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Process Management and Improvement in a Tech Start-up

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Master Thesis

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Abstract

This project was developed in the technological start-up Smart Separations and aimed at analysing and improving its business processes.

The project objectives included the development of the company's process map, the identification of the critical processes that need improvement, the analysis of the current situation, the design of improved versions of the processes, and the development of process management tools, namely a process tracker and a set of key performance indicators.

The first major step consisted of the preparation of the process map of the company. This model provided an overall view of the company's activities and led to the critical processes that should be addressed first. The decision fell on the processes of the area Technical Studies, namely on the process Feasibility Study and on the process Internal Product Development.

For a detailed analysis of these processes, a multilevel approach was adopted. The first modelling level identifies the main phases of the process, the participants, and their roles. Then, for each phase needing improvement, a detailed swimlane model was developed to describe the current situation (AS-IS model) and the new, improved solution (TO-BE model).

For the management of the processes, two tracking tools were developed: the Technical Data Tracker intended to keep track of the technical data regarding the testing activities. The Test Progress Tracker is intended to control the status and progress of the running testing activities.

Finally, a set of key performance indicators focused on managing and assessing the activities involving external labs were also designed and evaluated. These indicators address issues such as the turnaround time and the quality of the reports issued by the external labs.

As a final remark, we may say that this project made evident the benefits of systematic multilevel business process analysis, from the overall process map of the company down to the detailed workflow models, as far as effective business management is concerned

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List of abbreviations

- BC: Basecamp
- BP2IT: Business Process to Information Technology
- BPM: Business Process Modelling
- CEO: Chief Executive Officer
- Dept: Department
- Docs: Documents
- FS: Feasibility Study
- IP: Intellectual Property
- IPD: Internal Product Development
- ISO: International Organization for Standardization
- KPI: Key Performance Indicator
- Labs: Laboratories
- NDA: Non-disclosure agreement.
- PM: Project Manager
- POs: Product Owners
- R&D: Research and Development
- SLA: Service Level Agreement
- SSL: Smart Separations, Ltd
- SOP: Standard Operating Procedure

1 Introduction

This dissertation was prepared with the aim of obtaining a master's degree in service engineering and Management at the Faculty of Engineering of the University of Porto (FEUP), and the underlying project was developed at Smart Separations, a technological start-up.

This chapter starts by introducing the background and the motivation of the project. Then it presents the company where the project took place and the objectives and research questions of the project. Finally, the working methodology and the structure of the documents are also presented.

1.1 Project background and motivation

Organisations are increasingly aware of the benefits of business process analysis and management as a methodology to overcome inefficiencies and achieve significant performance gains. Despite this, many companies still do not know the origin of their internal problems, processes, context, how to analyse them, or what process implementation entails. Moreover, it is still not well understood that process improvement and analysis encompass an understanding of the company as a whole, its functioning, and its processes. Especially in small and medium-sized companies, where they tend to be more flexible, active, informal, and generally more disorganised.

The company where the project took place- Smart Separations - faced difficulties once its processes were not yet systematically analysed and documented. In particular, it was difficult for the company to keep control of the running processes and monitor the performance of its key activities.

The lack of internal process standardisation also led to situations where similar processes were managed differently depending on each process owner.

The inexistence of companywide process management tools challenged the data collection and led to data and document duplication situations

Therefore, it became imperative for Smart Separations to look carefully at its processes in order to tackle inefficiencies and boost productivity and performance.

1.2 Smart Separations, Ltd

Smart Separations is a young company founded in 2013 in England by a former bioengineering researcher. It is an innovation and science company that aims to develop technologies to improve people's quality of life, mainly through nanotechnology.

The company has been operating in the UK and Portugal since 2018. Although it is based in England, both units work together to achieve the same goals as a single company.

Smart Separations started with the aim of creating ceramic membranes for filtration purposes. Currently, the company has a patented process to manufacture microporous ceramic membranes that can function as filters and/or support catalysts through microfiltration. These have applications in research and development, air purification, manufacturing, gas emission reduction, food, and beverage (e.g., wine clarification), water filtration (drinking water and wastewater), and biotechnology. So, as it can be seen, it has applicability in different industries.

In addition, it was developed new nanotechnology of antiviral coatings capable of destroying SARS-CoV-2 on surfaces and preventing the spread of COVID-19. Thus, this technology applied to air filtration can filter particles and eliminate bacteria and viruses from the air, eliminate odors, or release fragrances into the air as the air passes through the membrane. Therefore, the company decided to create a new generation of antiviral coatings with ViraTeq technology.

Derived from this, Smart Separations is currently entering the manufacturing and commercialization phase of these two technologies, ceramic membranes and antimicrobial coatings.

With the pandemic outbreak, although the development of antimicrobial properties was already underway, Smart Separations decided to change the focus of the company's business. The development of ceramic membranes was temporarily abandoned to prioritize the production of antimicrobial coatings (ViraTeq technology), making it Smart Separations' core product.

Due to the previously reported factors, the company's revenue currently comes from selling Feasibility Study to potential clients interested in antimicrobial technology, hence maximizing the potential of the products and services the company offers. In addition, they aim to create a commercial team to attract more potential customers, develop more products, build their factory to start commercializing their products, and invest heavily in regulation. Bearing in mind that the antimicrobial agent used by the company is a biocide and requires specific regulation for each country in which they operate.

The company's mission is precise: "To improve the quality of life through innovation in the areas of health, environment, and human causes."

1.3 Problem description

Smart Separations started with a small structure that allowed the CEO to control all activities going on in the company. At the time, processes were not documented because that was not seen as a priority by the company's management.

As the company grew, it was no longer feasible to keep the centralized management model, so there was a need to implement and document processes. At that time, just a few processes were implemented. That was the case for the shipping and the internal communication processes.

Although implementing these processes brought important benefits to the company, a systematic analysis of the company's processes was to be done due to a lack of resources.

More recently, the pandemic offered new business opportunities to the technology developed by Smart Separations. The size of the company increased significantly, turning the communication and coordination problems even more acute.

As a result, the same people started working on various tasks simultaneously and in different ways, and no one had a sense of who was overseeing each project.

It was also not possible to get a uniform perception of how some core activities of the company worked, showing a lack of alignment in the execution of tasks by employees.

In addition, the lack of standardization in the documentation created contributed to duplicate files containing the same information. Sometimes, some documents created by different product owners did not always include all the necessary and relevant parameters.

So, as seen, these are some of the problems resulting from the lack of implementation and consolidation of processes.

1.4 Objectives and Research Questions

Given the situation described above, it was evident the need to conduct a throughout analysis of the business processes and equip the company with management tools to monitor its activities and evaluate its performance.

Thus being, the company's defined the following general objectives for this project:

- Analyze the processes and improve the working procedures by designing and standardizing the workflow of the processes.
- Develop a set of management tools allowing to manage the execution of the processes
- Define performance indicators: allowing the company's performance to be evaluated.

Therefore, this project aims to propose a set of improvement recommendations regarding the workflow of the processes, the management systems, and the process KPI's and, as far as possible, implement them in the company.

After extensive analysis and re-targeting the focus of this dissertation, it was possible to identify the following research questions:

- What are the critical processes of Smart Separations that need improvement?

- What processes should be addressed first, and what are the most relevant improvements?
- How to manage the processes in terms of progress and in terms of management?
- What are the most appropriate tools and performance indicators to manage the processes?

1.5 Methodology and document organization

This dissertation followed a qualitative case study approach, where process data was collected in a series of semi-structured interviews with the main actors involved in those processes. Then an inductive approach was conducted to frame a set of orientations, guidelines, practices, and tools intended to improve processes' efficiency and effectiveness. Namely, the workflows of the processes were redesigned, process tracking tools were designed and put into practice, and a set of KPIs for the company management dashboard were specified.

In this dissertation, the process analysis, management, and improvement followed a multi-level approach that starts from a high-level view of the company, provided by the overall process map and detailed analysis of the most significant phases and activities.

This approach suits the project's needs since its goal was to capture its core processes through a high-level view of the business. Along with this multi-level approach, it was possible to break the process into parts to achieve a progressive approach, get a more detailed view of each process, and analyse the most relevant ones.

As mentioned earlier, one of the first questions we faced was, "What are the critical and priority processes to be analysed in Smart Separations?

The process map development was initiated by gathering information from one-to-one meetings with the Product Owners, the Product Managers, and the CEO to solve this problem. The result of this stage was the process map presented in Chapter 3.

This process map was instrumental in providing a global view of the company's activity that allowed the processes whose analysis should be a priority.

The next step was a detailed analysis of each one of these processes. Here an AS-IS and a TO-BE model were prepared for each process, as discussed in Chapter 4.

This analysis was a complex endeavor that required multiple meetings with Smart Separation team members, whose views were not entirely coincident.

After the detailed analysis of each process, it was possible to think about the management tools. Three types of management tools were identified: (i) the Technical Data Tracker, which allows for a history of all tests performed, (ii) the Progress Test Tracker, which allows the tracking of process execution and evolution, and (iii) the determination of performance indicators to evaluate process performance, as discussed in Chapter 6.

The structure of this dissertation closely follows the steps of the methodology presented above.

After this introduction, Chapter 2 presents a review of concepts on business process management.

Chapter 3 presents the Smart Separation process map and the decision on the processes to be addressed in this project.

Chapter 4 presents the detailed analysis and modeling of these processes

Chapter 5 addresses the design of the process management tools to put in place, namely Technical Data Tracker and the Test Progress Tracker

Chapter 6 presents the design of the performance indicators that apply to the external laboratories' testing activity.

Lastly, chapter 7 will summarize the main results achieved in the project and perspectives for further developments.

2. Literature Review

2.1 Business Processes Concepts

Business Process Modelling is widely used within organizations as a method to increase awareness and knowledge of business processes (Dumas, La Rosa, Mendling, & Reijers, 2018). It can deconstruct organizational complexity and facilitate information sharing between the whole company organization (Dumas et al., 2018). Every day, organizations worldwide strive to find their intended purpose, and do that, they will encounter business processes. These can be defined as a set of logically connected activities triggered by events that allow the transformation of resources - information, materials, etc. - into valuable outputs for the stakeholders involved, ultimately reflecting how work is carried out inside them (White & Corp, 2004). Similarly, we can define a business process as a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer (Champy & Hammer, 1993). Also, they can serve as a source of competitive advantage as they can affect the way customers perceive the quality of service provided and the efficiency with which it is delivered (Dumas et al., 2018). Companies often use Business Process Modelling to get competitive advantages in their market. The fact that every business process has a customer, either internal or external, means that most activities within a company can be considered a business process or part of it (Andersen, 2007).

2.1.1 Business Process Classification

There is a market need for a standard process of different companies to facilitate their identification and organization of business processes (Andersen, 2007). One of the well-known classification system is the Value Chain Model (Porter, 1985). It classifies business processes into two main categories:

- **Core processes** or primary activities are value-creating processes as they belong to the organization's value chain and are directly related to the provision of products and services to the customers (Porter, 1985). For example, processes as manufacturing, promotion, sales, and after-sales.
- **Support processes** or support activities are non-value creating processes as they are not part of the organization's value chain but rather enable the successful accomplishment of core processes (Porter, 1985). For example, processes related to human resource management, accounting, and IT management.

Later it was defined a third category of processes: **management processes.** These contribute to establishing guidelines and strategic directions for the core and support processes, leading them to a higher level of performance (Dumas et al., 2018).

2.1.2 Business Processes Modelling

The graphical representation of business processes or workflow is what represents the business process modeling. They can be used to share information between relevant stakeholders and test and explore alternative scenarios and clarify assumptions, objectives, and surroundings (Andersen, 2007). It is an approach for describing how businesses conduct their operations, and it includes graphic descriptions of the companies' activities, events, and flow logic that constitute a business process. This representation can be used to translate the understanding of the process to relevant stakeholders, as well as to test and explore alternative scenarios and clarify assumptions, objectives, and surroundings (Dumas et al., 2018). Business process models can be used to document how the company works today (AS-IS), as well as the way it should work (TO-BE)

There is a common difficulty when approaching the most appropriate level of detail of the business process model. When designing it overly detailed, the model may become too difficult to understand, but if it is designed very generic, it may omit relevant aspects of the process (McDermott & Sharp, 2008). The most effective way to handle this dilemma is to consider hierarchical modeling levels, each one with a different level of detail (Andersen, 2007). This way, it becomes possible to present all the relevant information and, at the same time, keep each model simple enough so that it can be easily understood. Regardless, business process modeling should stop when value is no longer extracted from a given detail level (McDermott & Sharp, 2008).

Several techniques for modelling business processes graphically and selecting the most appropriate one depending on the characteristics of the process being analysed and the purpose of the model (Andersen, 2007). Nevertheless, any process model always highlights the work to be executed (tasks), the sequence of execution (workflow), and who executes it (actors) (McDermott & Sharp, 2008).

The following sections present in more detail some of the most used modelling approaches.

- **Business Process:** it is mainly referred to as a business process map, this type of model is regarded as the first level in the hierarchy, not representing an individual process, but rather how all the processes are connected inside the organization (Andersen, 2007). It can facilitate one's understanding of the interactions among internal departments and external stakeholders when performing such processes (Andersen, 2007).

- **Traditional Flowchart:** it can be defined as the graphical representation of the flow of activities in a process (Andersen, 2007). In its most basic form, different symbols are

used to represent activities and arrows to highlight the connections between them. Still, there are several variants, depending on the information that needs to be depicted (Andersen, 2007). A traditional flowchart diagram offers more flexibility to analysts as elements are freely disposed of according to the workflow, without dedicated lanes to the actors. It is a suitable modelling technique for transverse processes with multiple actors and complex workflows (Faria, 2020b).

- **Cross-functional Flowchart**: is commonly known as swimlane diagram. A cross-functional flowchart represents the actors of the activities and the functional department they belong to, contributing to a complete depiction of the process compared to a traditional flowchart (Andersen, 2007). All the tasks performed by an actor along a process appear in the corresponding lane, highlighting the flow across the organization and the participation of each one in the process (Faria, 2020b). Also, modelling business processes using swimlane diagrams can support analysts in identifying unnecessary activities and interactions between resources, consequently allowing the formulation of improvements, namely responsibility redefinition or changes in the sequence in which activities are performed (Andersen, 2007). However, cross-functional flowcharts may not be the most suitable business process modelling technique when documented processes are very complex. For example, when containing several decision points, loops, and alternative flow paths, the same actor performs most activities or many actors with punctual participations (Andersen, 2007).

- **Responsibility Matrix:** it can be defined as a graphical representation that highlights the roles of the actors involved in the process, something that is not possible using other modelling techniques, allowing process analysts to identify accountability misunderstandings, improve resource utilisation, and team dynamics (Jacka & Keller, 2012). Nevertheless, they do not offer any flexibility to process analysts as they do not allow the representation of complex workflows and multiple actors (Faria, 2020b). Typically, there are four levels of participation (Jacka & Keller, 2012): Responsible (R) refers to an actor that is responsible for performing a given activity; Accountable (A) refers to an actor that holds authority over an activity; Consulted (C) refers to an actor that ought to be consulted before the process can advance; Informed (I) refers to an actor that does not participate in the process, but needs to informed about the occurrence of a given activity.

2.1.3 Business Process Performance

Once business processes are defined or redesigned, establishing performance measures is critical to ensure that those are producing the desired outcomes (Rummler & Ramias, 2010). However, defining and implementing performance metrics can be very challenging due to the cross-functional nature of business processes, requiring interdependent decisions and actions, as well as the human judgments involved (Rummler & Ramias, 2010). Commonly failing points at this phase include lack of process performance accountability and understanding, absence of a structured approach when selecting metrics, and adopting measures with no connection to the business reality (Rummler & Ramias, 2010). Nevertheless, the literature agrees that the

establishment of performance measures should reflect the organization's strategy, vision, objectives, and mission (Van Looy & Shafagatova, 2016).

When measuring process performance, a multiplicity of perspectives may be employed: time, cost, quality, and flexibility (Dumas et al., 2018). These are the most relevant perspectives used. Regardless, each one can be further deepened into several process performance measures (also referred to as process performance metrics, Key Performance Indicators, KPIs), capable of quantifying the extent to which the organization achieves a specific goal (Van Looy & Shafagatova, 2016).

Performance measurement gained importance in both literature and practice, ever since organizations started to define their strategy in terms of results to become increasingly more efficient and effective (Van Looy & Shafagatova, 2016). While measuring the performance of a process, two fundamental dimensions - efficiency and effectiveness - should be considered (Fraser, 2006). Efficiency performance measures are those directly related to productivity and costs incurred with the production and delivery of a given product or service (Fraser, 2006). Examples include the availability and usage of critical resources, the material costs from external suppliers, and the costs incurred by internal activities (production, delivery, storage, etc.). Effectiveness measures are those directly related to the quality of the product or service, i.e., the adequacy of the value proposition given customers' needs (Fraser, 2006). Examples include responsiveness and delivery delay, compliance with deadlines, faulty products or services, and customer satisfaction.

Performance indicators are generally divided into lagging indicators and leading indicators. Lagging indicators are outcome indicators that provide information about the success of the strategy used, that is, past events (Faria, 2020b). Leading indicators are leading indicators that provide information that drives or is related to future actions (Faria, 2020b). This type of indicator allows the adoption of preventive actions that can help achieve strategic goals. These are usually indicators captured at the level of each individual process and are difficult to measure or obtain.

In the literature, it is still possible to find a different approach that defends a division of indicators into three levels: Key Result Indicators (KRI), Performance Indicators (PI), and Key Performance Indicators (KPI) (Fraser, 2006). The KRI is characterized by reflecting various actions, such as customer satisfaction and return on investment. These indicators are useful in analysing long periods, such as monthly or quarterly, and indicate whether the company is moving in the right direction. However, due to being a reflection of several actions, they do not indicate what is necessary to improve the results obtained. Performance Indicators (PI) are characterized by referring to shorter periods of time and being focused on a single activity. This group includes not KRI indicators and does not have the necessary importance to be considered KPI. Examples of these indicators are the percentage of employees who continuously make suggestions (Coughlan & Coghlan, 2002). Finally, the Key Performance Indicators (KPI) represent a set of measures focused on the most critical aspects of organizational performance for the organization's current and future success (Andersen, 2007). KPIs are designed to summarize comparable data meaningfully and to convey as much information as possible succinctly.

A KPI presents itself as a metric, however, a metric should not always be considered a KPI. The main difference is that KPIs always reflect strategic value indicators, that is, important for the business and its objective. At the same time, metrics can represent the measurement of any type of activity (Fraser, 2006). To easily identify a KPI, it must contain the following characteristics (Fraser, 2006):

- Specific: defines a specific area for improvement;
- Measurable: quantifies, or at least suggests, an indicator of progress;
- Assignable: specifies who executes;
- Realistic: indicates what results can actually be achieved, taking into account available resources;
- Time-Related: Specifies the period in which the results are to be achieved.

Although companies value the use of KPIs to assess their performance, there are still several difficulties in applying this type of system (Faria, 2020a). The implementation of a performance measurement system can be seen as a process change or as a redistribution of power in the organization (Fraser, 2006). Employees involved may not understand the urgency of a measurement system and consequently actively or passively resist such implementation (Bourne, Mills, Wilcox, Neely, & Platts, 2000). The focus of organizations should not be the number of measures implemented but the set of essential measures to their development and evolution (Bourne et al., 2000).

One of the main obstacles to performance measurement is related to the fact that the indicators used in organizations are not integrated or aligned with the business process (Fraser, 2006). Indicators are often not chosen according to the company's strategic objectives, making their use in the organization's management processes unfeasible (Fraser, 2006). The success of an organization depends on the amount of time invested in defining and conveying its vision, mission, and values.

2.2 Business process analysis

The core of this dissertation stays on the analysis of the Smart Separations processes, from the global company level to the detailed workflow of tasks.

A multi-level process analysis and modeling methodology should be adopted. Hereafter, it is presented the main stages of such methodology.

2.2.1 Process Identification

When engaged in BPM initiatives, organizations start by defining the process architecture (or business process map). This includes identifying, determining the boundaries and relationships between the major processes (Dumas et al., 2018). The process architecture of an organization changes over time, reflecting changes in both internal and external contexts (Dumas et al., 2018).

Having defined or revised the process architecture, organizations have to select the business processes that will be a target of the BPM activities. Several criteria can be used to guide this assessment. An organization's resources and capabilities are decisive factors, given that most organizations do not own sufficient resources to address all processes simultaneously (Coughlan & Coghlan, 2002). Additionally, given their differences in terms of maturity and importance (Dumas et al., 2018), organizations must understand the extent of internal change they will trigger to decide which to commit to and invest in improving (Coughlan & Coghlan, 2002). With each successful project, companies develop competencies and gain experience with BPM, critical for future initiatives (Dumas et al., 2018).

Generally, the three most commonly used criteria for process selection are (Dumas et al., 2018): strategic importance, health, feasibility. The first criterion aims to select processes critical to the pursuit of the organization's strategic goals. The second aims at identifying the more problematic processes that will benefit the most from BPM initiatives. The feasibility criterion intends on pinpointing the processes where results are more attainable and rational.

2.2.2 Process Discovery

In this phase, information about the current state of the processes previously selected is gathered and documented using process models (Hübner, Holzapfel, & Kuhn, 2015). Process discovery is an arduous activity due to the fact that processes are performed by several resources, which means that process analysts have to consult different domain experts with a limited acquaintance to business process modeling techniques. Additionally, conflicting and overly detailed knowledge may be provided, requiring additional involvement of the analyst (Dumas et al., 2018).

Process analysts can use several methods to gather information about a process, grouped into three main categories (Dumas et al., 2018): evidence-based techniques - document analysis, observation, and automated process discovery -, interviews and workshops. Each one has its own strengths and weaknesses. Also, given budget and time constraints, analysts usually apply a mixture of methods to gather as much complementary information as possible (Dumas et al., 2018). The different methods with strengths and weaknesses:

- **Document Analysis.**
  - Strengths: structured information and independency from stakeholder's availability.
  - Weaknesses: outdated material and the wrong level of abstraction.
- **Observation**
  - Strengths: context-rich insights.
  - Weaknesses: potentially intrusive, stakeholders likely to behave differently, and only a few cases and not all processes can be observed.
- **Automated Discovery**
  - Strengths: extensive set of cases and objective data.
  - Weaknesses: potential issue with data quality and level of abstraction, data may not be available or be available only in part, and data extraction and preparation is time-consuming.

