, not only within the company's employees but also when it comes to their partners.

Among the services provided by the company, it can be listed, but not exclusively: CMMI consultancy, for services and software development, preliminary risk analysis and areas of expertise and ITmark consultancy, which

> ITMark combines several improvement models into a single Quality Management System and assesses and certifies processes focused on three main areas: Business Management, Service Management and Safety Management.

Another of the Strongstep products is SCRAIM, a virtual platform for project management. According to the platform's website, "SCRAIM is a Software-as-a-Service solution designed to improve the way you work with your operations and customers". The platform offers multiple features, such as project creation and planning, time management, dashboards, and task overview, among many others.

3.2 Problems identified

Although developed to assist project managers and teams in their work, the platform presents a few challenges for the users. Some of the features implemented are not user-friendly or easy to navigate or do not perform as expected when first planned. From the employees' perspective, there are some difficulties regarding the creation of tasks, time logs management, and effort measurements, among others. These difficulties are mostly generated due to the excessive steps needed to create a new process or project, for example, or the lack of knowledge regarding the platform.

Regarding the individual's daily performance and routine, there are some difficulties related to the workflow. Some of the procedures are being performed intuitively, however, the SCRAIM team workflow does not present a clear standardisation. This creates an opportunity for human error, considering that each individual can apply a different method to work, which can cause a mismatch between what is expected and what is delivered.

Knowing about this difficulty, Strongstep decided to research the reasons for those issues, as well as to improve the efficiency of the SCRAIM development processes as well as the support processes. For this, it was suggested a research project where the researcher (the intern in this case), will utilise different models and methodologies, such as Lean Thinking and CMMI, to generate a gap analysis, having the initial objective to identify improvement opportunities for SCRAIM and its processes.

4 Methodology

4.1 Quantitative research

To conduct this dissertation project, two different types of research could be used: quantitative research and qualitative research. While the first one focused more on statistical analysis, the second one focused more on verbal descriptive and interpretative analysis of data.

Goertzen (2017) defined quantitative research as the collection, analysis, study and interpretation of numerically structured data that can be measured, focusing on answering the "what" and/or "how" questions, depending on the situation. It is important to make it clear that quantitative research is more suitable to answer questions that are quantifiable, such as, but not restricted to: "How many?", "What is the probability of?", "what portion was affected", etc.

There are six main aspects of quantitative research, according to Goertzen (2017):

I. It deals with numbers to assess information.
II. Data can be measured and quantified.
III. It aims to be objective.
IV. Findings can be evaluated using statistical analysis.
V. It represents complex problems through variables.
VI. Results can be summarised, compared, or generalised.

In addition to those characteristics stated above, Hammersley (2012) also wrote: about hypothesis-testing, procedural objectivity, identifying systematic patterns of association and controlling variables. Due to the nature of this dissertation research project, the method chosen was qualitative research, presented in the following segment.

4.2 Method used in the project: Single Case Study Assisted by Qualitative Research

As stated before, the goal of this dissertation is to understand, study and analyse the working methodologies used by the Strongstep team to create a formal process regarding the development of the SCRAIM platform, to answer the research question:

RQ1: What are the improvement opportunities for the SCRAIM team at Strongstep?

To conduct this analysis, a single case study combined with qualitative research was conducted. Bryman (2008: 366) defines qualitative research as "a research strategy that usually emphasises words rather than quantification in the collection and analysis of data". Sandelowski (2004: 893) defined it as

> an umbrella term for an array of attitudes towards and strategies for conducting inquiry that are aimed at discovering how human beings understand, experience, interpret, and produce the social world.

As could be demonstrated by those two definitions, the definition of qualitative research can vary vastly, depending on the criteria that the study is being conducted. Although there are several different definitions for qualitative research, Hammersley (2012) brings our attention to the fact that what is important is to understand the set characteristics that some of the different types of qualitative research share, and, therefore, what makes qualitative research qualitative. Note that not all the qualitative methods share all those characteristics. Hammersley (2012) defines qualitative research as

> a form of social inquiry that tends to adopt a flexible and data-driven research design, to use relatively unstructured data, to emphasise the essential role of subjectivity in the research process, to study a small number of naturally occurring cases in detail, and to use verbal rather than statistical forms of analysis.

Finally, Hammersley (2012) provides a list of six common characteristics among the different types of qualitative research:

I. A flexible, "inductive", "abductive" or data-drive orientation.
II. Relatively unstructured kinds of data are used.
III. Subjectivity.
IV. The study of "natural" settings.
V. Small number of cases studied.
VI. Verbal rather than statistical analysis of data.

DiCicco-Bloom and Crabtree (2006) explained briefly the three different types of interviews that can be used as a method for data collection in qualitative research: Unstructured interviews, more equivalent to the guided conversation, where the interviewer "elicits information about the meaning of observed behaviours, interactions, artefacts and rituals, with questions emerging over time as the investigator learns about the setting"; Semi-structured interview, "organised around a set of predetermined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewee(s)"; Individual in-depth interviews, "are widely used by health care researchers to co-create meaning with interviewees by reconstructing perceptions of events and experiences related to

health and health care delivery". The authors do not discuss structured interviews once they state that this type of interview is mostly used to collect quantitative data.

A case study research method can be defined "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Yin, 1984).

Considering the final objectives of this dissertation project, the path chosen to be followed was that of a single case study, where the intern analysed the context of the SCRAIM team at Strongstep, and its phenomenons, with some aspects of qualitative research. The data that is necessary to proceed with the dissertation project was collected through reactive observation, where the intern was an observer and took notes on meetings in order to understand the processes and procedures done by the Strongstep employees and how they interact and conduct the work with the clients. In addition, theoretical material regarding the internal processes of the company was utilised for training as well as a source of information.

Moreover, to collect more data necessary to develop the dissertation project based on a qualitative approach, a set of semi-structured individual interviews were done with the SCRAIM team at Strongstep, covering all the capability areas described in the CMMI model. All the semi-structured interviews were conducted by the same interviewer, done by video call, each lasting approximately one hour, to generate a process gap analysis report.

Once in possession of all the relevant data necessary to continue with the research, the data was analysed using the CMMI model, based on the second analysis level, to generate an improvement opportunities report. This report is meant to showcase the gaps and discrepancies among the processes currently applied by the company's team and the CMMI model, point out the current flaws and problems, in addition to where the company should improve, change or implement processes.

Once the data analysis is concluded, a process formalisation was then initiated. When this formal process's initial draft was completed, a comparison with the current process and Lean PDCA was conducted. By applying the LEAN thinking, its methodologies and tools, the now documented processes can be optimised and the different types of waste generated in software development at Strongstep can be tackled and eliminated, in order to answer the second research question:

RQ2: What are the actions needed to address the improvement opportunities in RQ1 and how to develop them?

The results and discussion of this entire process is being presented in the next section. Figure 04 represents a roadmap of the entire research process.

