

Primary Good Production Process Improvement

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*For my parents
who taught me the most important lessons about life
and who have always believed in me*

Abstract

The project entitled *Primary Good Production Process Improvement* was carried out in Tabaqueira E.I.T., the Portuguese affiliate of *Philip Morris International*, in the factory Primary department.

The company is engaged in the production of cigarettes, both for the domestic market and for export. It also produces tobacco semi-products for export or for other affiliates.

This project seeks to address the need to improve the performance of subprocesses enabling the Primary production, particularly their performance system-wise due to errors in some points of the process with severe implications to the workload of the different process participants.

Initially, the Primary process was divided in different subprocesses so that a detailed workflow of the whole process could be developed. Each subprocess is modeled in order to expose waste, identify improvement opportunities and define critical process control points.

The goal of these critical process control points is to spot mistakes that might have occurred during the process and prevent them from passing on to the downstream processes and to the next month.

These controls are executed through applications developed using MS Excel, VBA and SAP Scripting embedded within the VBA code. These applications generate reports that verify and alert the user in case errors exist, allowing for their timely correction.

The identified improvement opportunities triggered the development and implementation of tools aiming at:

- i. Process simplification;
- ii. Automation of routine and repetitive tasks;
- iii. Elimination of non-value added activities;
- iv. Decreasing the errors frequency.

These tools were designed for MS Excel software and are also based on VBA and SAP Scripting.

Lastly, Standard Operating Procedures were created for activities whose standards were not yet defined and also for the newly implemented procedures, so that they could be effectively institutionalized

This project focused on simplification of the subprocesses related to the execution of the Primary production, with an emphasis on reducing the cycle time of these subprocesses and on error elimination, since the indirect costs of these errors are significant and may affect other processes.

Resumo

Melhoria do Processo de Produção do Primário

O projeto intitulado ‘Melhoria do Process de Produção do Primário’ foi realizado na afiliada portuguesa da multinacional *Philip Morris International*, Tabaqueira E.I.T., em particular no Primário da fábrica. A empresa dedica-se à produção de cigarros para o mercado interno e para exportação, bem como à produção de semi-produtos do tabaco, também para exportação ou para outras afiliadas.

Este projeto surgiu como resposta à necessidade de melhorar subprocessos associados à produção do Primário, em particular o desempenho dos seus subprocessos a nível de sistemas, devido ao aparecimento de erros em determinados pontos do processo com implicações na carga de trabalho dos diferentes intervenientes.

Começou-se por dividir o processo Primário em diferentes subprocessos por forma a detalhar o fluxo de trabalho ao longo do processo. Cada um dos subprocessos é modelado e caracterizado com o objetivo de expor atividades que geram desperdício ou passos que são desnecessários, identificar oportunidades de melhoria e definir pontos de controlo no processo.

O objetivo destes pontos de controlo é detetar erros que possam ter ocorrido e impedir que estes passam para os processos a jusante ou para as atividades do mês seguinte.

Estes controlos são executados através de aplicações desenvolvidas utilizando o *software* MS Excel e as linguagens de programação VBA e SAP *Scripting*, esta última incorporada no código VBA. Estas aplicações geram relatórios que verificam e assinalam a existência de erros, permitindo a sua correção atempadamente.

As oportunidades de melhoria identificadas despoletaram o desenvolvimento e implementação de ferramentas que visam:

- i. Simplificação dos processos;
- ii. Automatização de tarefas rotineiras e repetitivas;
- iii. Eliminação de atividades sem valor acrescentado;
- iv. Diminuição da ocorrência de erros no processo.

Estas ferramentas foram desenvolvidas em MS Excel e têm também por base código VBA e SAP *Scripting*.

Por último, foram definidos *Standard Operating Procedures* para atividades cujos *standards* ainda não estavam definidos e para os novos procedimentos implementados, por forma a serem institucionalizados de forma efetiva.

O foco deste projeto é então a simplificação dos subprocessos ligados à execução da produção do Primário, com ênfase na diminuição do tempo de realização das diferentes atividades e na eliminação de erros, já que os custos indiretos associados a estes erros são significativos e poderão afetar outros processos.

Acknowledgements

To the development of this dissertation many were those who contributed. Without their valuable insights and support, this project would not be as rich. Below, I will try to mention and reference them all.

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Acronyms

3PL – Third Party Logistics

BBS – Basic Blended Strips

BPMN – Business Process Management and Notation

DIM – Direct Input Materials

ERP – Enterprise Resource Planning

ET – Expanded Tobacco

FG – Finished Goods

FMEA – Failure Mode and Effect Analysis

GI – Goods Issue

GR – Goods Receipt

HMI – Human Machine Interface

IS – Improved Stems

KMS – Knowledge Management System

LSP – Logistics Service Provider

PMIM – Philip Morris International Manufacturing

PMS – Primary Monitoring System

PO – Process Order

PSS IV – Production Supervision System IV

SL - Small Lamina

SOP – Standard Operating Procedures

STO – Stock Transfer Order

VBA – Visual Basic for Applications

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1 Introduction

This section begins with a presentation of the company where the project took place.

Afterwards, the project is defined and framed within the company, including a description of the main motivations, goals and expected results. Also, scope and focus of the project are presented.

Subsequently, the research methodology, portraying the rational by which the project was conducted is explained.

Finally, the structure of this dissertation is presented and subsequent chapters are briefly described.

1.1 Company presentation

Tabaqueira was founded in 1927, by the business man Alfredo da Silva, installing its first facilities in the region of Poço do Bispo, Lisbon. As the result of the strategic decision of expanding the activity and upgrading facilities, in 1966 the factory of Albarraque was founded.

The following decades saw a period of continuous growth for Tabaqueira, both in volume produced and market share.

In 1974, Tabaqueira is nationalized as a consequence of the so-called 'Portuguese Revolution'.

In 1996 Philip Morris International, PMI, bids for 65% of the company's capital and starts the process of re-privatization, concluded in December of 2000, with PMI taking over more than 99% of the company's social capital.

Being part of the PMI universe, Tabaqueira has a wide product portfolio, producing some well know international brands like Marlboro, L&M or Chesterfield, apart from famous local brands like SG or PORTUGUÊS

The Tabaqueira factory

The Tabaqueira factory is divided in three productive departments being: Primary, Secondary and Filters.

The Primary department is where raw tobacco leaf is processed and transformed into cut filler (tobacco used on cigarette manufacturing) before Secondary feeding. This productive process has the characteristics of a batch production process, having each particular cut filler a specific batch laydown¹. Also, each cut filler batch is referenced to a given code, e.g. BL12P, called the blend code and is produced according to a given specification or recipe², created centrally by PMI Leaf department. Moreover, each produced batch, from a particular blend, has a batch identifier, called a batch TP to ensure product traceability.

In the end of the productive process, cut filler batches are stored in bins, cartons or silos before being transported to the Secondary department, pneumatically.

The primary department also contains an area called 'Pack-off', where improved stems and cut filler for exportation are packed, labelled and prepared for warehouse transportation. The operations of the Pack-off area are subcontracted to a Logistics Service Provider, LSP, and will be discussed in more detail on chapter 3.2.3.

The Filters department is where the filters used in the different cigarette brands³ are manufactured. Filters are then 'shot' pneumatically to link-ups in the Secondary department, according to the cigarette brand being produced.

The Secondary department is where cigarettes are manufactured. Cut filler coming from the Primary is fed into link-ups⁴, where cigarettes are automatically manufactured - cut filler is wrapped in smoking paper and the filter is joined with the cigarette using tipping paper - and aggregated in packs, which in turn are packed in volumes. These are then wrapped in plastic and further aggregated in boxes, ready for transportation to the Finish Goods Warehouse, FGW.

Figure 1 depicts what has just been described.

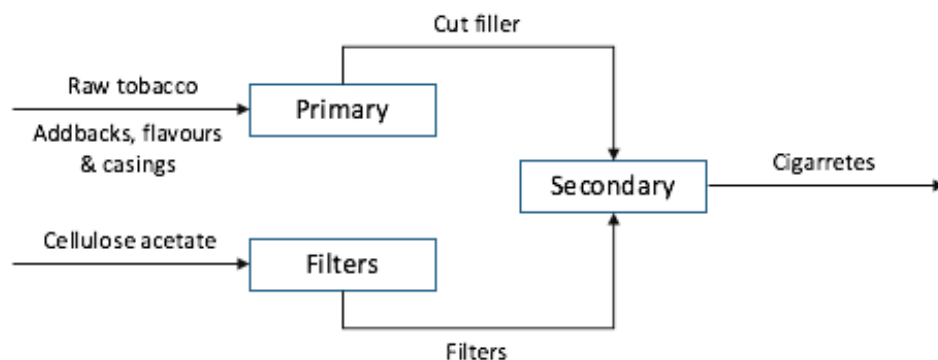


Figure 1- Factory productive departments

¹ Batch laydown refers to the specified quantity in which batches need to be produced. They vary according to the blend code.

² A specification list contains details of batch composition as well as critical process variables and process parameters values.

³ Each cigarette brand has an almost unique combination of filter and smoking paper, giving different smoking and flavor properties.

⁴ In Portuguese, these are called 'cigarreiras'. Manufacturing cells comprising a maker – cigarette making machine - and a packer – packaging machine

The Tolling Business Model

Philip Morris International is currently operating under a tolling manufacturing business model, with practically all its affiliates already operating under this business model.

Broadly speaking, tolling means to provide manufacturing services for a fee by a contractor (the toller), to a company issuing (letting) a contract for those services. Tolling implies that processing of materials takes place. This type of contract stipulates a particular division of responsibilities among three entities: the Entrepreneur, the Toller and the Buy & Sell entity. Figure 2 describes the main business flows and the main responsibilities of the involved entities.

Under this business model, Philip Morris International Manufacturing, PMIM (the entrepreneur), lies responsible for the sourcing and supplying of raw materials to the factories, planning mid-term production and managing inventories for tobacco leaf, direct input materials, DIM, and finished goods, FG. The toller, Tabaqueira factory, produces according to production requirements given by PMIM. As a toller, Tabaqueira commits itself to, among other things, produce cigarettes according to the specifications from PMIM and to define its conversion cost. On the other hand, it earns a fee for converting raw materials into finished goods for PMIM.

This type of business model introduces rather interesting particularities in terms of production planning. For example, since production requirements and capacity are allocated by central departments, production plans are frequently altered and adjusted to fit the requirements. This makes the planning exercise rather volatile and the planning task reactive instead of a predictive. Also, because all raw materials are allocated centrally, communication between the factory supply chain department and central departments must be constant in order to avoid either material shortages or excess stock.

Furthermore, this type of business model implies that responsibilities for the different aspects of the business are clearly separated. As depicted on Figure 2 the toller company is only responsible for managing its assets and own resources and has no visibility over other aspects of the business, for example, market demand. As such, there is the risk that the different entities involved gain an excessively narrow vision of the business and focus too much on its daily activities, disregarding the business as whole.

However, the tolling model confers all affiliates the ability to focus on their primary responsibilities and core competencies, which is the efficient production of quality products within specifications.

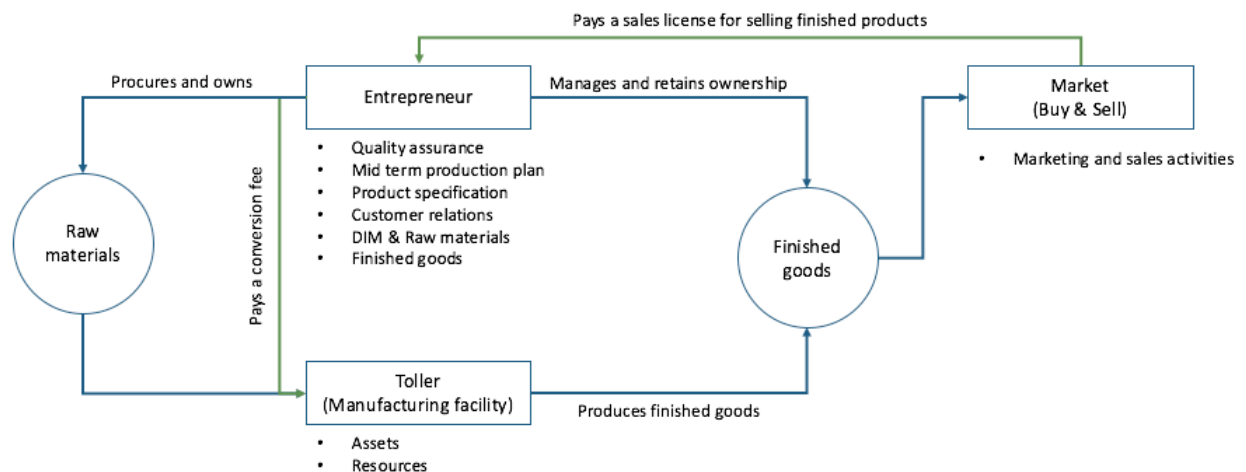


Figure 2 - Tolling manufacturing business model

1.2 Project description and motivation

In this subchapter, a more detailed description of the Primary Production process is presented and the project is framed within the Primary department processes. Main motivations, goals and expected results are also discussed.

1.2.1 Project focus and scope

The present project, entitled ‘Primary Good Production Process Improvement’, was conducted in the Primary Production department of the Tabaqueira factory.

The focus of the project was not the productive process itself, meaning that studies aimed at, for example, improving the productive process output / efficiency or reducing raw material waste across the productive process were out of the scope of the current project. Rather, it emphasizes more on information flows throughout the Primary subprocesses enabling the Primary production execution, and the impact that shop-floor operations have on the company’s information systems.

Nevertheless, careful analysis is made to the productive process because information generated throughout the process serves as input for other subprocesses (e.g. production recording subprocess) and needs to be accurate and reliable.

The ‘Good production’ process deals with the confirmation and recording of process orders⁵. To ensure that it can be carried out, proper information about raw material consumptions and final production quantities need to be readily available. In this work, the ‘Good Production’ process was considered to be a subprocess of the Primary process, named Production recording.

The production recording subprocess also receives inputs from the pack-off subprocess, therefore the pack-off area operations were considered to be within the scope of the project and will be analyzed in subsequent chapters.

Although not directly linked to the production recording and confirmation activities, the inventory process is also under the scope of the project and will be explored with some detail on subsequent chapters because it deals with stock adjustments and with system material movements that influence previous production recordings, and more importantly, the factory yield results⁶.

The project spans not only the factory Primary department but also the Supply Chain department. In fact, the value chain under analysis stretches until the Primary Production Planning and Scheduling, which starts at the Supply Chain department.

⁵ Process orders can be described as a manufacturing orders used in the process industry. A more detailed description of their use and structure will be presented in due time

⁶ Yield is a key indicator used to monitor and benchmark production performance

1.2.2 Motivations, goals and expected results

The present project comes as a response to two important needs identified by the Primary Production and Primary Planning team managers:

- i. the need to eliminate part of the errors that appear in the SAP R/3 system at some points of the process;
- ii. the need to improve the performance of some Primary subprocesses, particularly in terms of how information flows through the supporting systems.

Errors on the SAP information system have direct implications in the workload of the different participants in the process since, generally, they need to be solved before the process can be completed. Moreover, they can also have significant impact to other processes since the SAP system integrates information concerning different functions of the company. As such, financial reports, for example, are generated based upon information produced by the Primary process. As such, errors affecting information integrity may distort these reports.

The initial assessment was that part of these errors and inefficiencies came from the fact that:

- i. the current process is quite manual and dependent upon the tacit knowledge of the different actors;
- ii. there is lack of standardization of activities in several subprocesses which lead to variable process outputs;
- iii. there are some points of the process where there is inefficient communication and process hand-offs;
- iv. some SAP information movements do not reflect shop-floor operations.

It is not difficult to evaluate the potential business impacts of these issues, the main ones being: non-value added time spent solving avoidable errors and performing non-value added activities and questionable data integrity. Moreover, outputs' variability puts great pressure on the different process participants' workload.

Therefore, this project aims to address the issues described and implement business solutions, or present improvement suggestions, to solve or at least mitigate them.

After its completion, it is expected that the following results have been achieved:

- i. Clear and holistic model of the Primary Process with focus on:
 - a) Primary Planning and Leaf Replenishment;
 - b) Primary Good Production Recording;
- ii. Identification and mitigation of the more error-prone activities;
- iii. Definition of critical process control points and creation of reports / applications that can carry out this control points;
- iv. Improved data flow between process actors;
- v. Process simplification through automation of process tasks;
- vi. Non-value added activities identification and elimination;

1.3 Research framework and methodology

To achieve the goals and address the project motivations, the project was conducted following a well-structured process improvement methodology, depicted in Figure 3

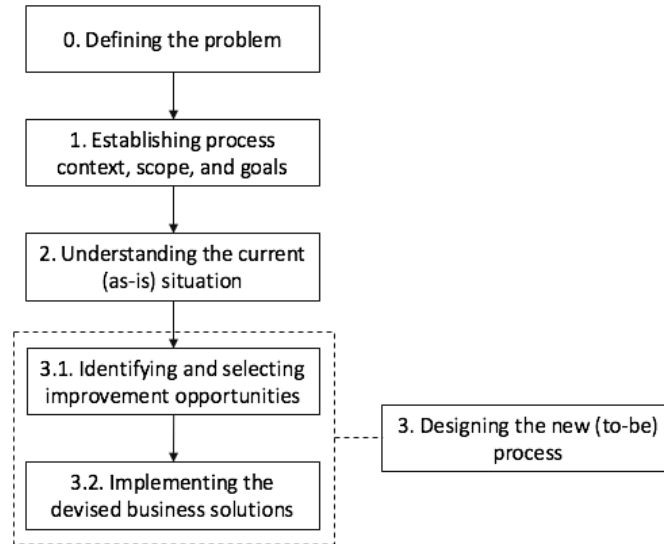


Figure 3 - Research framework used throughout the project

Stage zero of the project is the problem definition, where the project purpose and motivations are stated. The first stage, includes identifying a set of related business processes, and for each, clarifying its boundaries, contents and goals. The second stage includes modeling the processes workflow and identifying main actors and process handoffs. Analysis of the current situation allows the identification of bottlenecks and waste activities.

The last stage of this research framework comprises two main phases: identifying and selecting improvement opportunities and implementing the devised business solutions. The output of this last stage is a new process workflow, reflecting the implemented changes.

In order to better organize and monitor the project evolution, a project chart was created and can be consulted in Appendix A.

1.4 Document structure

This dissertation is structured in 5 main chapters, organized according to the research framework previously described. In the present chapter the research problem was thoroughly defined the project background has been described and framed within the organization.

In the next chapter, an extensive academic literature review is presented about the subjects that fall within the scope of the project and the techniques employed.

Chapter 3 portrays the conclusions from stage 1 and stage 2 of the research framework. In Chapter 4, improvement opportunities are identified, implemented solutions are described and improvement suggestions for future follow-up are presented. This chapter corresponds to the stage 3 of the employed methodology, comprising both phases 3.1. and 3.2.

The fifth and final chapter in this report presents the conclusions, summarizing the main contributions of the project and results achieved, and a discussion of possible future work.

2 Literature review

This chapter is intended to be a compendium of literature reviews gathered from recent publications on the field of business process improvement. Different methodologies are covered as well as the most commonly used tools on each of them.

The tools used during the different phases of the project are presented and possible alternatives to some of them are discussed.

Additionally, on the last subchapter, attention is given to the topic of Enterprise applications, particularly, Enterprise Resource Planning, ERP, and Knowledge Management Systems, KMS.

2.1 Business Processes

‘Every organization—be it a governmental body, a non-profit organization, or an enterprise—has to manage a number of processes’ (Dumas, Rosa *et al*, 2013).

As noted on the previous statement, business processes are integral parts of any organization and should be managed and improved in order to ultimately increase bottom-line performance.

Several authors including Dumas, Rosa *et al* (2013), Hammer and Champy (1993) or Davenport (1993), and organizations (see ISO 9001), propose a definition intended to capture the essence of business processes. Dumas, Rosa *et al* (2013) define a business process as ‘a collection of inter-related events, activities and decision points that involve a number of actors and objects, and that collectively lead to an outcome that is of value to at least one customer’.