- **Interviews**
  - Strengths: context-rich insights.
  - Weaknesses: requires the spare time of stakeholders and is time-consuming.
- **Workshops**
  - Strengths: context-rich insights and direct resolution of conflicting views.
  - Weaknesses: requires simultaneous availability of multiple stakeholders and is time-consuming: multiple sessions typically required.

2.3 Process Analysis

The aim of this stage is to detect opportunities for process improvement (Dumas et al., 2018). For that purpose, qualitative and/or quantitative techniques can be deployed to identify, document, and analyse issues conditioning the performance of as-is processes, each one with its own requirements in terms of resources, complexity, among other factors (Andersen, 2007). Keeping in mind the project being developed, in the following sections, there are some of the most suitable techniques.

2.3.1 Value-added Analysis

It focuses on analysing each step of a process in terms of the value it generates from a customer point of view, classifying them into three categories (Dumas et al., 2018):

- Value Adding steps (VA) are those that bring satisfaction and produce value for the customer.
- Business Value Adding steps (BVA) are those that are non-value adding for the customer but are relevant for the organization's operations to flow easily.
- Non-value Adding steps (NVA) are those that do not fit into the other categories.

Given this categorization, process analysts should focus their efforts on eliminating non-value-adding steps during the next phases of the BPM lifecycle.

2.3.2 Root Cause Analysis

Commonly referred to as problem-solving techniques, the main goal of this vast family of methods is to identify and understand the possible causes of a problem or undesirable event that is preventing a given process from experiencing a better performance (Dumas et al., 2018). One of the most widely used diagrams specifically in the quality management field is cause-and-effect diagrams, also known as fishbone diagrams. This type of diagrams enables a greater understanding of the information gathered as causes are grouped into categories and sub-categories according to their degree of kinship. Common categories such as people, machines and equipment, methods, materials, measurement, and environment (organizational culture and

structure, physical environment, etc.) for physical processes and people, processes, framework conditions, and Work environment in case of service processes can be used as guidelines to this activity (Andersen, 2007).

2.3.3 Pareto Analysis

Commonly referred to as the 80-20 rule, the Pareto principle was first formulated by the Italian mathematician Vilfredo Pareto during the 1800s, stating that the majority of effects, often around 80 percent, resulting from a small number of causes, often only 20 percent (Andersen, 2007). The Pareto chart is a technique used to graphically represent this biased reality, emphasizing the degree of severeness of each cause of a given problem, usually expressed in monetary or frequency terms. Also, it can aid process analysts in identifying the more significant issues in which they should focus on the subsequent phases of the BPM lifecycle (Dumas et al., 2018).

2.4 Process Improvement

After detecting, analysing, and possibly quantifying the processes' shortcomings, this stage aims to develop possible solutions or improvements that will address the issues previously identified, consequently allowing the organization to fulfill its performance goals (Dumas et al., 2018). Generating new ideas and choosing the ones most suitable to address the problems identified are the first steps of this stage (Sharp, 2001). To do that, creative techniques such as brainstorming, affinity diagrams, six thinking hats can be employed (Dumas, 2008; Andersen, 2007). Also, improvement suggestions may have been provided by the stakeholders involved in the previous stages of the BPM initiative, so it is worth reviewing previous material collected (McDermott & Sharp, 2008). The next and final step is developing and documenting the improved version of the process with the required level of detail (McDermott & Sharp, 2008).

A wide spectrum of process redesign methods is available, as represented by the Redesign Orbit proposed by Dumas et al. (2018). Methodologies are classified according to three criteria: ambition, nature, and perspective. The first refers to the degree of change it intends on generating; the second to the essence of the tools used; and the third to the point of view adopted by the redesign method (Dumas et al., 2018).

Heuristics Process Redesign is a methodology that consists of applying a set of principles with the previous history of successful application, leading to an improved version of processes (Dumas et al, 2018). In total, there are 29 process heuristics available, grouped into six categories according to the elements that portray a given business process (Reijers & Mansarb, 2002; Dumas et al, 2018): customers, business process operation, business process behaviour, organization, information, technology, and the external environment.

2.5 Process Implementation

Once redesigned, the to-be version of the process is implemented, generally requiring organizational change management and/or process automation (McDermott & Sharp, 2008). The first includes all activities necessary to change how process participants work, thus, guaranteeing a pacific transition to the improved version of the process: clarifying the extent of required changes and reasons that justify them, when they will come into effect, provide training, etc. On the other hand, the second refers to implementing or refining IT systems to support process participants in the performance of tasks of the improved process: establishing assignment rules and prioritization principles, sharing required information with process participants, etc. According to Andersen (2007), the implementation phase can be disaggregated into several subtasks, each one equally important for the success of the initiative:

- Assess and prioritize the implementation proposals based on the expected effects of the solutions developed and the necessary requirements.
- Develop an implementation plan, covering relevant elements such as the activities that must be carried out, the sequence in which they should take place, and who is responsible for each one. Furthermore, a schedule for the implementation phase should be presented and targets for the solutions being implemented, and an estimation of the costs.
- Blossom a positive atmosphere for the required changes to occur, as studies have demonstrated that resistance to change is the leading cause of failure of change projects in organizations, despite using the suitable change approach (Andersen, 2007). To overcome this issue, involving all the employees impacted by the process being improved and keeping them informed about the project, and developing and following a communication plan are possible strategies to enhance the acceptance of the change.
- Execute the implementation itself.

3. Process Map analysis

According to the multi-level methodology introduced in section 2.2, the first step when addressing the overall analysis of the process organization stays on designing the process map and identifying the corresponding critical processes.

In order to collect the information needed to prepare the process map, a set of interviews with the top managers of Smart Separations, namely the CEO, Business Development Manager, and Product Owners, was conducted.

The information collected from the interviews led to the construction of the Process Map, represented in Figure 1.

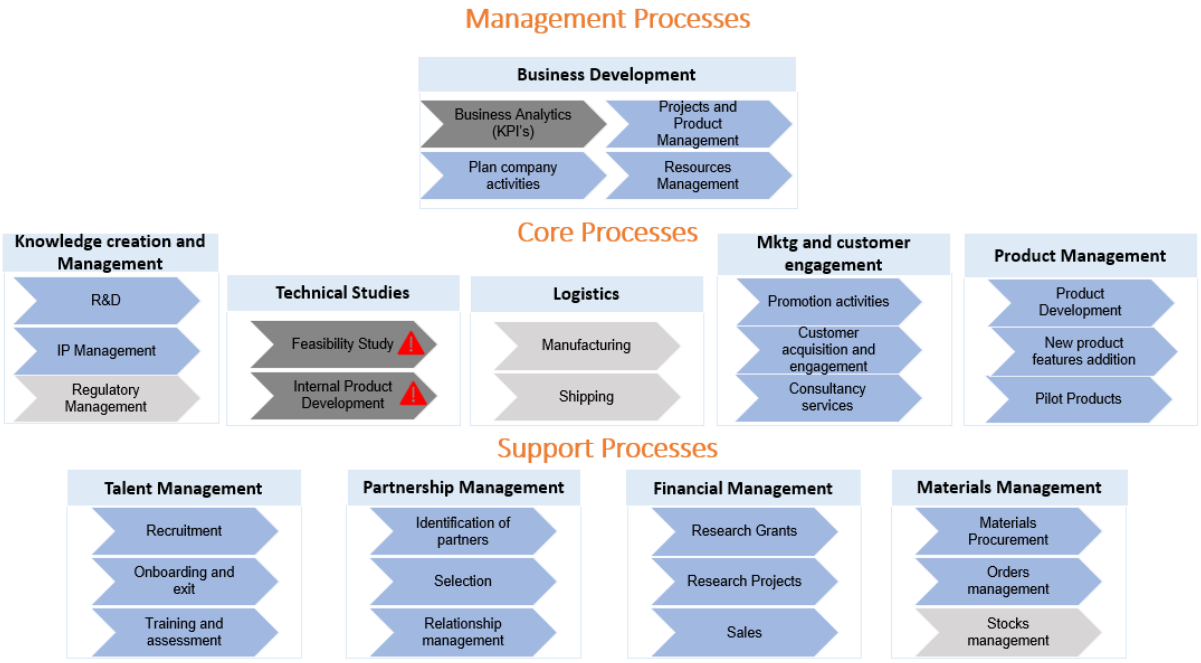

Figure 1: Smart Separations process map

The process map is organized into three main layers: management, core, and support processes. Within each layer, processes are organized in groups, each one corresponding to an activity area.

The **Core processes** were displayed according to the following five groups:

- **Knowledge Creation and Management:** Research and Development (R&D), Intellectual Property (IP) Management, and Regulatory Management processes are included.
- **Technical Studies:** this area includes the Feasibility Study and the Internal Product Development processes, which will be analysed in more detail within this project.
- **Logistics:** includes the Manufacturing process, due to start next year, as well as the Shipping process.
- **Marketing and Customer Engagement**: comprehending Promotion activities, Acquisition, and Customer Engagement. The company also offered the Consulting Services process. However, these have been discontinued.
- **Product Management**: portrayed by the Product Development process, the New Product Addition features process, the Antiviral Trials process, and the Pilot Product processes.

Support processes were arranged in the following groups:

- **Talent Management:** including the Recruitment process, the Onboarding and Exit processes, and the Training and Assessment processes.
- **Partnership Management:** involving the processes associated with Partner Identification, Selection, and Relationship Management processes.
- **Financial Management:** linking to Research Grants, Research Projects, and Sales processes.
- **Materials Management:** involving the Materials acquisition, Order management, and Stock management processes.

For **Management processes,** only one group was considered:

- **Business Development:** The addressed processes include Business Analytics regarding the definition of the company's performance indicators. Also, the Project and Product Management, Company activities planning, and Resources management processes.

From the data collected in the interviews, it was also possible to identify those processes that needed improvement and, between them, those which must be prioritised.

The following table summarizes the initial situation at Smart Separations, as far as process maturity status and priority of action are concerned.

PROCESS	INITIAL SITUATION	PRIORITY
MANAGEMENT PROCESSES		
Business Development		
Business Analytics (KPI's)	Needs improvement	Critical
Planning the company activities	Ok	N/A
Projects and Product Management	To be implemented	Low
Resources Management	To be implemented	Low
CORE PROCESSES		
Knowledge creation		
R&D	Ok	N/A
IP Management	To be implemented	Low
Regulatory Management	Needs improvement	High
Promotion activities	Needs improvement	Low
Customer acquisition and engagement	Needs improvement	High
Consultancy Services	Needs improvement	Low
Customer service	To be implemented	Low
Logistics		
Manufacturing	To be implemented	High
Shipping	Ok	High
Product Management		
Product Development	Needs improvement	Low
New Product features addition	To be implemented	Low
Antiviral Assays	Needs improvement	Low
Technical Studies		
Feasibility Study	Needs improvement	Critical
Internal Product Development	Needs improvement	Critical
SUPPORT PROCESSES		
Talent Management		
Recruitment	Ok	N/A
Onboarding and exit	To be implemented	Low
Training and Assessment	Needs improvement	Low
Partnership Management		
Partners Identification	To be implemented	Low
Partners Selection	Needs improvement	Low
Relationship Management	Needs improvement	Low
Financial Management		
Research Grants	Needs improvement	Low
Research Projects	Needs improvement	Low
Sales	To be implemented	Low
Materials Management		
Materials Procurement	To be implemented	Low
Orders Management	To be implemented	Low
Stocks Management	Needs improvement	High

Table 1- Situation at the beginning of the project and currently

The process maturity assessment resulted from a series of meetings with the Smart Separations management team, namely the CEO, Product Owners, and Lab Manager. From these meetings, a consensus was built up on the idea that the processes that should be addressed first were those of Technical Studies activity area, namely the processes Feasibility Study and Internal Product Development. These two processes are critical because they directly impact business performance, and simultaneously, they present multiple improvement opportunities.

The **Technical Studies** area includes two main strands of action: one dealing with the request coming from external customers- Feasibility Study- the other dealing with the request from internal customers, SSL- Internal Product Development process.

A **Feasibility Study** is triggered by a request of an external customer to test a particular substrate where Smart Separations will cover their sample to measure the antimicrobial activity. In this case, the tests are performed by an external laboratory.

In the case of **Internal Product Development**, by default, the tests are performed in the internal lab of Smart Separations. Whether the internal lab is not equipped to perform a specific test, the test request is forwarded to an external lab.

As such, the two strands have one sub-process in common – Perform Test. According to the opinion of Intelligent Separations managers, this is the most critical process included in the Feasibility Study and Internal Product Development processes. As such, these must be carefully managed, especially when using external laboratories.

In the next step, we will dive into the detailed analysis of these processes to redesign an improved version of them. For each process, the AS-IS and TO-BE models will be presented. These models will address the following perspectives: the main phases, milestones, main activities, people involved, and the tools for managing the process phases.

In Chapter 4, the tracking tools that aim to monitor the status of the process course will be analysed, and by collecting data from these tools, KPI's will be designed to evaluate the company's performance.

Figure 2 summarizes the concepts introduced so far from the Technical Studies process area.

[MLCPFdS1]

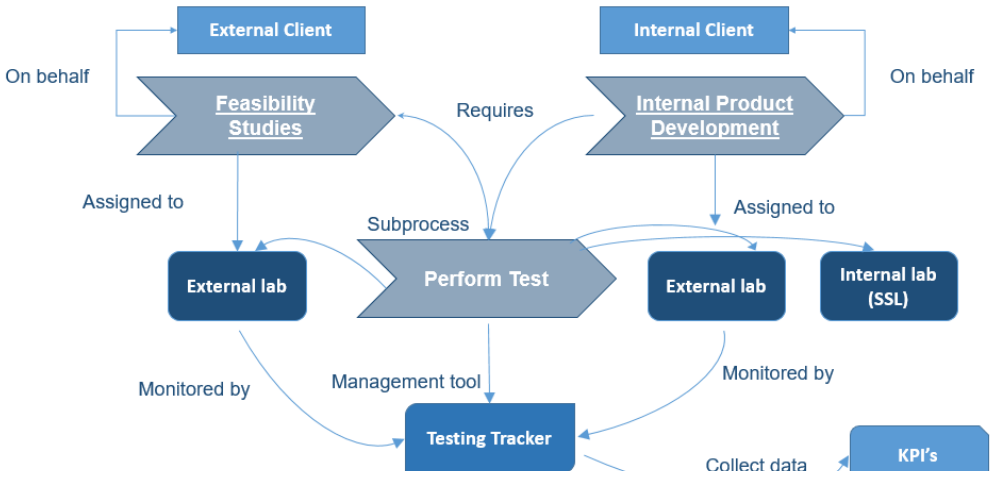

Figure 2- Technical Studies: Conceptual Map

4. Technical Studies: AS-IS and TO-BE analysis

As previously stated, the process modelling will focus on the Technical Studies process. The detailed analysis of the Feasibility Study and Internal Product Development using the AS-IS and TO-BE models of each phase of the process will be presented next.

4.1 Feasibility Study process analysis

The process fact sheet of Figure 3 summarizes the key elements of the Feasibility Study process, namely its trigger, result, inputs, outputs, and main activities.

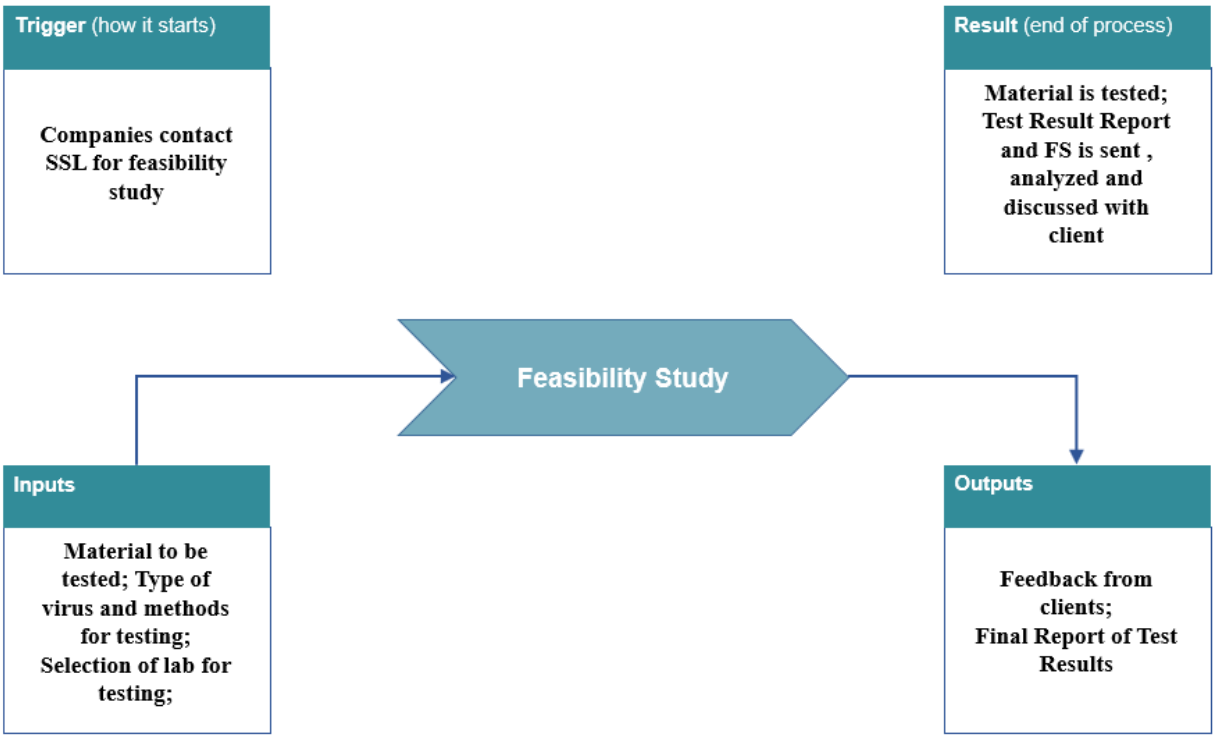

Figure 3- Fact sheet of Feasibility Study process

The second model that we considered when analysing this process is the responsibility matrix.

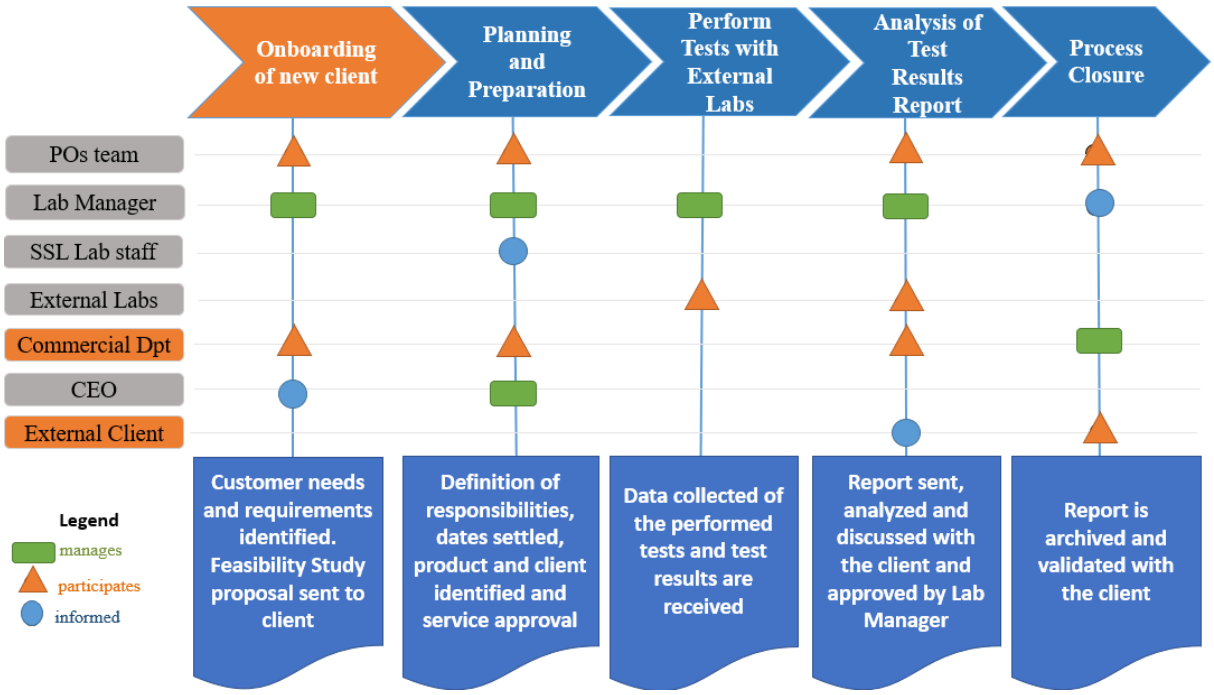

Figure 4- Responsibility Matrix of Feasibility Study Process

This high-level model details the main phases of the process, the main outcome of each stage (i.e., the milestone), actors in each phase, along with their responsibility, as represented in Figure 4.

In terms of responsibility, a green circle means that the actor is the main responsible for achieving the phase's milestone in time and quality. An orange circle indicates that the author participates in the phase. A blue circle means that the actor is notified (informed) about the major events in the process.

A Feasibility Study includes five phases as follows:

- **Phase 1: Onboarding a new customer:** the participants involved in this phase are the POs, who identify the tests to be performed. The Commercial Department is responsible for satisfying the customer, defining their needs and requirements, and sending the Feasibility Study proposal to the customer.

The milestones to be reached in this phase of the process are identifying the customer's needs and requirements and sending the Feasibility Study proposal to the customer.

- **Phase 2: Planning and Preparation:** the POs are responsible for deciding the external lab to perform the tests, the Lab Manager is responsible for managing the planning, preparation, and delegation of responsibilities of the Feasibility Study. Also, it is responsible for overseeing the Feasibility Study and definition of milestones. The Smart Separations Lab staff is informed about this planning.

  To execute the tests, it is necessary to have financial approval from the CEO.