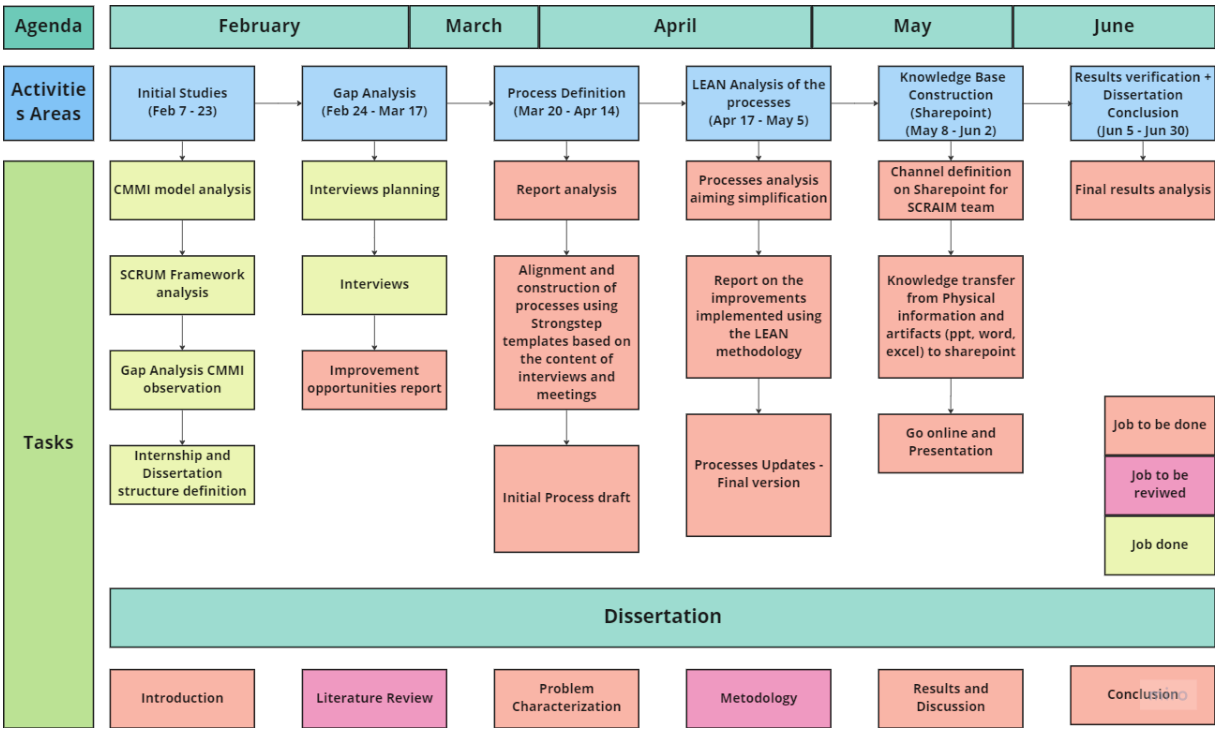


Figure 04: Research Process Roadmap

5 Results and Discussion

In this section, the results of the analysis will be discussed, as well as the decision made about how to address the problems and the improvement opportunities identified.

5.1 Lean PDCA

As explained in section 4.2 of this document, the methodology chosen to proceed with the single study case analysis of the SCRAIM team at Strongstep was that of Lean PDCA, more detailed in section 2.5.1. In this section, the total work will be broken down and explained in more detail, as well as the issues found and the suggestions to address them. Afterwards, a final consideration regarding the final results will take place.

5.1.1 Plan

In the Plan phase, the starting point was the problem identification through CMMI level 2 gap analysis and the identification of Lean 7 wastes in software development, followed by a prioritisation of which issues should be focused on and how to solve them.

As presented in Figure 01, on page 06, a maturity level 5 gap analysis comprehends a total of 29 practice areas. However, a maturity level 2 gap analysis on the CMMI model, applied for a development company, comprehends only nine of those: Planning (Plan), Monitor and Control (MC), Estimating (Est), Requirement Development and Management (RDM), Configuration Management (CM), Process Quality Assurance (PQA), Managing Performance and Measurement (MPM), Governance (Gov) and Implementation and Infrastructure (II). The overall results for the maturity level 2 gap analysis conducted for the SCRAIM team are presented in Table 01:

	Level 2								
	PLAN	MC	ESTM	RDM	CM	PQA	MPM	GOV	II
LEVEL1	FI	FI	FI	FI	FI	LI	PI	FI	PI
SP1.1	FI	FI	FI	FI	FI	LI	PI	FI	PI
SP1.2	FI	FI	N	N	N	N	PI	N	N
LEVEL2	PI	LI	LI	FI	PI	PI	PI	PI	PI
SP2.1	FI	PI	FI	FI	FI	PI	LI	LI	PI
SP2.2	FI	LI	LI	FI	LI	PI	LI	PI	PI
SP2.3	FI	FI	FI	FI	FI	PI	FI	PI	N
SP2.4	LI	FI	N	FI	FI	PI	PI	NI	N
SP2.5	PI	N	N	LI	FI	N	NI	N	N
SP2.6	PI	N	N	FI	NI	N	PI	N	N
SP2.7	FI	N	N	N	N	N	N	N	N
SP2.8	FI	N	N	N	N	N	N	N	N

Table 01: Overall results for maturity level 2 gap analysis for SCRAIM team (NI - not implemented; PI - partially implemented; LI - largely implemented; FI - fully implemented)

For a practice area to be considered fully implemented, it can only have a maximum of two of its components being largely implemented, or one being largely implemented and the other one partially implemented. In case there are three or more components to be considered largely implemented or lower, the practice area is considered at maximum largely implemented, which, as a consequence, will have more improvement opportunities and/or more impactful ones.

As it can be noticed from Table 01, the SCRAIM team processes present improvement opportunities in multiple capability areas. For the sake of this dissertation, the ones chosen to be prioritised were those that were only partially implemented at level 2, in this case, Plan, CM, MPM, Gov, II.

A deeper investigation of the gap analysis revealed that many of the mismatches between the results found and the CMMI model were generated by the same problems, even between some of the different practice areas. The main issues identified, and the main objectives of this project, are:

- There is no formal process definition.
- No audits are being done to ensure quality.
- Lack of formal training process and roadmap and overall documentation.

It is important to point out that, as per PQA, the reason why this practice area was not named prior in this document is that this is a practice area that focuses on Processes and Quality Assurance, which means, the steps, documents and procedures to be taken to guarantee the quality of the work. In other words, this is a practice area focused on audits, and therefore it is already listed among the issues previously identified above.

The missing formal process definition generates an unclear workflow for the employees, as well as a misunderstanding about the company’s work methodology. Indirectly, it also aggregates to the difficulty of training processes, causing confusion about when the activity takes place, for how long and who is involved in it. By not having audits being done (or is rarely done), it makes it more difficult to ensure quality in the work being produced, as well as per the development process itself and the final product. The lack of a formal training process, documents and a more detailed roadmap can impact the employee's knowledge of the tools utilised by the company, as well as per the team and individual activities, resulting in more mistakes and as a consequence a non-optimal time usage.

In order to resolve those issues, it is fundamental that the company address these main three issues, defining formal processes, incorporating the audits more frequently and having a clear training process.

As shown in Figure 03 in section 2.4, there are seven different types of waste in software development based on Lean Thinking. The results found for those waste, are as follows:

1. Extra Features: some of the ones identified are the risks and costs management tools, which were rarely used and are hard to navigate; the “kanban” section does not present a clear visual tool, and being overwritten with unnecessary information; the “my calendar” section did not bring much utility to the user.
2. Requirements: bad requirements definition, especially when it comes from the commercial team, that did not present clear information about the requirement from the clients, and functionality or is not aligned with the current reality of the platform.
3. Extra Steps: some features and functionalities present multiple ways to achieve the same result, such as the “edit time log” function. Although this sometimes can be good, it also generates extra steps and a higher level of difficulty to understand it.
4. Finding Information: when it comes to the platform itself, some naming conventions are being used that are not user-friendly or intuitive, such words as "kanban" for example. As per the employees, this brings to the lack of a knowledge base to learn how to navigate and use the SCRAIM platform.
5. Defects Not Caught by Tests: it has happened that the user found a way to achieve an objective within the platform that was not originally thought of by the developers and quality assurance employees. This generated bugs that were not caught by the original tests.

To address those wastes identifies, the company needs to: 1 - Remove and/or adapt the non-utilised extra features, to make it more clear and efficient; 2 - Restructure the Product Backlog, prioritising what adds more value for the customer and for the user; 3 and 5 - Add more constraints to the user, make it very clear how to navigate and utilise this functions and features, preventing bugs and mistakes; 4 - research and utilise more user-friendly naming convention, features and symbols, in addition, to generate a training document for utilising the platform.

A general waste also identified in the interviews was the time consumed for the Scrum Daily Monday meetings, for the entirety of the Strongstep employees. Every Monday, the

employees must inform the activities done on the entire previous week, as well as all of those planned for the current week. Considering that the company has a total of 18 employees, this represents a very time-consuming task, sometimes with the meeting lasting for over an hour. The amount of effort wasted, in hours, among all the employees in this meeting can add up to at least 13,5 hours per week, time that could be applied to complete other activities. The Daily Scrum is designed to be done only within each team in addition to not recap the fullness of the last and current weeks. This design was thought to make the Daily meetings more informative, efficient and fast, gathering only the people to whom it concerns.

5.1.2 Do

In the Do phase, the actions to solve the problems identified previously must take place, focusing mainly on the process's definition. Audits will be discussed in the Check and Act, section 5.1.3, and as per the training process since this is a transversal process, it will be discussed in section 5.1.4

The first stage of the process definition was to formalise the current processes being applied at Strongstep, related to the SCRAIM team. As stated in section 5.1.1.1, this dissertation is focusing mainly on five of the CMMI practises areas. To formalise the processes, it was necessary to first identify which of the practice areas are related to which of the processes (having in mind that more than one practice area can be related to the same process). It is important to point out that the processes presented in this section are all associated with Plan already. At Strongstep, Plan is a transversal practice, although not yet formalised, since every activity is already planned considering the company's capacity, limitations, resources and standards.