According to Davenport (1993) a process can be defined as ‘a structured, measured set of activities designed to produce a specified output for a particular customer or market’.

Hammer and Champy (1993) define a process as being ‘a collection of activities that takes one or more kinds of input and creates an output that is of value to a customer’.

These definitions are similar in the sense that they all refer to a collection of activities, arranged in such a way as to produce a desired outcome that is of value to a certain customer. Indeed, the key concept of a process, its *raison d’être*, is that of creating added value to the customer (Mongillon and Verdoux, 2003).

Processes are often categorized according to different criteria. For example, Sharp and McDermott (2009) and Weske (2012) argue that not all processes can be reduced to a defined set of activities.

In fact, Weske (2012) classifies business processes in repetitive or collaborative, according to its degree of repetition. Sharp and McDermott (2009) present a similar classification, dividing business processes in:

- i. Executive or strategic processes: processes that are not repetitive and cannot be reduced to a set of activities, being more fruitful to analyze them from the information needs point of view;
- ii. Creative or collaborative processes: like executive processes, these processes can hardly be reduced to a workflow model;
- iii. Transactional processes: processes comprising highly repetitive work following a sequence of steps and decisions, generally highly suitable for workflow modeling.

Also common to the abovementioned definitions is a set of elements that constitute a business process. Sharp and McDermott (2009) argue that a process comprises the following core elements:

- i. triggering event: what happens to make the process (or activity) start - it can be an action or decision, a temporal event or a given condition;
- ii. activities (steps) or decisions;
- iii. actors or participants: those who carry out the steps of the process;
- iv. result: what's expected by the customer or any other stakeholder.

The work performed during process execution is what transforms process inputs into process outputs. This work is comprised of a set of activities, steps or tasks.

Weske (2012) distinguish activities that make up a given business process depending on the level of software system support:

- i. system activities: do not involve a human user and are executed by information systems;
- ii. user interaction activities: are performed by knowledge workers (humans), using information systems, involving no physical activity;
- iii. manual activities: are not supported by information systems

Also relevant to the discussion of business process improvement initiatives is the concept of process enablers. Sharp and McDermott (2009) define an enabler as being 'a factor that can be adjusted to impact process performance'. They present six business process enablers:

- i. Workflow design: work plan for responding to a triggering event, showing the sequence of steps, decisions, and handoffs carried out by the process's actors between the initial event and the final result;
- ii. Information systems: includes systems, information, computers and other devices, telecommunications equipment, and the networks they comprise;
- iii. Motivation and measurement: concern how people, organizations, and processes are measured and assessed, and the associated consequences (be a reward or a punishment);
- iv. Human resources: relates to having the right people, with the right skills doing the right job;
- v. Policies and rules: includes the rules and policies established by the enterprise to guide or constrain business processes, as well as applicable laws and regulations;
- vi. Facilities design: workplace design and physical infrastructure such as equipment, furnishings, machinery, lighting, air quality, and ambient noise.

Sharp and McDermott (2009) clearly emphasize the role of the first two enablers, workflow design and information systems, on business process performance.

Nonetheless, they stress the importance of all enablers acting in concert so that the process can deliver the expected results.

Additionally, it is worth mentioning another important aspect that relates to all processes: the process customers.

Every process has a customer, a reason to exist, and the goal of every process is to ultimately satisfy its customer. Process customers can be internal (usually other processes) or external to the organization. Processes serving external customers are said to be core processes, since they are the reason the company exists (Sharp and McDermott, 2009).

2.2 Business Process Modeling

Davies and Reeves (2010) state that, ‘for the purpose of a business process review initiative, business process modeling is the act of representing both the current ‘As-Is’ and future ‘To-Be’ processes of an organization, so that the current process may be analyzed and improved, enabling ease of communication and a common understanding with different stakeholder groups’. Therefore, business process modeling is an essential component for the deployment of many of the business process improvement methodologies (Turetken, Rompen *et al*, 2016). In fact, mapping the current and the target business process are steps undergone in a typical process improvement initiative (Conger, 2010).

For a process-oriented improvement project to be successful communication is a key in the development of both As-Is and To-Be models, since these need to be understood by those responsible for the improvement change and the stakeholders involved (Reijers, Mendling *et al*, 2015). As such, among other characteristics, process models are required to be intuitive and easily understandable.

Criticality of business process models understandability is recognized among the scientific community and several studies have been conducted on the factors affecting process models understandability, e.g. Reijers and Mendling (2011).

Turetken, Rompen *et al* (2016) argue that ‘in order to process models to successfully serve for their potential uses, they should be perceived as understandable by their audience’.

Reijers and Mendling (2011) define process model understandability as ‘the degree to which information contained in a process model can be easily understood by a reader of that model’. Furthermore, they investigate the influence of two factors on process model understandability:

- i. Personal factors related to the model reader (e.g. expertise, preferences over information representation, perceptual capabilities);
- ii. Factors that relate to the model itself (e.g. notation and secondary notation, level of abstraction and hidden dependencies).

In their work, they conclude that model features and personal characteristics are indeed likely relevant factors when it comes to understanding a given process model. Furthermore, they add that model purpose can influence the understanding of a model.

To this regard, Polyvyanyy, Smirnov *et al* (2015) mention the following reasons as to why business process modeling may be undertaken:

- i. to communicate a message;
- ii. to share knowledge or vision;
- iii. as a starting point for redesigning or optimizing processes;
- iv. as precise instructions for executing business tasks.

Therefore, ‘when modeling a business process, the specific purpose and target audience for which the model is being created need to be kept in mind’ (Dumas, Rosa *et al*, 2013).

In fact, this is one of the guidelines to be considered when modeling processes. Jeston and Nelis (2006) list additional guidelines as follows:

- i. approval and governance: specify who will approve and maintain the process models;
- ii. the big picture first: the initial step in process modeling is to define how the process fits into the overall value-chain and only then drill to down to its subprocesses;
- iii. ascertain the standards applicable to the modeling process and abide by them.

Moreover, Davis (2012) presents a generally accepted set of modeling principles to follow in order to produce valuable process models:

- i. principle of correctness: assure that correct semantics and syntax are used, according to the selected method;
- ii. principle of relevance: the level of detail used should be according to the modeling purpose and only the relevant items should be modeled;
- iii. principle of clarity: models must be easily understood and usable; if a process is too complex, it should be split in order to be modeled.

2.2.1 Business Process Modeling Notation (BPMN)

According to the Object Management Group, the Business Process Modeling Notation, BPMN, is a ‘business process modeling standard developed to provide a notation that is readily understandable by all business users. It creates a standardized bridge for the gap between the business process design and process implementation’.

BPMN was created to ‘standardize the way organizations model their business processes in face of many different modeling notations and viewpoints’. In doing so, BPMN allows an organization to communicate and pass on process information to all of its stakeholders being business users, process implementers, customers, or suppliers (Weske, 2012).

It is largely accepted that BPMN is a widely used powerful notation, according to Sharp and McDermott (2009) and Dumas, Rosa *et al* (2013). Nonetheless, BPMN is a language that contains a huge amount of symbols, far too many than are necessary to document the main concepts and flow of a business process (Sharp and McDermott, 2009). For this reason, only a fraction of the available symbols in this language are used to model and characterize the business processes on this project.

Weske (2012) divide the notational elements used on BPMN in four basic categories, each of which consisting of a set of elements:

- i. flow objects: they include events, activities and gateways;
- ii. artefacts: are used to show additional information about a business process and can be associated with flow elements, serving only information purposes (meaning that the execution of a process is not influenced by them); supported artefacts are data objects, groups or annotations;
- iii. connection objects: connect flow objects, swimlanes, or artefacts;
- iv. swimlanes: are used to represent the roles of those involved in the process.

A representation of these elements can be found in Appendix B.

For a complete representation and more detailed characterization of the elements that constitute each of the abovementioned categories please refer to Weske (2012).

2.2.2 Modeling techniques

Successful business process modelling depends on a number of factors. Particularly important is the appropriate selection of available modelling methods, techniques or process flow analyses (Damij, Damij *et al*, 2008).

Reijers and Mendling (2011) state that ‘process models typically capture in some graphical notation what tasks, events, states, and control flow logic constitute a business process’.

There are several formats for diagramming a business process (Sharp and McDermott, 2009). Below, three of them are described.

Process Workflow Models

Process workflow models are commonly referred to as swimlane diagrams, given the close analogy between the lanes on the diagram, attributed to each participant or actor in the process, and the swimming pool lanes attributed to each swimmer.

Swimlane diagrams use the same core symbols that the BPMN describes – lanes, activities and sequence flows (Sharp and McDermott, 2009).

Sharp and McDermott (2009) argue that the following characteristics rendered swimlane diagrams the *de facto* standard for depicting business processes. As such, swimlane diagrams:

- i. are simple, self-explanatory and easily understandable by almost everyone;
- ii. represent every actor of the process and emphasize their responsibilities, the interactions with other actors and their activities, whether they are value-added activities or not;
- iii. are highly visual, highlighting time and sequence dependencies as well as the flow patterns (sequential or parallel flows).

Flowcharts

According to Gelinas, Sutton *et al* (2009), a (system) flowchart is ‘a graphical representation of information processes (activities, logic flows, inputs, outputs, and data storage), as well as the related operations processes (entities, physical flows, and operations activities). Including both computer activities, the systems flowchart presents a logical and physical rendering of the who, what, how, and where of business processes and information systems’.

Dumas, Rosa *et al* (2013) state that flowcharting is one of the oldest process modeling language consisting, in its basic form, of rectangles, representing activities, and diamonds, representing points in the process where a decision is made.

Flowcharts are useful to perform a detailed analysis of a system or business process. In fact, task level details are often documented using flowcharts (Sharp and McDermott, 2009).

Process Scope Diagrams

Process Scope diagrams, are used to analyze the relationship between a given process and its environment, as opposed to the process workflow diagrams previously described, which look primarily at the internal workings of a given process. These are essentially box-like diagrams, where the process under analysis is observed from a black-box perspective.

Process Scope Diagrams are particularly useful at an early stage of the process analysis, when taking a broad look at an overall process during scoping, before moving on to the process workflow modeling (Harmon, 2014). The inputs and outputs of the process are identified as well as the guides that govern the process and the enablers that support it (Sharp and McDermott, 2009).

Process scope diagrams are also referred to as IGOE diagrams. IGOE is an acronym that stands for Inputs, Guides, Outputs and Enablers.

Appendix C shows the elements that constitute this type of diagram and a description of each of them. The following description of this type of diagram is based on the description presented in Harmon (2014).

The process under analysis is placed in the center of the diagram. On the left side of the diagram, the inputs to the process, coming from from other processes, organizations, systems, or external stakeholders, are listed. On the right side, process outputs, going to other processes, organizations, systems, or an external stakeholder, are registered. Inputs and outputs can link the process(es) in the process area to individuals, documents, products, systems, organizations, or other processes. To make the diagram more perceivable and intuitive the following elements are used: little figures for people, rectangles for organizations or systems, and rectangles with rounded corners for processes are used. The area above the process area is reserved for the guides or controls and the area below the process area is where information about enablers that support the execution of the processes is entered.

State modeling

The Business Analysis Body of Knowledge Guide, BABOK, Iiba (2015), presents yet another technique for analyzing and modeling a given system: state modeling.

Accordingly, state modeling is defined as ‘a tool used to describe and analyze the different possible states of an entity within a system, how that entity changes from one state to another, and what can happen to the entity when it is in each state’.

Iiba (2015) defines an entity as ‘an object or a concept within a system, used in several processes and with a finite and defined life cycle, with a beginning and an end’.

State models are used to describe:

- i. a set of possible states for an entity;
- ii. the sequence of states that the entity can be in;
- iii. how an entity changes from one state to another;
- iv. the events and conditions that cause the entity to change states;
- v. the actions that can or must be performed by the entity in each state as it moves through its life cycle.

Iiba (2015), argues that while workflow models depict all of the entities allocated to a given process, states models offer a complementary, showing what happens to one entity across all the processes that affect it or use it.

2.3 Qualitative Process Analysis

‘Analyzing business processes is both an art and a science’ (Dumas, Rosa *et al*, 2013).

The previous statement makes it clear that process analysis is not always an exact and straightforward science. Although many process improvement methods are quantitative in nature, this research is based mainly in qualitative methods for process analysis, generally used during the analysis stage of any business process improvement initiative.

In this section, a set of tools commonly used to qualitatively analyze processes are presented.

Root-Cause Analysis

Business processes are performed on a day-to-day basis in an organization’s life. However, none of them are flawless and there are always errors, misunderstandings, incidents, unnecessary steps and other forms of waste.

Root-cause analysis is a family of techniques to help analysts identify and understand the root cause(s) of problems or undesirable events.

Dumas, Rosa *et al* (2013) consider undesirable (or negative) events in the context of process analysis, as being ‘recurrent issues that prevent a process from having a better performance or from performing at acceptable levels of performance’.

In the context of the current project, from the variety of techniques used to perform a root cause analysis, only a few techniques have been used, namely: cause-effect diagrams, brainstorm sessions and *gemba* walks.

Cause-effect diagrams were developed by Kaoru Ishikawa in 1982 to support systematic identification and classification of different types of causes that might contribute to a problem (Conger, 2010). This type of diagram is also called fishbone or Ishikawa diagram.

Cause–effect diagrams depict the relationship between a given negative effect and its causes (Dumas, Rosa *et al*, 2013).

Figure 4 depicts a cause-effect diagram with pre-specified cause categories.

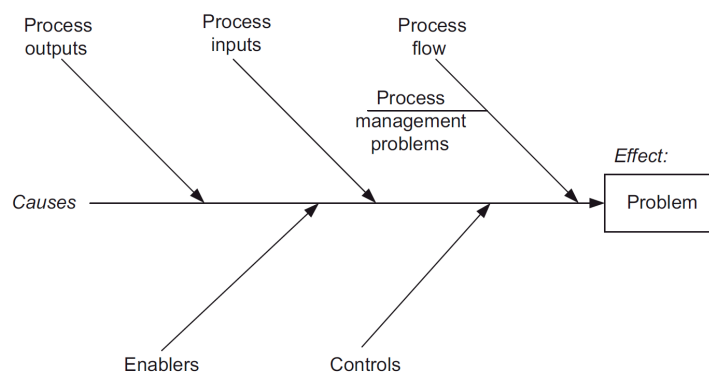


Figure 4 - Cause-effect diagram, adapted from Conger (2010)

A3 Reports

A3 is a problem-solving methodology that facilitates the search for the root of the problem. The A3, also called A3 report, is a technique pioneered by Toyota that puts together on a single sheet of A3 paper the identification of the problem, the analysis conducted, the proposed corrective actions, and action plan devised (Pyzdek and Keller, 2009).

It provides a simple way to describe, clearly and efficiently, a given problem, where each section of the A3 report builds upon the previous one. This methodology is applied successfully to several industries and can be used by professionals with no engineering or business background (Sobek II and Jimmerson, 2004).

The section names used can vary, according to the problem this method is being applied to. Appendix D shows the typical flow of the problem-solving A3 report, according to Sobek and Smalley (2008) and depicts its relationship with the PDCA cycle. In fact, this methodology's logical flow almost replicates the one followed by the PDCA cycle: the problem is initially defined using historical data, the current situation is evaluated and strengths and weaknesses are assessed, leading to the proposed solutions and the definition of actions plans (Silva Filho and Calado, 2013). Moreover, Sobek and Smalley (2008) state that A3 thinking enables the implementation of PDCA management, by providing a structured methodology to understand, analyze and solve a given problem.

Figure 5 shows the template used during the brainstorming sessions carried out throughout the project.

Figure 5 - Template for an A3 report

SIPOC

According to the International Institute of Business Analysis Iiba (2015), SIPOC is a 'process analysis method, originated in the Six Sigma methodology, which provides a simple overview of the process'. In fact, Wedgwood (2006) argues that 'SIPOC is useful in understanding the scope and purpose of the process'. Fredendall and Thürer (2016) also state that 'SIPOC diagram is a tool used to identify the relevant elements of a value stream'.

Particularly, SIPOC is used to look at the process and understand the Suppliers, Inputs, Process, Outputs and Customers of the process being analyzed. Information related to each process step is represented in a tabular summary (Conger, 2010).

Fredendall and Thürer (2016) present a description of the elements involved in a SIPOC analysis:

- i. Supplier: the provider of the inputs (may be a department within the company or it may be an external supplier);
- ii. Inputs: requirements that can be either material or information, including inputs that will be changed by the process and resources that will be used but not changed (Berman, 2014);
- iii. Process: set of steps that are internal within the company or department that is responsible for performing some transformation of the inputs into something else;

- iv. Output: identifies what is sent from the process to the customers and, ideally, should provide a satisfactory input to the customer;
- v. Customer: whoever receives the output of the process; it is worth mentioning that there may be multiple outputs of a process and multiple customers.

Standardization

Standard work definition and process standardization have proven benefits across several different industries.

‘Without standards, the potential for improvement is limited. Things will come back to the chaotic state and will be doing nothing but firefighting’ (Suzaky, 2010).

This statement shows the importance of following standard procedures, not only to perform daily routine jobs but also to sustain eventual improvements that have been achieved.

Suzaky (2010) argues that standard work definition should be embedded within an improvement cycle, so that they can be updated to reflect eventual improvements and new working methods. Mílkva, Prajová *et al* (2016) also argues that improving standardized work is a never-ending process, considering it the basis for continuous improvement. Therefore, standards are not static and should be revised periodically. These new standards become the basis for further improvements. Figure 6 depicts an improvement cycle, proposed in Suzaky (2010).

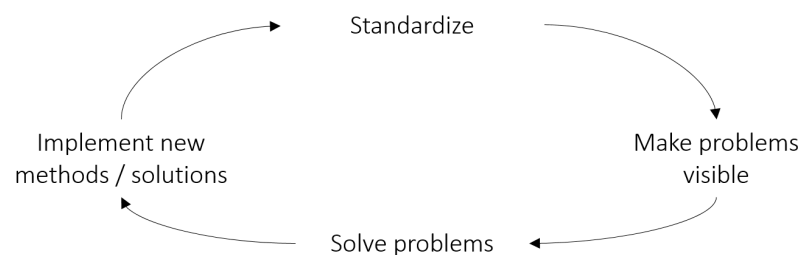


Figure 6 - Improvement cycle, adapted from Suzaky (2010)

In the first part of the cycle problems are identified through the analysis of the current state and standard work. Then, new solutions and methods that solve the problem under analysis are to be found. On the third step, these solutions are to be implemented and tested. Should they produce satisfactory results, a new standard work procedure is to be created and put in place in order to sustain and institutionalize the improvements and the gains achieved.

As far as business processes are concerned, Tregear (2010) states that standardization means ‘the development of a standard or best-practice process to be used as a template for all instances of the process throughout the organization’.

Concerning companies with multiple business units or regional departments, Hammer (2010) argues that standardizing processes across all parts of the enterprise ‘presents a single face to customers and suppliers, yields profound economies in support services such as training and IT systems, allows the redeployment of people from one business unit to another, and yields a host of other benefits’. Mílkva, Prajová *et al* (2016) add the following benefits resulting from standardizing business processes:

- i. easier training of new operators;
- ii. reduction in variability of processes output;
- iii. clarification of working procedures;

- iv. facilitated communication.

Moreover, standardized work definition can be used a learning tool that promotes problem solving and team involvement on improvement initiatives.

FMEA

FMEA is an acronym for Failure Mode and Effect Analysis. This technique has been used to analyze business processes in several different industries, e.g. healthcare (Onofrio, Piccagli *et al*, 2015), manufacturing (Almannai, Greenough *et al*, 2008) and financial (Pyon, Woo *et al*, 2011)

According to Tague (2005), failure modes relate to the ways, or modes, in which something might fail. Failures are any errors or defects, especially the ones that affect the customer. Effect analysis refers to studying the consequences, or effects, of those failures.

Moreover, FMEA differentiates the different failure modes in terms of their relative impact, ranking them and prioritizing the possible causes of failures, facilitating the development of prevention strategies (Monti, Jefferson *et al*, 2005).

As such, the main of FMEA is to eliminate possible failure modes and mitigate the respective associated risks (Stamatis, 2014).