  The Commercial Department participates in this phase by identifying the customer and the product of the Feasibility Study. It is also accountable for sending, analysing, and negotiating the Feasibility Study contract with the customer. To be able to execute the tests on the customer's required substrate, the external client needs to send the samples to Smart Separations.

  The final milestones to achieve in this phase are defining the people responsible for the process, establishing the critical dates, identifying the product and the customer, and the approval for Smart Separations to perform the service.

- **Phase 3: Perform Tests with External Lab:** it involves the External Labs, responsible for performing the tests and sending the Test Results Report to Smart Separations. The Lab Manager manages the relationship with the external labs and their performance.

  The milestones of this phase are the collection of the raw data, performing the tests, and receiving the test results. This is a common phase with the Internal Product Development process, as mentioned earlier.

- **Phase 4: Analysis and Discussion of Test Results Report:** the participants involved in this phase are the POs who receive, save, and analyse the Test Results Report. The Commercial Dept is responsible for communicating and discussing the Test Results Report with the client. If the Test Results Report presents errors or needs changes, the Lab Manager or POs request the necessary changes to the External Lab.

  Then, the External Lab is required to action the requested in the Test Results Report. The Lab Manager is responsible for managing the relationship between Smart Separations and External Lab, and the External Client is informed.

  This phase’s milestones is sending the reviewed test result report once the Lab Manager validates it

- **Phase 5: Process Closure:** the PO's will take the necessary actions based on the test result report, always supervised by the Lab Manager. The Commercial Department will then send the Feasibility Study to the client.

In another round of meetings with the company managers directly involved in this process, it was collected the information needed for the swimlane models representing the detailed workflow of the processes within each phase.

The models for the five phases of the Feasibility Study process are presented in Appendix A.

Hereafter it will solely discuss the swimlane models for those phases that need improvement: *Planning and Preparation*, *Analysis of Test Results Report* and *Process Closure* phases.

4.1.1 Planning and Preparation Phase

Figure 5 summarizes the AS-IS and TO-BE model for **Planning and Preparation** phase.

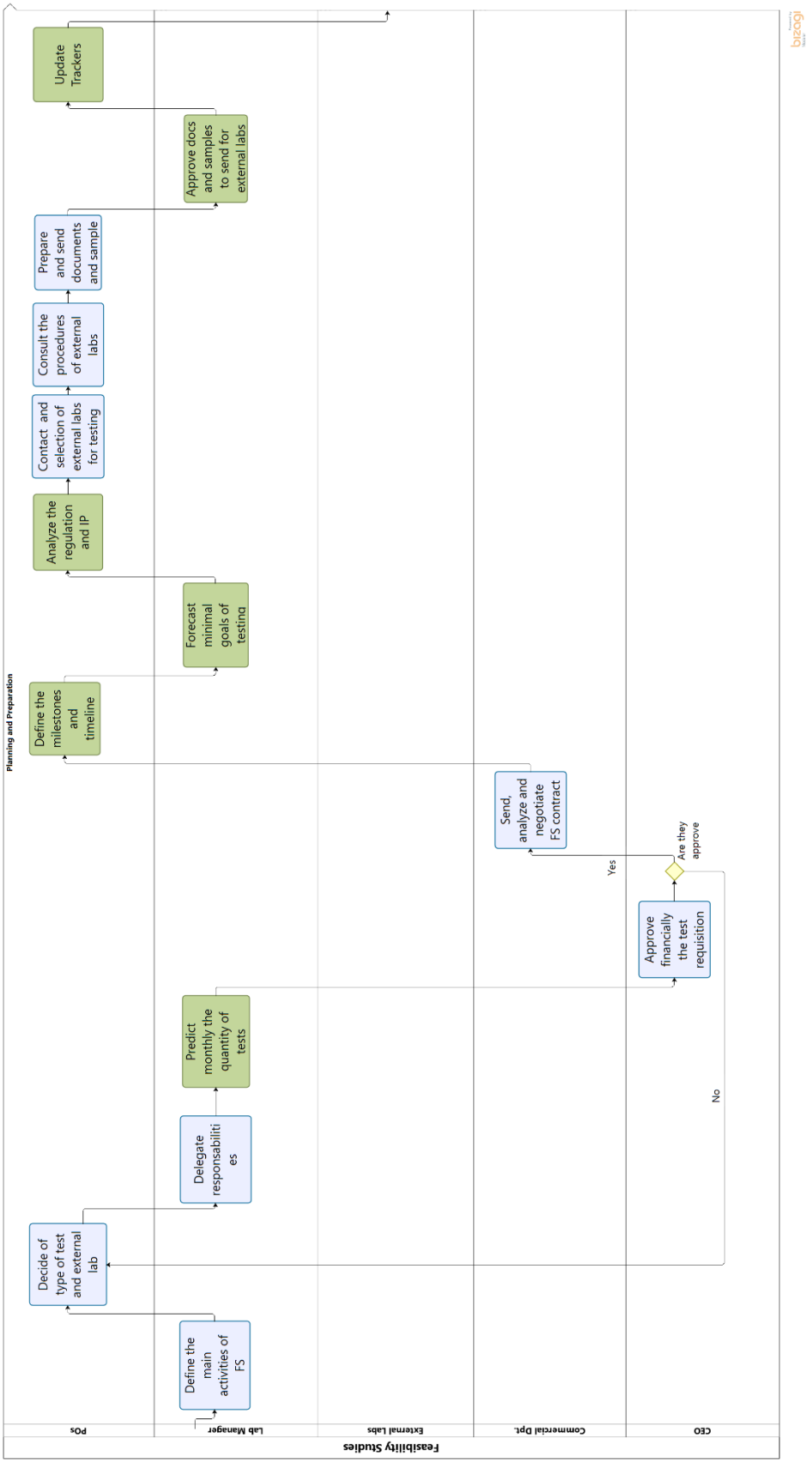

Figure 5- Phase of Planning and Preparation of Feasibility Study Process: AS-IS and TO-BE

The tasks of the process in its initial version are represented with a blue background. The set of tasks with green background corresponds to our proposal for the improvement of the process.

The rationale for these new tasks is as follows:

- **Forecast the number of tests to be performed:** There is always a great deal of urgency in conducting the tests and in receiving the test results. The fact that there is no budget planning for the tests causes the CEO to postpone the approval of the tests resulting in additional payment to external laboratories to get the test results urgently.

  As such, a monthly test forecast is suggested to predict the budget allocated to tests each month and allow for a more efficient test approval.

- **Define the milestones, timing, and prediction of minimum objectives for the tests:** At the beginning of each process (Feasibility Study or Internal Product Development), the company determines the type of tests needed to be performed in external laboratories. However, the external labs often realize that they were not as prepared to test that substrate, or Smart Separations change the priority of performing the tests.

  With this in mind, the company has no defined action plan, so it is essential to strengthening the implementation of the planning and preparation phase and the implementation of these activities.

  In addition, it would also be crucial to determine a timeline for the entire Feasibility Study process and clarify the milestones achieved with testing. In this way, it would be possible to have greater visibility of the objectives to be achieved and a better plan for the activities to be carried out.

- **Analyse the regulations and intellectual property:** To avoid problems during the Feasibility Study process, it would be prudent to analyse the regulations and intellectual property required for testing. This way, it was possible to anticipate possible regulatory setbacks in marketing products of different countries and ensure their intellectual property.

- **Approve documents and samples for sending to external laboratories:** When sending documents and samples to external labs, they are often sent late or do not meet the lab's requirements and have errors resulting in a delay in testing, as the documents have to be corrected. Therefore, the lab manager's verification and approval of documents and samples before sending them to the external lab are important to reduce testing delays.

- **Update the Technical Data Tracker (Database) and Test Progress Tracker:** There is a need to create tools to track the process considering the independent management of the process by each PO, lack of visibility of responsibilities, and lack of control and recording of activities performed in the company.

4.1.2 Analysis of the Test Results Phase

The second phase of the Feasibility Study process that needs improvement is the **Analysis of Test Results** phase. Figure 6 will show the activities performed in the AS-IS and TO-BE models for this phase.

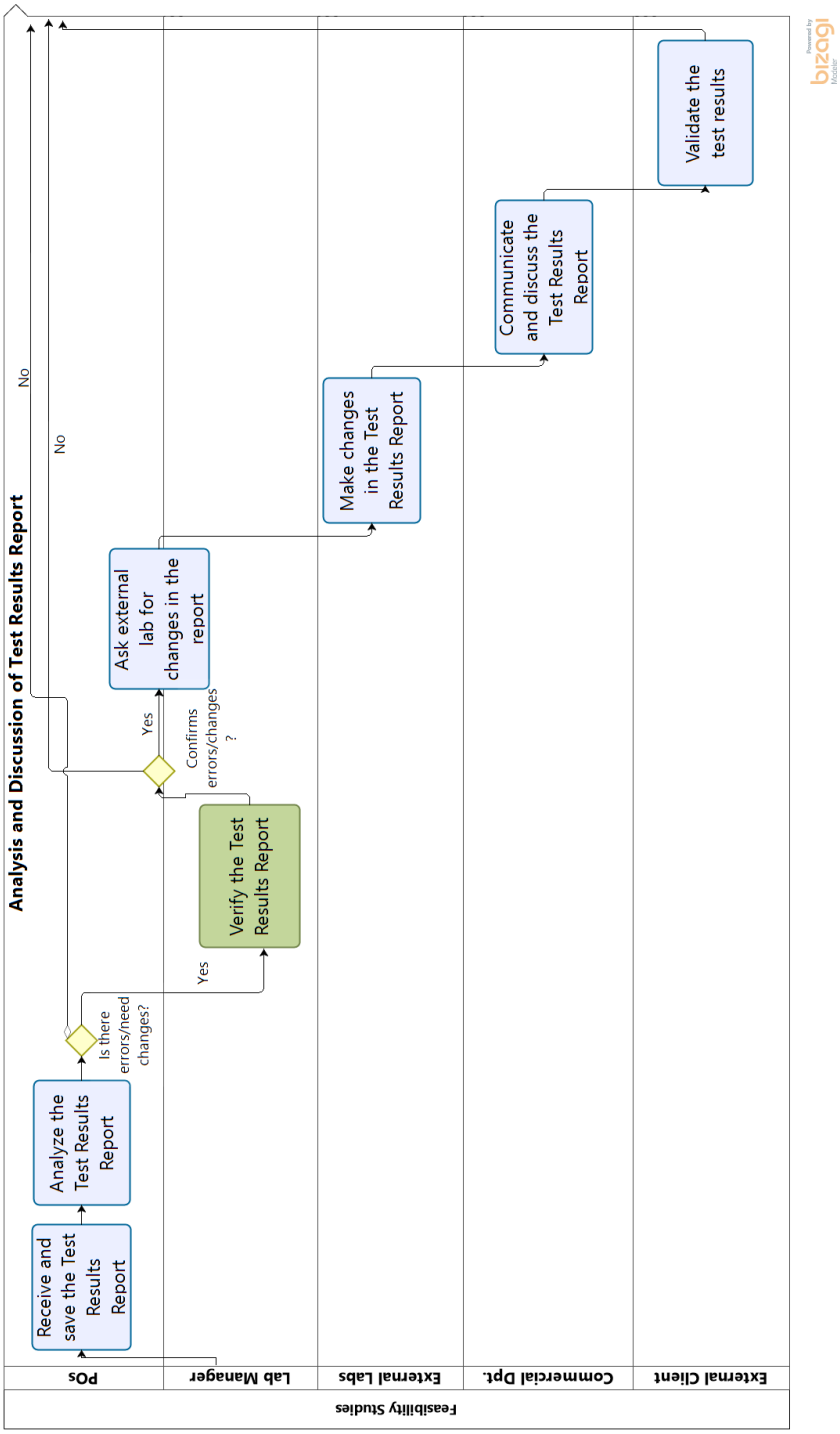

Figure 6- Phase of Analysis and Discussion of Test Results Report of Feasibility Study Process: AS-IS and TO-BE

The rationale for these improvements is as follows:

- **Verify the Test Results Report:** The Lab Manager's additional verification of the Test Results Report would be beneficial to the company in order to overcome some of the difficulties experienced in this process.

  The fact that the test results and their reports are not uniform means that they usually need to be changed due to errors or missing relevant information. With this, the POs have to analyse the errors and contact the external labs again to make these changes, causing a delay in delivering and analysing the respective reports.

  Thus, with the double-checking of the Test Results Report from the Lab Manager, it would be possible to centralise the confirmation of the need for changes in the reports, reduce the request for corrections to external labs, and reduce the time to receive the test results reports.

4.1.3 Process Closure Phase

For the **Process Closure** phase, a number of significant improvements are also suggested, as represented in Figure 7.

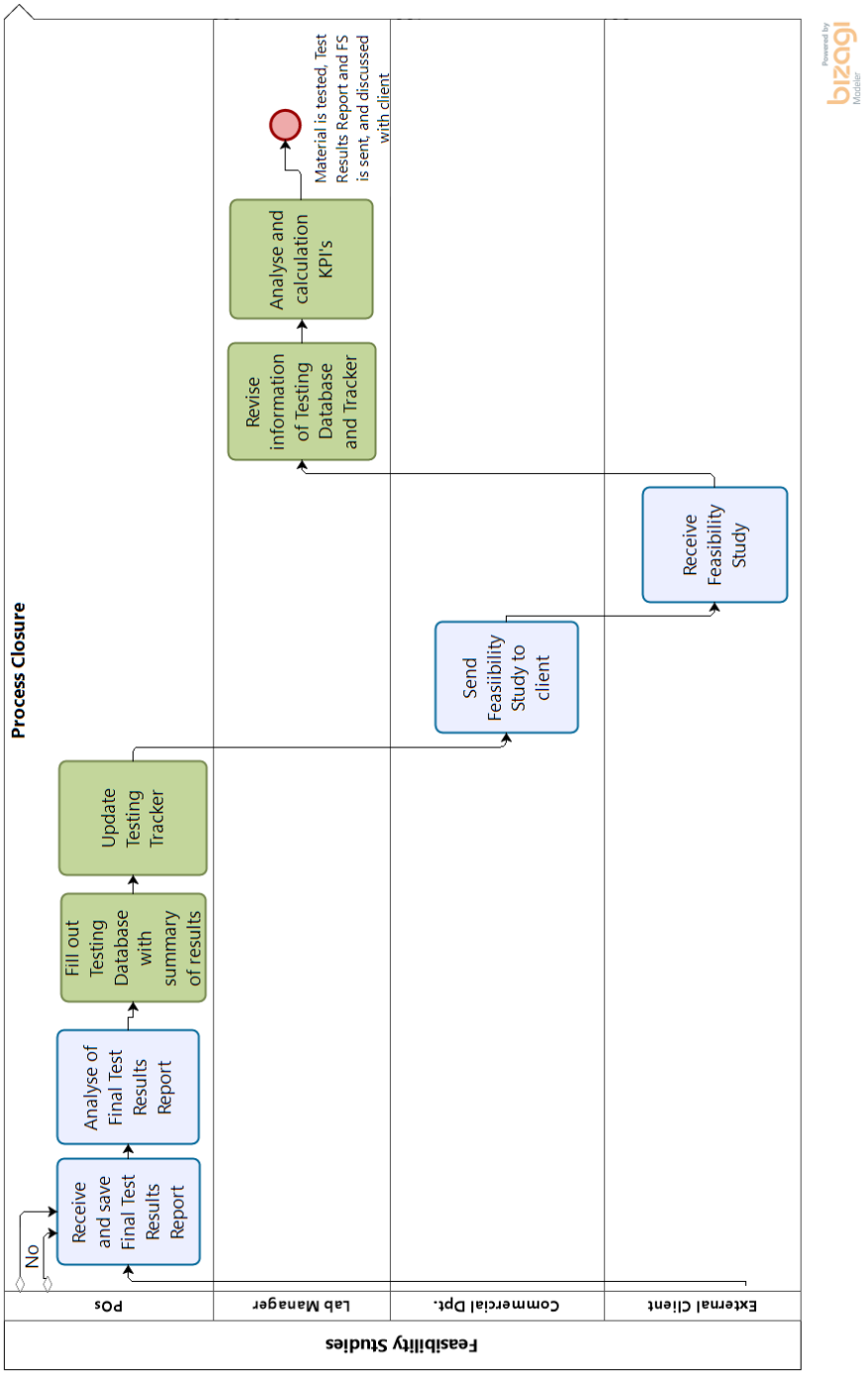

Figure 7- Phase of Process Closure of Feasibility Study Process: AS-IS and TO-BE

According to the company's objectives for this dissertation, indicated in section 1.4, some management tools were developed to enable the management and permanent monitoring of processes and the calculation of performance indicators developed in more detail in the next section of this dissertation document.

With this in mind, suggestions for improvement for the last phase of the Feasibility Study process include the use of these tools and the review of the information contained in these files, as well as the evaluation of the organization's performance through the calculation and analysis of KPI's.

In summary:

The analysis of the workflow of the Feasibility Study process and through meetings with company members led to the identification of some cross-cutting problems and difficulties present throughout the process:

- Internal communication problems
- Lack of visibility of the responsibility of each process
- Different people manage the same type of process in different ways.
- Lack of contact with customers by the Product Owners (that manage the process), since only the commercial representatives maintain direct contact with the customers. This way, it becomes difficult to clarify technical questions when needed.

The improvement suggestions presented before aim to tackle these difficulties.

4.2 Internal Product Development Process

This section presents the analysis of the Internal Product Development process similar to the previously done analysis.

As before, below, Figures 8 and 9 represent the fact sheet and the responsibility matrix of this new process.

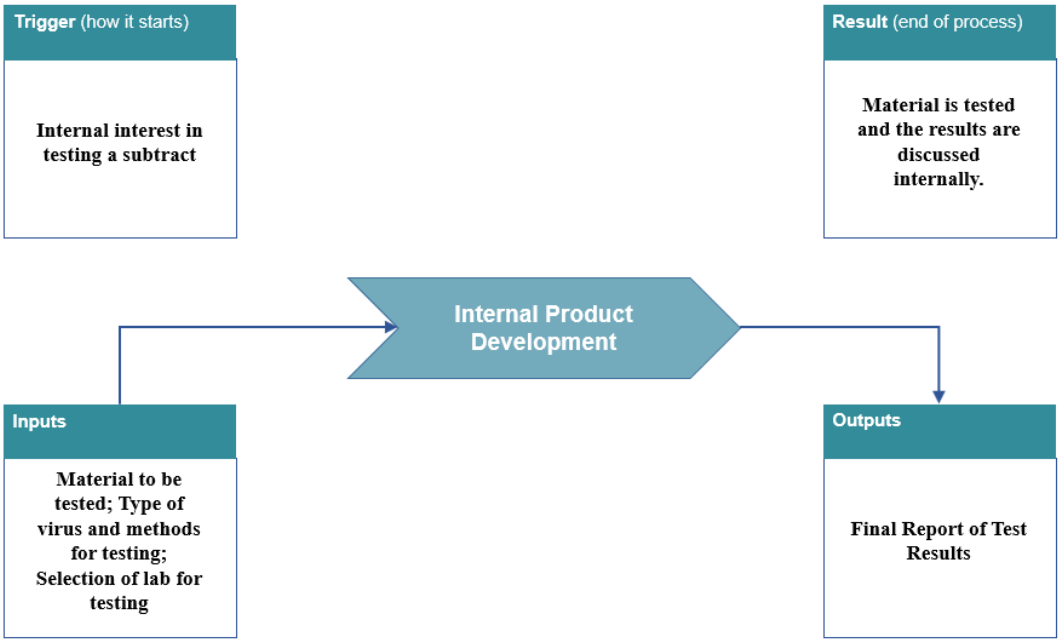

Figure 8- Fact sheet of Internal Product Development process

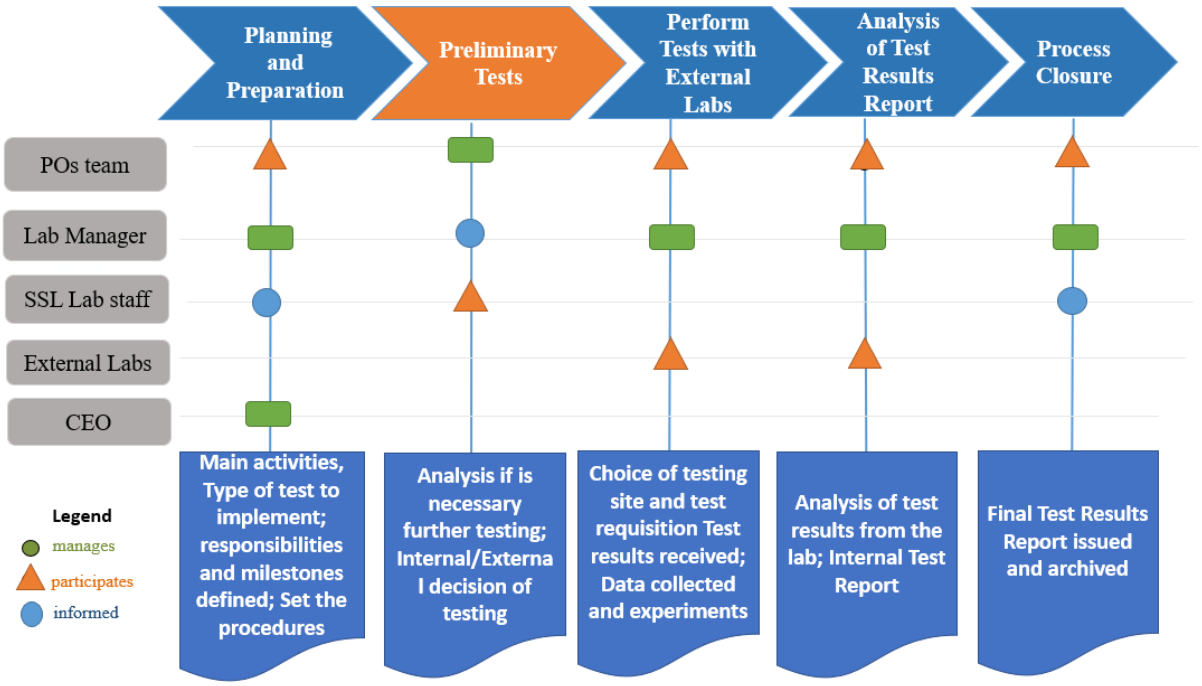

Figure 9- Responsibility Matrix of Internal Product Development Process

The swimlane models for the five phases of this process are presented in Appendix B.