As a result, three different processes were formalised. The first one, named Strategy Process, is associated with Gov and II. Figure 05 shows an overview of this process:

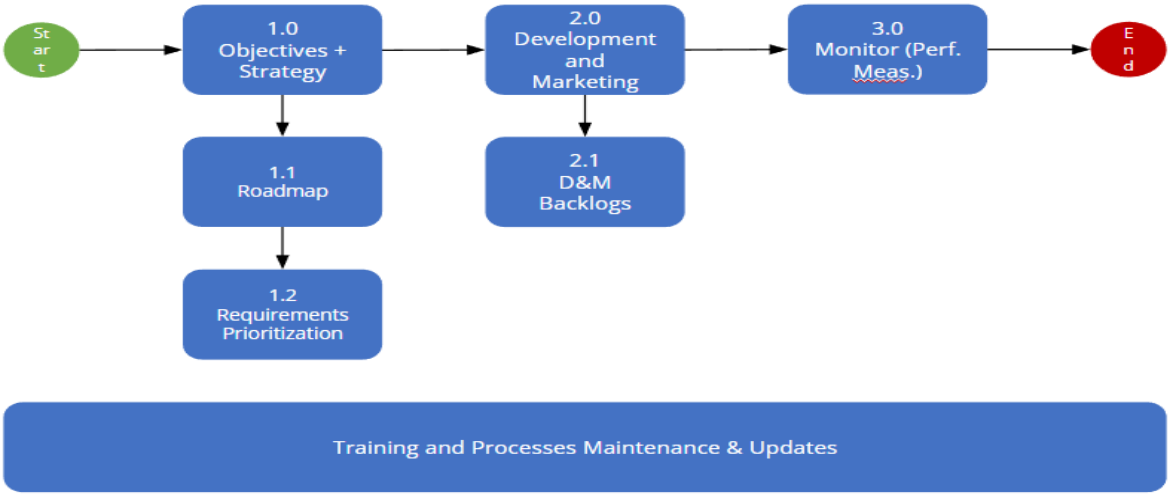


Figure 05: Strategy Process Overview

This first process aims to clarify the high-level managing strategy and objectives regarding the SCRAIM platform and its development process. This is the process where it is defined the product roadmap and backlog, the development methodology, marketing, and performance measures, among other ones within these cited. "Training and Processes Maintenance and Updates" is a transversal activity, since this activity is applied for new employees, new features, updated versions of the platform, etc.

The second process, named as Configuration Management Process, is related to CM. Figure 06 shows an overview of this process:

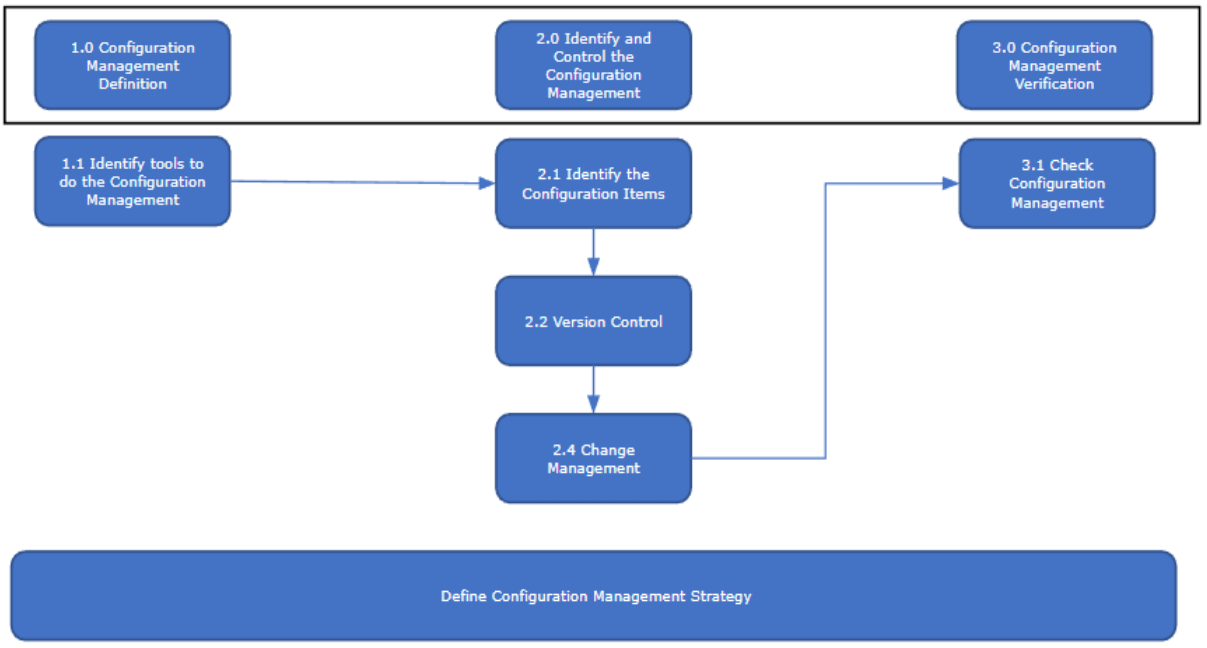


Figure 06: Configuration Management Process

The objective for this second formalised process is to define the Configuration Management Strategy by the high-level management, based on the configuration tools and configuration items necessary for the SCRAIM team, always having two different points of view: the development of the SCRAIM platform and the documentation generated by this process or to support this process. A key component of this process is to check the versions of the documents regarding changes, updates and controls.

The third process formalised is that of the Development Process. Based on the Scrum agile methodology for software development, as explained in section 2.2, the product owner and Scrum master are responsible for the development flow. The Development Process can be seen in Figure 07:

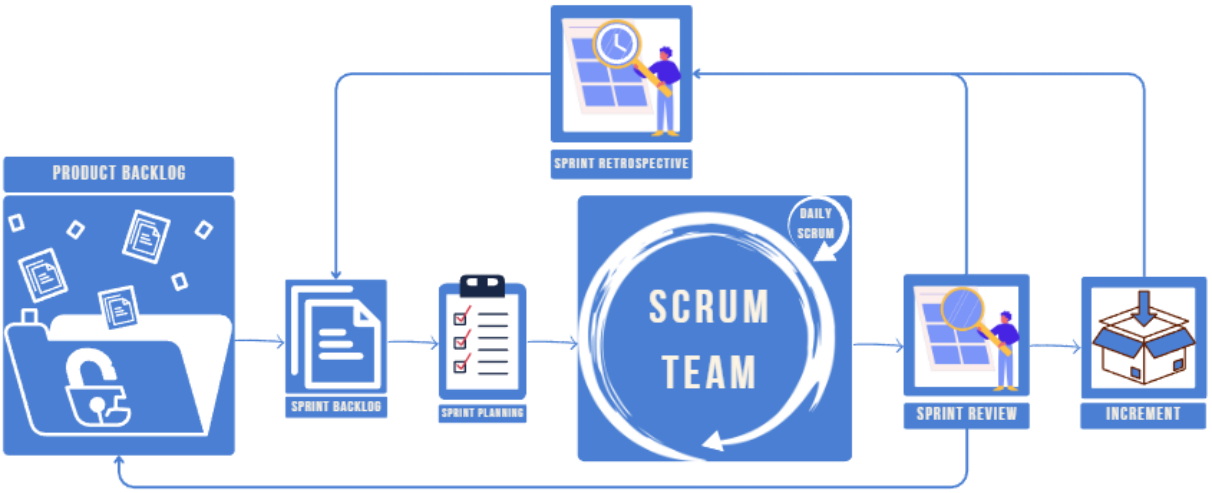


Figure 07: Development Process Overview

his process is part of the Strategy Process, more specifically steps 2.0 and 2.1 (Figure 05), with its base workflow being utilised not only for the development of the SCRAIM platform itself but also for the Marketing team.