The process for conducting a FMEA analysis is triggered whenever the need to improve arises. Stamatis (2014) present an eight-step approach to conduct a FMEA effectively:

- i. Build the team and brainstorm – it is advisable to gather a cross-functional and multidisciplinary team;
- ii. Define the As-Is situation – this stage seeks to ensure that the problem is clearly understood by everyone and to provide an overview and a working model of the current process;
- iii. Prioritize – this stage seeks to identify which opportunities to address;
- iv. Collect data – this stage deals with data collection regarding the identified errors and failure modes;
- v. Analysis – in this stage, the data gathered on the previous stage is analyzed in order to gain insights on what may have caused the failures; qualitative and quantitative techniques are usually employed at this stage to help identify the effects of each failure, existing controls and estimate severity, occurrence and detection;
- vi. Results – this stage seeks to quantify the values for the severity, occurrence, detection and risk priority number, RPN;
- vii. Confirm – in this stage the results from the previous step are evaluated and action plans are devised accordingly;
- viii. Repeat the process – this last stage comes in line with the continuous improvement philosophy, which the long-term goal is to eliminate every single failure.

FMEA's main output is a table, containing several columns portraying all the information generated during the analysis described above. A template can be found on Appendix E with a brief explanation on how to fill in the table and calculate the values for the severity, occurrence, detection and RPN ranks. Appendix E is based on Stamatis (2014).

2.4 Business Process Outsourcing

‘In a world of end-to-end customer-focused processes, what matters in the marketplace is the cost of entire processes, regardless of who owns which part of the chain’ (Smith and Fingar, 2007).

This idea defended by Smith and Fingar (2007) puts forward the fact that the basis for competition is changing. Companies are turning to business process outsourcing as a means to gain flexibility and improve profitability, ultimately remaining competitive in the marketplace.

Jacobs and Chase (2013) define outsourcing as ‘the act of moving some of a firm’s internal activities and decision responsibility to outside providers’. Outsourcing implies the celebration of a contract where the terms of the agreement are established, particularly the responsibilities of both parties.

Other reasons that motivate companies to outsource a particular process are presented in Conger (2011):

- i. increased access to innovative practices;
- ii. upgrades in technology;
- iii. reduced operating costs;
- iv. increased quality of work.

Nonetheless, this author argues that ‘these benefits can only be achieved if the company manages the outsourcing process well and oversees the outsourced work as if it were still within the business’.

Jacobs and Chase (2013) still presents the following reasons as why companies choose to outsource their processes:

- i. improve credibility and image by associating with superior providers;
- ii. gain access to new markets, particularly in developing countries;
- iii. improve effectiveness by focusing on what the firm does best;
- iv. increase flexibility to meet changing demand for products and services;
- v. improve risk management.

Outsourcing entire business processes is a strategic decision that can also have drawbacks.

Activities previously coordinated within one firm will now be allocated to different firms and coordinative actions will now have to span the boundaries of these firms (Gadde and Hulthén, 2009). Dumas, Rosa *et al* (2013) argue that outsourcing can render managing the business process more complex due to the need for extra coordination.

Conger (2010) identifies additional issues related to business process outsourcing:

- i. outsourcing core capabilities that define the company’s distinctive competency;
- ii. low morale among staff members due to people displacement;
- iii. communication problems if the companies are from different countries.

Jacobs and Chase (2013) state that there has been a dramatic growth in outsourcing in the logistics area. Nonetheless, Gadde and Hulthén (2009) alert that ‘logistics outsourcing requires the establishment of linkages to the activities of a new business partner and also new links between this logistics service provider and the activities of customers and suppliers of the outsourcing company’.

In fact, logistics outsourcing does not come without its problems and in some situations operations are brought back in-house. According to Gadde and Hulthén (2009) and Jacobs and Chase (2013), some problems reported as the basis for the failure of logistics alliances are:

- i. service performance;
- ii. disruption to inbound flows;
- iii. inadequate provider expertise;
- iv. inadequate employee quality, sustained time and effort spent on logistics;
- v. loss of customer feedback;
- vi. inability of 3PL providers to deal with special product needs and emergency circumstances

2.5 Business Processes and Information Systems

Laudon and Laudon (2015) define an information system as ‘a set of interrelated components that collect (or retrieve) process, store, and distributed information to support decision making and control in an organization’.

Nowadays, information systems are an integral part of many organizations and for some of them there would be no business without an information system (Laudon and Laudon, 2015). Entire business models are enabled by information systems and technologies.

Business processes require information as an input and produce information as an output. Sharp and McDermott (2009) argue that ‘information systems act as an enabler for business processes by automating or supporting steps, capturing or presenting information, or managing and expediting the workflow’. Taylor (2007) acknowledges the importance of mapping how information flows through the process, signaling the means by which information is conveyed. Moreover, the criticality of identifying control points and what information is necessary to perform this control is also stressed by the author.

Laudon and Laudon (2015) argue that ‘typically, organizations have systems supporting processes for each of the major business functions’. Nonetheless functional systems, operating independently of each other, are becoming obsolete and ‘a thing of the past because they cannot easily share information to support cross-functional business processes’. In the next subchapter, two types of enterprise applications, aimed at integrating cross-functional business processes, are described.

2.6 Enterprise applications

Laudon and Laudon (2015) define enterprise applications as ‘systems that span functional areas, focus on executing business processes across the business firm, and include all levels of management’.

Enterprise Resource Planning and Knowledge Management systems are discussed below.

Enterprise Resource Planning systems

Rushton, Croucher *et al* (2006) state that an Enterprise Resource Planning system, ERP, 'is a transaction-based information system, integrated across the whole business'.

Monk and Wagner (2012) argue that ERP systems help companies integrate their operations 'by serving as a company-wide computing environment that includes a shared database delivering consistent data across all business functions in real time'. Davenport (1998) states that this single comprehensive database, collects and feeds data into modular applications supporting virtually all of a company's business activities and when new information is entered in one place, related information is automatically updated. An example can be found in Laudon and Laudon (2015): an order placed by a customer may trigger the warehouse to pick the ordered products and schedule shipment; the accounting department may then be notified to send the customer an invoice

From the perspective of process improvement through improved information flow, Dumas, Rosa *et al* (2013) argue that 'the idea of a single shared and centralized database enables the optimization of information usage and information exchanges, which is a key enabler of process improvement'.

Companies opt to implement ERP for several reasons. Two of them have already been presented above: enabling the optimization of information usage and information exchange and integration of business process across the organization. In fact, according to Markus (2001), integration is 'the most frequently identified capability of the ERP system and one of the key reasons why organizations implement an ERP system'.

ERP systems are not tailored to the business of a particular company. On the contrary, they are design to suit the needs of a range of companies. In fact, Dehnert and Van Der Aalst (2004) argue that 'ERP systems like SAP R/3 are based on reference models describing typical business processes within the organizations'. Davenport (1998) points out some dangers of choosing an almost universal application, such as a mismatch between the company's business processes and the system's technical imperatives, or misalignment between the company's strategy and the system's assumptions. As such, there is an implicit trade-off between the use of customized solution (proprietary applications), tailored to the processes of the organization and the use of a generic one.

To this matter, Davenport (1998) argues that the more customized an enterprise system becomes, the less able it will be to communicate flawlessly with other systems (e.g. suppliers, customers), although they can also confer greater flexibility to the internal business processes.

Knowledge Management Systems

Melo, Netto *et al* (2010) state that 'the main purpose of knowledge management is to transform implicit knowledge into formalized (explicit) representations, clearly stated and simply managed, which render intellectual capital available for decision-making, development and innovation'.

Knowledge management systems enable organizations to better manage processes by capturing and applying knowledge and expertise. These systems are responsible for collecting relevant knowledge (either tacit or explicit knowledge) within the company, and leveraging it by making it available to the right people, at the right time whenever it is needed to take management decisions or improve business processes (Laudon and Laudon, 2015). Constantinescu (2008) states that 'knowledge that supports the decision making process is an obvious vital resource'. Moreover, the same author draws attention to the important role played by technology as an enabler of an organization's knowledge management strategy, considering it 'vital to enable the capturing, indexing, storing and distribution of knowledge across and with other organizations'.

3 Primary process characterization

The Primary process is very complex, comprising hundreds of related activities with several interactions with other processes. Therefore, an end-to-end overview of the whole process is necessary to understand how activities interlink with each other. Failing to do so could create a narrow vision of the process thus jeopardizing potential improvements.

This chapter presents the findings and conclusions of the analysis conducted on stage 1 and 2 of the employed project methodology.

It chapter begins with a description of the productive process where the main material flows are presented.

Subsequently, the Primary subprocesses are identified and the process landscape is presented. Each of these subprocesses are then further analyzed, modeled and documented so that a thorough analysis of waste and non-value added activities can be produced.

3.1 Primary productive process

Primary production is the process responsible for transforming raw tobacco leaf into cut filler, for cigarette production. The main material inputs to the process are:

- i. raw tobacco leaf, which arrives in cartons or bales at the production site
- ii. add backs such as Improved Stems, IS, Expanded Tobacco, ET, and Small Lamina, SL;
- iii. casing and flavor, produced at the Casing Kitchen, and used to balance the taste characteristics of the final product

Figure 7 summarizes the material inputs and outputs of the Primary productive process.

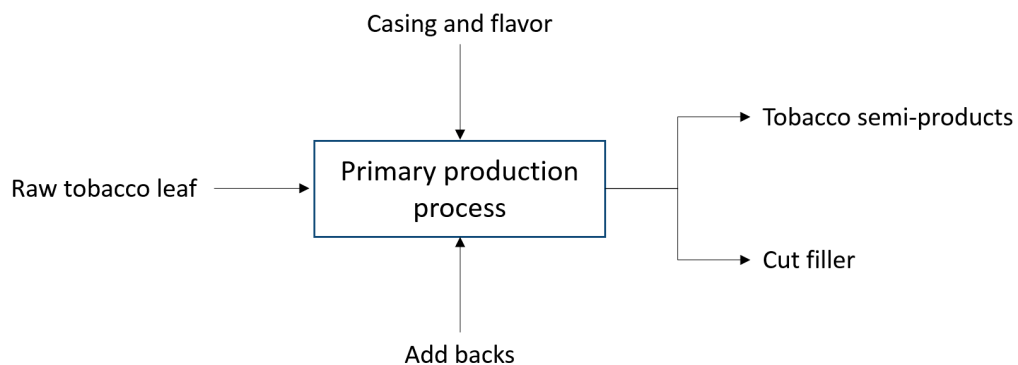


Figure 7 - Overview of the Primary production process

These materials are introduced at different stages of the process.

Appendix F depicts the Primary productive flow as well as the main stages of the process.

Cartons and bales of different types of raw tobacco leaf⁷⁷ for a given production batch arrive at the Infeed area on a just-in-time basis. Here, they are lined up in a specific order and temporarily stored prior to production.

When the order to start the production of particular batch is given, cartons are loaded into the production line, opened, and separated from tobacco leaf. Cartons are rejected, tobacco bales are sliced and these slices move on to the next phase of the process: conditioning. In this phase, slices are sent through a conditioning cylinder, called Direct Conditioning Cylinder, DCC, in which steam is added to loosen, moisten and sterilize the tobacco.

The conditioned tobacco is sent to storage silos, called pre-blending silos, where some blending occurs. These pre-blended tobacco is then sent to the casing application area, passing through a cylinder where tobacco is sprayed on by a casing solution⁸.

The different types of tobacco are then blended together at the total blend silos in homogeneous layers.

The final tobacco blend is cut and dried to meet the required parameters for Secondary processing. ET, SL and IS are added to the cut filler rag⁹. Tobacco is then sprayed with flavors, Ripper-Shorts, RS,¹⁰ are added according to the production plan and the final mixture is stored in silos, bins or boxes.

3.1.1 Material flows vs. information flows

Almost every activity from the Primary process uses (reads) or produces (writes) information.

This process is comprised of multiple information flows that follow the development of the productive process from end-to-end. Ultimately all this information is captured on the SAP information system and used for several purposes. For example: reporting, product traceability, inventory management, performance tracking, accounting, material requirements planning.

Material flows are essentially associated with the production execution subprocess, where incoming materials (inputs such as raw tobacco leaf, addbacks and off-spec products) are consumed and semi-finished products are issued (as outputs).

The pack-off subprocess is also comprised of physical material flows, since this subprocess is responsible for producing products for export and move them to the warehouse. All of the other analyzed subprocesses do not involve physical material movements and deal only with information gathered from these subprocesses.

Following, a description of the main material flows and associated information flows is presented.

⁷⁷ Tobacco leaf cartons are classified in Bright, Burley or Oriental. In their composition these cartons have a variety of grades (parts of the tobacco plant) carefully selected to yield the required quality characteristics of the final product

⁸ Casing composition varies according with the blend being produced

⁹ Cut filler rag is the name attributed to cut filler being transported on the conveyors

¹⁰ Ripper-shorts is cut filler salvaged from rejected cigarettes from the link-ups on the Secondary process. This cut filler is then reintroduced on the Primary process, when a batch of the same cut filler blend is being produced

Material storage

Materials are (temporarily) stored in a certain storage location, before being moved (to another location), consumed or shipped to the customer. To each of these storage locations corresponds, in the system, a given code. Table 1 shows the correspondence between the most relevant factory storage locations and the respective SAP system parametrization.

Table 1 - Storage locations and respective system parametrization

Physical storage location(s)	System parametrization
Infeed area	LF10
BBS	BS10
Pack-off	SP10
Cut filler silos	CF10
Improved Stems silos	ST10
Casing Kitchen	CA10

Material consumptions

Actual raw materials consumptions occur during the productive process and need to be captured on the company's information system.

Capturing actual raw materials consumptions means posting these movements on the correct process order. There are three ways in which these can be done: manually (by manually changing the process order), by automatic backflush consumption via the product's Bill Of Materials (BOM) or via SAP exports from PSS IV.

Table 2 depicts the ways in which the different consumption movements are posted for each material type.

Table 2 - Modes of material consumptions

Material	Mode of consumption
Raw tobacco leaf	Backflush via BOM
Ripper-Shorts	SAP exports from PSS IV
Improved Stems	Manually
Expanded Tobacco	Manually
Small Lamina	Manually
Casing and flavor	SAP exports from PSS IV

SAP generates a document for each posted material movement, whether the movements are posted manually, by an external system or automatically, by the system.

Appendix G visually describes a number of material movements for a particular process order.

Material movements

Materials can be moved from one storage location to another (e.g. raw tobacco leaf being transferred from Coruche warehouse to factory production site). This originates incoming materials on the receiving storage location and outgoing materials on the issuing storage location.

Thus stock levels need to be updated both on the origin and destination's storage location. On SAP R/3 this is done via documented material movements, which reflect this physical material movement on the information system and increases/decreases stock levels for those particular materials on the respective storage locations.

The main material flows and the information flows associated have been briefly presented.

Following, the item that links shop-floor and systems operations - process order – is further analyzed.

Process Orders

The Process Order, PO, is the element that integrates and links shop-floor and systems operations. In fact, from an initial analysis of the Primary process, PO can be identified as the work item that is moving through the process in all the relevant subprocesses of the Primary process landscape, analyzed further ahead in this chapter.

As such, it is pertinent to map and analyze the different possible states of this entity within the Primary process. Figure 8 presents an overview of the path followed by one process order, from creation to completion.

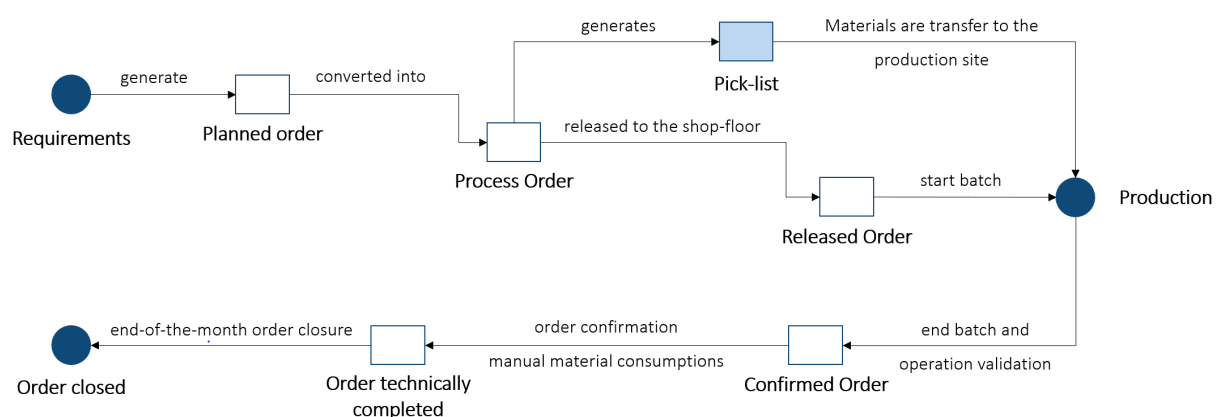


Figure 8 - Process Order lifecycle

SAP R/3 system computes production requirements and generates Planned Orders. Planned Orders are then converted into Process Order according to the Primary production plan and whenever it is necessary to produce a particular material (improved stems or cut filler).

Once a PO has been created, it automatically generate reservations on the system for the materials set out in the BOM.

Stock Transfer Orders¹¹, STO, are then created and associated with a particular PO. STO are used to keep track of raw tobacco leaf transfers from Coruche warehouse to the production site at Tabaqueira (e.g. issued or received goods movements are posted against a particular STO, which in turn is associated with a particular PO).

¹¹ Stock transfer orders are used to procure materials internally, from two plants within the same organization, when they are located far away from one another.

Pick-lists are created whenever it is necessary to transfer raw tobacco leaf from the warehouse to the production site. These are generated according to the recipe associated with the PO.

A PO can only be produced after it is released to the shop-floor, in this case to an external system: Production Supervision System IV (PSS IV).

Once the production of a process order is completed, the operation needs to be confirmed. Operation confirmation triggers the automatic posting of the consumption of several of the input materials, according to what is described above. Other material consumptions need to be posted manually, as described in Table 2.

After the order is confirmed, it needs to be set to a technically completed status so that requirements and reservations still open on the system, referring to that order, are eliminated and closed. At the end of the month, all orders are permanently closed and no further alterations or movements can be done on that particular PO.

3.1.2 Systems Integration

Tabaqueira uses several different information systems, each with a different purpose. Most of them are common to all PMI affiliates, while others were specifically developed to Tabaqueira.

Nonetheless they all need to be integrated and they all serve the strategic objectives of the company. Thus, it is important to understand how each of the systems enables the execution of the different business processes.

Appendix H presents a high-level representation of how the relevant to the project systems relate to each other.

The SAP R/3 system is the ERP implemented in all affiliate companies to integrate business processes from several business functions (Logistics, Production, Procurement, Accounting and Finance). Appendix I presents the main transactions used during the project and their purpose.

PSS IV enables the production execution and is used to monitor not only the current state of each batch being produced but also the historic of the parameters used in each batch. Moreover, it is responsible for exporting information to the SAP system, namely the materials consumed for the production of a given batch, through the SAP export functionality.

The Human Machine Interface system, HMI, communicates with the programmable devices (PLC and PID) and with other devices, such as valves, actuators, motors and sensors. It is through this system that production parameters are set up, such as temperatures, conveyors speed and flow rates.

Lastly, PMS makes the connection of bar code scanners with PSS IV. As such, whenever something is read using bar code scanners, it uploads the information to PSS IV, so that information can be exported to SAP.

3.2 Primary subprocesses

Having understood the material and information flows associated with the productive process, and how they are captured on the company's information systems, the next step of the analysis is the identification and mapping of the Primary subprocesses. Figure 9 depicts the process landscape of the Primary department, representing the relevant subprocesses along with the relationships between them.