As it became apparent from the responsibility matrixes, these two processes have many common points but also some important differences between them.

The analysis of the two processes shows that the main differences between them are as follows:

- Feasibility Study process has the phase of Onboarding with the new customer that does not exist in the other process
- Internal Product Development has the Preliminary Tests phase, in which basic and experimental tests on the samples are performed in the Smart Separations lab and do not apply to the other process.

This means that the Feasibility Study process has two actors that are not present in the Internal Product Development process: the external client and commercial department

Figure 10 and Table 2 highlight the differences between the two processes.

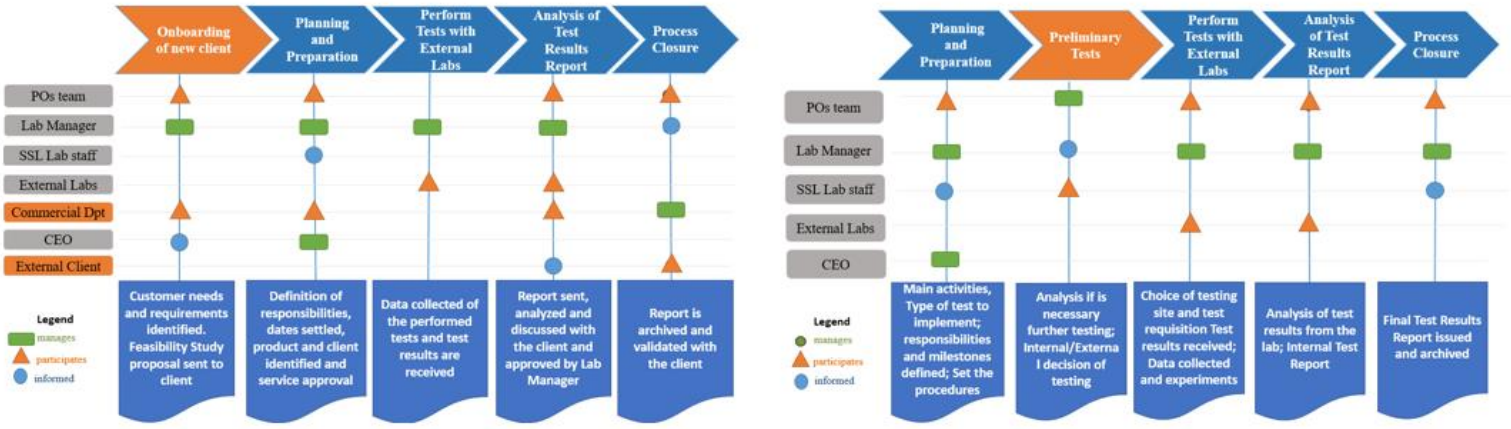

Figure 10- Comparison between Responsibility Matrix of Feasibility Study and Internal Product Development Process

There are also several differences at the responsibility level within each phase. Those differences are summarized in Table 2.

	Onboarding of new client		Planning and preparation		Preliminary Tests		External Testing		Analysis of Test Results		Process Closure	
Actors	**FS**	**IPD**	**FS**	**IPD**	**FS**	**IPD**	**FS**	**IPD**	**FS**	**IPD**	**FS**	**IPD**
PO's Team	P	-----	P	P	----	M	-----	P	P	P	P	P
Lab Manager	M	-----	M	M	----	I	M	M	M	M	I	M
SSL Lab Staff	------	-----	I	I	----	P	-----	-----	-----	-----	-----	I
External Labs	-----	-----	-----	-----	----	-----	P	P	P	P	-----	-----
Commercial Dept	P	-----	P	-----	----	-----	-----	-----	P	-----	M	-----
CEO	I	-----	M	M	----	-----	-----	-----	-----	-----	-----	-----
External Client	-----	-----	-----	-----	----	-----	-----	-----	I	-----	P	-----

Legend: **M**-Manages; **P**- Participates; **I**-Informed
FS- Feasibility Study process; **IPD**- Internal Product Development process

Table 2- Comparison table for each of the phases of the Feasibility Study and Internal Product Development processes

5. Tracking System

The analysis of the technical studies processes made evident the need for a process tracking tool, providing two main functionalities: control the progress and the status of the running processes, and collect the data needed to calculate a set of KPIs allowing the performance of these critical processes.

From the discussions with the Smart Separations team, it was decided in a consensus that the tracking tools should focus specifically on controlling the interactions of the company with external labs as this is a critical point for the business's success.

In the current situation, people feel a lack of control and increased risk of interactions with external labs that cause several problems to Smart Separations. Inevitably, the fact that they use external laboratories affects Smart Separations' relationship with its customers since the outcomes of these processes will always depend on the efficiency and quality of services provided by the external laboratories.

It was also decided that two distinctive tools will be put in place as part of this project: one providing a record of the technical data regarding all the tests performed in the internal and external labs. The second tool is targeted to external lab tests and is intended to keep track of the progress status of the running processes.

The following sections present the analysis and design of these management tracking tools for the Feasibility Study process as this analysis would be pretty similar to the other process.

5.1 Initial Tracking tool

In the first moment, the company tracked the testing activity with just two external labs. It kept a separate tracker for each Product Owner, so it was impossible to have an overall view of the testing process.

Moreover, the following problems were identified regarding the existing tracking tools:

- The document missed important data regarding the tests performed in external labs. On the other hand, some data fields were not filled as they were irrelevant.
- It only tracked two specific external labs, i.e., it did not consider the other external labs that the company also uses.
- It did not track the entire testing process with the external labs.
- The file was not filled out completely, nor was it updated regularly enough.
- When filling it in, since several different people were using the same file, the information contained in the document was confusing and often duplicated, creating misunderstandings among employees.

Appendix C presents a summary of the data recorded on the existing tracking tool.

5.2 Improved Tracking tools

This section discusses the improved versions of the management tools: two trackers developed regarding the testing activity, a support document for these two trackers, and a tracker created for the company regulatory, namely:

- **Technical Data Tracker:** as mentioned before, it keeps track of the technical data for the tests performed in the internal and external labs
- **Test Progress Tracker:** keeps track of the progress and status of the tests conducted only in external labs.
- **Test Procurement Sheet:** this is a document that was also developed intended to display all the tests possible to be performed in each external laboratory
- **Labelling Process Tracker:** it is another new record regarding the company's regulatory area intended to track the creation of labels within Smart Separations.

Given this section, it is possible to look at the Feasibility Study, Internal Product Development processes in their current state, and the proposed improvements in terms of the activities, documents, and software used, available in Appendix D and E.

5.2.1 Technical Data Tracker

Initially, it was being developed a testing database intended to help understand the status of any tests, pursue and promptly test suppliers, and verify capability. Later, as part of this project, this database was adapted into the Technical Data Tracker, where all data relating to tests performed both internally and with external laboratories are recorded.

Thus, through the Technical Data Tracker, it is possible to access the history of all tests performed, track the tests, and have complete visibility into the status of the tests.

The following swimlanes and tables represent each phase of the process, the data that should be collected in the fields of Technical Data Tracker, and the tasks where each field should be recorded. In the swimlanes, each task is labelled with a number corresponding to an entry into the table that details the tracker's content.

The same analysis for the Internal Product Development process is presented in Appendix F.

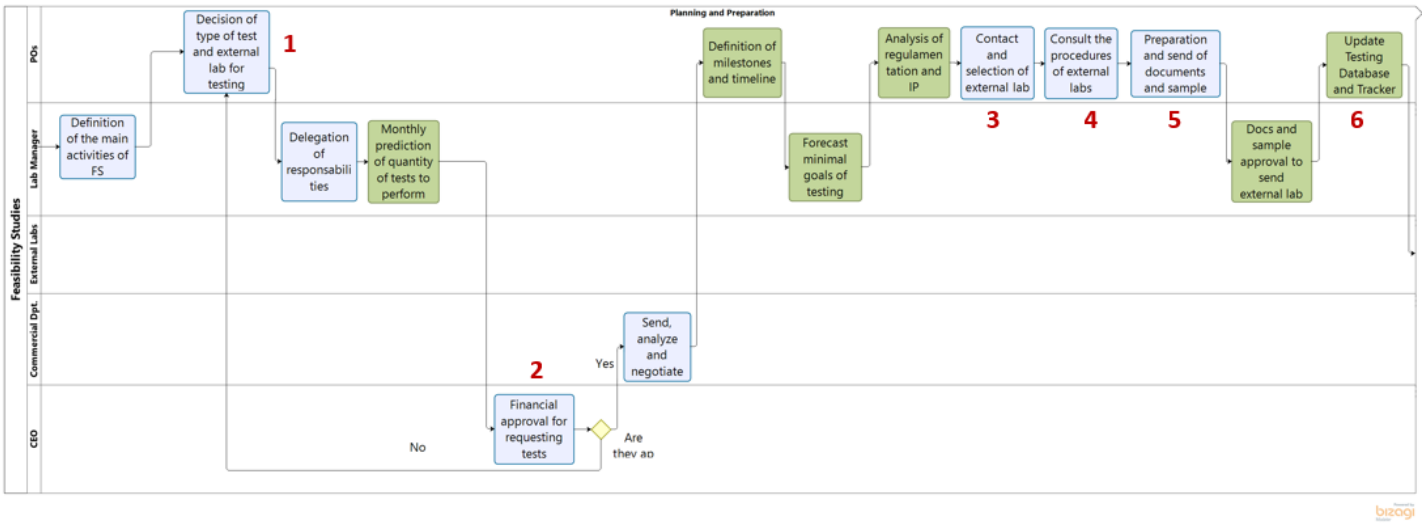

Figure 11- Swimlane of phase Planning and Preparation (TO-BE) of Feasibility Study

Phase	Activity Number	Activity Description	Technical Data Tracker Fields
Planning and Preparation	1	Decision of type of test and external lab for testing	-Testing Ref #. -Sample Ref. -Internal Test or External Test. -Type of Test. -Testing Lab. -Description (experimental set-up, sample condition). -ISO/Test -Microorganism to Test -Cost per sample (£) -Cost per sample (€)
	2	Financial approval for requesting tests	N/A
	3	Contact and selection of external labs for testing	-Procurement Ref -Contact Name -Email of contact
	4	Consult the procedures of external labs	Sample's requirements
	5	Preparation and sending of documents and samples for external labs	Ref# Shipping Number from Shipping Tracker
	6	Update Testing Database and Tracker	X

Table 4- Relationship between phase Planning and Preparation (TO-BE) of Feasibility Study process and Technical Data Tracker fields

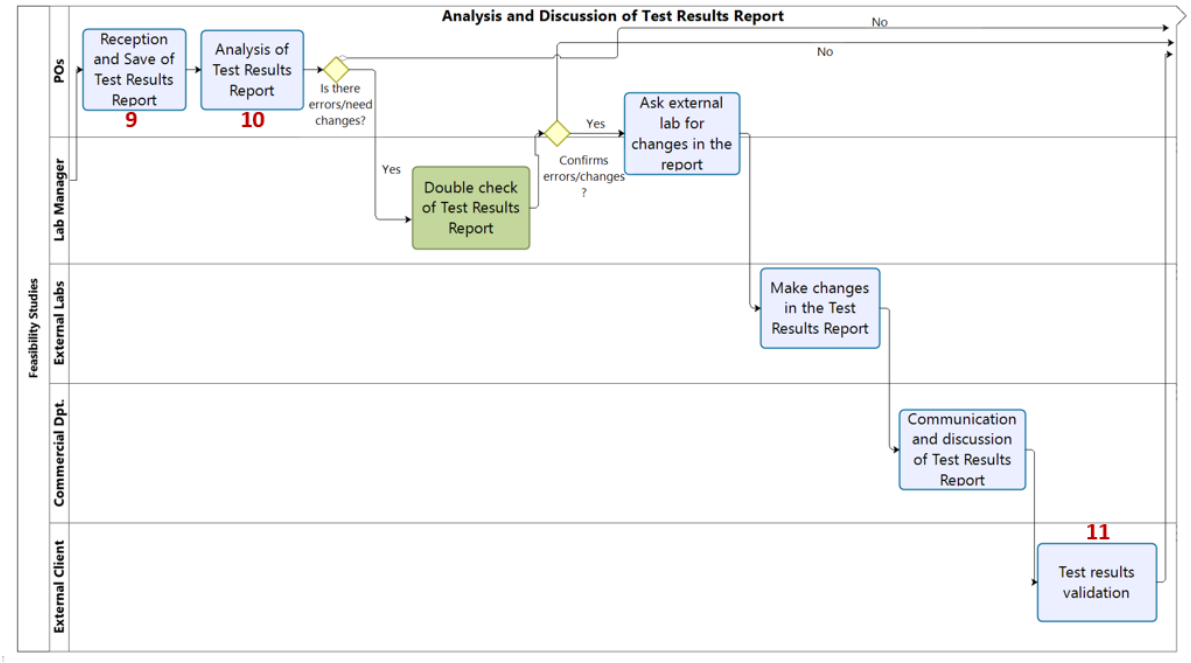

Table 5- Relationship between phase Analysis and Discussion of Test Results Report (TO-

Figure 12- Swimlane of phase Analysis and Discussion of Test Results Report (TO-BE) of Feasibility Study process

Phases	Activity Number	Activity description	Technical Data Tracker fields
Analysis and discussion of Test Results Report	9	Reception and Saving the Test Results Report	Link to External Report (find template here)
	10	Analysis of Test Results Report	Summary of Results/ Conclusions
	11	Test results validation.	Report reviewed and approved by Lab Testing Manager

BE) of Feasibility Study process and Technical Data Tracker fields

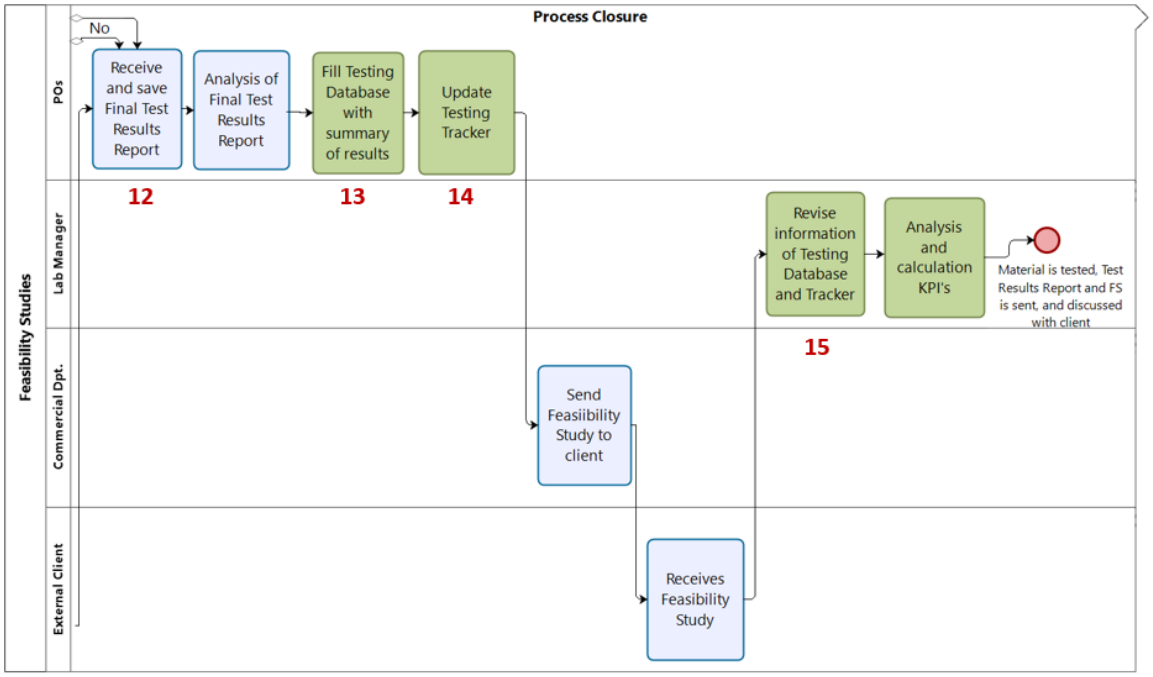

Figure 13- Swimlane of phase Process Closure (TO-BE) of Feasibility Study process

Phases	Activity Number	Activity description	Technical Data Tracker
Process Closure	12	Receive and Save Final Test Results Report	-Link to External Report - Link to Final Report if changes
	13	Fill Testing Database with a summary of tests results	Summary of Results/ Conclusions
	14	Updating Testing Tracker	X
	15	Revise information included in Testing Database and Tracker	Test completed

Table 6- Relationship between phase Process Closure (TO-BE) of Feasibility Study process and Technical Data Tracker fields

5.2.2 Test Progress Tracker

As mentioned before, this section is intended to monitor and track the progress of tests performed in the external labs only.

In addition, the following factors have reinforced the need to create this tracker:

- **Confidentiality:** Although an NDA is used to ensure the confidentiality of the information shared, it is often not enough. Hence, it is important to ensure that the information transmitted with external laboratories is confidential.
- **Standardization of information shared with external laboratories:** to avoid miscommunication both internally and externally with the laboratories, it is crucial to standardize and ensure communication that allows acknowledgment of the same information for both parties.
- **Tracking and quality assurance of performed tests**: a significant number of new samples are regularly sent to external laboratories for testing. This raises many uncertainties regarding the testing methods, test completion, and reliability of its results.

This said the Test Progress Tracker aims to:

- Monitor one of the phases of the FS and IPD processes through a tracker to control testing with external labs
- Centralize requesting laboratory tests' process
- Ensure quality of tests, delivery times, and standardization of test information
- Improve and maintain the healthy relationship between Smart Separations and external laboratory partners
- Centralize information and assure a more effective internal communication

As in the previous section, the Feasibility Study process swimlanes and the table with the process activities with the correspondent data to fill in the Test Progress Tracker will be presented. The same analysis for the Internal Product Development process is shown in Appendix F.

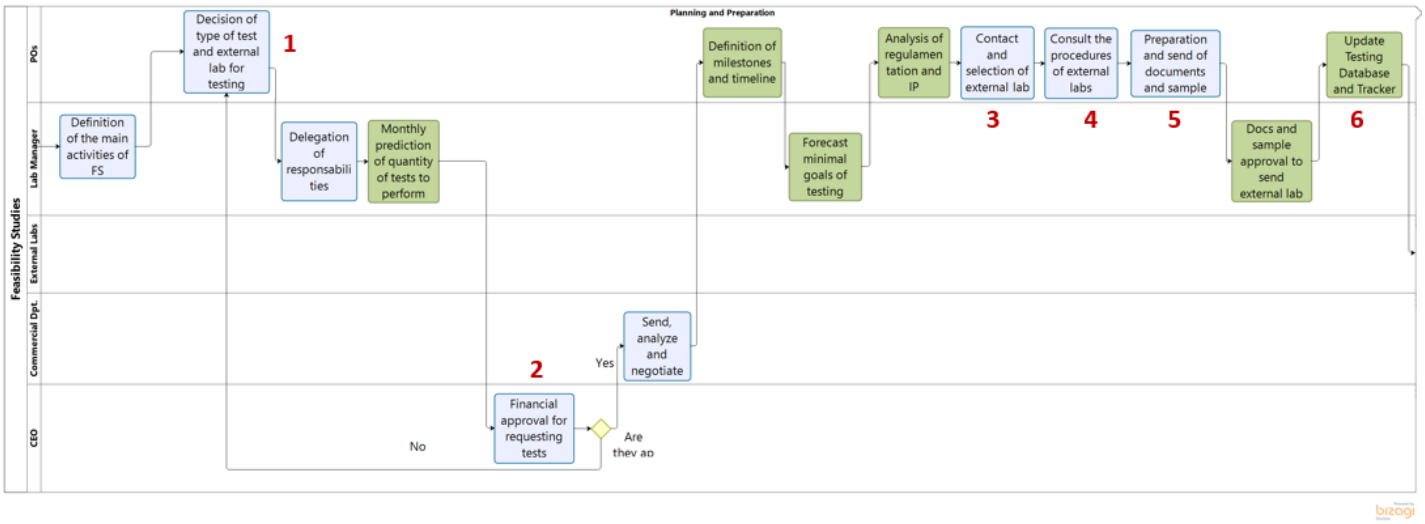

Figure 14- Swimlane of phase Planning and Preparation (TO-BE) of Feasibility Study

Phases	Activity Number	Activity description	Test Progress Tracker field
Planning and Preparation	1	Decision of type of test and external lab for testing	-Testing Ref -Substrate code -External Lab Name
	2	Financial approval for requesting tests	Test financially approved?
	3	Contact and selection of external labs for testing	-Service requested (procurement ref code)
	4	Consult the procedures of external labs	N/A
	5	Preparation and sending of documents and samples for external labs	-Testing request date -Test requested approved by Testing Lab Manager -Purchase order sent? -Purchase order sent date -Sample Submission Form Sent? -Sample Submission Form Sent Date -Samples shipped -Parcel approved? -Samples shipped on (date) -Samples received on (date) -Sample shipping tracker number/link
	6	Update Testing Database and Tracker	X

Table 7- Relationship between phase Planning and Preparation (TO-BE) of Feasibility Study process and Test Progress Tracker fields