In the case of the SCRAIM development team at Strongstep, each sprint usually takes a week to be completed, with the sprint planning and sprint review occurring in the same meeting at the end of the week. In this meeting, all the updates regarding the new increment and the tests held to validate it are shared with the team, making sure that the new increment presents no defaults and bugs and that it works accordingly to the previous increments, or how to tackle eventually found issues. In addition, the product owner presents what is planned for the next sprint.

One of the multiple issues caused by the lack of formalised processes was the lack of understanding about who is responsible for each activity. As a result, to complement the

newly formalised processes presented in section 5.1.2, a responsibility matrix was created to showcase who is responsible for each of the activities of the processes, and the milestone of each of these activities. Figures 08 and 09 represent, respectively, the responsibility matrix for the Strategy Process and the Configuration Management Process, where CEO represents the Strongstep's CEO, PO is the Product Owner, MKT is the marketing team and DEV is the SCRAIM developers.

	Responsible	Accountable	Consulted	Informed	MileStones
Objectives + Strategy	CEO	PO			• Needs and Objectives definition • Strategy Presentation Plan
Roadmap	CEO, PO	DEV			• SCRAIM Roadmap • Strategy Presentation (Updated)
Requirements Prioritization	PO	DEV			• Updated Product Backlog (SCRAIM)
Development and Marketing (D&M)	DEV	PO		CEO	• Sprint Planning • Development and Marketing roadmaps • SCRAIM backlogs (Updated) • SCRAIM (Sprints)
D&M Backlogs	PO	DEV, MKT		CEO	• D&M Backlogs (Update)
Monitor (Performance Measurements)	PO			CEO	• Roadmap update • KPI's Repository
Training and Processes Maintenance & Updates	PO	DEV		CEO	• Training programs and roadmap.

Figure 08: Strategy Process responsibility matrix

	Responsible	Accountable	Consulted	Informed	Milestones
Configuration Management Definition	CEO	PO	DEV		· Configuration Management strategy
Identify tools to do the CM	PO		DEV	CEO	· Configuration Management strategy (Update)
Identify the Configuration Items	PO	DEV			· Configuration Management strategy (Update)
Version Control	DEV, MKT	PO			· Configuration Management strategy (Update)
Change Management	PO	DEV		CEO	· Configuration Management strategy (Update)
Check CM	PO	DEV, MKT			· Configuration Management Verified

Figure 09: Configuration Management Process responsibility matrix

The responsibility matrix presents a more efficient way to understand the full process. Being able to understand the outcomes of each individual activity and those who were responsible for it in a clear way facilitates training processes, showcases the need of each of those activities and does not consume extra time for this understanding. When needed for deeper evaluation, onboarding or training purposes, a more detailed version of each of the activities can still be provided.

5.1.3 Check and Act

In Lean PDCA methodology, Check and Act work together and can be treated as one. The Check phase is related to audits, making sure that all processes are being followed according to the process definitions. The Act is when the new procedures become the regular procedures, in other words when the new processes and working flow become part of the company's culture and tradition.

When it comes to Lean Thinking, multiple tools can be added to prevent the 7 wastes generation. For Lean Implementation, it will be discussed the 5S tool, as well as the Kanban tool, as explained previously in sections 2.5.2 and 2.5.3, and how these tools can improve the efficiency of the SCRAIM team, and even at the fullness of Strongstep.

When it comes to MPM, this area is responsible for representative indicators controlling the business, not only for SCRAIM but also for the whole company. This being one of the most important methods to determine the SCRAIM level of success, it is important to have indicators that are easy to measure and that assist to determine when some deviation occurs. Based on the gap analysis and the process formalisation, it is indicated the use of two main KPIs: NPS and On Time. The first is used by the marketing team and it measures the level of satisfaction as well as the number of customers that are satisfied. The second measures the efficiency of the company's supply chain, which means analysing if the company is meeting the time delivery goals.

Moreover, while conducting the CMMI level 2 gap analysis, it was identified that the SCRAIM team has one level 3 practice area being correctly applied, the Validation and Verification. This practice area is responsible for the testing and verification of the new features developed during the sprint and is conducted by the PW together with a quality assurance employee. This aligns well with Lean Thinking, considering that testing processes are a way to prevent waste in the format of bugs and errors, and also in time. A fourth process formalised to tackle this practice area was the Testing Process, which can be seen in Appendix A.

5.1.3.1 5S - Knowledge Base Construction

As explained in section 2.5.2, the 5S is a Lean tool developed to organise the working environment. When it comes to software development, such as the SCRAIM team, the focus for this tool is less on the physical aspect of the working place, and more on the virtual aspect of it. In order to apply the 5S tool, a knowledge base was created on the online platform Sharepoint. The SCRAIM Sharepoint will be used not only for consulting documents and training but also as the place where the processes documentation are stored and where they could be accessed by the employees.

I. Seiri: Sort, having in your workplace only what is necessary.

The SCRAIM Sharepoint was designed to address the three main issues identified in section 5.1.1. Figure 10 represents the menu structure for the platform content:

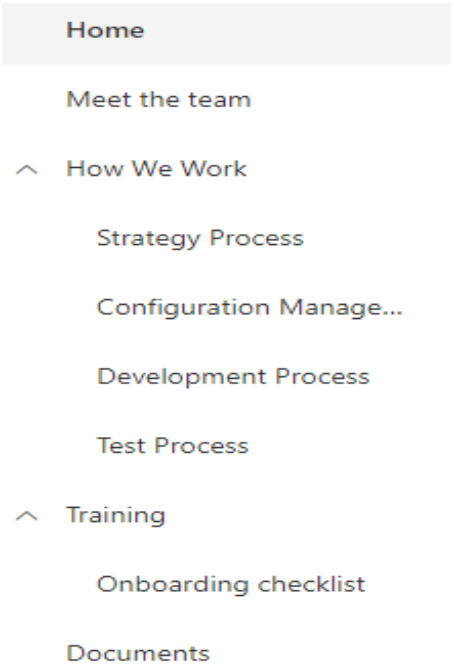


Figure 10: SCRAIM Sharepoint organisational structure

As can be seen in the figure above, the "How We Work" page contains the now formalised processes, with each of them having an individual page, where the employees can visualise the processes map, as well as have an explanation of each activity, in addition to the inputs and outputs of each of those activities.

The "Documents" section will contain the documents needed through all of the SCRAIM processes, in addition to the audit checklist proposed further in this section. More about the organisation of this page will be said next, on "Seiton".

The final page, "Training", contains the guidelines and videos for the new employees to explore and learn how to use the many SCRAIM features. More about training will be presented in section 5.2.

II. Seiton: Set in order, defining a place for everything, and everything in its own place.

To define the place for all the documentation needed in the processes, first it was necessary to analyse which documents were necessary based on the outputs of each activity of the individual processes. Each of the documents has an individual folder, and a scheme of the folders contained in one of the processes is represented in Figure 11. A full version of all the folders can be visualised in Appendix B.

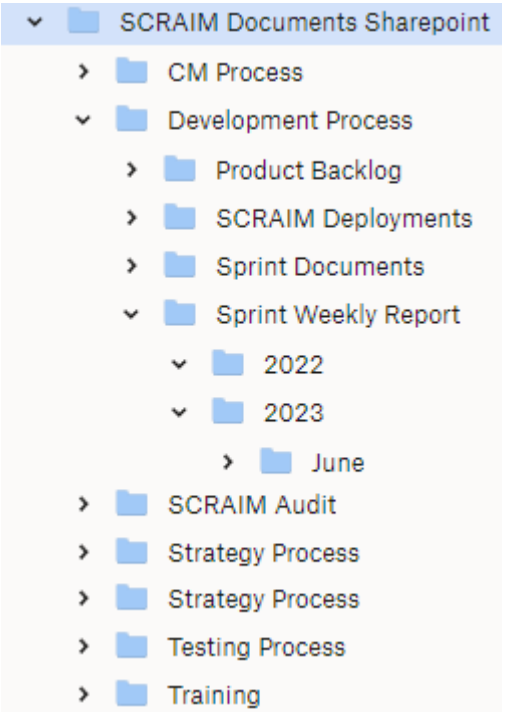


Figure 11: Folder scheme for SCRAIM documents on Sharepoint

III. Seiso: Shiny, having a sense of cleanliness and organisation.

To maintain the organisational structure of the folder and to be able to locate easily the documents needed, it is necessary to avoid creating new folders or misplacing documents in folders they were not supposed to be in. In addition, outdated document versions must be moved to the "outdated" folders, contained in each of the subfolders, as exemplified in Figure 11.