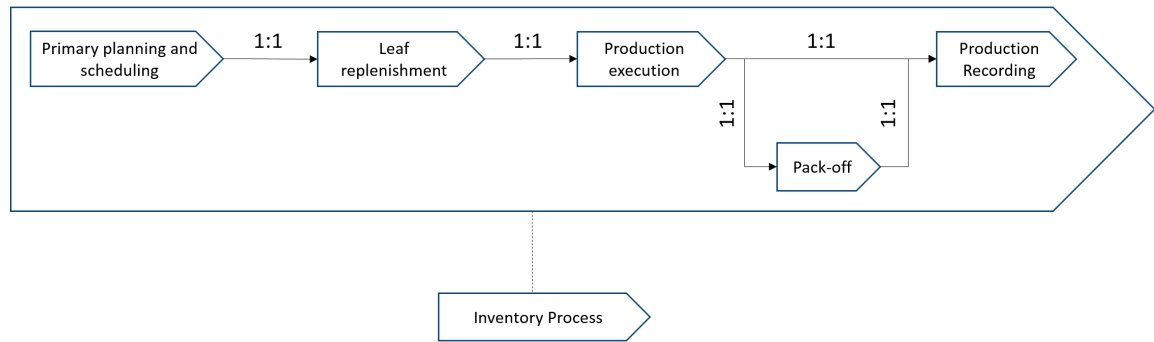


Figure 9 – Process landscape of the Primary department

The proposed model for the Primary business processes landscape creates a conceptual and graphical representation of the work that needs to be completed to deliver tobacco products to the process' customers (Secondary and Outbound Logistics processes). As depicted on Figure 9, there is a 1:1 relationship between this subprocesses, suggesting that they are all part of the same Primary process value-chain.

The analysis of each of the identified subprocesses was done according to the following methodology:

- i. Firstly, the goals and a description of each subprocess' workflow is presented, except for the Primary planning and scheduling, which is presented on Appendix J because it does not lie within the scope of the project;
- ii. A scoping analysis is conducted, whenever deemed appropriate, in order to understand how each subprocess interacts with each other and what are the enablers and the controls in place for each of them;
- iii. A SIPOC analysis are also conducted, whenever necessary, to better frame the subprocesses on the process landscape depicted on Figure 9 – whenever applicable the symbol N/A is used, meaning that a particular element of the SIPOC analysis is not applicable to a particular activity;
- iv. Whenever deemed appropriate, identified errors and failure modes are discussed and analyzed in terms of their impact on process performance. Moreover, possible reasons for process underperformance are also stated; alternatively, a root-cause analysis is performed;
- v. Lastly, the workflow associated with each subprocess is modeled using swimlanes or process flowcharts.

3.2.1 Leaf replenishment

Leaf replenishment deals with the process of transferring tobacco leaf from Coruche warehouse to the Tabaqueira factory, according to daily production requirements.

The Coruche warehouse logistics operations are outsourced to a contracted LSP, which is responsible for the picking and delivering (at the production site) of tobacco lots. Tobacco lots are introduced in the productive process according to a given order, specified in the batch recipe. This sequence is discriminated in a document called pick-list, generated at Tabaqueira, by the Process Specialist, and sent to Coruche warehouse. Thus, trucks can be loaded in a way that, when unloading, batches are already in the correct sequence and ready to be introduced in the process. Tobacco lots are shipped several times a day, in a just-in-time basis. The hours that trucks arrive at the production site are set out by the Production Planner, and are determined from the daily production schedule.

When the tobacco lots leave the Coruche warehouse, the LSP team running Coruche warehouse operations posts the Goods Issue, GI, against a particular STO and that particular stock is classified as being on transit. When the trucks arrive at Tabaqueira, tobacco lots are checked and the truck's content is compared with the respective pick-list. Afterwards, the LSP team running the inbound operations at Tabaqueira posts the Goods Receipt, GR, against the particular STO. This workflow was modeled using a swimlane diagram that can be consulted on Appendix K.

The first four activities of the process are performed by the Primary planner and they represent almost 50% of his daily workload due to a number of errors and system inconsistencies, preventing a smooth flow of the process. These errors were usually encountered during the activity of STO creation. Naturally, they need to be corrected before the process could go on which, sometimes, causes delays.

In order to understand the reason behind these errors occurring during the creation of STO, a root-cause analysis was performed. The output of this analysis is the cause-effect diagram depicted on Figure 10.

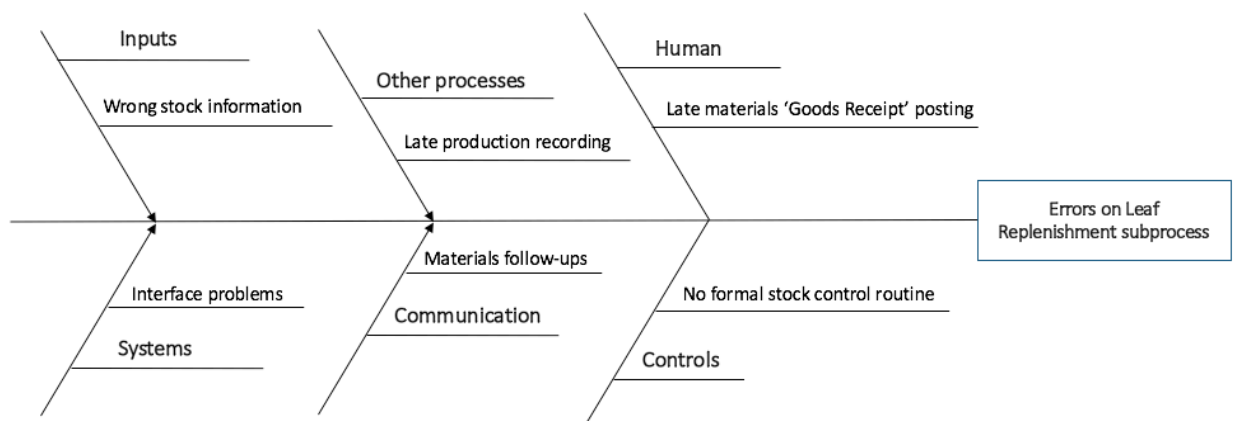


Figure 10 - Cause-effect diagram for the Leaf Replenishment subprocess

It is important to highlight the fact that there are no formal process control mechanisms or routines in place to detect or prevent these errors from happening.

A SIPOC analysis was conducted to understand this subprocess' customers and where errors would have the most impact. This analysis can be found in Appendix L.

3.2.2 Production execution

Production Execution deals with the productive process *per se*. It comprises the following activities:

- i. defining which order to produce and sending the operation to the HMI;
- ii. starting the line (start batch);
- iii. controlling and monitoring production;
- iv. validating the operation

In order to be produced, process orders need to be released to PSS IV. Note that this activity – process order release – is part of the Leaf Replenishment subprocess.

Prior to production, released orders are passed on to the HMI system. Then, the operator at the Infeed area starts the line (start batch) with the approval of the Primary Supervisor in charge. The process is controlled and monitored by the production team, and process parameters are adjusted according to information collected by the production system through sensors, thermometers and scales, through the HMI system, installed in all workstations that exist along the productive process.

When the Production Supervision System, PSS IV signals the batch termination, the Primary Supervisor validates the operation. This task (operation validation) triggers a series of materials movements on the SAP information system with direct influence on the downstream process of Production Recording:

- i. PMS exports and posts the data regarding RS and OS material consumptions for the produced PO on the SAP information system;
- ii. Raw tobacco leaf cartons are automatically consumed from its storage location and posted on the produced PO.

The SIPOC analysis conducted for the Production Execution process can be consulted on Appendix N. This analysis leads to the conclusion that the following three activities generate outputs for which the customers are other subprocesses: ‘Load addbacks’, ‘Production execution and monitoring’ and ‘Confirm operation and validate batch’.

From the analysis conducted, it was identified that the activity ‘Confirm operation and validate batch’ had the greatest impact due to the fact that errors generated by this particular activity have great impact on downstream processes, namely on the production recording subprocess. These errors stemmed from:

- i. batches confirmed one or more days after the end batch notification from PSS IV – the implication being that system conflicts were generated;
- ii. batches confirmed before the operation has physically ended – the implication being that information exported to SAP was not complete and had to be posted manually, jeopardizing product and data integrity

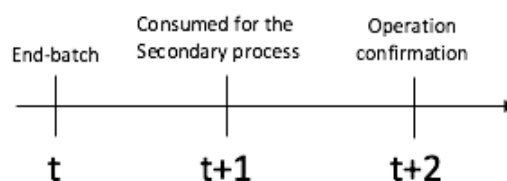


Figure 11 - Example of a misaligned operation confirmation

The situation depicted on the Figure 11 traduces the situation described on the first topic. For example, one particular cut filler batch is produced on day t , is used on day $t+1$ by the Secondary process to produce cigarettes and its operation is yet to be validated. Since the date exported to the SAP system is the operation confirmation date, this situation would imply that something yet to be produced has already been physically consumed, which in theory is impossible.

The case described on the second topic occurs when the operation confirmation is executed before the batch has ended meaning that all the information that was going to be captured by the systems (PMS and PSS IV) after that particular moment will not be passed on to the SAP system and will have to be manually introduced, leaving room for errors and unnecessary variations.

However, it is worth mentioning that, from the systems point of view, no mechanism to prevent these situations from happening is in place. These situations will only be detected either at the end of the month, when month-end activity reports are generated or upon the production recording subprocess, when it is already too late to act upon it.

A flowchart model for this subprocess can be found in Appendix M.

3.2.3 Pack-off

The pack-off area is the area of the Primary where cut filler and improved stems for export are packed, labeled and prepared to be shipped. There are two improved stems silos feeding the improved stems export line and two cut filler silos feeding the cut filler export line. Despite being under the management of the Primary department, the pack-off process is outsourced to an Logistics Service Provider, LSP.

A process flowchart was used to model and describe the pack-off subprocess and is presented on Appendix O. Moreover, a description of the workflow is presented next.

The LSP team operating the pack-off area is briefed at the beginning of the day about what to produce from the Primary Supervisor on duty. During most of the day, pack-off operations are left without supervision from the Primary Supervisor since there are no SOP for this function concerning the pack-off area. Therefore, production errors that might occur in the process (e.g. wrong label application or wrong box format) are not detected on time, generating additional workload to correct them when they are identified further ahead, on downstream processes, e.g. when pack-off production is being recorded by the Primary Process Specialist.

This particular business process lacks the management attention and is commonly regarded as not being under the scope of the Primary department.

The information produced by this subprocess is compiled manually, in two different paper records:

- i. One kept by Tabaqueira, serving as input for the Production Recording subprocess;
- ii. One kept by the LSP operating the process for the purpose of performance tracking and management requirements.

These records contemplate information concerning the material being packed (such as the blend code or the TP batch), the number of boxes produced (packed) for each material and additional information such as breakdowns or stoppages. They are filled in manually, which frequently leads to incomplete or unreadable information. Moreover, most of the information required by Tabaqueira is also used by the LSP, originating duplicate information on two different paper records.

Besides paper records, production is also registered on the Production Monitoring System (PMS), through bar code scanning of every produced box.

These two sources of information are then used by the production recording subprocess for the export production recording. From the SIPOC analysis depicted on Appendix P, it can be concluded that production records, generated by this subprocess, need to be accurate and readily available so that they can be used further ahead by the Production recording subprocess.

However, the record keeping activity generates several types of waste, such as:

- i. information duplication: two paper production logbooks - one for Tabaqueira used as input on the Production Recording process, and another one to be kept by the LSP with the purpose of tracking the performance of teams responsible for this process;
- ii. movement of people to get the paper record used by Tabaqueira to and from the Pack-off area;
- iii. time spent trying to obtain missing or unreadable information;
- iv. time spent inputting data from paper production logs into MS Excel files for further processing.

3.2.4 Production recording

Production recording deals with the confirmation of both cut filler and improved stems process orders, either for internal consumption or for export. The goal of this subprocess is to reflect the physical flow of materials on the SAP information system, particularly materials consumed and good production issued.

As stated in the beginning of the chapter, Process Orders are the link between shop-floor operations and SAP information system records and also the work item moving along the process. This process is triggered every day so that the production of the day before is recorded and reflected on the SAP system. This process comprises the following activities:

- i. Verification of material consumptions for cut filler and improved stems orders;
- ii. Manual consumptions for Expanded Tobacco, Small Lamina and Improved Stems to cut filler process orders;
- iii. Pack-off production recording;
- iv. Error corrections;
- v. Checking file updating;
- vi. Closure of confirmed process orders.

The activities involved on the confirmation and recording of process orders vary according to the order type and the material. Presently, the production recording subprocess generates about 90% of the Process Specialist workload, including confirmation of cut filler and improved stems orders for internal consumption and confirmation and recording of cut filler and improved stems export orders.

From these orders, cut filler orders are the ones that take up most of time, consuming up to 2h a day and generating around 50% of the Process Specialist workload. Confirmation and recording of cut filler orders takes up so much time because consumptions of ET, SL and IS are executed manually. In the particular case of SL, this material needs to be created, on the system, before it can be posted and consumed by a given process order. This intermediate step does not add value to the product and will be the target of improvement actions.

Note that this step is only taken system-wise. Physically, no leaf processing occurs and the leaf is introduced to the productive process in the same state as it arrives. Nonetheless, it is a necessary step.

The small lamina creation procedure is described in Appendix Q. It can be seen that this process requires the user to run three SAP transactions every time SL is to be created and posted to a particular cut filler order.

This activity, alone, consumes on average 20 minutes per day, and, because of the repetitive nature, demonstrates great potential for automation.

Moreover, errors encountered during the confirmation and recording process need to be eliminated. These errors occur almost exclusively on cut filler orders. As such, confirmation and recording of cut filler orders will be the focus of the improvement efforts, since this is a particularly error-prone activity because it is subjected to human intervention and is affected by a number of errors that undermine process performance. The process flowchart for cut filler orders recording is shown on Appendix R.

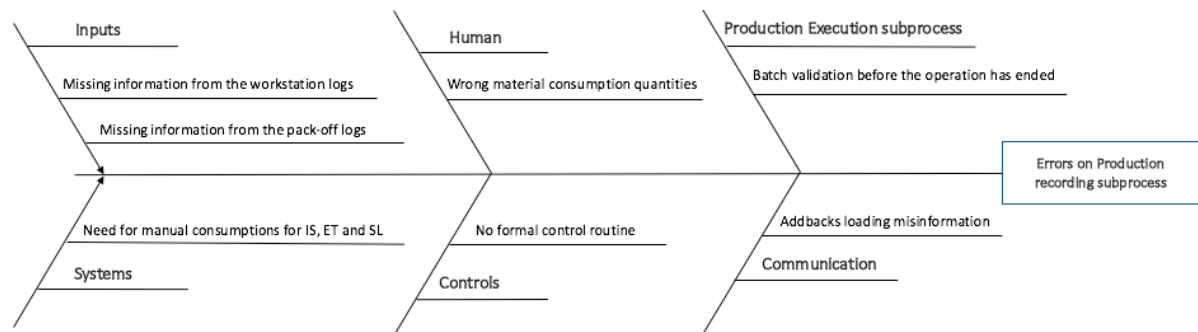


Figure 12 - Cause-effect diagram for the Production Recording subprocess

Generally speaking, Figure 12 depicts a cause-effect diagram presenting the identified causes for process underperformance.

The fact no process control mechanisms are in place ought to be highlighted. In fact, this means that what was recorded for the orders, either for export or for internal consumption, is not verified. For example, if the wrong quantity of a particular material is posted, this erroneous information will pass on to the next processes that require information about process orders as inputs. As such, the existence of process control mechanisms is quite important, because eventual errors or inconsistencies can be prevented from passing on to 'customer processes'.

On another topic, as depicted on the Process Scoping analysis, presented on Appendix S, this process receives information from the Production Execution and Pack-off subprocesses.

In order to improve this process' performance, the 'supplying processes' need to be addressed and their consistency evaluated. In fact, one of the root causes for the production recording subprocess underperformance stem from erroneous inputs from 'supplying processes'.

Also within the scope of this subprocess is the closure of already confirmed process orders.

Closing a given order involves running three SAP transactions and perform the activities manually. This procedure is shown in Appendix T.

Currently, it takes on average, 60 to 90 seconds to close a single PO. Considering that, on average, 300 to 350 process orders are on a monthly basis, the total amount of time spent closing process orders could range between 5h up to 8h and 45min.

Because this activity is rather repetitive and manual, potential gains can be achieved through automation.

3.2.5 Inventory process

Although the inventory process is not a core process, it was included within the scope of the project because of the following reasons:

- i. it generated a great deal of workload during the end-of-month activities of the Production Process Specialist and, therefore, it needed to be speeded up and simplified;
- ii. it had a direct impact on yield results, a key indicator for the Primary process value-chain.

The main goal of the inventory process is to assess the actual quantities for each item held on stock and analyze eventual differences between physical stock and the stock documented on the SAP system.

These differences should be reflected upon the SAP system after careful consideration and analysis. These adjustments are done item by item and manually through the SAP interface.

It should be noted that the inventory counting activities for the month of March were observed on-site in order to follow how operations were conducted. The main conclusions are stated next, after the description of the inventory process.

The inventory process is triggered monthly. It starts with a request for inventory counting, from the Production Process Specialist, listing the items (generally cut filler, improved stems, ripper-shorts, expanded tobacco, small lamina and the items of the casing kitchen) that should be subjected to counting as well as the ideal timings.

On the specified day, the Primary Supervisor in charge directs the team and distributes the tasks among the team operators, compiles the counting for each item in a file and sends it to the Process Specialist.

The Process Specialist computes the differences between physical and SAP stocks using a specific MS Excel file. The results are then sent for the approval of the Business Unit Manager. After the approval, the differences are reflected on the SAP information system, either by 'creating stock' or 'consuming stock'. Specific transactions are used (documented on Appendix H) to perform these adjustments which are all manual. The inventory process workflow model is portrayed in Appendix U.

As far as the inventory process is concerned the majority of the errors attributed to this process came from the following activities:

- i. Inventory count;
- ii. Adjustments calculations;
- iii. Adjustments execution

These activities are all performed manually, where the human factor has plenty of influence. As such, they are subjected unexpected variations, inherent to human activities.

4 Implemented solutions and improvement opportunities

As mentioned on Chapter 3, the Primary process is a rather complex process and process identification, scoping and analysis were fundamental to prioritize and identify improvement opportunities.

This project tackled five subprocesses and aimed at improving their performance. This was achieved either by eliminating unnecessary activities (waste), simplifying tasks, defining new process control points aimed at detecting eventual errors and creating standard operating procedures to reduce the processes' output variation.

This chapter describes the business solutions developed for each of the tackled subprocesses, starting with a description of one of the tools used to implement the process improvements – SAP Scripting. Next, business solutions developed and implemented in each individual subprocess are described. Additionally, improvement suggestions are presented, as well as their potential impact, for future follow-up. Both the solutions and the improvement suggestions were envisioned by formulating performance objectives of the process at the highest level of abstraction, in the form of the desirable state the process should ideally reach.

SAP Scripting

SAP Scripting is a functionality that enables the user to generate (record) a script (piece of code) which reproduces the steps taken in the SAP GUI interface (for an example of the SAP GUI interface please refer to Appendix V). This script can then be used to communicate with the SAP GUI and reproduce the actions taken during the script recording. Embedding this script in VBA (Visual Basic for Applications) code, creates the potential to automate virtually any activity or task performed on the SAP GUI, greatly simplifying business activities, at a very low cost.

What was previously an explicit step of a particular process can now be run on the background, implicitly, without requiring that the user has any sort of activity with the SAP GUI.

From the research conducted on this particular tool, it was concluded that one can achieve the greatest productivity gains when this tool is applied to scripting activities comprised of repetitive tasks, involving very few decision points. Most of the times, these are also low value-added activities and generate a great deal of workload to those who perform them. However, they need to be executed for the process to be completed and SAP Scripting allows them to be performed at a much faster speed (processing speed) instead of being dependent upon the manual user speed.

An additional advantage is that the likelihood of error is significantly decreased since most of the inputs are no longer human-dependent.

SAP Scripting was used to develop tools that would simplify and streamline activities on the following subprocesses: Leaf Replenishment, Production Recording and Inventory process.

4.1 Leaf replenishment

As described on 3.2.1 the leaf replenishment subprocess main goal is to replenish the factory with raw tobacco leaf in such a way that daily production can be carried out with no interruptions.