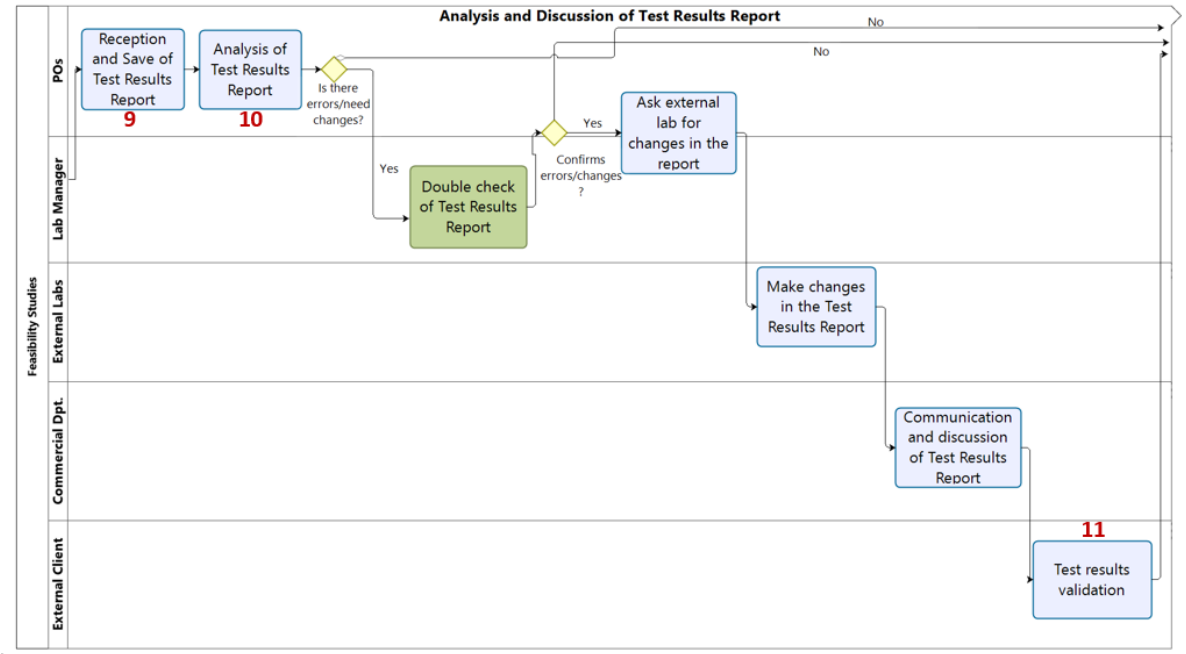

Figure 15- Swimlane of phase Analysis and Discussion of Test Results Report (TO-BE) of Feasibility Study process

Phases	Activity Number	Activity description	Test Progress Tracker field
Analysis and discussion of Test Results Report	9	Reception and Saving the Test Results Report	Report received date (1st version) Final Report Received date
	10	Analysis of Test Results Report	N/A
	11	Test results validation.	Report reviewed and approved by Lab Manager? Final Report approved date

Table 8- Relationship between phase Analysis and Discussion of Test Results Report (TO-BE) of Feasibility Study process and Test Progress Tracker fields

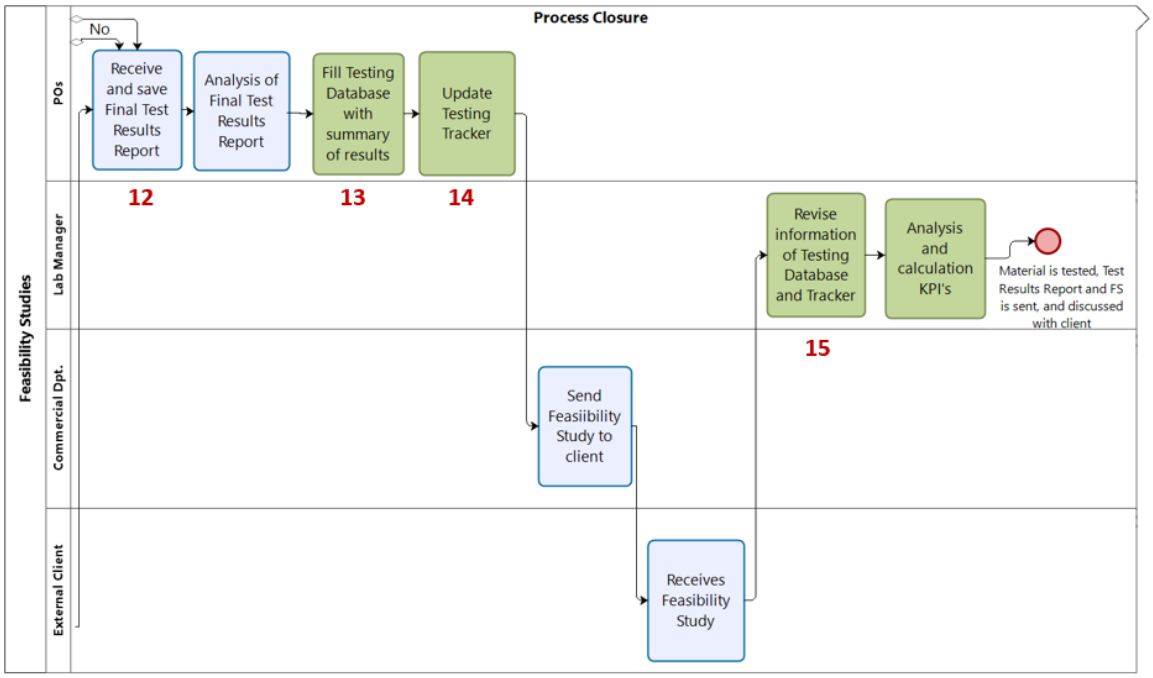

Figure 16- Swimlane of phase Process Closure (TO-BE) of Feasibility Study process

Phases	Activity Number	Activity description	Test Progress Tracker field
Process Closure	12	Receive and Save Final Test Results Report	Final Report saved and shared on Basecamp?
	13	Fill Testing Database with summary of tests results	x
	14	Updating Testing Tracker	x
	15	Revise information included in Testing Database and Tracker	N/A

Table 9- Relationship between phase Process Closure (TO-BE) of Feasibility Study process and Test Progress Tracker fields

5.2.3 Test Procurement Sheet

In addition to creating trackers, it was also required to create a supporting document to ensure the proper operation of trackers for the testing activity. With this in mind, the Test Procurement Sheet was developed during this project.

- **Test Procurement Sheet:** designed to display all the possible tests to be performed in each external laboratory, contains info on the different test suppliers, costs per test, the standard delivery time, and highlights the top 3 suppliers of each lab.

  This document allows consulting in a single view all the necessary information to order tests at external laboratories, facilitating the search and labs selection.

Table 10 shows the fields included in the Test Procurement Sheet.

Field number	Fields available in Test Procurement Sheet
1	Procurement Ref #
2	Test
3	Type of test
4	Type of test description
5	Subcontractor
6	Test description
7	Available microorganisms
8	Location
9	What do they consider a sample?
10	Size of sample
11	Control uncoated sample needed?
12	Sample Requirement
13	Price/sample (£)
14	Price/sample (€)
15	Turnaround time
16	Contact email
17	Test capability/quality
18	Comments/Other Considerations
19	Date of last update
20	Contact Point within Smart Separations
21	Relationship status
22	Feedback of Experience External Lab

Table 10- Existing fields of Test Procurement Sheet

5.2.4 Labelling Process Tracker

Smart Separations also needed to develop a tracker related to the company's regulatory area.

- **Labelling Process Tracker:** A tracker regarding the label creation sub-process of the company's regulatory area. This tracker is intended to monitor labels creation taking into account a product can only go to market with certified labels and sales regulations of each country assured. Namely, the antimicrobial agent used by Smart Separations for being a biocide requires specific rules for each country. For that reason, it has to be compliant with the necessary regulations for it to be launched.

The procedures to be followed from the Labelling subprocess of the Regulation area are:

- POs draft the label and provide information
- Consultants review the label
- PO's and PMs review the label
- PO's and PMs manage the translation
- The Product Design Manager is responsible for the Final Product Label

Table 11 presents the available fields of the Labelling Tracker.

Labelling Tracker	
Write label and provide information	Received label from PO to revision?
	Received flyer/brochure from PO to revision?
	Package size
	Countries (commercial priorities) info
Revision 1: Material to send to consultants'	Reviewed by Regulatory Team?
	Sent to consultants?
Consultants' Feedback	Received revision from consultants?
	Which consultant?
	Feedback posted on basecamp?
Revision of Label after consultants' feedback	Revision from PO based on consultants' feedback
	Revision from regulatory team
	Sign off
Translation	Languages
	Costs
	Translation done?
Design	**Documents to send**
	Sent signed off label to designer
	Number of languages per label in each country
	Revision
	Designer sent label
	Regulatory team and PO reviewed the label
	Regulatory team signs off label
Label Status	Label finished?

Table 11- Labelling Tracker fields

Through weekly meetings with company members resulting from the development of this project and the creation of the tracking system, it was possible to monitor these management tools, identify necessary changes and recognize some suggestions for improvement.

In summary:

After analysing the monitoring system developed for Smart Separations, it was possible to conclude that some management tools built have many similarities but with different objectives, specifically Technical Data and Test Progress Trackers.

As mentioned before, the main difference between the trackers is related to their primary goal. The **Technical Data Tracker** can be classified as a technical tracker since it is meant to be a database that exposes technical knowledge through the history of testing activities, whether performed internally or externally. On the other hand, the **Test Progress Tracker** can be considered as a current status tracker. It is intended to be a tool for execution control given it allows to understand the current status of the tests with the external laboratories.

Later, in the next chapter, with the data present in the Progress Test Tracker, it will be possible to obtain information to calculate performance indicators for the processes under study.

A comparative table between the Technical Data and the Progress Test Tracker is presented in Appendix G.

Note that the documents have different functions and, as such, cannot be substituted for each other because they cover different topics of the testing activity.

6. Performance Indicators

As previously mentioned, one of the primary goals of this project was to define a set of KPIs. At the beginning of the survey, the company already had some department-level KPIs, but it lacked process KPIs.

Initially, the department-level KPIs aimed to set goals and analyse the company activity. With this in mind, the managers of each department set the primary goals to be achieved. Every three months, employees have a performance review to assess whether these objectives have been achieved and to determine the following required objectives to be completed.

And so, after the analysis of the Technical Studies processes, it was decided that the company should also have KPIs that allow monitoring the performance of these critical processes regarding the external labs' relationship. This process had been deemed critical.

From our analysis, we design the following set of KPI's:

- **KPI 1: Time samples sending:** Period of time elapsed between the sending of the samples to the external lab and the reception of those in the lab
- **KPI 2: Turnaround Test Results:** Period of time elapsed between the samples received in the lab and Test Results Report received by Smart Separations
- **KPI 3: Time First VS Final Report:** Period of time elapsed between the Date of **Final** Test Results Report and Date of Test Results Report **(1st version)** received by Smart Separations
- **KPI 4: Deadline Test Report:** Period of time elapsed between the Date Test Results Report **(1st version) is expected** to be received by Smart Separations, and Date Test Results Report **(1st version) was actually received**
- **KPI 5: Number of empty fields:** Number of empty fields of Test Progress Tracker not fulfilled.
- **KPI 6 and 7: Number and Rate of errors:** Check if there were needed changes in the first version of the Test Results Report sent by the external lab and received by Smart Separations;
- **KPI 8: Cancellation Rate:** The number of tests requested to the external labs that are cancelled

Hereafter, it will be presented the detailed analysis of such KPI's.

The following swimlanes and tables present additional information on these KPI's. The swimlanes indicate the tasks involved in the calculation of KPIs. For example, KPI 1 regards the time elapsed between sending the samples to the external lab and the reception of those in the lab. Hence, Figure 16 highlights these two tasks in the swimlane model, and Table 13 highlights a detailed definition and calculation of each KPI.

Each KPI was calculated using a sample of 35 processes recorded by the Product Owners and Lab Manager in the Test Progress Tracker since the beginning of its implementation in April. In Appendix H it is available the data collected from Test Progress Tracker for the KPI's calculation.

KPI 1: Time samples sending

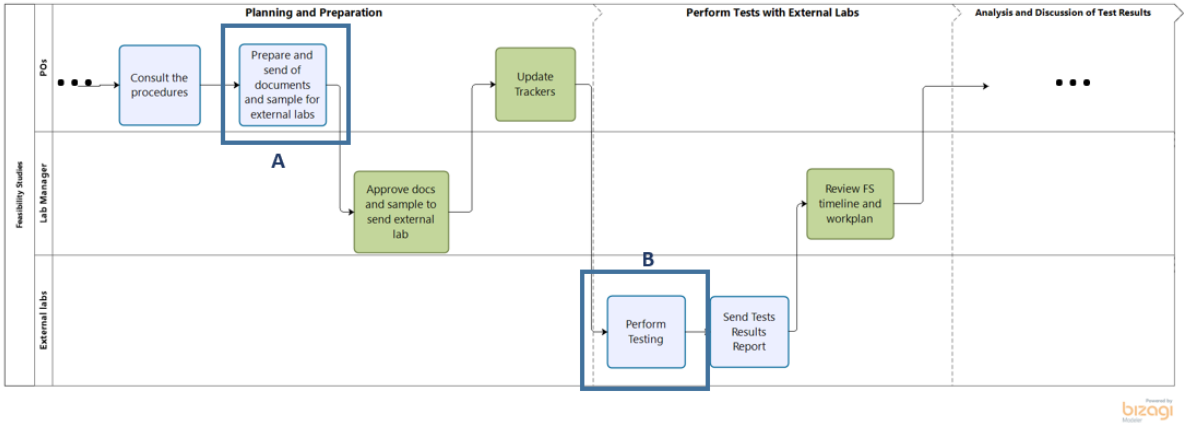

Figure 17- Phases of Planning and Preparation and Perform Tests with External labs of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T. Progress tracker fields	Unit measure
Deadlines							
SSL Responsibility							
1	**Time samples sending**	Period of time elapsed between the sending of the samples to the external lab and the reception of those in the lab	Date of samples received in the lab - Date of samples sent by Smart Separations	2,83	4,45	"Samples shipped on (date)." "Samples received on (date)."	Days

Table 12- KPI designed for the process phases of Planning and Preparation and Perform Tests with External labs

KPI 2: Turnaround Test Results

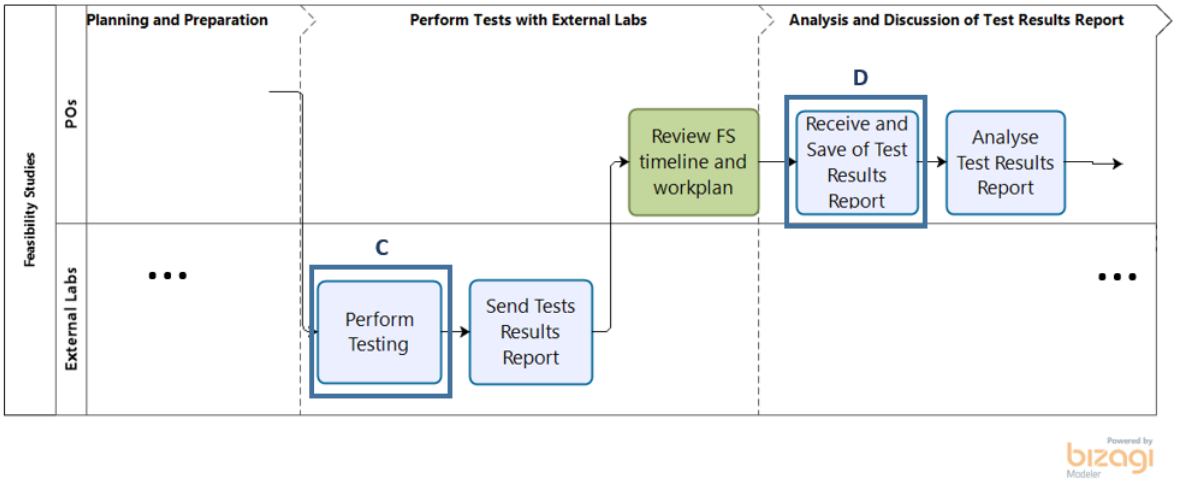

Figure 18- Phases of Perform Tests with External labs and Analysis and Discussion of Test Results Report of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Deadlines							
External Lab Responsibility							
2	**Turnaround Test Results**	Period of time elapsed between the samples received in the lab and Test Results Report received by Smart Separations	Date Test Results Report (1st version) received by Smart Separations- Date Samples received in the lab	23,86	21,39	"Samples received on (date)." "Report received date (1st version)."	Days

Table 13- KPI designed for the process phases of Perform Tests with External labs and Analysis and Discussion of Tests Results Report

KPI 3: Time First VS Final Report

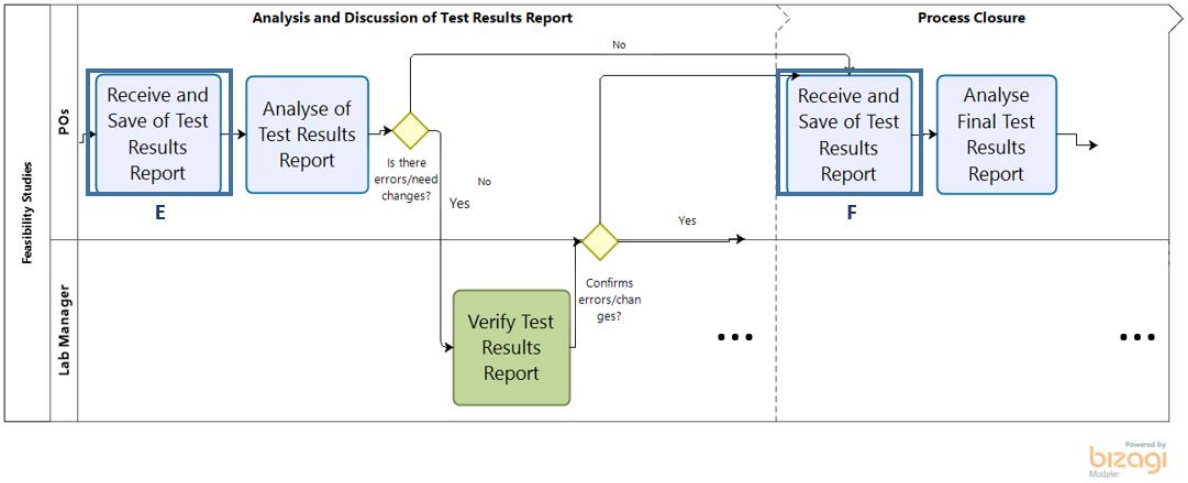

Figure 19- Phases of Analysis and Discussion of Test Results Report and Process Closure of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Deadlines							
External Lab Responsibility							
3	**Time First VS Final Report**	Period of time elapsed between the Date of Final Test Results Report received by Smart Separations and Date Test Results Report (1st version) received by Smart Separations	Date Final Test Results Report received by Smart Separations- Date Test Results Report (1st version) received by Smart Separations	0,00	N/A	"Report received date (1st version)." "Final Report Received date."	Days

Table 14- KPI designed for the process phases of Analysis and Discussion of Test Results Report and Process Closure

KPI 4: Deadline Test Report

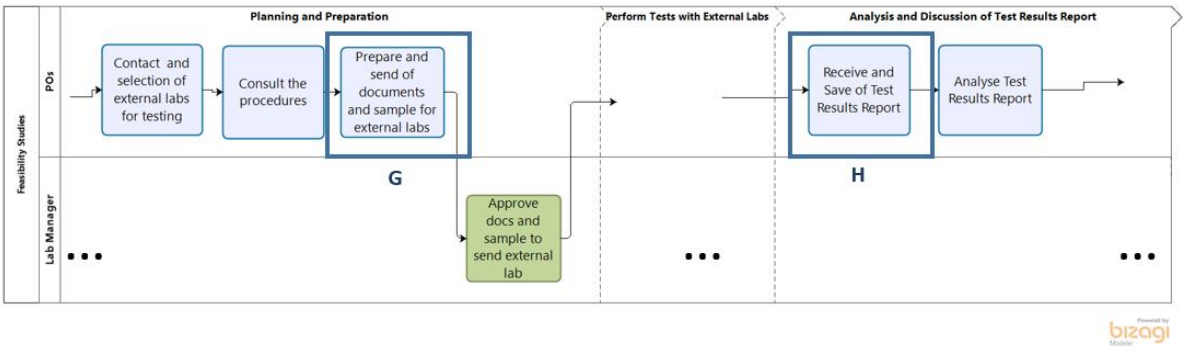

Figure 20- Phases of Planning and Preparation and Analysis and Discussion of Test Results Report of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Deadlines							
External Lab Responsibility							
4	**Deadline Test Report**	Period of time elapsed between the Date Test Results Report (1st version) is expected to be received by Smart Separations, and Date Test Results Report (1st version) was actually received by Smart Separations Results received	Date by which results is expected to be received by Smart Separations- Test Results Report Date was actually received by Smart Separations	-1,06	2,97	N/A	Days

Table 15- KPI designed for the process phases of Planning and Preparation and Analysis and Discussion of Test Results Report

KPI 5: Number of empty fields

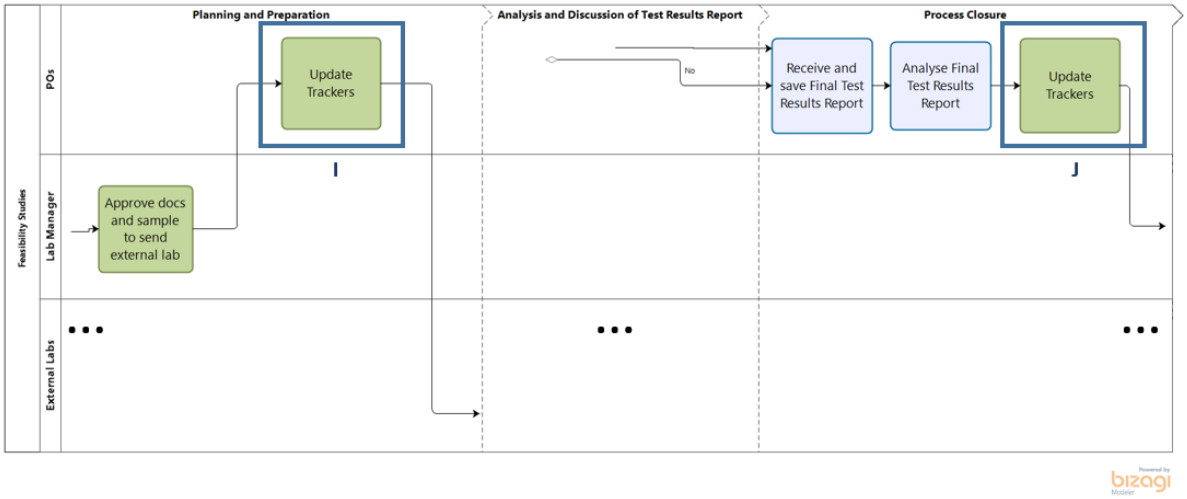

Figure 21- Phases of Planning and Preparation and Process Closure of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Effectiveness							
Smart Separations Responsibility							
5	**Number of empty fields**	Number of empty fields of Testing Tracker not fulfilled.	Sum of empty fields in the Testing Tracker per test	5,68	4,14	"Report received date (1st version)." "Final Report received date."	Quantity

Table 16- KPI designed for the process phases of Planning and Preparation and Process Closure

KPI 6 and 7: Number and Rate of errors

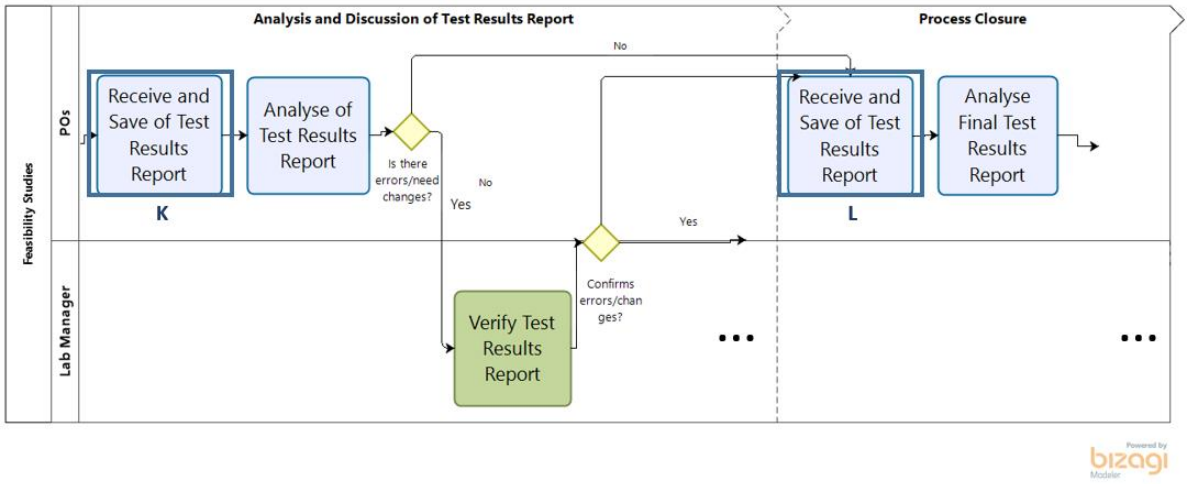

Figure 22- Phases of Analysis and Discussion of Test Results Report and Process Closure of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Effectiveness							
External Lab Responsibility							
6	**Number of total erroneous reports received by the lab**	Check if there were needed changes in the first version of the Test Results Report sent by the lab and received by Smart Separations;	Count of reports where Date Final Report approval >= Date Draft Report received	0	N/A	"Report received date (1st version)."	Quantity
7	**Rate of erroneous reports received by the lab**		(Count of reports where Date Final Report approval>= Date Draft Report received)/ Count of total reports received by the lab	0 %	N/A	"Final Report approved date."	