IV. Seiketsu: Standardise, defining rules and procedures to ensure everything is recorded and without ambiguity.

To standardise the folder, facilitating its navigation and document location, the following rules must be respected:

a. There will be an empty template (when needed) for the documents. A new document version must be created from this template (when applicable).
b. To create a new document version, the following name structure must be followed: "*company.name_document.name_process.name_YYYY.MM.DD_version*". As an example: "strongstep_development.roadmap_strategy_2023.06.30_v1.7".
    i. For documents that are created based on the date, such as audit documents, the name structure should be as followed:

"*company.name_document.name_process.name_YY.MM.DD*". As an example: "strongstep_audit_SCRAIM.audit_2023.06.30".

ii. For different versions, utilise one of the following:

i. for minor changes, such as orthographic errors: 0.1>0.2 ; 1.1>1.2;

ii. for major changes: 1.0>2.0 ; 2.3>3.0;

c. No new folder should be created unless a new document was created and is related to the formalised processes.

d. Documents must be moved to the "outdated" folders only when a new document version is created. For documents that are related to date, they must be allocated to the correct year and month folders.

V. Shitsuke: Sustain, evaluating how the processes are being properly followed.

To make sure the procedures for the documentation are being followed, in the audit file there is a section contained to verify the correct follow up of the rules. In addition, workshops must take place with the employees to explain the new procedures for the documentation process.

5.1.3.2 Kanban

As explained in section 2.5.3, Kanban is a visual tool designed to give the reader a fast summary of the operations. When it comes to Strongstep, built within the SCRAIM platform, there is a feature called "kanban" that was previously identified as a Software development type of waste, classified in the waste category "extra features".

The reason for this classification is that this feature was hardly ever used. In its current version, the tool is confusing and not user-friendly, presenting information on all the projects and activities at once, while also linking together all the members involved in the project, utilising more text than other forms of visual elements. All of these elements combined make it difficult for the reader to keep track of the activities being presented, and he would end up wasting time in his attempt to understand the real status of the presented activity. Figure 12 shows the current version of Kanban.

To correct this feature and make it more aligned with Lean Thinking, the designing process should be user centralised, relying on visual elements and colour schemes that are more intuitive for the user to input the information, or for the reader to understand the overall progress for each individual project faster and more effectively. The Kanban should present only the most important information about each activity being displayed, as well as have an

intuitive user flow to manage their activities to avoid unnecessary frustrations and prevent software errors related to misuse.

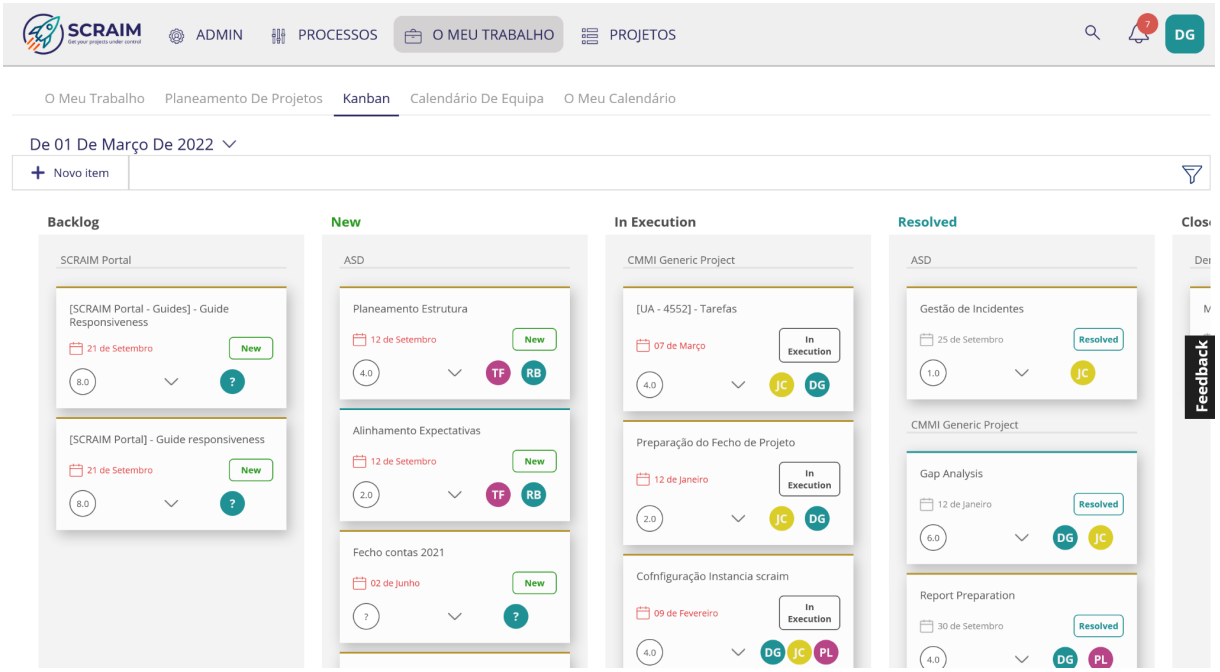


Figure 12: Current Kanban version

Figure 13 presents an alternative mockup for SCRAIM's Kanban, applying the previously cited suggestions.

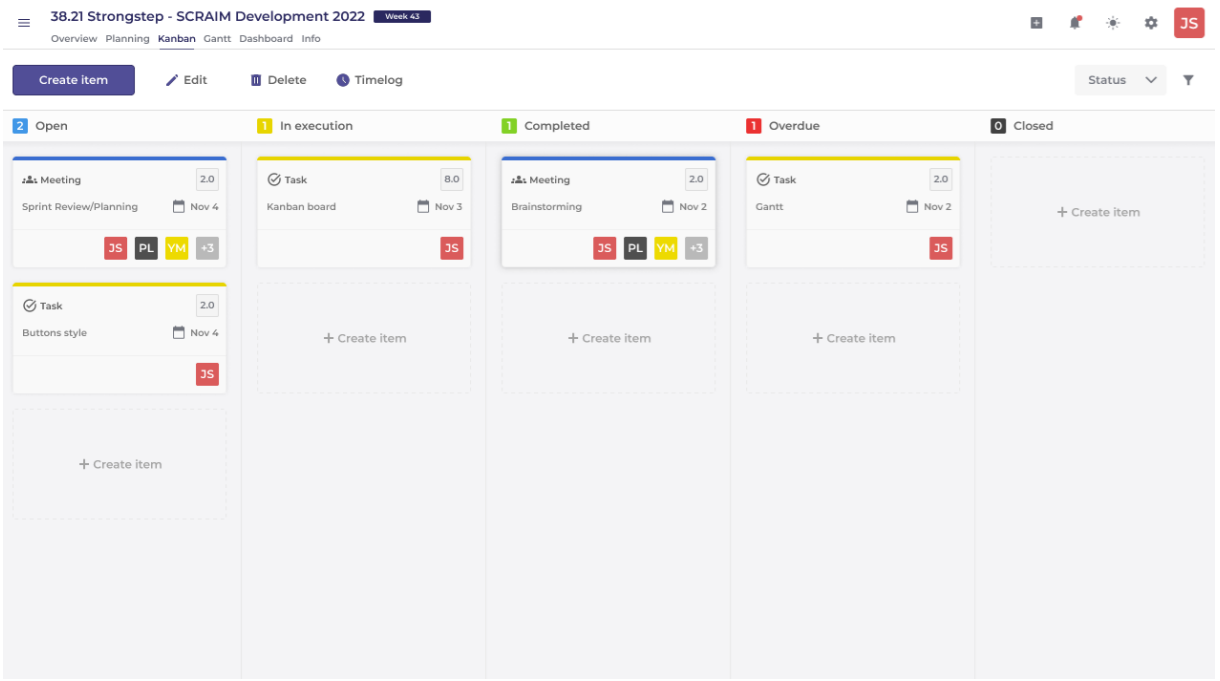


Figure 13: Alternative Version for Kanban

5.1.3.3 Audit Report

As stated in section 5.1.1, one of the main issues identified in the CMMI gap analysis was the fact that audits are not being done at the SCRAIM processes. This may cause problems such as, but not limited to misinformation caused by non-updated document versions; delays on roadmaps due to errors not being identified in time; procedures not being properly followed by employees, among others.