Process control points

From the root-cause analysis of the errors occurring during this process, presented in 3.2.1, it was concluded that one of the activities that introduced significant delays on this process was the creation of a STO for each PO created. These delays occurred because errors in this stage were frequent and needed to be solved first, before the process could be completed. Also, these errors generated a great deal of workload to solve because their root cause needed to be first identified and only then the error could be solved.

In 3.2.1, the root-causes for the errors occurring during the creation of STO were identified:

- i. Missing GR on the part of the LSP;
- ii. Errors generated on the interface with the LSP software;
- iii. Errors generated during leaf consumption by backflush;
- iv. STO is not referenced to any PO;
- v. PO is missing STO.

In order to monitor the occurrence of these errors and facilitate their swift identification, process control routines were proposed.

For this process, this routine verification was implemented through the development of an MS Excel application named Primary Planning Control Report. This application integrates four types of reports and aims to be an important process control tool in the sense that allows the user to detect and act upon any error encountered.

The fundamental requirements specified were that it had to be user friendly and consume as little time as possible to run. The final interface can be consulted on Appendix x.

The way this application works is very straight forward. In fact, the user selects which report to run and inputs the date interval. Then clicking the 'Extract data' button SAP data extractions are performed automatically. For this matter, SAP Scripting language, embedded with VBA code was used to perform the extractions automatically.

The 'Run report' button imports the data from the SAP extractions and runs the necessary calculations.

As previously stated, this control is comprised of four reports, monitoring four different types of errors.

The first report signals any STO for which materials have been issued from Coruche warehouse (GI movement) and are still pending GR on the part of the LSP for more than one day. This means that received stock is yet to be accounted for in the SAP system and cannot be consumed to any Process Order.

The second report checks that the following balance applies all the time:

$$\text{Stock at Infeed} + \text{Stock in STO yet to be delivered} = \text{Stock Reservations for open PO}$$

If, for some reason, this balance does not verify, it is an indication that some error may exist since stock reservations for PO which production is yet to be confirmed (meaning that, on SAP there are still open requirements for those particular PO) must be covered by the amount

that there is in stock at the Infeed area plus the amount that is allocated on STO yet to be delivered.

It is worth mentioning that once the GR is posted for a particular STO, stock at the Infeed storage location (please refer to Table 1) is automatically updated and the stock yet to be delivered for that particular STO becomes zero.

The third report assures that every created STO contains the same materials, in the same quantities as the associated PO. This ensures that what gets transferred to the factory site from Coruche warehouse checks out with the requirements for producing that particular PO.

Moreover, this report also ensures that every created PO has a STO created, guaranteeing that the abovementioned balance verifies. In fact, if this is not the case, this would mean that stock reservations for open PO would be greater than stock at the Infeed plus stock in STO yet to be delivered, since there are open requirements unaccounted for (not covered by any STO).

Lastly, the forth report is used to verify if there is any STO not referenced to any PO. If this is the case, materials associated with no planned production will create an imbalance between the second member of the abovementioned equilibrium: Stock at Infeed plus materials in STO yet to be delivered will be inevitably greater than the Stock reservations for open PO, since the STO is not associated with a given PO.

4.2 Production recording process

Production recording concerns the recording and confirmation of all Process Orders produced. Export orders also fall within the scope of this process.

From the analysis conducted in 3.2.4 it was concluded that the main reason why this process takes so much time to be completed is due to manual consumptions of IS, SL and ET and to manual corrections of eventual errors found.

Because this subprocess does not add value to the final product, despite being necessary and mandatory, it should be performed as quickly as possible and consume the least amount of time possible. Equally important, it has to be executed without errors because it has direct implications on downstream processes.

4.2.1 Business solutions

For the Production Recording subprocess, three applications have been developed with the express purpose of expediting the process by simplifying some of the activities involved:

- i. PO closing application – automate the procedure for closing process orders;
- ii. Small Lamina creation application – eliminate the manual creation of SL;
- iii. Automatic checking file update – completely eliminate manual data handling.

This activities have been identified on 3.2.4 has particularly suited for been automated due to their characteristics: repetitive, no decision points in-between and time consuming.

This low-cost business process automation allowed for considerable cycle time reductions for this subprocess as outlined below.

PO closing application

The PO closing application is meant to tackle the fact that process order closure was a non-value-added manual activity comprised of a repetitive set of steps involving no decision points in-between. Nonetheless, it is a mandatory activity that must be performed on the SAP system and, as such, it cannot be eliminated. Nonetheless, it should be performed as quickly as possible.

This application runs on VBA code it was designed to run on MS Excel. Moreover, SAP Scripting was embedded within the code to communicate with the SAP GUI and automatically perform the set of steps previously performed by the Process Specialist.

As documented on 3.2.4, closing a process order took, on average 60 to 90 seconds. Considering that, on average, 300 to 350 process orders needed to be closed on a monthly basis, the total amount of time spent on this activity by the Process Specialist could range between 5h up to 8h and 45min.

This application has made it possible to cut the time spent doing this task in 95%, producing savings by at least 8h a month. This number concerns only the time directly saved with the use of this application – it does not take into consideration the eventual productivity gains that may arise as a result of the additional free time for the Process Specialist to perform more value-added activities.

Small Lamina creation application

Small Lamina creation is an activity performed during the Production Recording of cut filler process orders. It was identified, on 3.2.4, as being a non-value added activity, particularly error-prone, that involved working on three SAP GUI transactions simultaneously, consuming a significant amount of time to perform.

As such, the Small Lamina creation application aims to streamline and simplify the set of activities performed during the Production Recording process, particularly, the Small Lamina creation routine.

Just like the Process Order closing application, this application was designed on MS Excel software and runs on VBA code, embedded with SAP Scripting to communicate with the SAP GUI, performing the set of steps previously performed manually.

The direct gains achieved with the implementation of this application are estimated as being 15 minutes per day. Additionally, indirect gains such as great reduction of error likelihood are still to be accounted for.

Automatic checking-file update

The automatic checking file update was envisioned with the purpose of automating the task of updating the production checking file with the latest production data.

This file integrates several types of information, used by different subprocesses (Leaf Replenishment, Production Recording, Inventory process).

As far as the production recording subprocess is concerned, this file needs to be updated every time an instance of this subprocess is completed, in other words, whenever an order is recorded and confirmed. This update concerns information regarding the quantity produced for a particular order, production date and consumptions of Expanded Tobacco, Small Lamina, Ripper-Shorts or Off-Spec tobacco.

As such, this application automatically fills in all of the required information. With this application, 15 minutes are saved on a daily basis, which translates into 5,5h monthly.

Just as the other created applications previously, this application was designed on MS Excel software and runs on VBA code, embedded with SAP Scripting to communicate with the SAP GUI. The application retrieves information about material consumptions for each PO given as input and automatically performs the set of steps previously performed manually for updating the checking file.

4.2.2 Process control points

In addition to the developed applications, intended to simplify and speed up the process, control points were also implemented in this subprocess, this time for controlling the export production recording procedure and the creation of Small Lamina. It is important to recall that both of process control points are intended to monitor and validate only activities executed on the SAP information system.

Export production control

The control implemented for the export production recording validates that the quantity consumed for a given export order equals the quantity produced. For example, when recording the export production of a particular cut filler blend, the cut filler quantity consumed from the cut filler storage location must be the same as the quantity of cut filler packed for export, since no processing occurs in-between.

This balance must be verified for all export orders and any mistakes made have great impact on other processes that use export orders information as inputs.

This control is made by means of a MS Excel application that extracts data from the SAP system and produces a report signaling eventual errors found. This application runs on VBA code and uses SAP Scripting to communicate with the SAP GUI and automate the information extraction process.

The interface for the export production control application can be found in Appendix Z.

Small Lamina creation control

The second process control point implemented relates to the creation of Small Lamina, for it to be consumed to cut filler orders.

As documented on 3.2.4, Small Lamina is not kept on stock and, therefore, before being consumed for a given process order, stock for this material needs to be created. This is done following a series of steps, depicted on Appendix Q, to transform a particular leaf code into Small Lamina. Only then it can be consumed and posted to cut filler orders.

This activity was classified as being particularly error-prone in which eventual errors impact the integrity of the data on the SAP system. Additionally, errors in the past have triggered the need to create a mechanism to control and monitor the Small Lamina creation process.

In this case, the quantity of tobacco leaf (posted as a consumption) to create stock for Small Lamina has to be equal to the quantity of Small Lamina posted on the respective process order. As mentioned in 3.2.4, SL orders do not trigger any physical process and are only handled system-wise.

This control is similar to the previous one. It is performed through an application designed for MS Excel software, that extracts data from the SAP system and produces a report signaling eventual errors found. This application runs on VBA code and uses SAP Scripting to communicate with the SAP GUI and perform the information extraction automatically.

The interface for the small lamina creation control application can be found in Appendix AA.

4.3 Pack-off process

The pack-off subprocess deals with the production of export products (cut filler and improved stems). This process is currently outsourced to a LSP, Rangel.

The need to improve this subprocess stems from the fact that it produces information that is used by other subprocesses, particularly the production recording subprocess. The information required are the production records, so that the export production can be recorded. From the analysis of the current state of the process made in 3.2.3, it was concluded that record keeping is an activity that generates several types of waste.

Additionally, other improvement opportunities were identified:

- i. poor visibility from the Primary supervision
- ii. lack of standards for production validation
- iii. errors due to lack of communication between the LSP team operating the process and the Production Supervisor

To address these improvement opportunities Standard Operating Procedures were created.

These standards, in the form of new operating routines, aimed to increase the visibility that the Primary department has over this process and mitigate the errors occurring as a result of the lack of ownership of the pack-off process by the Primary department.

Prior to describing the implemented solution and the new standard routines created, it is worth mentioning that, given that the pack-off process is currently outsourced to a LSP, the improvement suggestions for further implementation had to be validated and discussed with the LSP supervision team first, since this would imply changing the operator's daily routine. This articulation between these two organizations has made possible to come up with a win-win situation, given that the implemented solution streamlines the information flow and facilitates the job of both the LSP operators and the process actors from Tabaqueira's side.

4.3.1 Pack-Off production file

To eliminate all of the abovementioned types of waste, the envisioned business solution would have to enable a simpler way to convey information through the process and the quality improvement of the information generated.

For this matter, a MS Excel file was designed to integrate the information used by everyone involved in the pack-off process and to simplify the activity of daily production record-keeping. Moreover, this file aimed to simplify the usage of the data generated during the pack-off process since this data would be readily available for the downstream processes to use it.

The pack-off production file was set-up on an HMI computer, connected to the company's Intranet, installed on the pack-off area workstation. To guarantee that information was

instantly available and could be used simultaneously by multiple actors of the process, a shared folder was created for storage of the daily production files.

The abovementioned file should comply with a series of requirements identified during the evaluation phase of the proposed solution, namely:

- i. it had to be intuitive, user-friendly and easy to work with;
- ii. it should contain embedded error-proofing mechanisms that would prevent the user from inputting data in a wrong format;
- iii. it should minimize manual inputs;
- iv. it had to contain fields contemplating information required by both the LSP and Tabaqueira;
- v. it had to be easily modified and updated;
- vi. it had to provide mechanisms to deal with unexpected situations (e.g. the name of a particular operator is not on the list of available options or a given blend code being produced does not show up on the list of available blends for production).

Figure 13 depicts the new process information flow. The production file integrates production information as well as information about eventual breakdowns or unplanned stoppages. Information about production requirements can be automatically retrieved from the SAP information system using SAP Scripting.

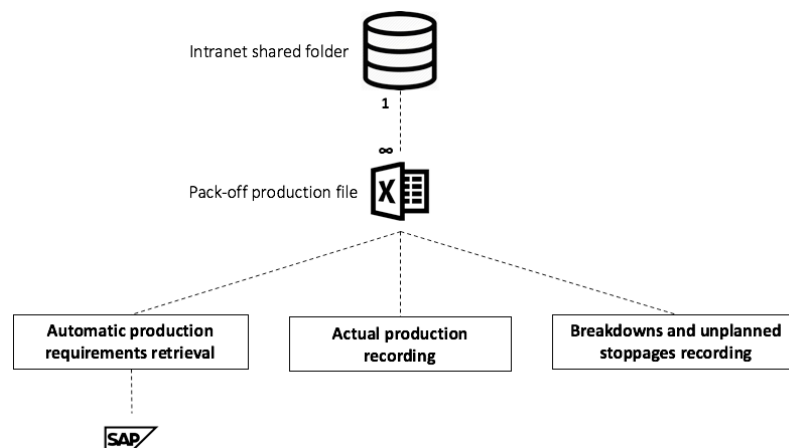


Figure 13 - Pack-off process information flow

The interface of an instance of the production file can be seen on Appendix AB.

The application was designed in accordance with the requirements identified. Its completion is essentially done choosing values from the options presented to the user. For example, produced blend codes are selected from a list of blends for which there are open production requirements. Upon selection of the blend code, only the batch TP codes referring to the selected blend are presented to the user. These production requirements are retrieved from the SAP system and need to be updated regularly. This activity takes less than 20 seconds and is easily performed by simply pressing a button.

Automatic data validation exists in several of the fields. For example, fields intended to receive numerical data were programmed to prompt a message to the user informing that the information input was of the wrong data type, whenever information of a type other than numerical was introduced.

The implementation of this new solution was made with the intention of improving the information flow and simplifying the production recording activity. Naturally this entails

changes to the previous process. The new standards and working routines are described on the next subchapter.

4.3.2 Standard Operating Procedures

To enhance process consistency and integrate the new pack-off production file into the process routines, standard operating procedures were created. These aimed also at increasing visibility over the pack-off process by the Primary production supervision.

Below, it is presented a short description of how the file is intended to work and the new standards to be implemented for the process.

Production file usage

- i. A new instance of the production file is created every day, by clicking a button; automatically all date related fields are updated with the current date;
- ii. Next, the headers, concerning the daily productions requirements and the daily briefing (that triggers a new instance of the pack-off subprocess) are to be filled-in;
- iii. During the day, information related with the hourly number of boxes produced is to be registered, as well as information related with eventual (planned or unplanned) stoppages (e.g. lunch brakes, shift changes or equipment breakdowns);
- iv. At the end of the day, the production file needs to be validated, by clicking a button, to ensure that all fields have been filled-in properly and the file is saved to the respective directory – in case there is crucial information missing (e.g. any of the fields from the header) the file prompts the user to finish filling-in the required information and signals the fields where information is missing.
- v. It should be noted that the database, containing information related to the production requirements, feeding this MS Excel file, needs to be updated – this is done automatically just by clicking a button, since the application connects to the SAP GUI and retrieves the required information.

Note: To prevent loss of information caused by any network or software failures, this file is saved every 5 minutes, while opened.

Standard Operating Procedures

The standards presented to discussion to the Primary supervision team consist on a proposal, based on the observation of the current practice and the envisioned to-be state of the process.

As such, the standard created contemplated which activities were to be performed by Tabaqueira's supervision team and which were to be performed by the LSP team.

Moreover, the standard defines a clear line of communication between Tabaqueira and the LSP, aiding in reporting problems, and also specifying how to use, manage and update the pack-off production file.

4.4 Inventory process

The inventory process is triggered once a month and the main goal of this subprocess is to reflect on the SAP information system the physical existences of materials used for production that belong to the Primary storage locations.

For this particular process, the greatest potential for improvements were identified as being:

- i. the streamlining of the adjustments calculation activity: involves retrieving information from SAP about stock quantities concerning all material codes under the Primary storage locations and compare these quantities with the real existences.
- ii. the standardization of the procedures for inventory counting.

To tackle the first improvement opportunity, an integrated inventory process application was developed and implemented. For the second improvement opportunity identified, standard operating procedures were developed and implemented.

4.4.1 Integrated Inventory Process Application

The inventory process comprises four main steps, as described in 3.2.5.

- i. Inventory count request;
- ii. Inventory counting;
- iii. Differences between physical and SAP stock levels analysis;
- iv. Adjustments performed on the SAP information system.

The Integrated Inventory Process application was developed for MS Excel software embedding SAP Scripting in VBA code. SAP Scripting is used to communicate with the SAP GUI and automate tasks previously executed manually. This way, step iii. is automated and simplified. Also, it significantly decreases the error likelihood since retrieving stock information from the SAP system is no longer a manual activity.

This application integrates several activities for the inventory process.

Firstly, stock counts are inputted directly on this file by the person in charge of the inventory counts, generally the Production Supervisor.

The next step on the process is to compare SAP stock quantities with the physical stock quantities. This can be performed in much less time, since the retrieval of data from the SAP system, for each material code kept in inventory, has been made automatically. Moreover, because data is inputted automatically on the MS Excel file, it reduces data handling by the user.

Once these differences have been approved the final step of the process is to reflect them on the SAP system via stock adjustments, either by consuming stock or creating stock (refer to 3.2.5 for a deeper description).

This last step is particularly important since it has potentially significant impacts on both Primary and Secondary yield and on financial results.

Nonetheless, this step is manually executed for each material code, leaving room for errors. In fact, past errors during this step of the process reinforced the need to fool-proof this particular step of the process.

Currently, stock adjustments are still performed manually. However, the envisioned to-be state of the process, provides a simple, expedite and automatic way for performing these adjustments. In fact, time restrictions have prevented the implementation of an automatic way to perform these adjustments and further increase the process robustness.

Nonetheless, the application already provides an automatic and robust way of retrieving information about stock levels for each material kept in inventory, which was considered to be satisfactory and ground-breaking by the inventory process owner, the Primary Process Specialist. Overall, this application allowed for substantial direct gains, through process streamlining and simplification, decreasing the overall time taken to complete the inventory process. Moreover, less obvious results have been achieved, particularly when it comes to fool-proofing the process, preventing potential errors from occurring and making it a more robust process.

4.4.2 Standard Operating Procedures

As described in Chapter 3, the inventory process lacked standardization in several of the activities that comprised the process.

The outcome of the physical stock counting was particularly affected by the lack of standardization because any of the four Primary production teams could be responsible for this activity and there was simply not guiding rules, leaving more room for variation. Moreover, counting errors were frequent due to unclear procedures.

To tackle this fact, a Standard Operating Procedure document was proposed for this process, in particular for the activities performed during the counting of inventory stock levels.

To produce this document, the process was followed *in loco* in the month of March and improvement opportunities were identified. Also, valuable inputs from the different production teams were incorporated.

As such, the final document comprises standard procedures and general guidelines to evaluate the:

- i. quantity of cut filler and improved stems kept in silos, boxes or bins;
- ii. quantity of each item on the DIM category on the Primary storage locations;
- iii. quantity of expanded tobacco, small lamina and ripper-shorts on the respective storage locations

4.5 Comments on the implemented solutions

A few comments are to be made concerning the implemented business solutions:

- i. for each application developed, an instruction manual was created, containing information on how to use, manage and update the application - the code developed is clearly explained as well as the rationale behind it;
- ii. appropriate training has been given to the appointed owners of the files;
- iii. they were designed to be user-friendly and easily updated;
- iv. these solutions were developed and implemented at a very low cost, without requiring virtually any investments or expenditure of resources;
- v. impact on the current workflow were kept to a minimum.

5 Conclusions

The project Primary Good Production Process Improvement was conducted with the objective of improving part of the Primary process value chain, namely the support processes concerned with the good production recording.

From the initial assessment of the project – stage 0 of the process improvement methodology followed - that culminated in the definition of the project scope and expected results, it became clear that the good production recording process should not be improved without considering the whole value chain. In fact, the other processes that are part of the same value chain needed to be incorporated on the improvement process in order to achieve better results.

As such, on stage 1 of the project the Primary process landscape was designed and the relationships between the subprocesses that constituted the Primary value chain under analysis were also established. Also, the relationships with its environment – SIPOC analysis and Process Scoping analysis – were studied.

On stage 2, the workflow associated with each subprocess was analyzed. Next, an analysis for process errors, waste and non-value added activities was conducted and the outputs of this analysis were used as inputs to the stage 3 of the process improvement methodology – selecting which improvement opportunities to tackle, devising and implementing business solutions.

Like in every other project, naturally, some constraints and limitations were encountered during the course of the project, the most important one being the time available to implement the envisioned business solutions.

Also, it is worth mentioning the fact that this project was conducted in a company that operates in a strictly regulated industry. Moreover, it is an affiliate of a multinational company, with standardized processes and procedures implemented in every affiliate that can hardly be changed.