Table 17- KPI designed for the process phases of Analysis and Discussion of Test Results Report and Process Closure

KPI 8: Cancellation Rate

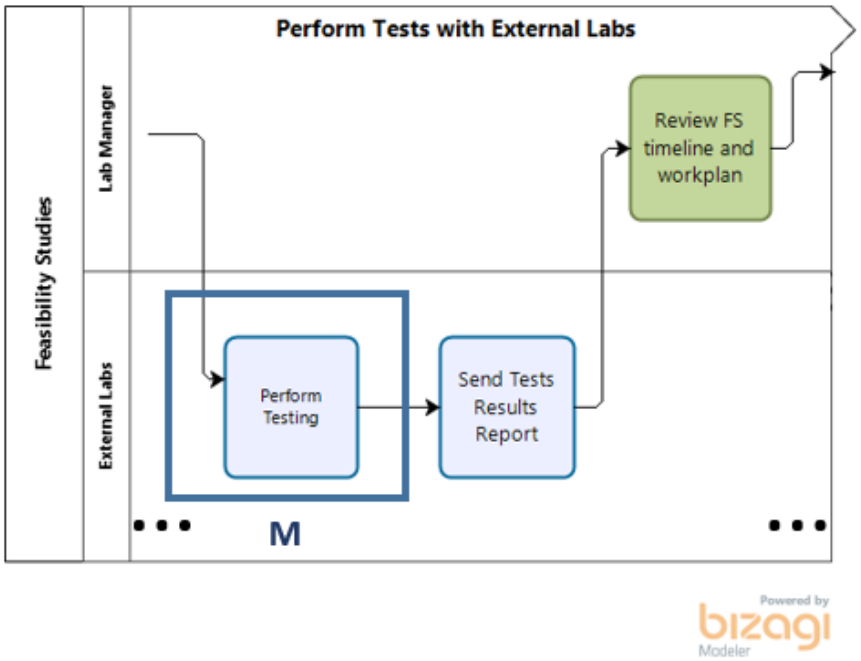

Figure 23- Phase of Perform Tests with External Labs of the Feasibility Study process

# KPI	KPI name	Description	Formula	Average Results	Standard Deviation	T.Progress tracker fields	Unit measure
Effectiveness							
Smart Separations Responsibility							
8	**Cancellation rate**	The number of tests requested to the external labs that are cancelled	The number of tests requested to the external labs that are cancelled	0,07	N/A	Status	Percentage

Table 18- KPI designed for the process phase Perform Tests with External Labs

As displayed in the figures and tables above, each KPI is linked to phases of the Feasibility Study process and specific fields for completion in the Test Progress Tracker.

The light blue lines in the table indicate whether the KPI is being calculated in terms of deadlines or effectiveness. In the case of deadlines, it is related to meeting deadlines. In terms of effectiveness, it is associated with the quality of service provided and customer satisfaction.

The grey lines show those responsible for meeting the KPIs in question.

In terms of efficiency regarding productivity and costs of activities, they were not calculated by the decision of the company's board members.

As previously stated, given that the Test Progress Tracker was recently implemented in Smart Separations, it was not possible to obtain sufficiently robust data for an in-depth analysis of the performance indicators until the end of this project.

After the analysis and calculation of the KPI's, it is possible to conclude that:

- **KPI 1: Time samples sending**
    - This KPI should be separated into 2, once it refers to 2 different tasks (delivering and receiving the samples) and it is performed by two different entities (Smart Separations and External Lab)
    - After analysing the standard deviation, it is highly recommended that a survey should be put into practice to justify delays above the average.
    - It is recommended to define a target to measure against the actual result, which will allow the monitor performance.
- **KPI 2: Turnaround Test Results**
    - This KPI should reflect the Service Level Agreement (SLA) from the lab.
    - The high standard deviation shows significant variance on this KPI. To better understand the cause of this variance, it is suggested that the lab should fill in a form. This should also justify any occurring delay if there is any and define an optimal number for this KPI.

- **KPI 3: Time First VS Final Report**
    - As the dates were the same, there was a second version of the reports. Therefore, it is not possible to conclude how efficiently the lab is making changes to the report.
- **KPI 4: Deadline Test Report**
    - The lab delays in average one day more than what is agreed to deliver the Test Results Report
- **KPI 5: Number of empty fields**
    - On average, six fields from the tracker are left empty. Employees should receive clear guidelines from the leadership to fill in the document correctly.
    - The process of filling this document was implemented two months before to the project ending date. Therefore, the Test Progress Tracker is too recent to be well integrated into each worker's daily tasks—more time is needed to conclude the tracker filling performance.
    - In the case this KPI remains high, it suggests some sort of automation or online platform for a more user-friendly approach.
- **KPI 6 and 7: Number and Rate of errors:**
    - As the dates were the same, there was a second version of the report, and thus, no errors were found. Consequently, its rate was not relevant.
- **KPI 8: Cancellation Rate**
    - As there was no target established for this KPI, one cannot infer about its success.
    - For future practice, it is suggested to add two extra fields to the Test Progress Tracker: one attributing accountability for the cancellation, either from Smart Separations, the client, or the lab. And another area for free text explaining the reason for cancelling.

7. Conclusions

7.1 Conclusions

Throughout the project, a long journey was made. As the project's scope in the original dissertation proposal was extremely broad and open, the first major achievement was the decision on which processes should be addressed first.

This was not an easy decision since, at the beginning of the project, there was no comprehensive and organized view of the full range of Smart Separations activities.

As mentioned in the body of the dissertation, the preparation of the process map was the critical step in gaining an overall understanding of the company's organization and operations, which enabled an informed decision to be made about which processes should be prioritised.

Another major challenge was collecting data required to create the process models and establishing consensus on the required solution to overcome the current difficulties. The Smart Separations team gathers people with different scientific backgrounds and mindsets.

Additionally, during the internship period, there were some structural changes in the company. One detrimental consequence of those changes was the fact that the dissertation supervisor in the company changed three times.

The fact that the company operates in technology innovation makes its processes quite volatile and relative. Each process often involves many variations and exceptions, so working procedures should be flexible enough to accommodate this variability. This makes process analysis and modelling even more challenging.

Despite these difficulties, it was possible to meet the core objectives assigned to the project. In fact:

- the process map of the company designed, and the critical processes needing improvement were identified
- it was achieved a consensus on the redesign of the processes (TO BE process models)
- the process tracking tools were redesigned according to the new process models
- a set of KPI’s was also defined for the critical processes involving the external laboratories

7.2 Perspectives for future work

Given the short period of the internship, it was not possible to put in place all the improvement proposals. As future work, it would be necessary to collect additional process data to assess whether the redesigned process meets the intended performance targets.

If so, and if the methodology employed so far proves its effectiveness, further critical processes should be analysed, namely Regulatory Management and Product Development processes.

As far as the process management tools are concerned, the company decided to create the first version of the trackers in Google sheets. However, the information gathering is too complex to be managed efficiently with this tool. We believe it would be more effective to implement a web database application, such as the use of electronic lab books.

Finally, to ensure the effective implementation and usage of the new management tools, it would be highly recommended to engage in the following actions:

- Organizing a training session regarding the filing of the trackers
- This session could be complemented by a set of small videos with step-by-step instruction made available in the company's intranet
- Holding clarification sessions with the POs for eventual doubts, difficulties, or improvement suggestions regarding the analysed processes as well as the tools created

Define a person in charge to champion this change, responsible for encouraging, monitoring, and reviewing the completion of trackers

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APPENDIX A: Relationship between the different phases of the Feasibility Study process in their respective phase-by-phase swimlane model

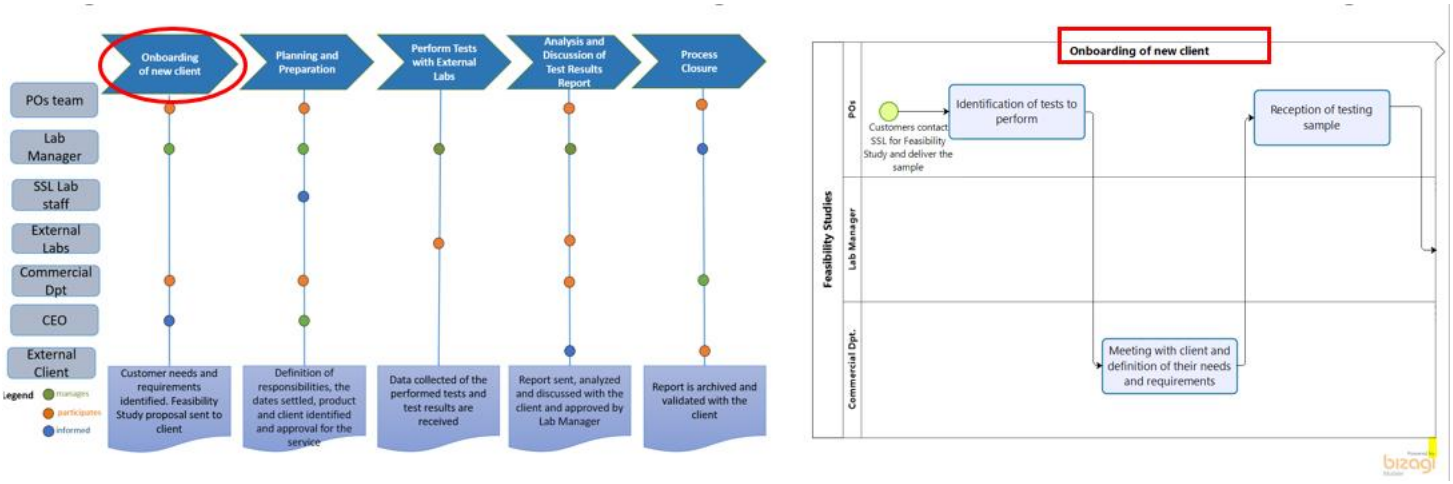


Figure A1- Feasibility Study phase of Onboarding of a new client

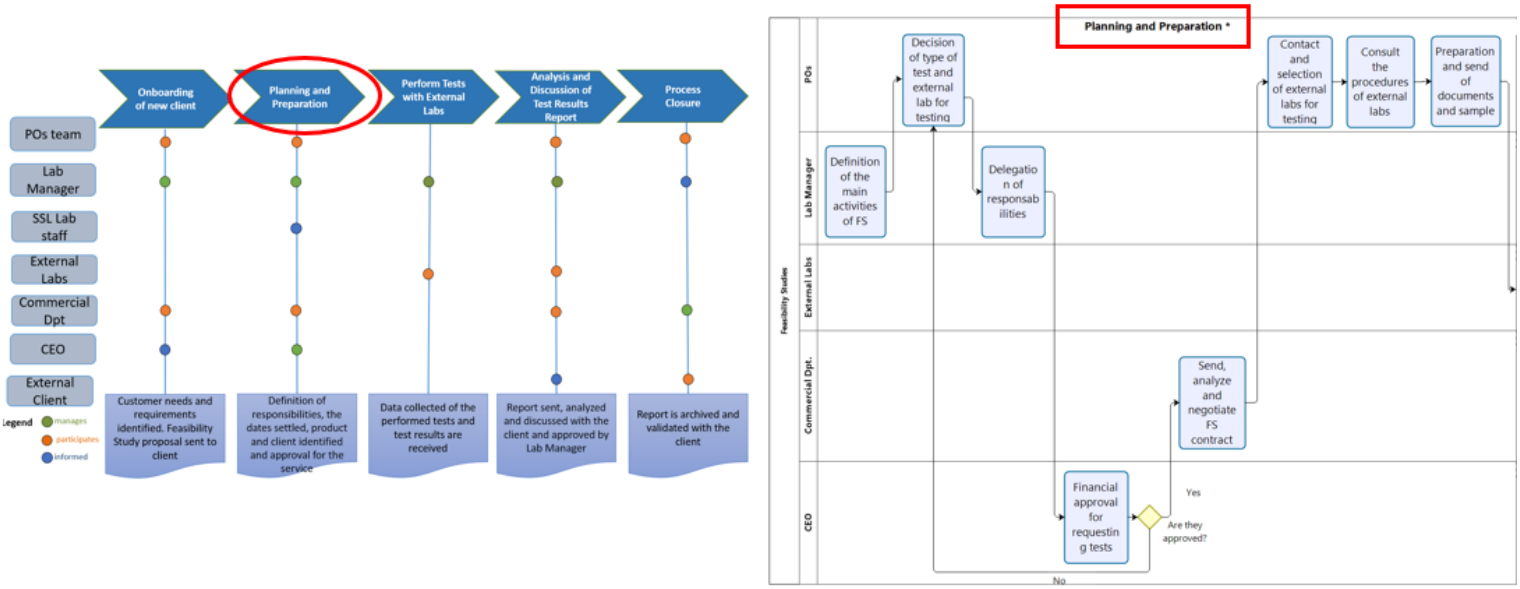


Figure A2- Feasibility Study phase of Planning and Preparation

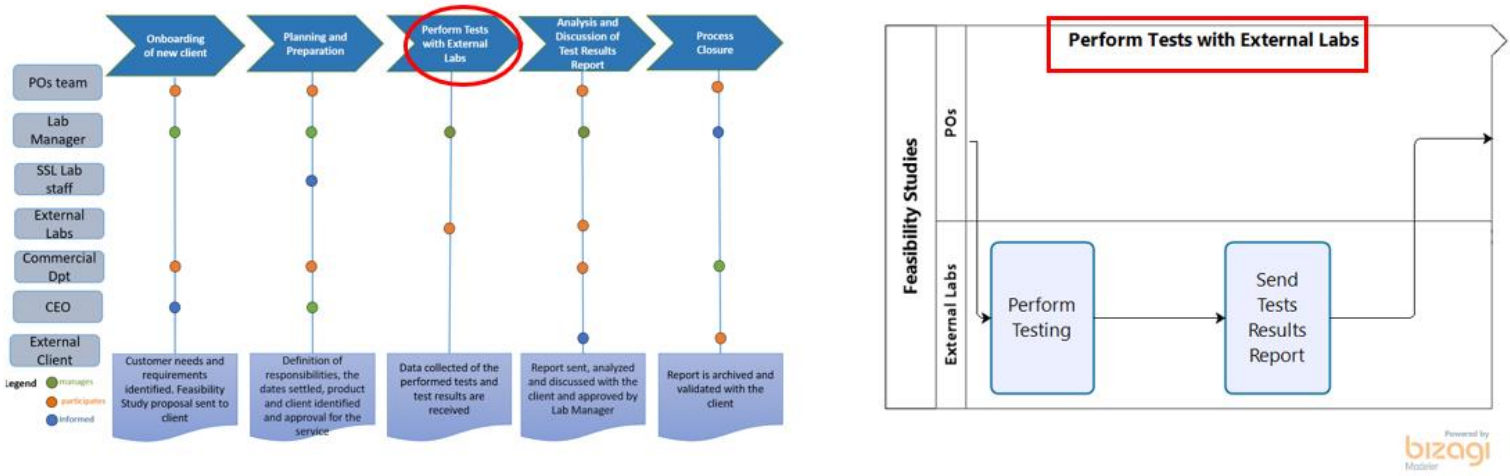


Figure A3- Feasibility Study phase of Perform Tests with External Labs

Figure A4- Feasibility Study phase of Analysis and Discussion of Test Results Report

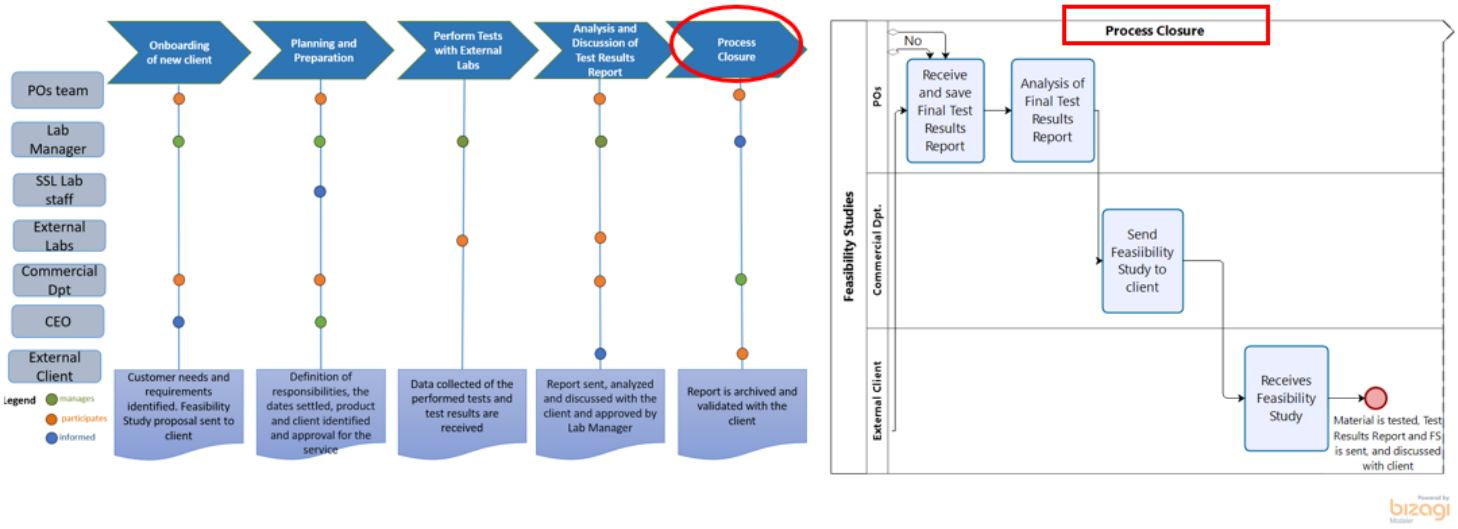


Figure A6- Feasibility Study phase of Process Closure

APPENDIX B: Detailed Internal Product Development Models

Phase-by-phase swimlane diagrams of Internal Product Development process

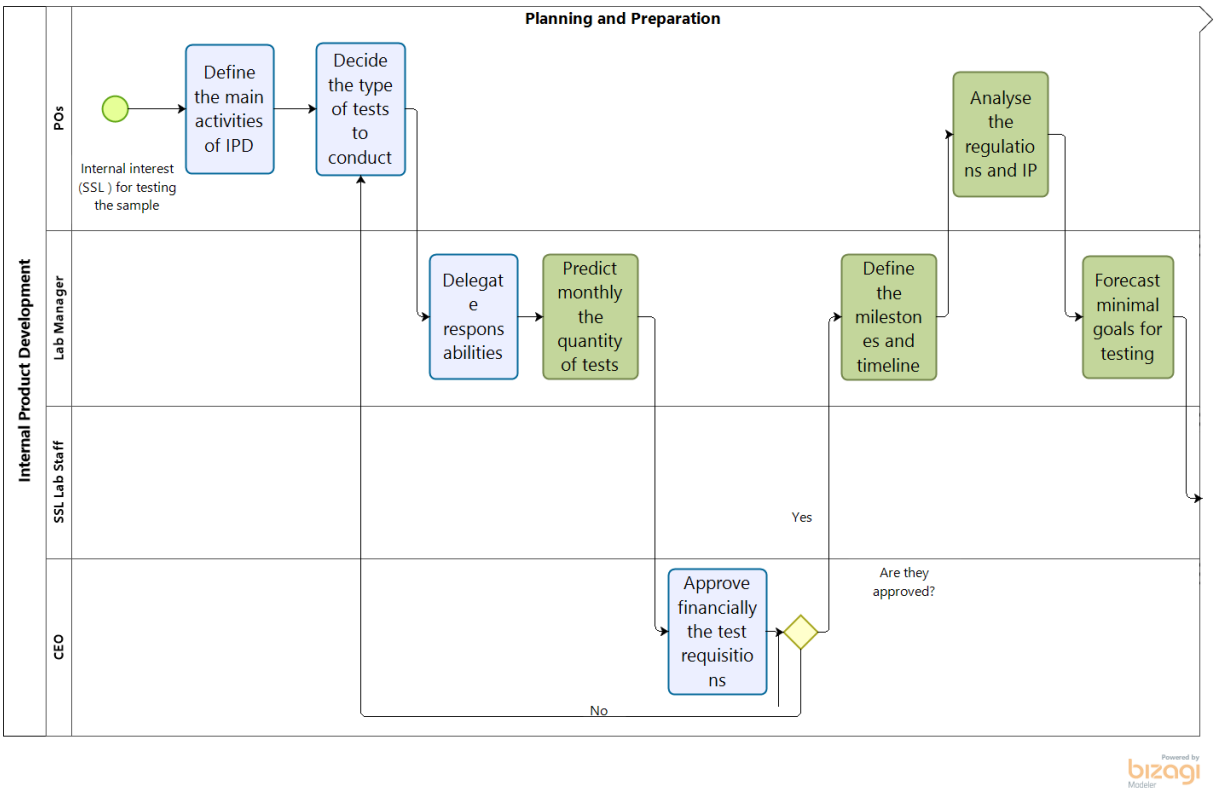


Figure B1- Internal Product Development phase Planning and Preparation: tasks of AS-IS and TO-BE models