To address this issue, Table 02 contains an audit checklist suggestion for the SCRAIM processes, based on their current workflow and the CMMI practice areas prioritised in the gap analysis. The full document of the audit file can be seen in Appendix C.

Strategy Process			**Development Process**	**CM Process**
Project Planning	Requirements	Audit	Monitoring and Control	Configuration Management
Have project stakeholders been identified and are their responsibilities described?	Is the Requirements Document completed?	Has an audit plan been defined?	In all sprints reviews are the reports of the projects (Sprints) presented and is the analysis of the indicators?	Are the documents properly placed in the project repository? Given the defined naming rules, are the documents adequately identified and following them?
Is the scope of the sprint discussed in the sprint planning meeting?	Are Sprint effort and cost estimates defined?	Have strengths and weaknesses been raised in audits?	Were the concluding meetings held as planned?	Were the documents in question created based on the templates of the organisation?
Have training needs been identified for project resources?	Has traceability been recorded and maintained?	How is information on the processes and methodology of work available?	Are the risks identified as planned being monitored?	Has the request for amendment to the changes that occurred in the Sprint been completed and submitted?
Have Sprints set the delivery date?	Are the requirements prioritised?	Who is responsible for complying with the specified methodology?	What indicators do you use to tell if the Sprint is in or out of the delivery plan?	Have baselines been tested and validated?
		Who is responsible for resolving the non-conformities found in audits?		

Table 02: SCRAIM Audit checklist

5.2 People Preparation

The final improvement opportunity to be addressed in this project is related to training and people preparation. To minimise human error and be more aligned with Lean Thinking, a strong training program must be implemented.

There are two different types of training programs for new employees: overall training, for every new employee regarding how to navigate and use the SCRAIM platform; technical training to be applied for new developers, regarding the specific development tools and software. It is important to point out that Sharepoint is also used for training, since it is in there where the documents are stored, in addition, some of its pages are dedicated to assisting the training program.

For the first, the training must comprehend tasks and information that are necessary to introduce the new employee to the company, to the team, to the platform as well as to teach him how to use the basic features, features which are necessary to perform the daily tasks routinely. An overall training plan was proposed, having a planned duration of one full day, and is represented in Figure 14. The Figure showcases the different topics to be approached during the training. In case the employee is also being trained to be a Process Manager, the training is extended by half a day more, and the specific tasks regarding this position (project creation, process creation, resources management and indicators management) are added to the training program. The variation for this training is in Appendix B.



Figure 14: SCRAIM Overall training roadmap

The second training takes place over three weeks and focuses more on the technical aspects for the developers. For this training, the milestones are already well-defined by the

company. In this training, the new developers must complete the predefined tutorials for Ruby and Ruby on Rails, which are both the programming language and MVC architecture framework that SCRAIM is based on. This training roadmap is represented in Figure 15.

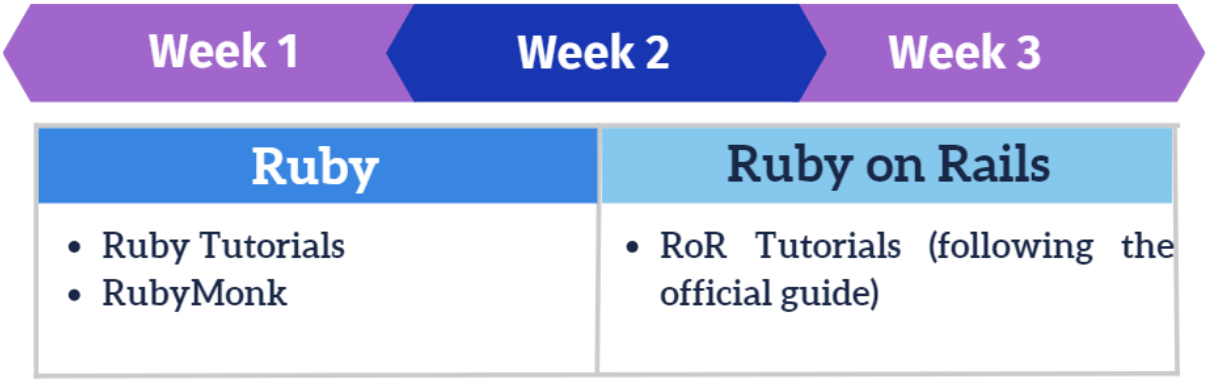


Figure 15: Ruby and RoR training roadmap

6 Final Considerations, Limitations and Future Research

In this chapter, the final considerations for the project are presented. First, the results found are summarised and explained on how they answer the research questions and the objectives. Then, a quick explanation regarding the limitations and difficulties of this project. Finally, what are the suggestions for future research to be continued from this project.

6.1 Results found

Each solution proposed in this project aimed to tackle a specific problem or problem that the SCRAIM team at Strongstep is currently facing. The solutions were designed and thought to facilitate their workflow, as well as to improve efficiency from multiple sides.

The combination of the Lean thinking with the CMMI model allowed the discovery of multiple improvement opportunities (the initial objective of this project), as well as the formalisation of four of the main SCRAIM processes: Strategy process, CM process, Development Process and Testing process. It also facilitated the construction of the knowledge base on Sharepoint. This step allowed the *RQ1: "What are the improvement opportunities for the SCRAIM team at Strongstep?"* to be answered.

The solutions proposed based on the CMMI gap analysis should result in increasing the company's understanding and control of its own process. Furthermore, it should help to increase its capacity to adapt and react to deviations and difficulties throughout the way.

When it comes to the solutions proposed based on Lean Thinking, PDCA methodology and tools, they should result in increasing overall processes efficiency. By applying the proposed solutions, the overall individual and total effort should be optimised and the number of human errors should decrease. Moreover, these solutions should add more value to the customer, by prioritising what they need and their user experience.

The different methods and tools utilised in the solutions creation and the solutions proposal answered *RQ2: "What are the actions needed to address the improvement opportunities in RQ1 and how to develop them?"*

The solutions proposed also addressed the three main objectives of this project:

- The formalisation of the SCRAIM processes.
- The SCRAIM Sharepoint construction, for training and documentation.
- The audit checklist document.

6.2 Limitations and difficulties for this Project

Throughout the development of the project, some difficulties and limitations needed to be overcome. Initially, the main difficulty was understanding the CMMI model, since the model is vast and comprehends many practice areas. Another aspect that presented a certain level of difficulty was how to conduct the CMMI gap analysis for a maturity level 2. To overcome these difficulties, the intern needed training specialised in the CMMI model.

Furthermore, the gap analysis itself presented some limitations. Considering all the improvement opportunities found in the analysis, there was only a limited number that could be addressed during this project, while the others had to be left aside.

The final difficulties were related to which tools and methodologies should be applied to propose the solutions. In the literature, there are many different Lean tools and methodologies, and a prioritisation of which ones would be best fitted for the company had to be made.

6.3 Future Research

Considering that the PDCA is a cyclical methodology, the next steps for the SCRAIM team should be to evaluate the performance after applying the proposed solutions and update the current processes to new versions. The new versions should be created to incorporate the proposed solutions until the new procedures and activities are automatically done by the employees. At this point, Lean Thinking will be part of the company at a cultural level.

Sharepoint and the documents folders should always be updated and constantly verified to maintain the cleanliness of the working environment, as stated in the 5S tool. This will facilitate when in doubt, the search of information and/or documents and templates. Audits being performed in the correct schedule will facilitate keeping track of how well the workflow is being followed, as well as identifying the sources of difficulties and problems in an easier way.

As a final consideration, a future research suggestion for the company is how to approach the other improvement opportunities not explored in this project. Out of the nine different practice areas that compose a CMMI maturity level 2, only five were selected and, out of the many improvement opportunities identified in those five, only three main issues were tackled.

To achieve maturity level 2, Strongstep needs to find solutions to all of the improvement opportunities found, not only the ones approached in this project. When level 2

is finally achieved, the company can search for a path that will lead it towards the CMMI maturity level 3, opening even more doors and allowing the company to grow even further.