Summary of contributions

Improvement of business processes is a never-ending process. New emerging technologies enable the innovation on how workflows are designed and how daily tasks are conducted.

One of the main contributions that the project gave to the organization was the knowledge brought inside on how SAP routines or activities can be streamlined, simplified and automated using SAP Scripting language. In fact, repetitive tasks or routines can be automated and performed much faster exploring the potential of SAP Scripting, together with VBA and MS Excel, a tool already known universally.

To this matter, it is worth highlighting the following business solutions and its successful implementations:

- i. Application developed for the closure of process orders: involved direct time savings in the order of 98% of the time required to perform this task manually, which translates in less 7h per month to perform this task;
- ii. Automatic checking file update: involved direct time savings of 15 minutes per day, which translates into 5h and 30 minutes monthly, in addition to the increase of the data reliability;
- iii. Small Lamina creation application: involved direct time savings of 15 minutes per day, (practically 10h per month), in addition to the increase of the data reliability;
- iv. Process control reports: the developed applications for controlling strategic points of the Leaf Replenishment and Production Recording process ensured that no errors passed on to the months of May and Jun – the implementation occurred in April;

Besides the direct gains achieved with the implementation of the business solutions previously described, the project brought yet another indirect gain: an explicit and formal representation of a chain of subprocess that was yet to be made. This representation served not only for the purpose of this project but also for future improvement initiatives, establishing a baseline for further improvement projects.

Future work

During the period in which this project was undertaken, it was not possible to tackle every situation or improve all aspects of the tackled processes. As such, improvement opportunities regarded as having significant potential impact are presented next so that they can be subject to future assessments.

The first point to follow up is the extension of the automation potential that the integration between SAP Scripting, VBA and MS Excel possesses to other activities. Particularly, it would be interesting to explore the possibility to expedite, simplify and streamline the first three main activities of the Leaf Replenishment process, which generate a great deal of the Primary planner's workload (around 50% of his available time) leaving more time for more value-added activities.

In the same record, the the Primary planning and scheduling subprocess workload falls upon the primary planner almost entirely. This subprocess involves handling several pieces of information, sourcing data from different Excel files and using several SAP transactions simultaneously.

It could be interesting to explore the possibility of automating at least some parts of this process or develop an application that could present the required information for the planning task in a more user-friendly way.

On a different topic comes a reminder for the issue and the importance of knowledge management. People have a high job rotation and, although it definitely has its perks, it brings up the issue of knowledge retention.

Standardization is one of the tools being used to counteract this fact, as well as the usage of collaborative information systems. However, the suggestion goes towards the implementation of a more formal approach for knowledge retention, leveraging the fact that Tabaqueira is part of a multinational company, where affiliates share similar difficulties.

Formal procedures on how to deal with these common problems could dramatically decrease the amount of time taken to solve them individually.

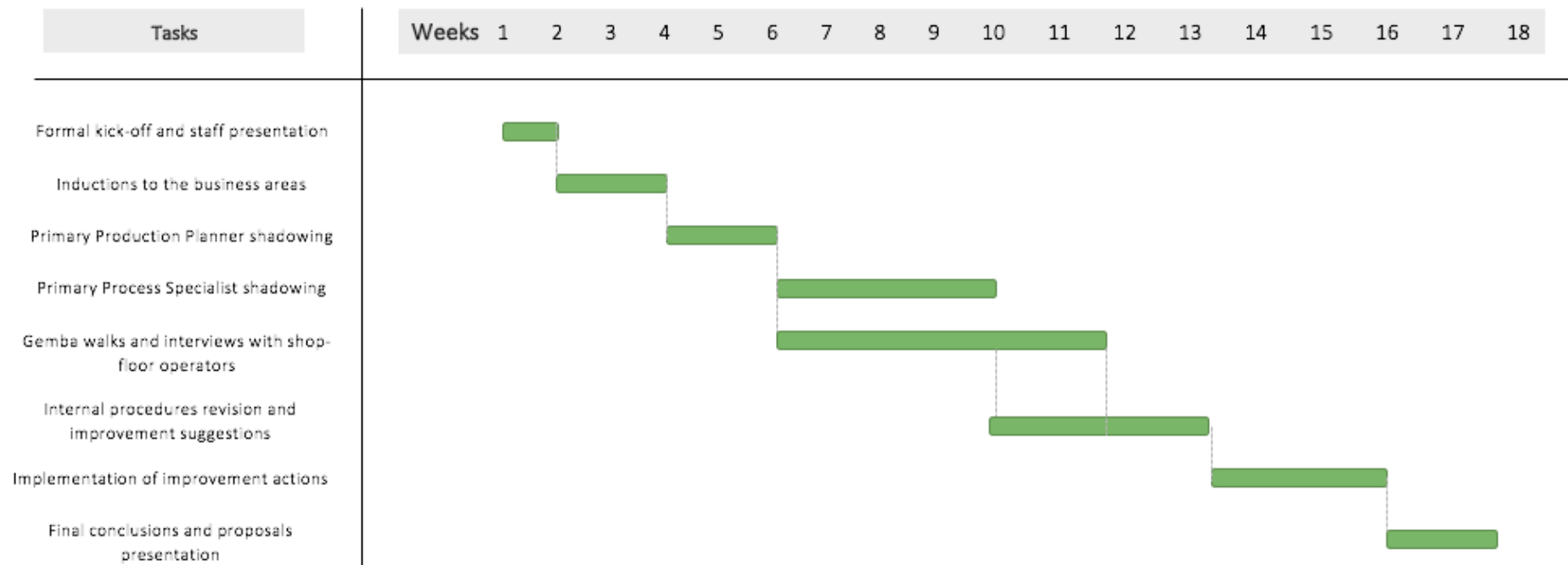
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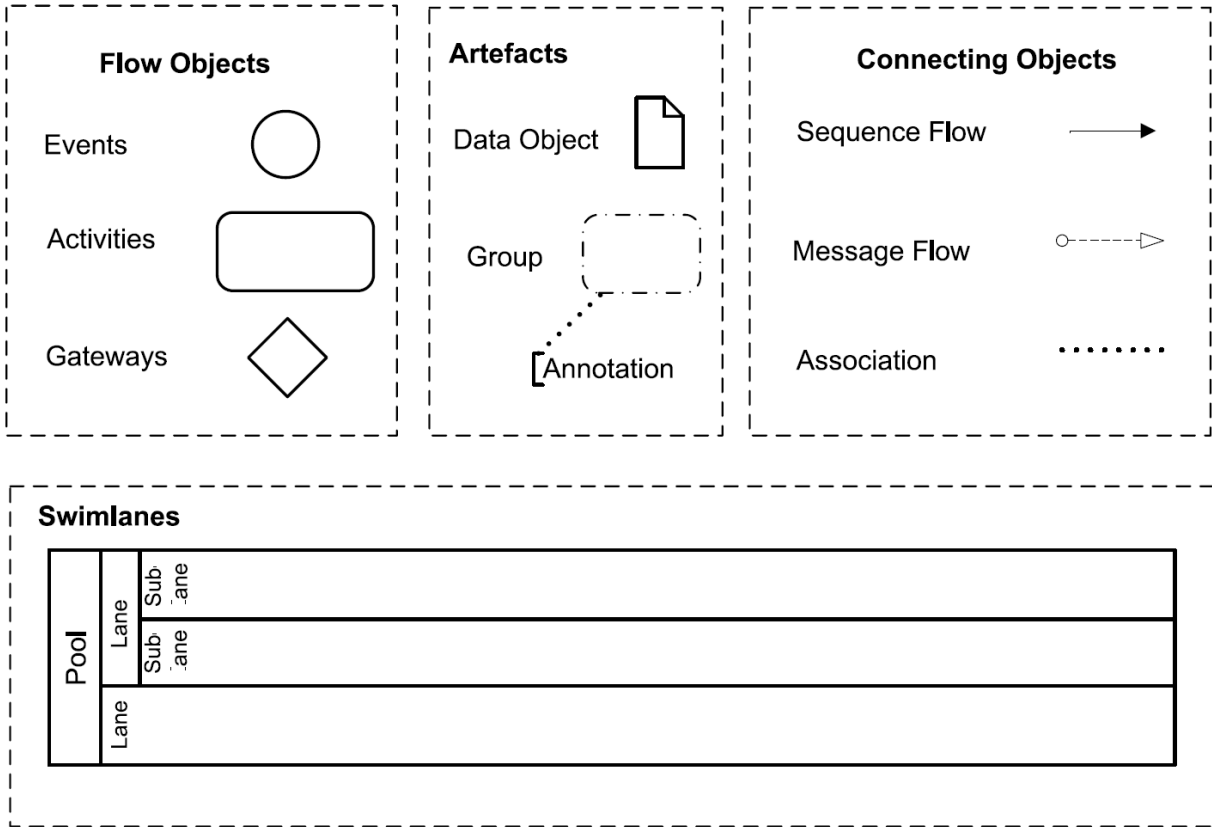
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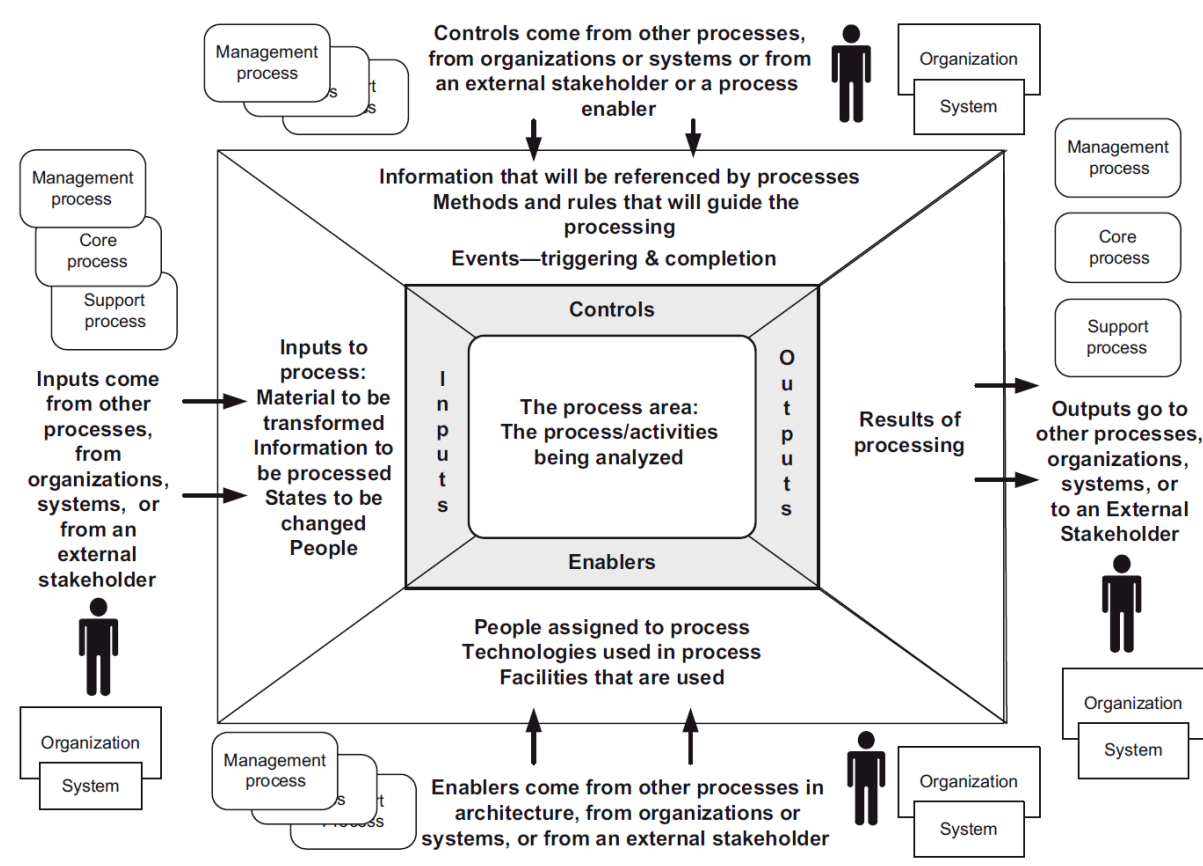
Appendix A: Project chart



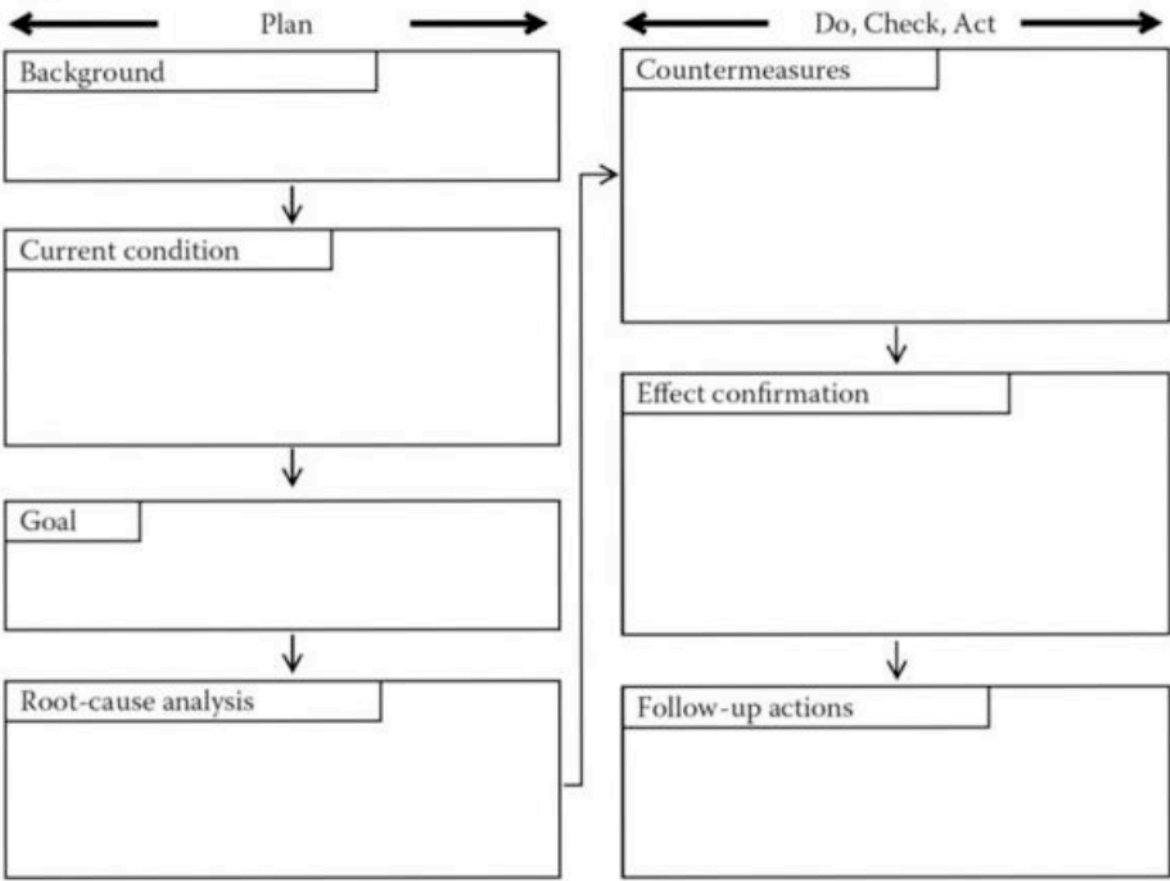
Appendix B: BPMN - Categories of elements



Appendix C: Elements of a Process Scoping Diagram



Appendix D: Typical flow of the problem-solving A3 report



Appendix E: Table template for the FMEA process

Failure mode	Potential effects	S	Potential causes of failure	O	Current process controls	D	RPN	Recommended actions	Action taken	S	O	D	RPN

S (Severity) –Rated on a scale of 1 to 10 where 1 is insignificant and 10 is catastrophic

O (Occurrence) - Rated on a scale of 1 to 10 where 1 is extremely unlikely and 10 is inevitable

D (Detection) -

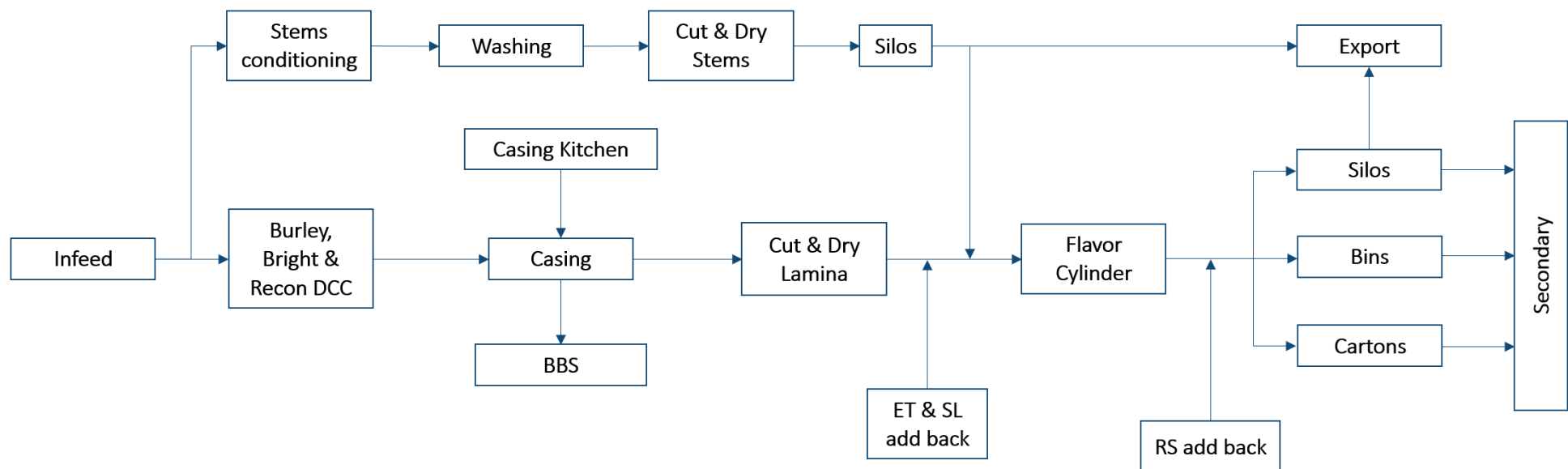
RPN (Risk priority number) – It is calculated as follows: $RPN = S \times O \times D$. It is used to set priorities for the actions to be taken

Recommended actions - actions that must be taken to eliminate or at least mitigate the cause(s) of the failure

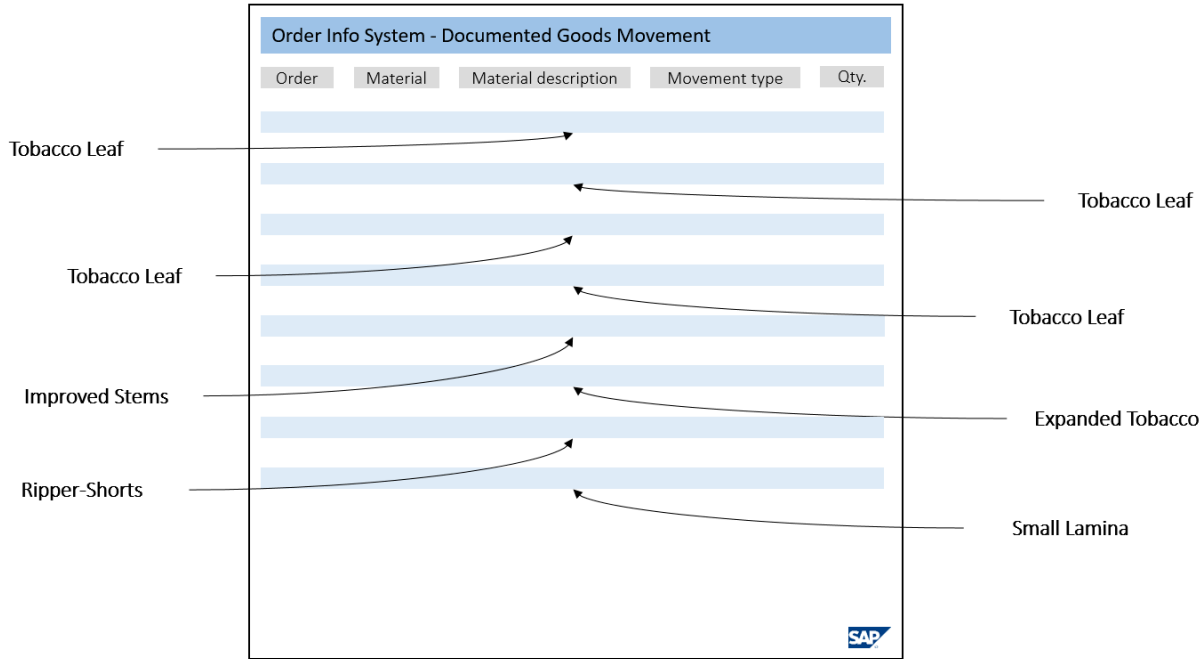
Actions taken – specify which actions, from the list of recommended actions, were truly taken