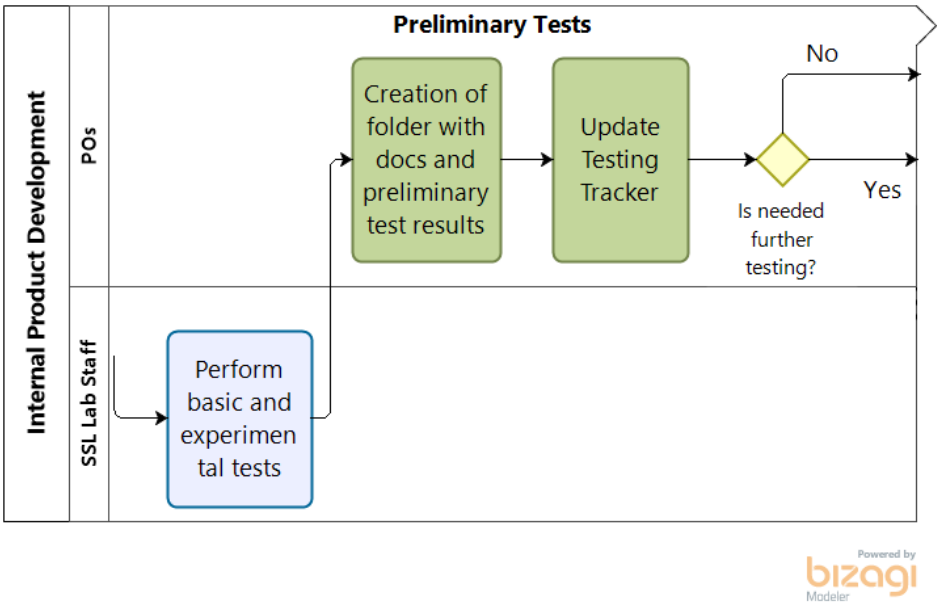


Figure B2- Internal Product Development phase Preliminary Tests: tasks of AS-IS and TO-BE models

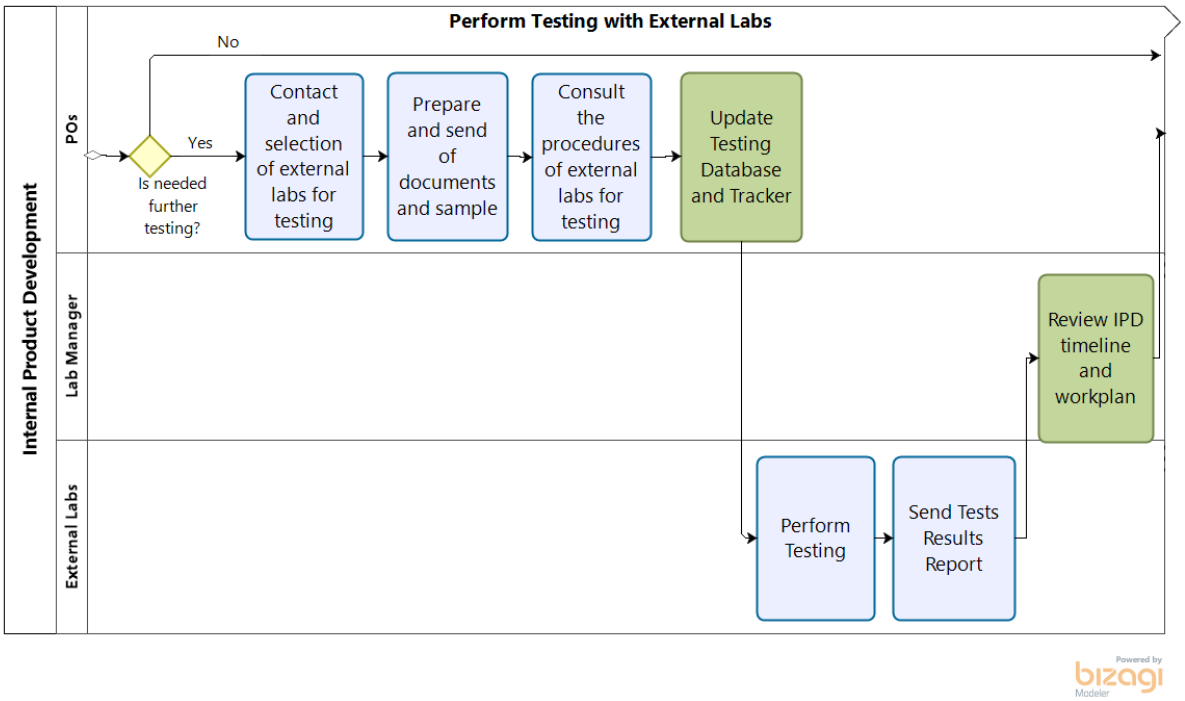


Figure B3- Internal Product Development phase Perform Tests with External Labs: tasks of AS-IS and TO-BE models

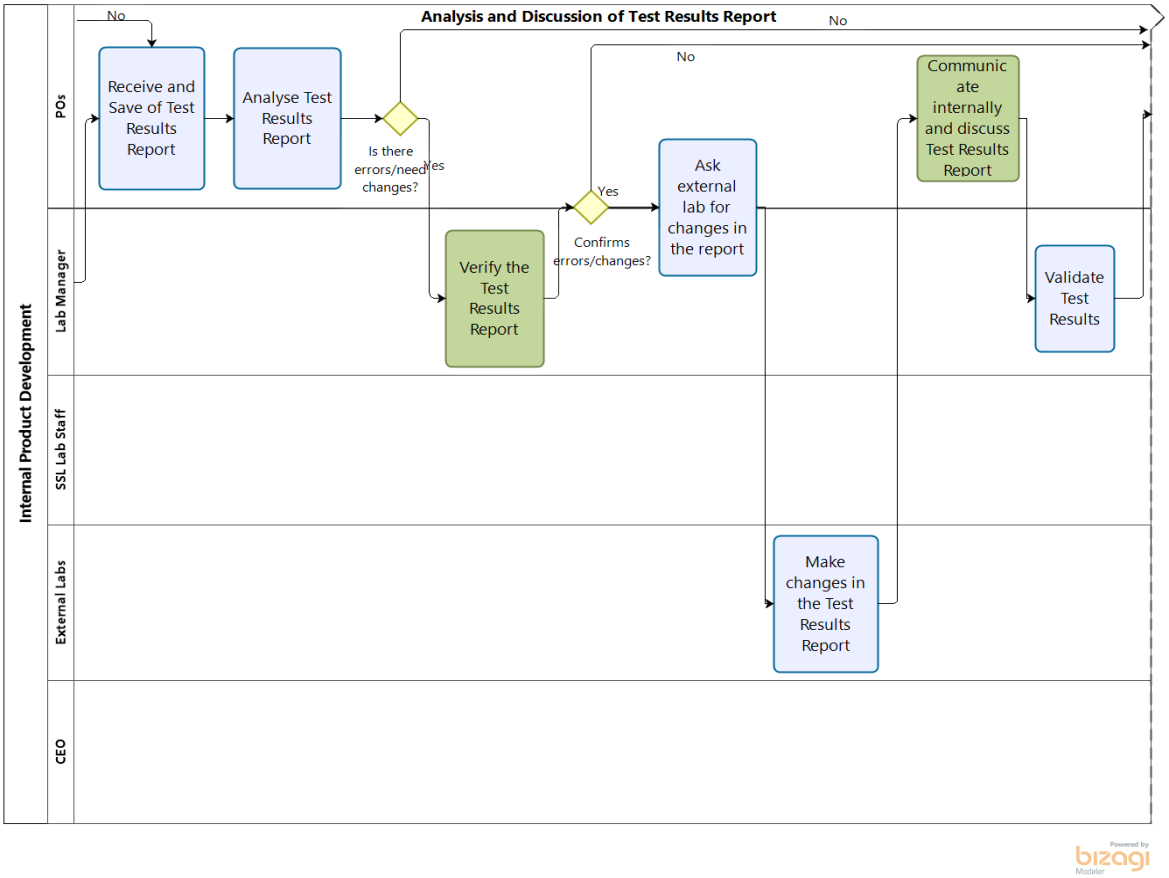


Figure B4- Internal Product Development phase Analysis and Discussion of Test Results Report: tasks of AS-IS and TO-BE models

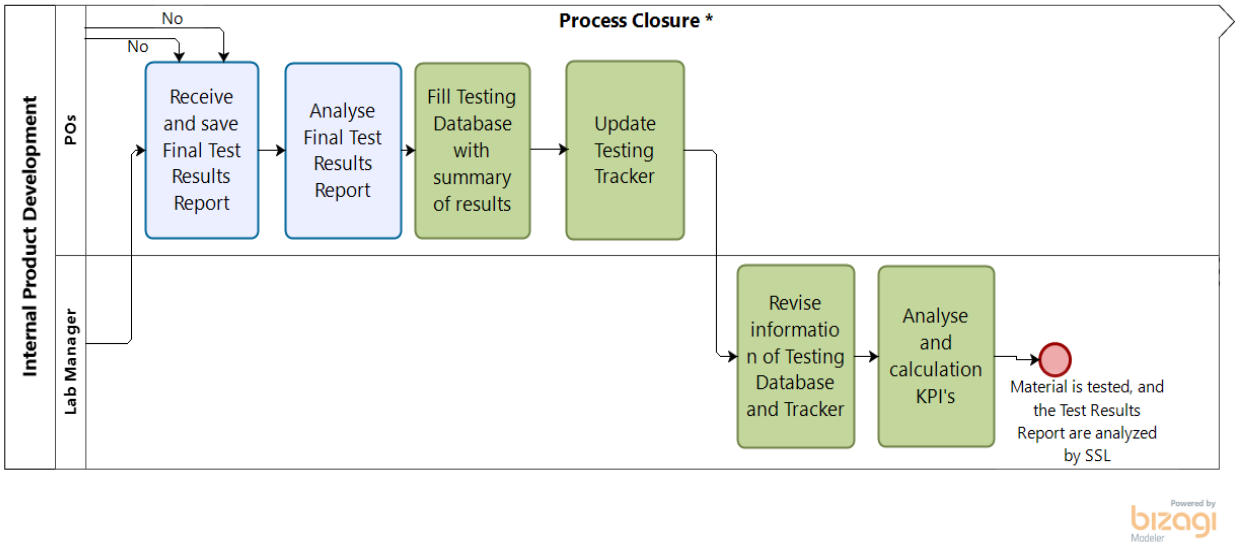


Figure B5- Internal Product Development phase Process Closure: tasks of AS-IS and TO-BE models

APPENDIX C: Data recorded on the existing tracking tool (AS-IS)

Field number	Fields to be completed
1	Sample ref
2	Substrate (Please type in and indicate the control)
3	Type of Test
4	Iso/test
5	Microorganism to Test
6	Contact Time, min
7	Number of samples used/sent
8	Cost per sample (€)
9	Priority/fast delivery
10	Date by which results will be available
11	Results received Date
12	Summary of Results/ Conclusions
13	Notes/ Other Relevant links
14	Test completed
15	Comments (please type here)

Table C- Existing fields included on the existing tracking tool

APPENDIX D: Summary of Feasibility Study process in its current state and improvement suggestions

FEASIBILITY STUDY (AS-IS & TO-BE)						
	Activities		Documents		Software used	
PHASES	AS-IS	TO-BE	AS-IS	TO-BE	AS-IS	TO-BE
Onboarding with new client	Identification of tests to perform; Meeting with the client; Definition of client needs and requirements; Reception of sample	N/A	Document: Questions for Feasibility Study Clients; Document: Customer Needs and Requirements	N/A	Basecamp Google Drive	N/A
Planning and Preparation	Definition of the main activities of FS; Decision of type of test and external lab for testing; Delegation of responsibilities; Financial approval for requesting tests; Send analyse and negotiate FS contract; Contact and selection of external labs; Consult the procedures of external labs; Prepare and send documents and sample for external labs;	Monthly prediction of the number of tests to perform; Forecast minimal goals for testing; Analysis of regulations and IP; Documents and sample approval to send to external labs; Update Testing Database and Tracker;	Project outline (Gant chart, Gdrive)	N/A	Basecamp	N/A
Perform Tests with Ext. Labs	Perform Testing; Send Test Results Report	Review the FS work plan	I3s and Matera Tracker	Testing Database	N/A	Google Drive; Basecamp
Analysis and discussion of Test Results	Reception and Saving the Test Results Report; Analysis of Test Results Report; Ask external labs for changes in the report; Made changes in the report; Test results validation.	Double-check of Test Results Report	N/A	External and Internal Test Report	Basecamp; Google Drive	N/A
Process Closure	Receive and Save Final Test Results Report; Analysis of Final Test Results Report; Send FS to the client; Receives Feasibility Study	Fill T. Data Tracker with a summary of results; Update Trackers; Revise information included in trackers; Calculation of KPIs	External Test Report	External Test Report; Trackers Test Procurement Sheet;	N/A	Basecamp; Google Drive

Table E- Summary of Feasibility Study process in its current state and improvement suggestions

APPENDIX E: Summary of Internal Product Development process in its current state and improvement suggestions

INTERNAL PRODUCT DEVELOPMENT (AS-IS & TO-BE)						
	ACTIVITIES		DOCUMENTS		SOFTWARE USED	
Phases	**AS-IS**	**TO-BE**	**AS-IS**	**TO-BE**	**AS-IS**	**TO-BE**
Planning and Preparation	Definition of the main activities ; Decision of type of tests to conduct; Delegation of responsibilities; Financial approval for requesting tests	Monthly prediction of the number of tests to perform; Definition of milestones and timeline; Analysis of the regulations and intellectual property required for testing; Forecast minimal goals for testing	N/A	N/A	Basecamp Google Drive	N/A
Preliminary Tests	Perform basic and experimental coating tests;	Folder creation of documents and preliminary test results; Update Tracker	N/A	Trackers; Procurement Sheet	Basecamp	Basecamp and LabOrders
Perform Tests with External Labs	Contact and selection of external labs for testing; Preparation and sending of documents and samples for external labs Consult the procedures of external labs; Analysis of regulations and IP; Update Tracker; Perform Testing; Send Tests Results Report	Update Trackers; Review IPD timeline and work plan	N/A	Trackers	N/A	Google Drive
Analysis and Discussion of Test Results Report	Reception and Saving the Test Results Report; Analysis of Test Results Report; Double check of Test Results Report; Ask external labs for changes in the report; Made changes in Test Results Report;	Double-check of Test Results Report; Internal Communication and discussion of Test Results Report; Test results validation	N/A	External Test Report; Internal Test Report;	N/A	Basecamp; Google Drive
Process Closure	Receive and save Final Test Results Report; Analysis of Final Test Results Report	Fill T. Data Tracker with a summary of results; Update Progress T. Tracker; Revise information on trackers; Analysis and calculation KPI's	N/A	Trackers; Procurement Sheet; Internal and Internal Test Report	N/A	Basecamp; Google Drive

Table G- Summary of Internal Product Development process in its current state and improvement suggestions

APPENDIX F: Relationship between the activities of Internal Product Development process phase by phase and Testing Database fields

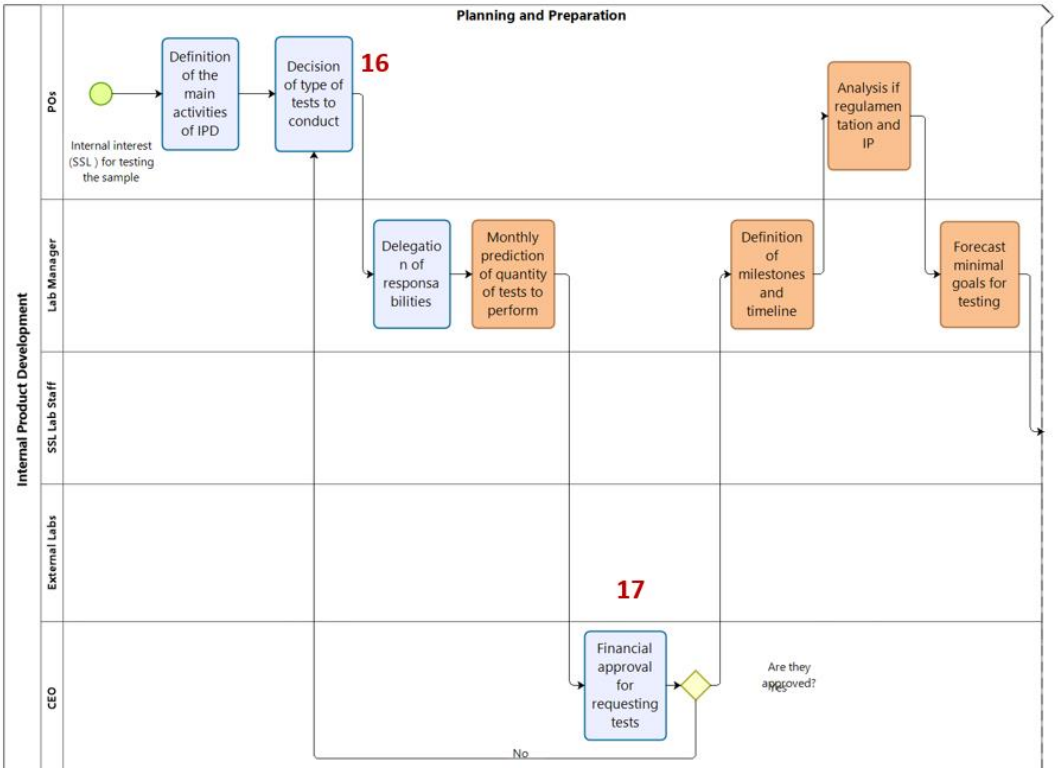


Figure F1- Swimlane of phase Planning and Preparation (TO-BE) of Internal Product Development process

Phases	Activity Number	P. Testing Tracker field	T. Data Tracker field
Planning and Preparation	16	Decision of type of test and external lab for testing	-Testing Ref #. -Sample Ref. -Internal Test or External Test. -Type of Test. -Testing Lab. -Description (experimental set-up, sample condition). -ISO/Test -Microorganism to Test -Cost per sample (£) -Cost per sample (€)
	17	Financial approval for requesting tests	N/A

Table F1- Relationship between phase Planning and Preparation (TO-BE) of Internal Product Development process and Trackers fields

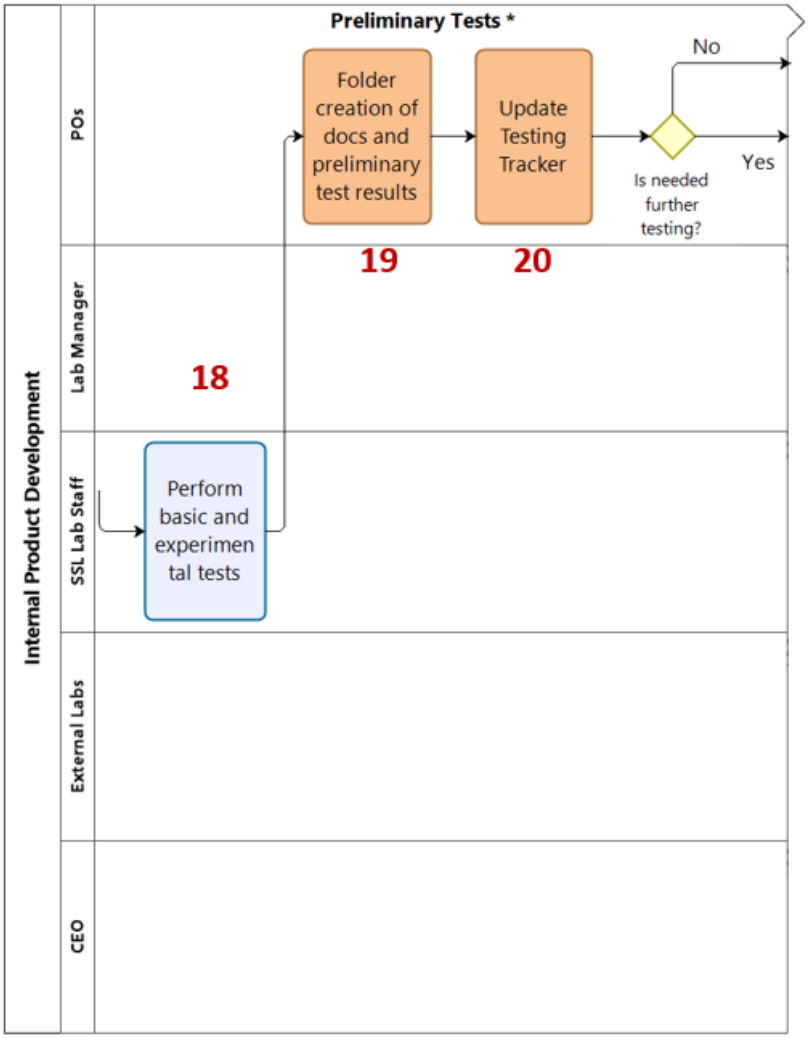


Figure F2- Swimlane of phase Preliminary Tests (TO-BE) of Internal Product Development process