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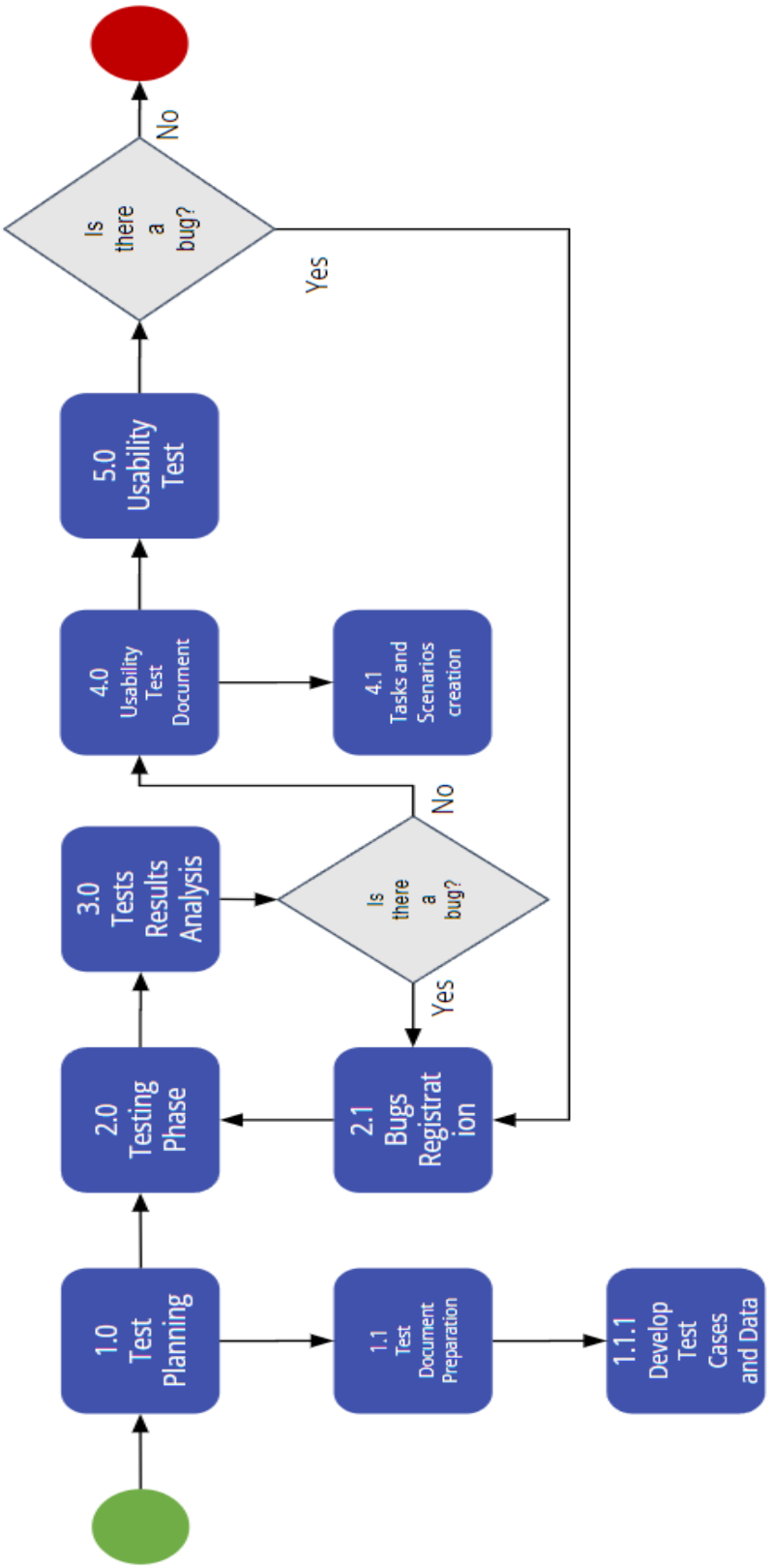
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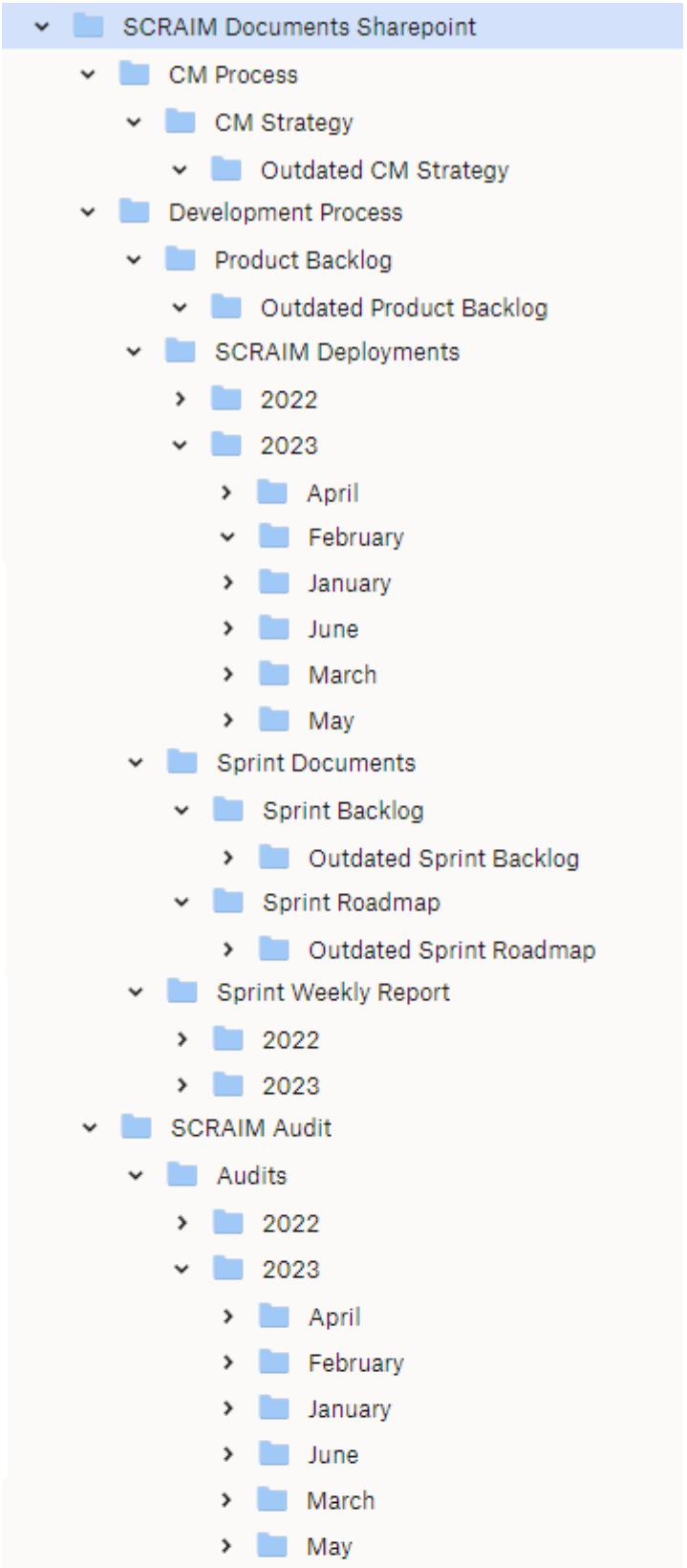
APPENDIX A: Other SCRAIM Processes