S, O, D, RPN under the ‘Action results’ tab pertain to the new ranks observed; the S, O, D and RPN ranks are revised and re-rated in order to measure the effects of the actions taken

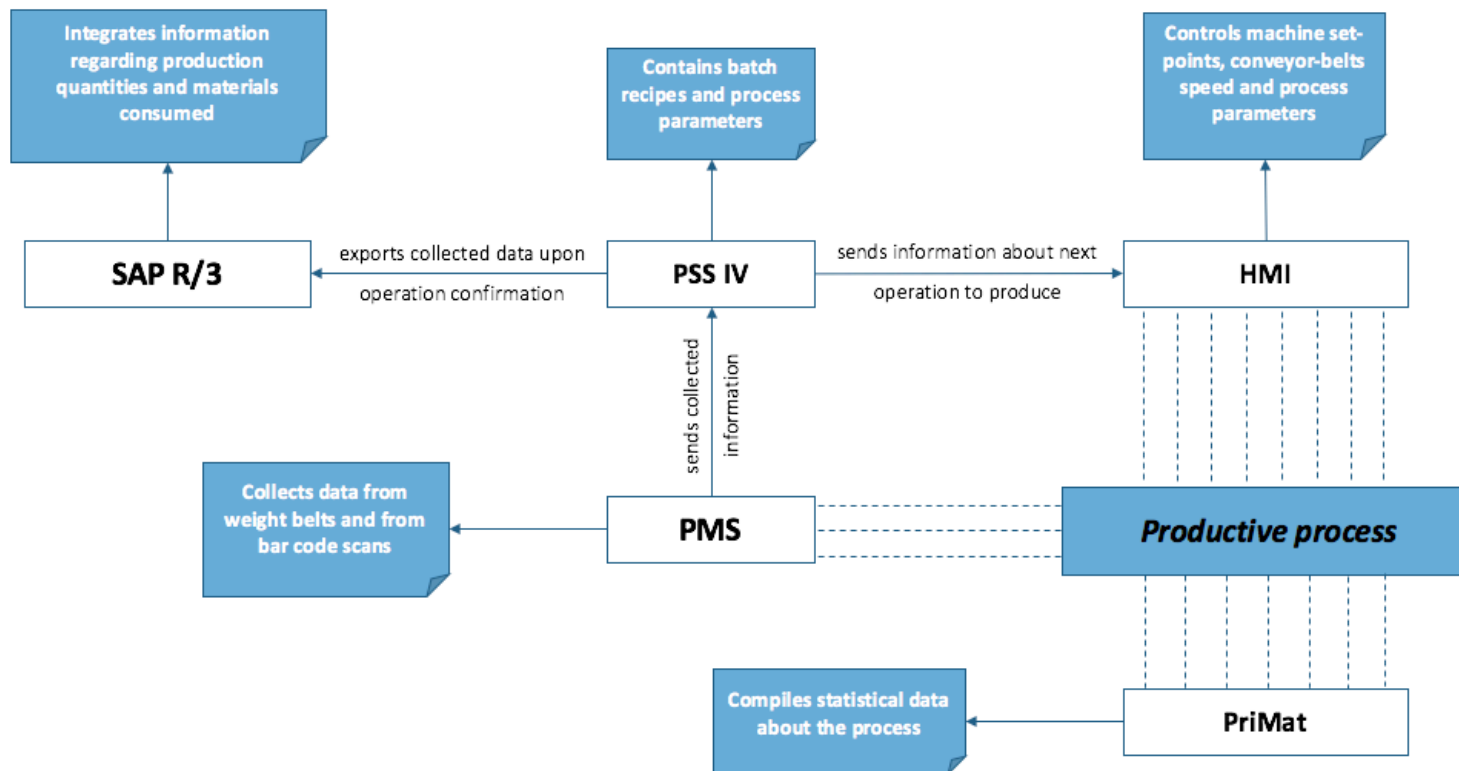
Appendix F: Primary productive flow



Appendix G: Representation of ‘Documented Goods Movements’



Appendix H: Systems interaction



Appendix I: Important SAP R/3 transactions

Transaction	Description	Subprocess
MB52	Stock information at plant and storage location level, by material	Leaf replenishment
MB51	Stock information at plant and storage location level, by material and on a given date	Inventory process
COOISPI	Process Order related information, such as documented material movements, item components,	Leaf replenishment / Production recording
ME2N	Stock Transfer Order information (materials, quantities, delivery status,...), by STO number	Leaf replenishment
ME2B	Stock Transfer Order information (materials, quantities, delivery status,...), by tracking number (Process Order)	Leaf replenishment
MB25	Open requirements for Process Orders	Leaf replenishment
COR2	Transaction used to change a PO (e.g. change the posted produced quantity or the production date)	Production recording / Inventory process
CO54	Message monitor – this transaction allows the user to manually process a message previously created	Production recording
CO57	Transaction used to manually create a message (e.g. to send a message to manually change the status of a process order)	Production recording
COID	Transaction used to close a given process order (set the status of the process order to TECO)	Production recording
MIGO	Used to manually post ‘Goods Receipt’ or ‘Goods Issue’	Production recording / Inventory process
COGI	Transaction that captures errors during automatic Goods Movements	Production recording

Appendix J: Production Planning and Scheduling description

The Primary production planning and scheduling subprocess does not lie within the scope of this project. However, a brief description of the main challenges and outputs it generates is presented in order to formulate an end-to-end picture of the whole process to be improved.

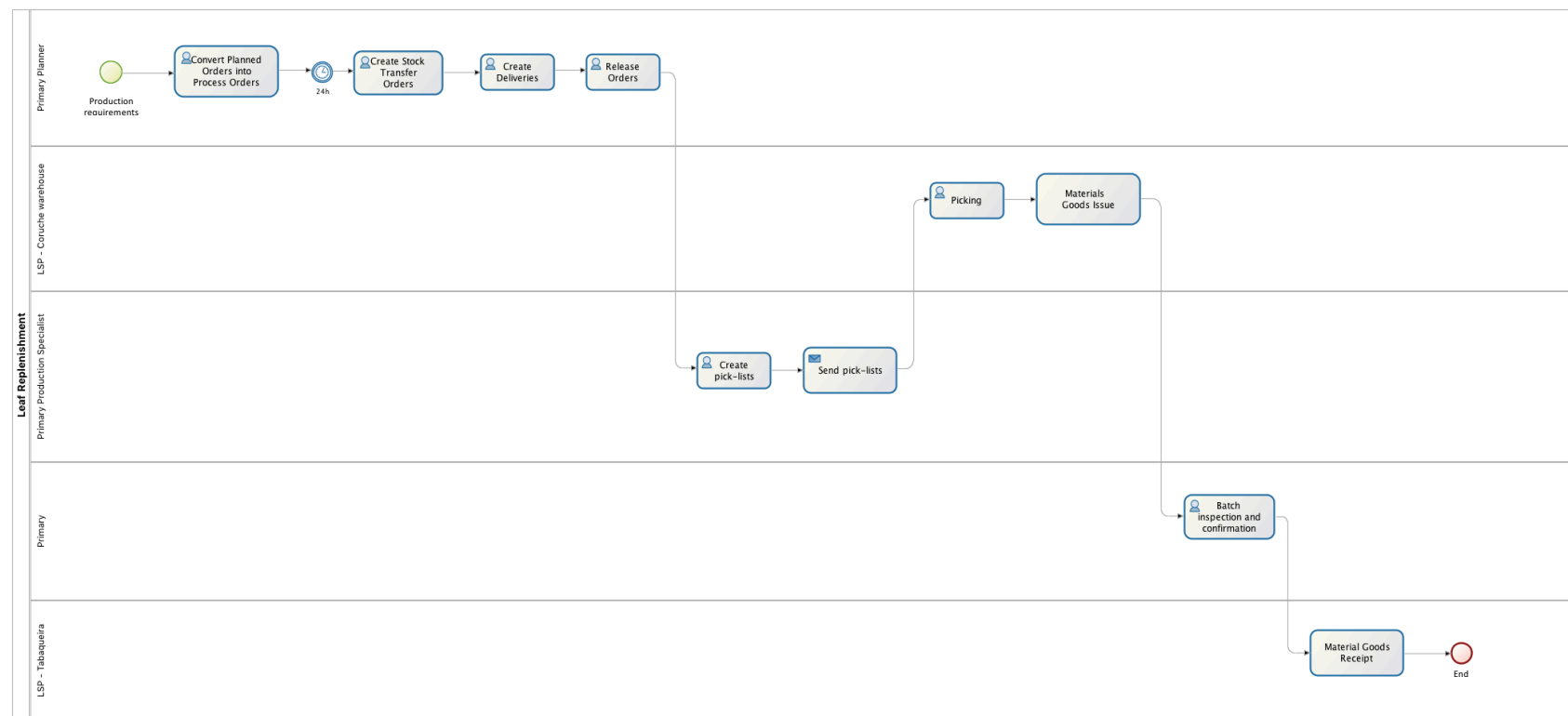
Primary production planning deals with short term planning only. This subprocess looks into the production requirements, which are derived from the Secondary planned production¹², and produces a short-term production plan (for a maximum time horizon of 15 days) as well as a daily production plan (daily operations scheduling). These are the main process outputs that will serve as important inputs to the Leaf Replenishment subprocess (described in 3.2.1), Production Execution subprocess (described in 3.2.2) and the Pack-off subprocess (described in 3.2.3).

It is worth mentioning that both the Primary production plan and the daily schedule are done using a MS Excel file.

The daily plan is shared with the Primary production teams serving as a guide to decide which operation to execute next. Moreover, whenever necessary, changes to the plan are reflected directly on this MS Excel file, either by the Primary Planner or by the Supervisor in charge.

¹² Secondary planned production is in millions of cigarettes; this number needs to be translated into tons of cut filler for Primary production planning purposes

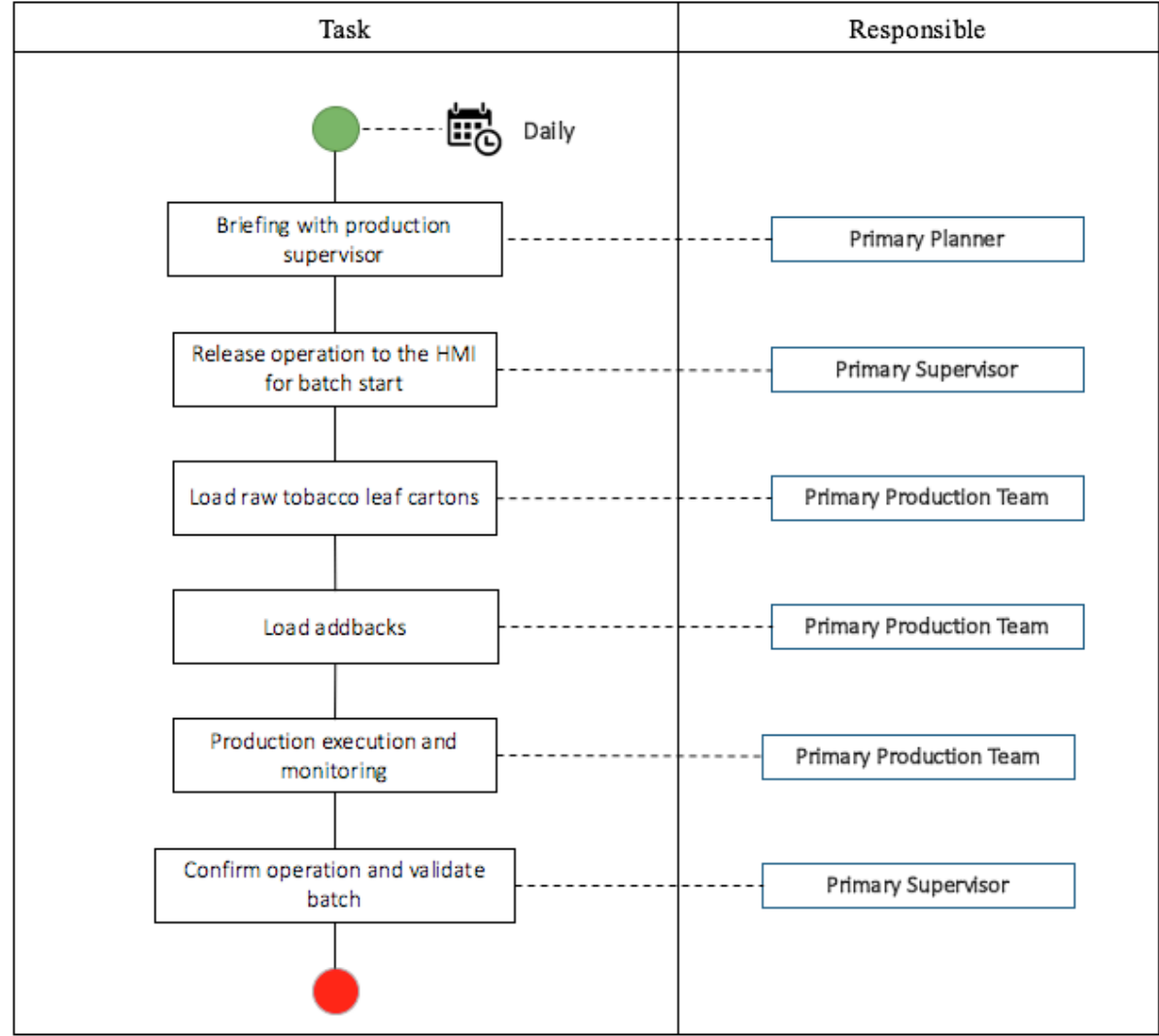
Appendix K: Leaf replenishment workflow model



Appendix L: Leaf replenishment - SIPOC analysis

Suppliers	Inputs	Process	Outputs	Customers
Primary Production Planning and Scheduling process	Primary Production Plan	Convert Planned Orders	Process Orders	N/A
N/A	Process Orders	Create STO	Stock Transfer Orders	N/A
N/A	Process Orders	Create Deliveries	Delivery document	Coruche LSP
N/A	N/A	Release Process Orders	Released Orders	Production Execution process
Primary Planning	Primary Planner message	Create and send pick-lists	Pick-lists	Coruche LSP
N/A	STO	Materials Goods Issue	Stock leaves LP30 OR LP40	N/A
LSP	Delivery and pick-list	Batch inspection and confirmation	Delivery confirmed	Production Execution process
N/A	STO	Materials Goods Receipt	Stock enters on LF10	Production recording process

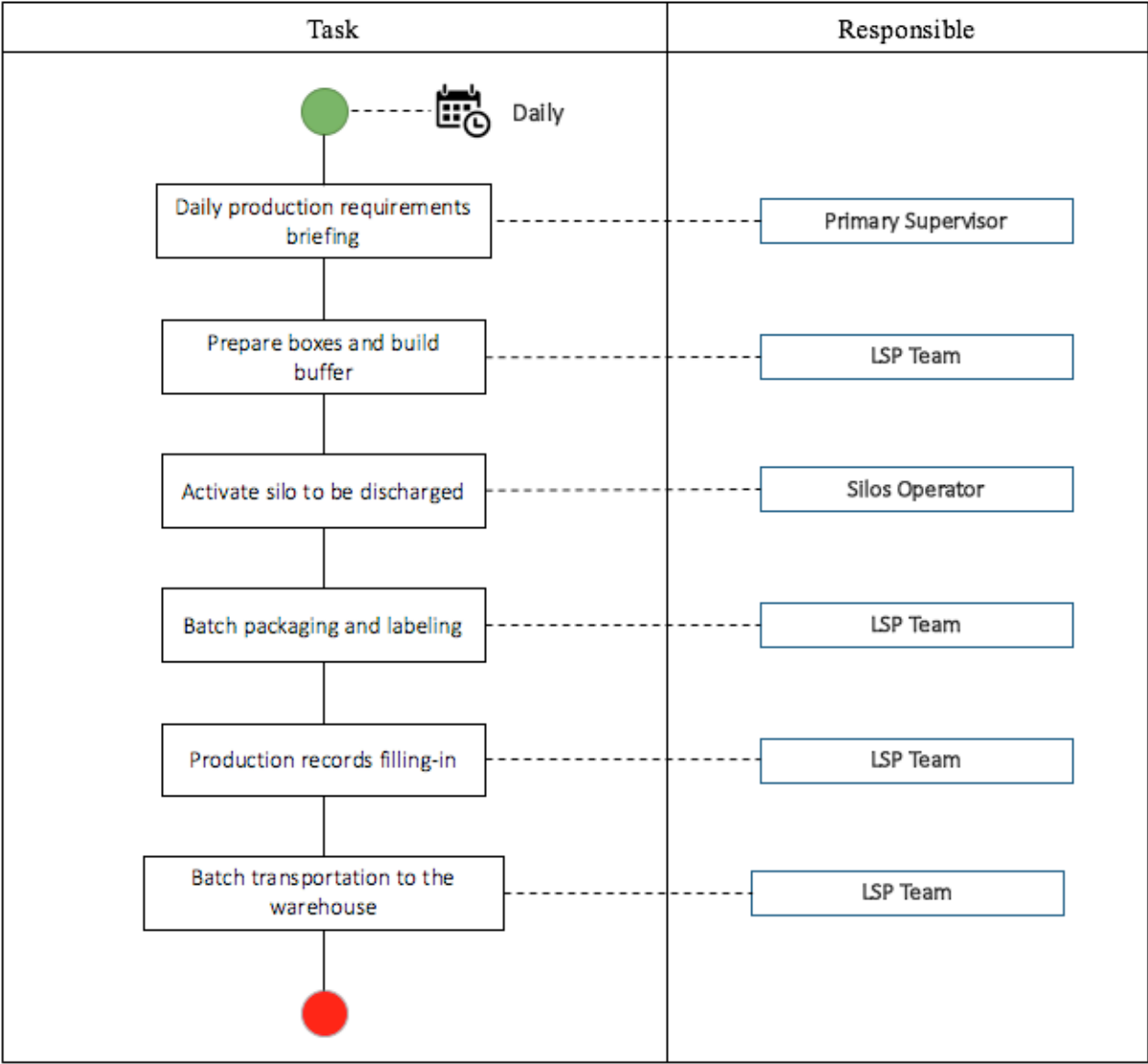
Appendix M: Production execution flowchart model



Appendix N: Production execution - SIPOC analysis

Suppliers	Inputs	Process	Outputs	Customers
Leaf Replenishment subprocess	Primary production plan	Release operation to the HMI for batch start	Order released to the HMI and ready for batch start	Production team
Coruche warehouse	Raw tobacco leaf	Load raw tobacco leaf cartons	Raw tobacco loaded into the line	N/A
Coruche warehouse Factory warehouses	Addbacks Primary production plan	Load addbacks (SL, ET, RS, OS)	Addbacks loaded into the line	Production recording subprocess
PSS IV and HMI systems	Process key parameters data	Production execution and monitoring	Finished or semi-finished products	Secondary process Pack-off and Production Recording subprocess
Primary Supervisor	N/A	Confirm operation and validate batch	Information exported to SAP	Production Recording subprocess