Phases	Activity Number	Activities	P. Testing Tracker field	T. Data Tracker field
Preliminary Tests	18	Perform basic and experimental tests	Testing Ref Substrate code	-Testing Ref # -SAMPLE Ref -Internal Test or External Test -Type of Test
	19	Folder creation of documents and preliminary test results	N/A	Link to Internal Report (find template here)
	20	Update Testing Tracker	X	X

Table F2- Relationship between phase Preliminary Tests (TO-BE) of Internal Product Development process and Trackers fields

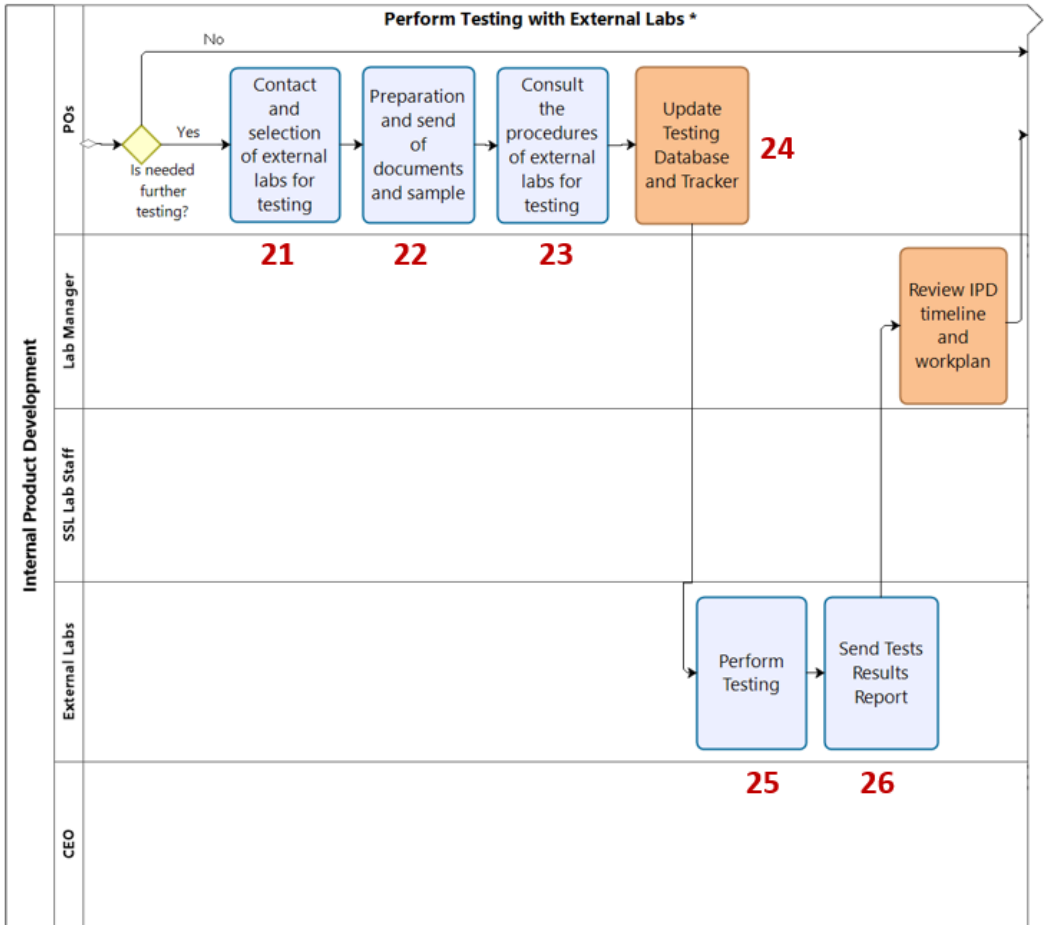


Figure F3- Swimlane of phase Perform Tests with External Labs (TO-BE) of Internal Product Development process

Phases	Activity Number	Activities	P. Testing Tracker field	T. Data Tracker field
Perform Tests with External Labs	21	Contact and selection of external labs for testing	-Service requested (procurement ref code)	-Procurement Ref -Contact Name -Email of contact
	22	Preparation and sending of documents and samples for external labs	-Testing request date -Test requested approved by Testing Lab Manager -Purchase order sent? -Purchase order sent date -Sample Submission Form Sent? -Sample Submission Form Sent Date -Samples shipped -Parcel approved? -Samples shipped on (date) -Samples received on (date) -Sample shipping tracker number/link	Ref# Shipping Number from Shipping Tracker
	23	Consult the procedures of external labs	N/A	Samples requirements
	24	Update Testing Database and Tracker	X	X
	25	Perform Testing	N/A	-Contact Time, min -Number of samples used/sent -Use neutralization solution -Priority/Fast Delivery
	26	Send Test Results Report	Date by which results will be available.	-Date by which results will be available -Summary of Coating Conditions

Table F3- Relationship between phase Perform Tests with External Labs (TO-BE) of Internal Product Development process and Trackers fields

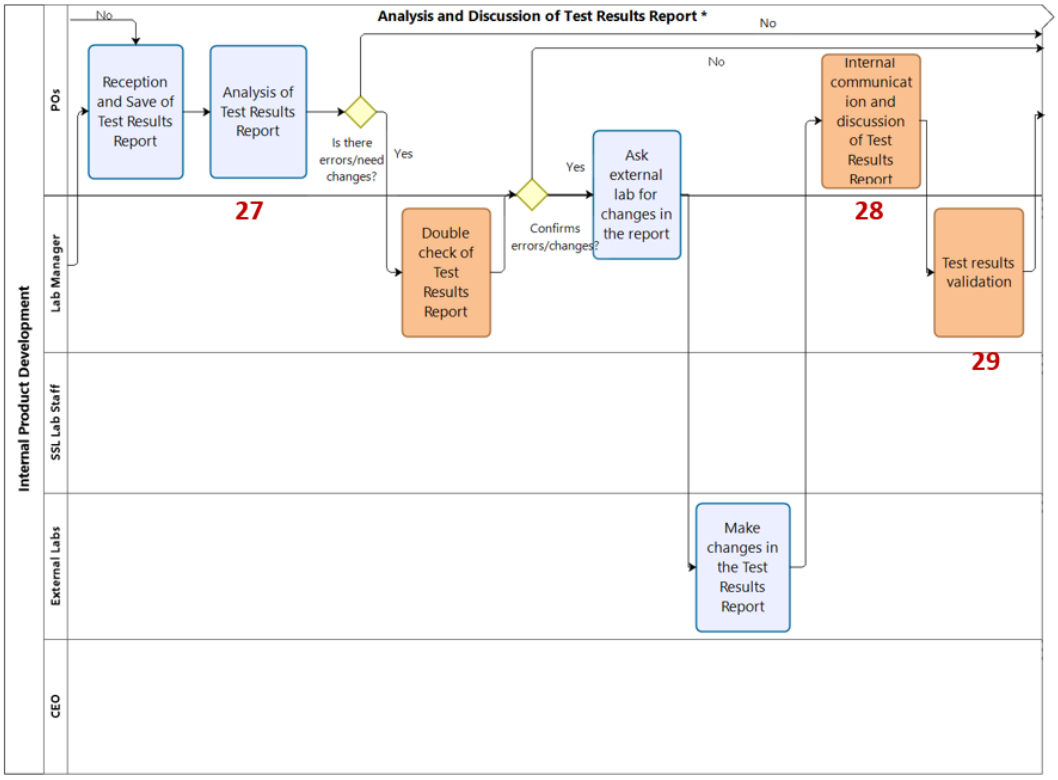


Figure F4- Swimlane of phase Analysis and discussion Test Results Report (TO-BE) of Internal Product Development process

Phases	Activity Number	Activities	P. Testing Tracker field	T. Data Tracker field
Analysis and discussion Test Results Report	27	Analysis of Test Results Report	N/A	Summary of Results/ Conclusions
	28	Internal Communication and discussion of Test Results Report	N/A	-Link to Internal Report -Link to External Report
	29	Test results validation	-Report reviewed and approved by Lab Manager? -Final Report approved date	Report reviewed and approved by Lab Testing Manager

Table F4- Relationship between phase Analysis and discussion Test Results Report (TO-BE) of Internal Product Development process and Trackers fields

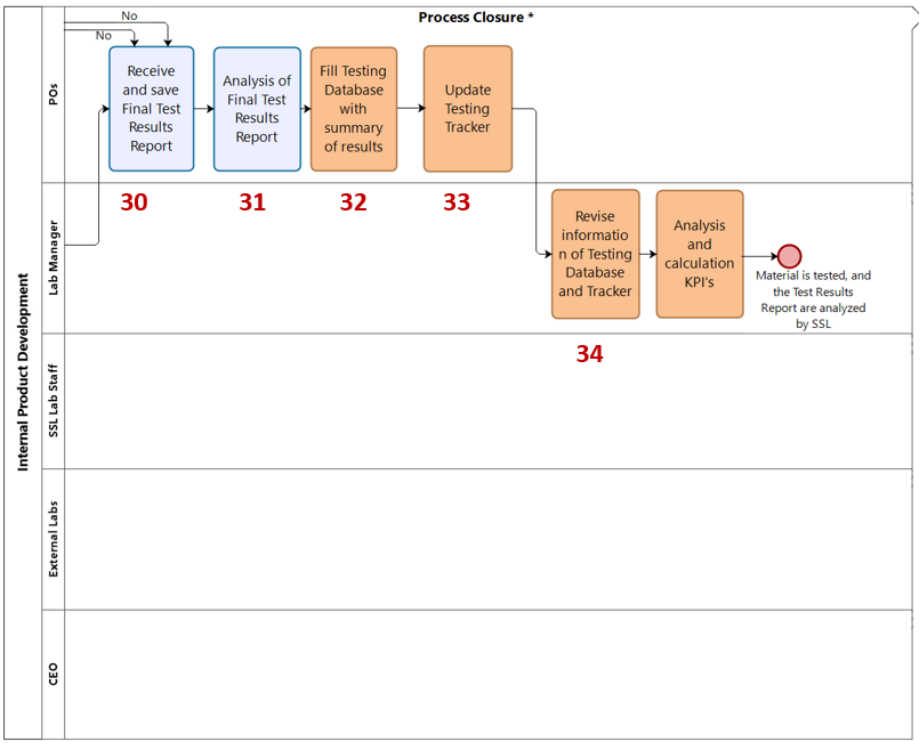


Figure F5- Swimlane of phase Process Closure (TO-BE) of Internal Product Development process

Phases	Activity Number	Activities	P. Testing Tracker field	T. Data Tracker field
Process Closure	30	Receives and save Final Test Results Report	Final Report saved and shared on Basecamp?	-Link to External Report (find template here) -Link to Final Report if changes
	31	Analysis of Final Test Results Report	N/A	Summary of Results/ Conclusions
	32	Fill Testing Database with a summary of tests results	X	X
	33	Update Testing Tracker	X	X
	34	Revise information included in Testing Database and Tracker	N/A	Test Completed

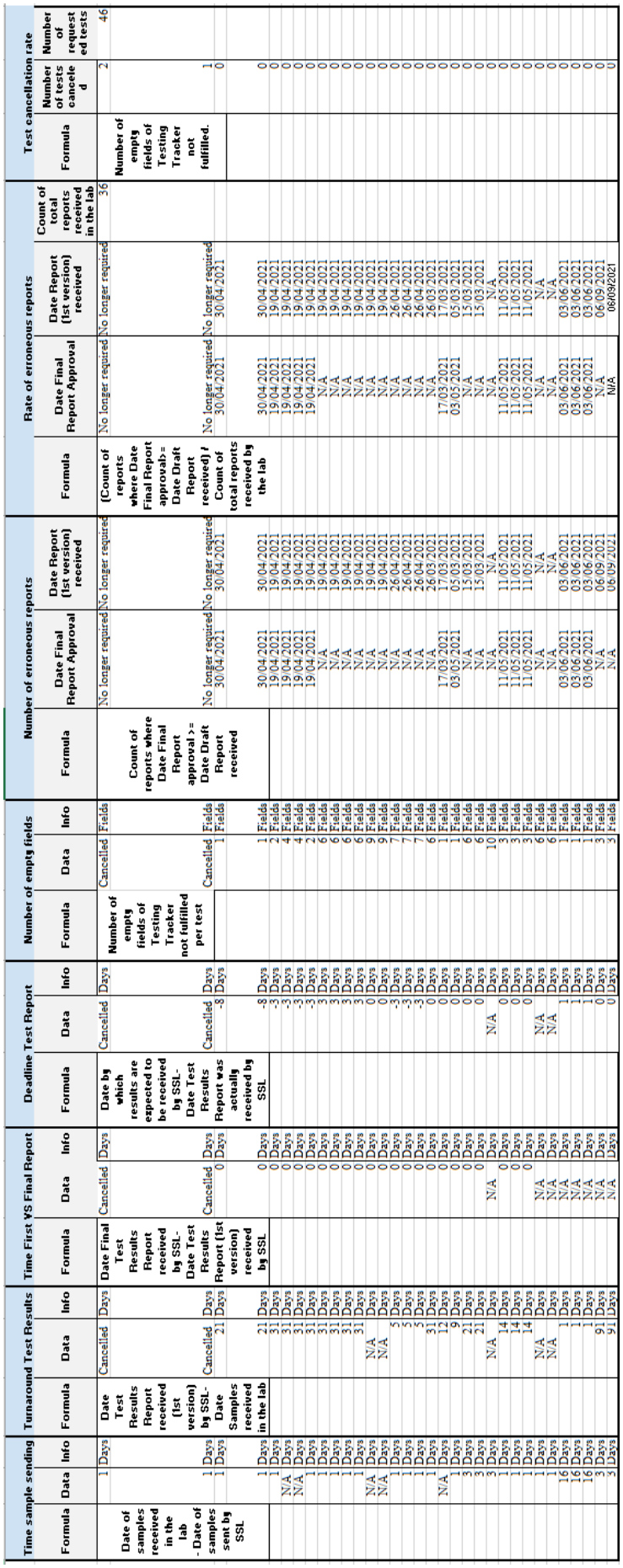
Table F5- Relationship between phase Process Closure (TO-BE) of Internal Product Development process and Trackers fields

APPENDIX G: Comparative table of Technical Data and Test Progress Trackers

Type of Data	Fields of Technical Data Tracker	Fields of Test Progress Tracker	Type of data
Technical	Testing ref #	N/a	N/a
Technical	Sample ref	Sample code	Technical
Technical	Client requesting the test	N/a	N/a
Technical	Person requesting the test	N/a	N/a
Technical	Product	N/a	N/a
Technical	Internal Test or External Test	N/a	N/a
Technical	Type of Test	N/a	N/a
Technical	Procurement Ref	Procurement ref code	Technical
Technical	Testing lab	External Lab Name	Technical
Technical	Person responsible at SSL to run the test	N/a	N/a
Technical	N/a	Samples approved by Lab Manager	Monitoring
Technical	Summary of Coating Conditions	N/a	N/a
Technical	Description	N/a	N/a
Technical	Iso/test	N/a	N/a
Technical	Microorganism to Test	N/a	N/a
Technical	Contact Time, min	N/a	N/a
Technical	Number of samples used/sent	Samples shipped	Monitoring
Technical	Use neutralization solution	N/a	N/a
Monitoring	Cost per sample (£)	N/a	N/a
Monitoring	Cost per sample (€)	N/a	N/a
Technical	Priority/fast delivery	N/a	N/a
Monitoring	Date by which results will be available	Date which results will be available	Monitoring
Technical	Ref# shipping	Sample shipping tracker number/link	Technical
Technical	Testing lab Contact name	N/a	N/a
Technical	Email of Testing lab contact	N/a	N/a
Technical	Testing lab Sample's requirements	Sample Submission Form Sent? Date	Monitoring
N/a	N/a	Samples shipped on (date)	Monitoring
N/a	N/a	Purchase order sent?	Monitoring
N/a	N/a	Purchase order sent date	Monitoring
Monitoring	Results received Date	Results received date	Monitoring
Technical	Summary of Results/ Conclusions	N/a	N/a
Link for docs	Link to Internal Report	N/a	N/a
Link for docs	Link to External Report (find template here)	N/a	N/a
Monitoring	Report reviewed & approved Lab Manager	Report reviewed & approved Lab M.	Monitoring
Link for docs	Link to Final Report if changes	N/a	N/a
Monitoring	Completed Overall Summary of Tests?	N/a	N/a
N/a	Notes/ Other Relevant links	N/a	N/a
Monitoring	Test completed	Closed date	Monitoring

Table G- Comparison between the Testing Database and Testing Tracker

APPENDIX H: Data collected from Test Progress Tracker for the KPI's calculation



Time sample sending			Turnaround Test Results			Time First YS Final Report			Deadline Test Report			Number of empty fields			Number of erroneous reports			Rate of erroneous reports			Test cancellation rate		
Formula	Data	Info	Formula	Data	Info	Formula	Data	Info	Formula	Data	Info	Formula	Data	Info	Formula	Date Final Report Approval	Date Report (1st version) received	Formula	Date Report (1st version) received	Count of total reports received in the lab	Formula	Number of tests cancelled	Number of requested tests
Date of samples received in the lab - Date of samples sent by SSL	1	Days	Date Test Results Report received (1st version) by SSL - Date Samples received in the lab	Cancelled	Days	Date Final Test Results Report received by SSL - Date Test Results Report (1st version) received by SSL	Cancelled	Days	Date by which results are expected to be received by SSL - Date Test Results Report was actually received by SSL	Cancelled	Days	Number of empty fields of Testing Tracker not fulfilled per test	Cancelled	Fields	Count of reports where Date Final Report approval >= Date Draft Report received	No longer required	No longer required	(Count of reports where Date Final Report approval>= Date Draft Report received) / Count of total reports received by the lab	No longer required	36	Number of empty fields of Testing Tracker not fulfilled.	2	46
	1	Days		Cancelled	Days										30/04/2021	30/04/2021	30/04/2021		30/04/2021				
	1	Days		21	Days		0	Days		-8	Days		1	Fields	19/04/2021	19/04/2021	19/04/2021		19/04/2021			0	
				31	Days		0	Days		-3	Days		2	Fields	19/04/2021	19/04/2021	19/04/2021		19/04/2021			0	
	N/A	Days		31	Days		0	Days		-3	Days		4	Fields	19/04/2021	19/04/2021	19/04/2021		19/04/2021			0	
	N/A	Days		31	Days		0	Days		-3	Days		4	Fields	19/04/2021	19/04/2021	19/04/2021		19/04/2021			0	
	1	Days		31	Days		0	Days		-3	Days		2	Fields	19/04/2021	19/04/2021	19/04/2021		19/04/2021			0	
		Days		31	Days		0	Days		3	Days		6	Fields		N/A			N/A			0	
		Days		31	Days		0	Days		3	Days		6	Fields		N/A			19/04/2021			0	
		Days		31	Days		0	Days		3	Days		6	Fields		N/A			19/04/2021			0	
	1	Days		31	Days		0	Days		3	Days		6	Fields		N/A			19/04/2021			0	
		Days		N/A	Days		0	Days		0	Days		9	Fields		N/A			19/04/2021			0	
	N/A	Days		N/A	Days		0	Days		0	Days		9	Fields		N/A			19/04/2021			0	
	N/A	Days		N/A	Days		0	Days		0	Days		9	Fields		N/A			19/04/2021			0	
	1	Days		5	Days		0	Days		-3	Days		7	Fields		N/A			26/04/2021			0	
		Days		5	Days		0	Days		-3	Days		7	Fields		N/A			N/A			0	
	1	Days		5	Days		0	Days		-3	Days		7	Fields		N/A			N/A			0	
	1	Days		31	Days		0	Days		0	Days		6	Fields		N/A			N/A			0	
	N/A	Days		12	Days		0	Days		0	Days		1	Fields	17/03/2021	17/03/2021	17/03/2021		17/03/2021			0	
		Days		9	Days		0	Days		0	Days		1	Fields	03/05/2021	N/A	05/03/2021		05/03/2021			0	
		Days		21	Days		0	Days		0	Days		6	Fields		N/A	15/03/2021		15/03/2021			0	
		Days		21	Days		0	Days		0	Days		6	Fields		N/A	15/03/2021		15/03/2021			0	
		Days		N/A	Days		N/A	Days		N/A	Days		10	Fields		N/A	N/A		N/A			0	
	1	Days		14	Days		0	Days		0	Days		3	Fields	11/05/2021	11/05/2021	11/05/2021		11/05/2021			0	
	1	Days		14	Days		0	Days		0	Days		3	Fields	11/05/2021	11/05/2021	11/05/2021		11/05/2021			0	
	1	Days		14	Days		0	Days		0	Days		3	Fields	11/05/2021	N/A	11/05/2021		11/05/2021			0	
		Days		N/A	Days		N/A	Days		N/A	Days		6	Fields		N/A	N/A		N/A			0	
		Days		N/A	Days		N/A	Days		N/A	Days		6	Fields		N/A	N/A		N/A			0	
	16	Days		1	Days		N/A	Days		1	Days		1	Fields	03/06/2021	03/06/2021	03/06/2021		03/06/2021			0	
	16	Days		1	Days		N/A	Days		1	Days		1	Fields	03/06/2021	03/06/2021	03/06/2021		03/06/2021			0	
	16	Days		1	Days		N/A	Days		1	Days		1	Fields	03/06/2021	03/06/2021	03/06/2021		03/06/2021			0	
	16	Days		1	Days		N/A	Days		0	Days		3	Fields		N/A	06/09/2021		06/09/2021			0	
	3	Days		91	Days		N/A	Days		0	Days		3	Fields		N/A	N/A		08/09/2021			0	