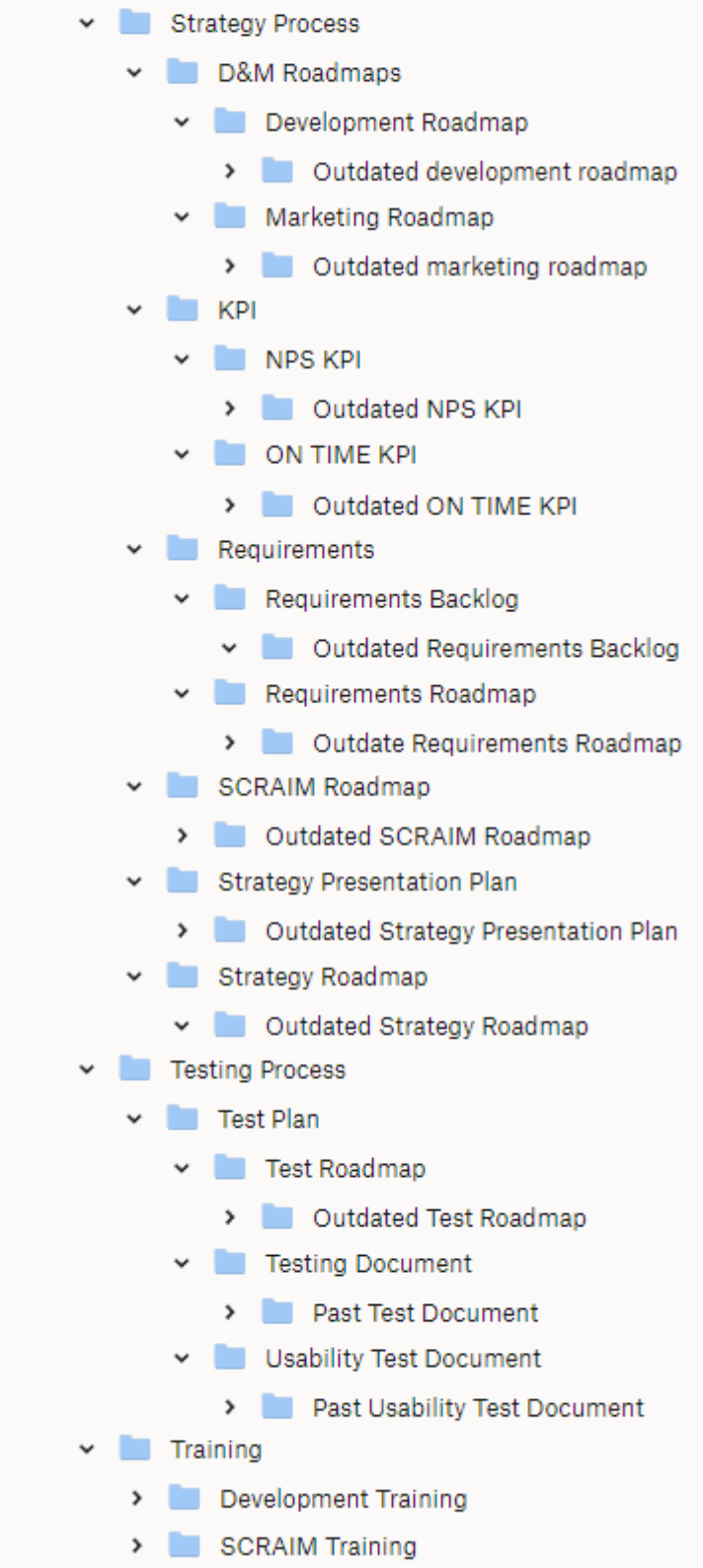


Appendix A Process 01: Testing Process

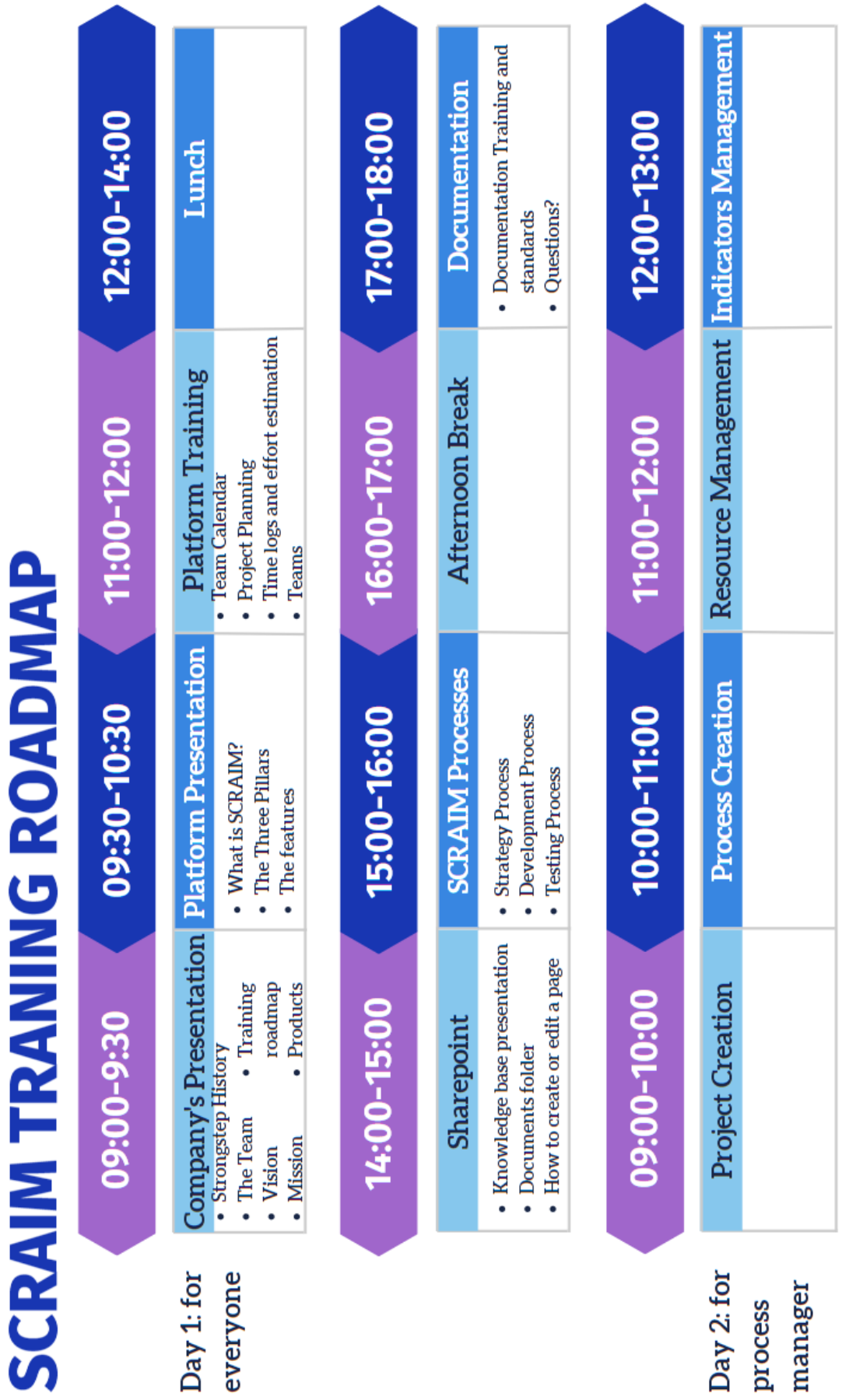
APPENDIX B: Complementary Figures

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Appendix B Figure 01: Full folder scheme for SCRAIM Sharepoint



Appendix B Figure 02: Full SCRAIM Training Roadmap

APPENDIX C: Other Tables and Documents

		Metrics					
	Questions	Repositories		Execution		Indicators	
Processes		Non-Conformity	Conformity	N/A	Not Yet	%Execution	%Adherence
Strategy Process	13	0	0	0	13	100	100
CM Process	4	0	0	0	4	100	100
Development Process	4	0	0	0	4	100	100
Total	21	0	0	0	21	100	100

			%Adherence			
	Month	%Execution	Total	Strategy Process	CM Process	Development Process
		100	100	100	100	100

Appendix Table 01: Overall SCRAIM audit results

SCRAIM Processes			AUDIT				
Process	Repository Reviews		Audit Evidence	Done?	Non-Conformity Type	Major	Comments
Strategy Process	Project Planning	Have project stakeholders been identified and are their responsibilities described?					
		Is the scope of the sprint discussed in the sprint planning meeting?					
		Have training needs been identified for project resources?					
		Have Sprints set the delivery date?					
	Requirements	Is the Requirements Document completed?					
		Are Sprint effort and cost estimates defined?					
		Has traceability been recorded and maintained?					
		Are the requirements prioritized?					
	Audits	Has an audit plan been defined?					
		Have strengths and weaknesses been raised in audits?					
		How is information on the processes and methodology of work available?					
		Who is responsible for complying with the specified methodology?					
		Who is responsible for resolving the non-conformities found in audits?					
CM Process	Configuration Management	Are the documents properly placed in the project repository? Given the defined naming rules, are the documents adequately identified and following them?					
		Were the documents in question created based on the templates of the organization?					
		Has the request for amendment to the changes that occurred in the Sprint been completed and submitted?					
		Have baselines been tested and validated?					
Development Process	Monitoring and Cotnrol	In all sprints reviews are the reports of the projects (Sprints) presented and is the analysis of the indicators?					
		Were the concluding meetings held as planned?					
		Are the risks identified as planned being monitored?					
		What indicators do you use to tell if the Sprint is in or out of the delivery plan?					

Appendix Table 02: SCRAIM processes audit