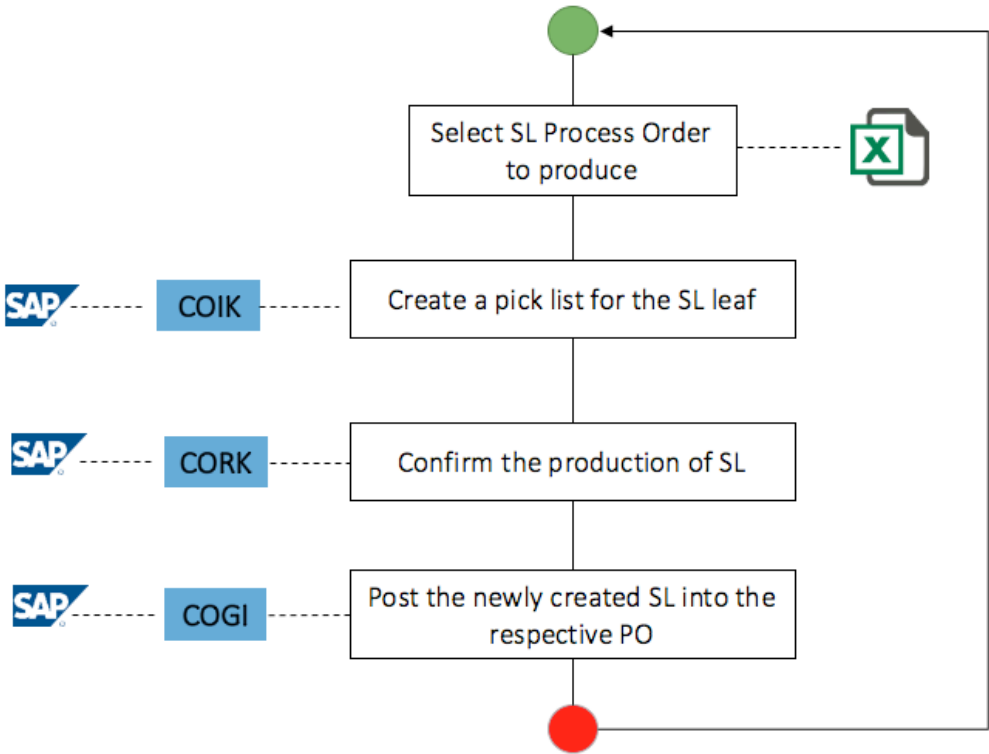
Appendix O: Pack-off flowchart model



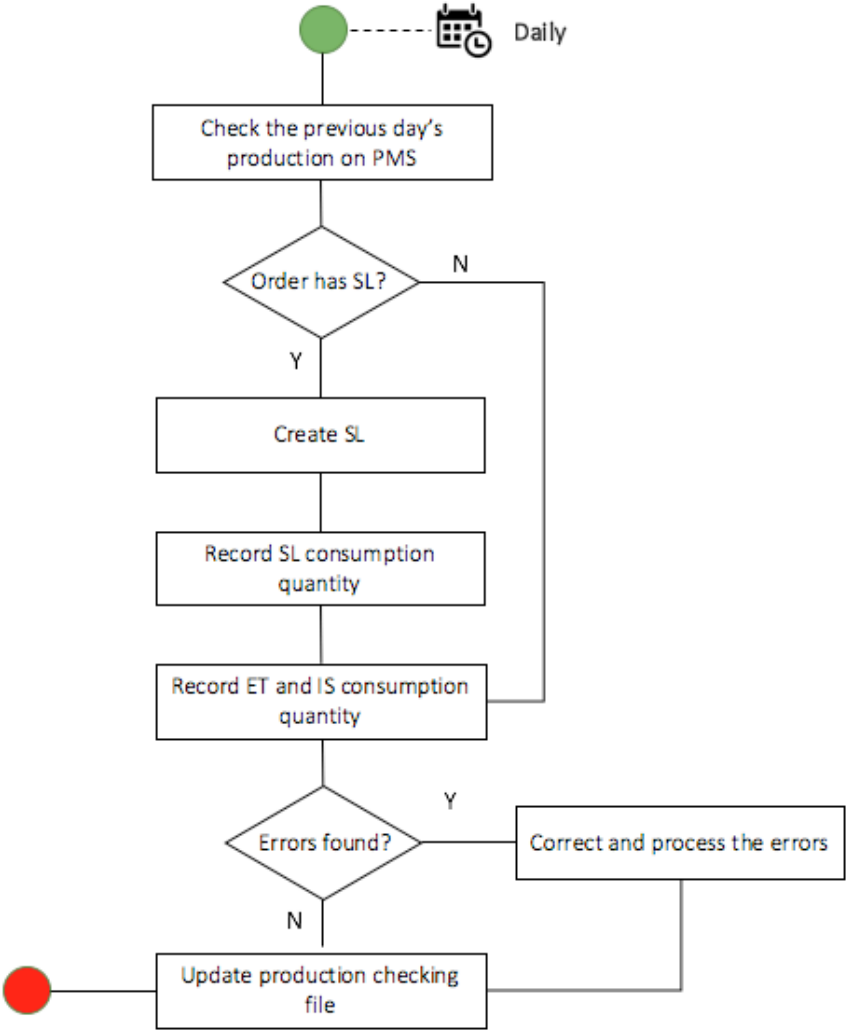
Appendix P: Pack-off process - SIPOC analysis

Suppliers	Inputs	Process	Outputs	Customers
Primary Supervisor	Production plan	Morning brief	Production objectives	LSP pack-off team
Silo workstation operator	Production plan	Activate silo to be discharged	Discharge available	LSP pack-off team
N/A	DIM	Prepare boxes	Box prepared	N/A
N/A	N/A	Pack cut filler	Cut filler boxed	N/A
N/A	Batch label	Label cut filler box	Box ready to be sent to warehouse	Warehouse
N/A	N/A	Pack stems	Stems boxed	N/A
Control room	Batch label	Label stems box	Box ready to be sent to warehouse	Warehouse
N/A	N/A	Fill in Tabaqueira's paper production log	Production log filled	Production recording process
N/A	N/A	Fill in LSP's paper production log	Production log filled	LSP Logistics department
N/A	N/A	Transport finished boxes to warehouse	Boxes moved to the export warehouse	Export warehouse LSP operator
LSP operators	Boxes ready for storage	Warehouse materials check-in	Stock updated on Primary and export warehouse storage locations	N/A

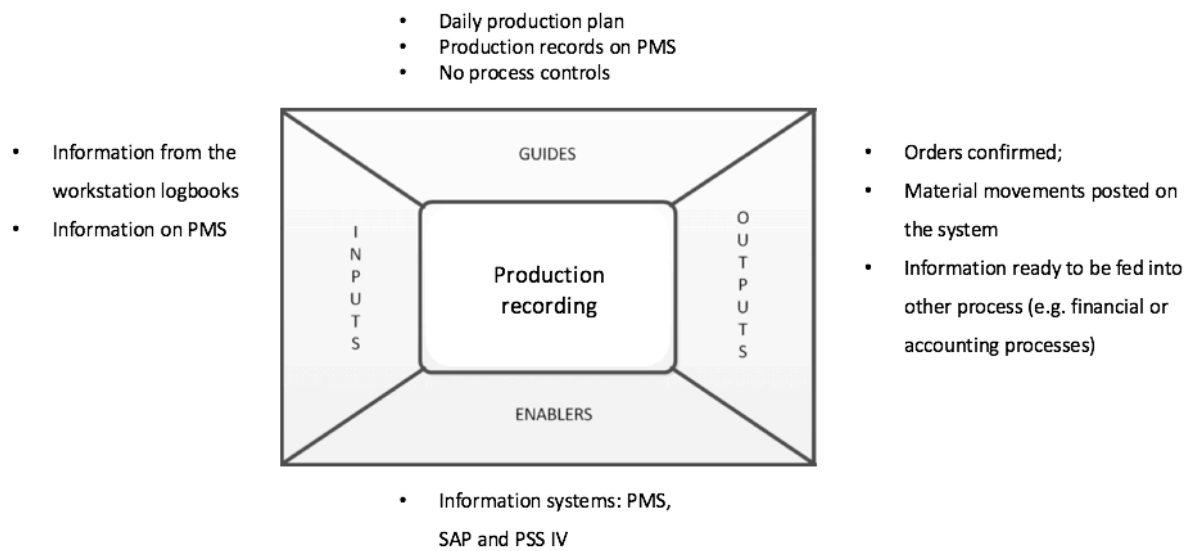
Appendix Q: Procedure for Small Lamina creation



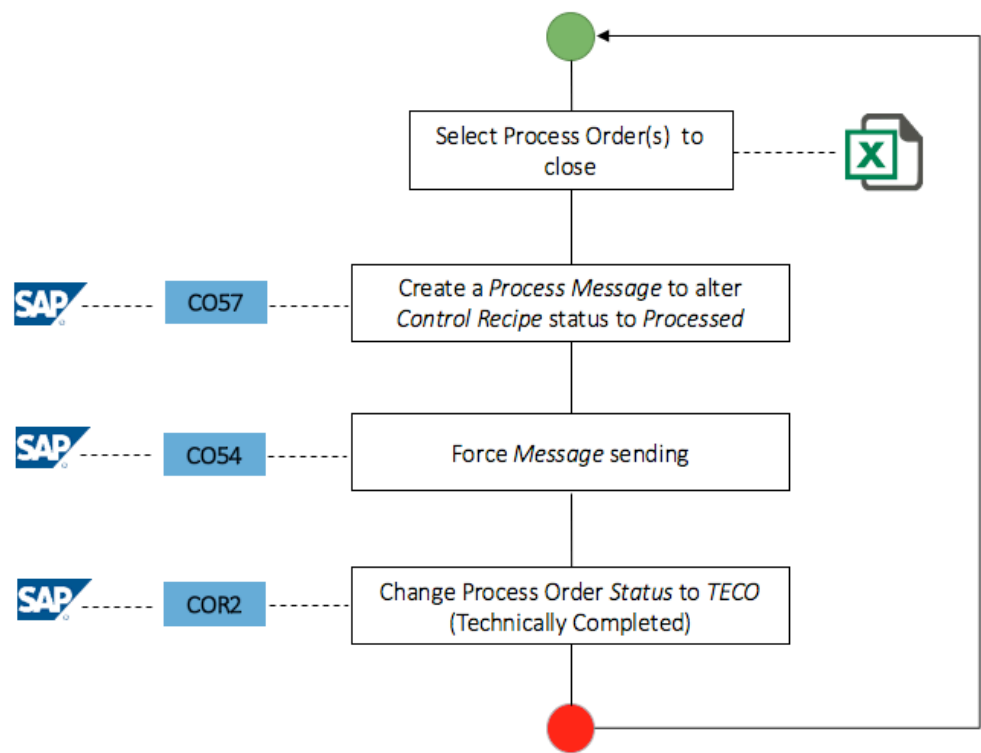
Appendix R: Production recording flowchart model - cut filler orders



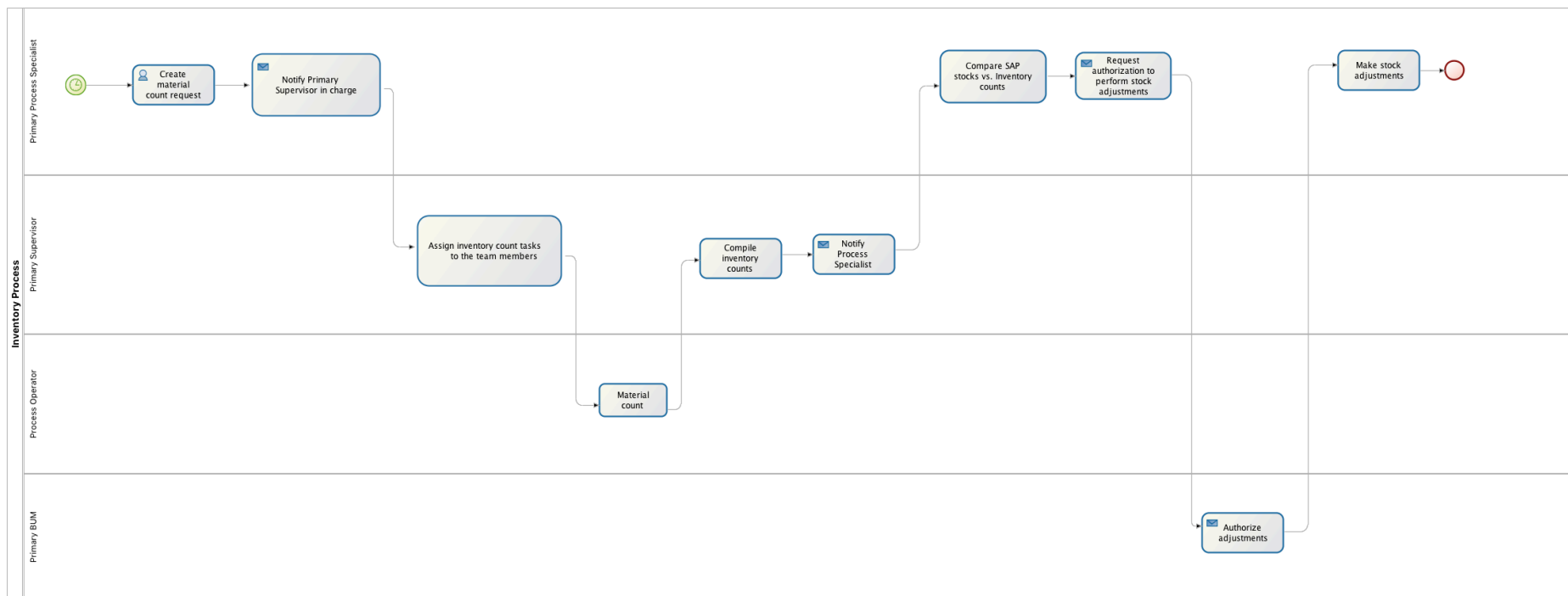
Appendix S: Production recording Process Scoping Diagram



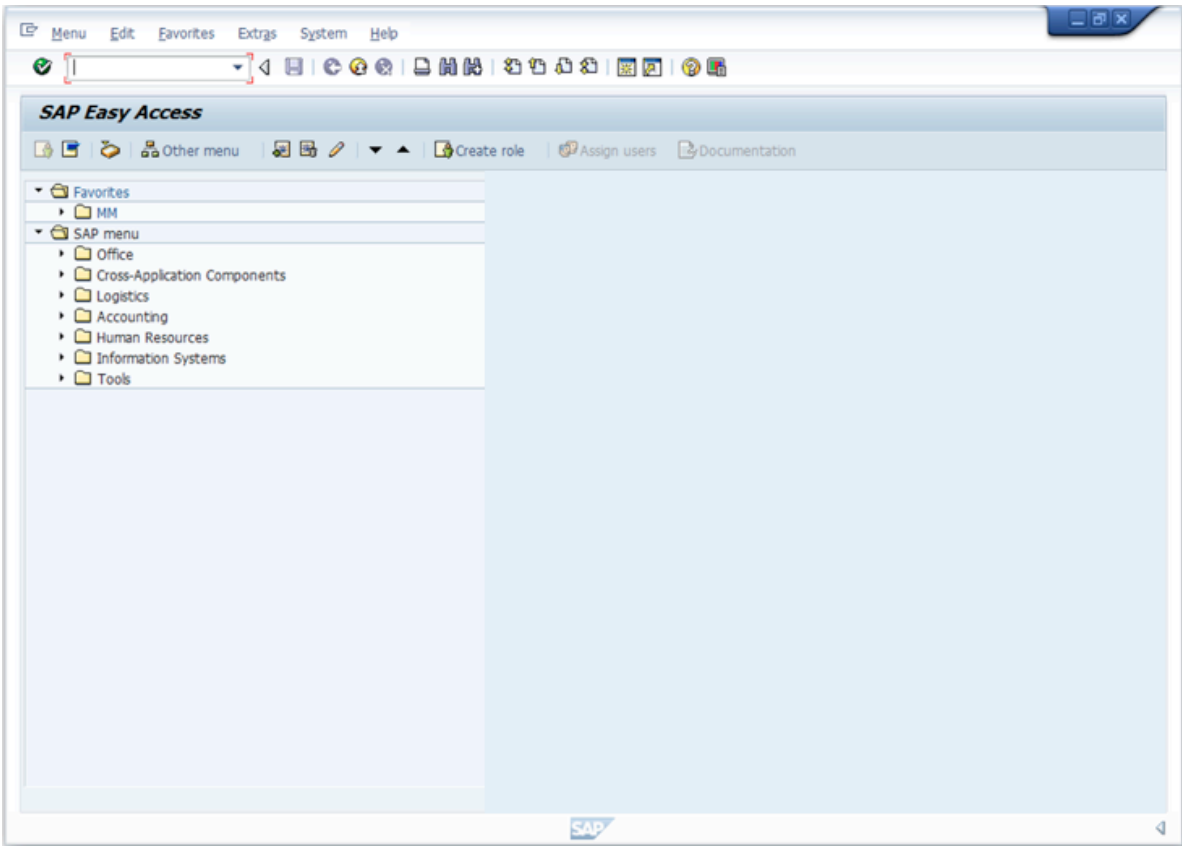
Appendix T: Procedure for closing process orders



Appendix U: Inventory process workflow model



Appendix V: SAP GUI interface



Appendix X: Primary Planning Control Report



TABAGUEIRA
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Primary Planning Control

Extract data

Run report

Date interval

Start dateEnd date

Legend:

Input data here

Errors found

Help!

☐ Verify pending 'Goods Receipt'

Help!

PO	STO	GI Date	GR Date
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR
		No GI yet	Waiting for GR

Help!

☒ Compare open requirements with current stock

Stock @ Infeed + Stock Tranfer
Orders created = Stock Reservations
for Process Orders

PO

☐ Check quantities and display errors

Help!

PO	STO	Material	Req. qt	Tsf. qt
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A
			#N/A	#N/A

Help!

☐ Cross-check created STOs with created POs

STO

Appendix Z: Export control application



☒ Cut filler Report

☐ Stems Report

Extract data

Run report

Legend:

	Input data here
	Errors found

PO Cut filler	CF Check
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A
	PO N/A

PO Stems	Stems Check
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK

Errors found

Appendix AA: Small Lamina creation control



Small Lamina Control Report

Extract data

Run report

Legend:

	Input data here
	Errors found

PO Small Lamina	Check
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK
	OK

Errors found

--

Appendix AB: Interface of the Pack-off production file



Registo de produção - Pack off

Data: 02-05-2017

[Criar nova folha de produção](#)

Briefing? ☐ Sim ☒ Não

Se sim, com quem?

Equipa:

Coordenador

Operador 1

Operador 2

Operador 3

Objetivos de produção:

CF - 100 cxs

CF - 120 cxs

Nervura cxs

Prioridade:

☒ Cutfiller ☐ Nervura

[Atualizar informação](#)

Última atualização a 09/06/2017

[Validar produção](#)

	CF - 1	CF - 2	Nervura 1	Nervura 2	Nervura 3
Material					
TP Batch					
Lot number					
Tipo calca					
07:00h - 08:00h					
08:00h - 09:00h					
09:00h - 10:00h					
10:00h - 11:00h					
11:00h - 12:00h					
12:00h - 13:00h					
13:00h - 14:00h					
14:00h - 15:00h					
15:00h - 16:00h					
Remanescentes					

Inserir Batch TP em falta

	CF - 1	CF - 2	Nervura 1	Nervura 2	Nervura 3
Material					
TP Batch					
Lot number					
Tipo calca					
16:00h - 17:00h					
17:00h - 18:00h					
18:00h - 19:00h					
19:00h - 20:00h					
20:00h - 21:00h					
21:00h - 22:00h					
22:00h - 23:00h					
23:00h - 24:00h					
Remanescentes					

Totals:

CF - 100	CF - 120	Nervura - 100
0	0	0

		Início	Fim
1º silo	NV		
	CF		
2º Silo	NV		
	CF		

		Início	Fim
Entrega de Amostras			
Preparação de calças			
Limpeza	NV		
	CF		

		Início	Fim
Almoço	Grupo 1		
	Grupo 2		

		Linha		Paragem	Início	Fim
		Nervura	CF			
Indefinição/ Avaria:	Grual/ Guincho					
	Vácuo					
	Strapex					
	Entupimento					
	Prensa CF					
	Outra					