

## Masterproef

*Showing the added value of BPMN in WMS*

Promotor :  
Prof. dr. Koenraad VANHOOF

Saif Alattar

*Master Thesis nominated to obtain the degree of Master of Management , specialization  
Management Information Systems*

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# FACULTY OF BUSINESS ECONOMICS

*Master of Management: Management Information Systems*

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## **ii. Introduction**

The use of business process modeling diagrams has widely been increased recently to provide a notation that is readily understandable by business users from business analysts that create the initial drafts of processes to the technical developers responsible for implementing the technology that will perform those processes and finally to the business people who will manage and monitor those processes. Thus BPMN creates a standardized bridge between the business process design and process implementation.

Warehouse management is the art of movement and storage of materials throughout the warehouse. Warehouse management monitors the progress of products through the warehouse. It deals with the receipt, storage and movement of goods usually finished and includes functions like warehouse master record, item/warehouse cross reference lists, transfers in process, safety stock...etc.

This research will delve into the possibilities of enhancing the warehouse management processes through the use of Business Process Modeling software. In the first chapter of this thesis, we will go through the theory and functionalities of business process management and business process modeling, I have chosen to use BIZAGI business process modeler as a modeling tool for modeling the processes in this case study. In the second chapter we will investigate the theory of warehouse management and the processes involved in a typical warehouse and also the use of warehouse management systems (WMS) for managing the processes in the warehouse. Then in chapter 3 I have applied the tools of BPMN to model the processes in the warehouse, by setting up to two process model for each process; the first is an AS-IS diagram of how the processes are being performed with an old WMS and the second model is a TO-BE diagram of how the processes are foreseen to be after

the use of a new WMS. A what-if analysis for different productivity levels has been conducted in chapter 4 for each of the warehouse processes and finally in Chapter 5 using the BPMN diagrams previously identified for each process, I have conducted a gap analysis to compare the old processes to the new ones. The intent of Business Process modeling notations is to represent a simple means of communicating business processes information to other business users, implementers, customers and suppliers in a more comprehensive diagrammatical approach. This will also serve in identifying which processes can be automated through using computer software and which should still require a human intervention as well as identifying the potential enhancement in processes' speed and cost.

The use of BPMN gives the possibility of comparing business processes on two different levels, the first is a tactical high level which answers to questions like "What are we doing in this processes?" and the second is more detailed operational lower level of modeling the process which answers questions like "How are we doing this process?", through using this concept we can investigate weather the processes have been changed in terms of what activities they are composed of after the installation of the new WMS in the warehouse or the use of this new systems had only an effect on the operational level of processes in which only they way they are performed is changed without changing what they are made of.





## Chapter -1 - Business Process Management

Before starting the chapter, it is handy to identify some important terms and Terminologies that are related to our topic.

**BPM – Business Process Management:** is a method to analyze, explain, build, manage and run information flows and process steps where the orchestration of processes is separated from execution.

**BPA – Business Process Analysis:** is the part of BPM that focuses on uncovering, designing and modeling business processes.

**BPI – Business process Improvement:** is the identification and continuous improvement of business processes supported by methodologies.

**BPMT – Business Process Management Technology:** is an automated solution that supports business process management in one or more ways. BPMT focuses on the technical part of BPM implementation.

### 1.1 The Evolution of Business Process Management and BPM systems

The origin of the current BPM level roots back to two different areas that have evolved during the last 20 years and more. The first area is the workflow which is represented by the person-to-person routing of scanned documents through a pre-plotted process map. Most of these workflow systems focused on document circulation. They entailed circulating a scanned paper document from one individual to another to enable them to perform some action, like data entry. These systems were very document/folder centric and hence they are referred to as Document Management Systems.

Enterprise Application Integration (EAI) is the second area, whose main objective is to automate the near-real-time exchange of data between systems, basically mainframe-based transaction processing systems or server-based relational databases. The main benefit of these systems was to reduce the errors and effort of data entry through avoiding re-keying of data. Besides the EAI systems served in advancing from batch oriented processing towards near real time or straight through processing.

Through the last ten years, these two areas have developed in diverse ways. Workflow developed light weight EAI capabilities but it also focused on Business Activity monitoring – BAM for management to understand the current status quo of the process. In addition to the development of process governance supporting programs like six sigma and finally Workflow developed simulation techniques to understand and enable optimization of processes.

On the other hand, EAI products developed lightweight workflow capabilities, but more importantly they were developed to look outside the organization, extending to Business -to -Business integration (B2B), allowing these organizations to implement loosely coupled processes with those of other organizations. Towards the end of those ten years, convergence started to take place between EAI and workflow. Both EAI and workflow products extended to include a functionality that was useful in both spheres such as business rules programs which gave better control over the process flow and integration and process modeling to reinforce the design of the workflow or EAI configuration. See the figure below which illustrates what developments took place in the workflow/EAI sphere. (Capgemini)

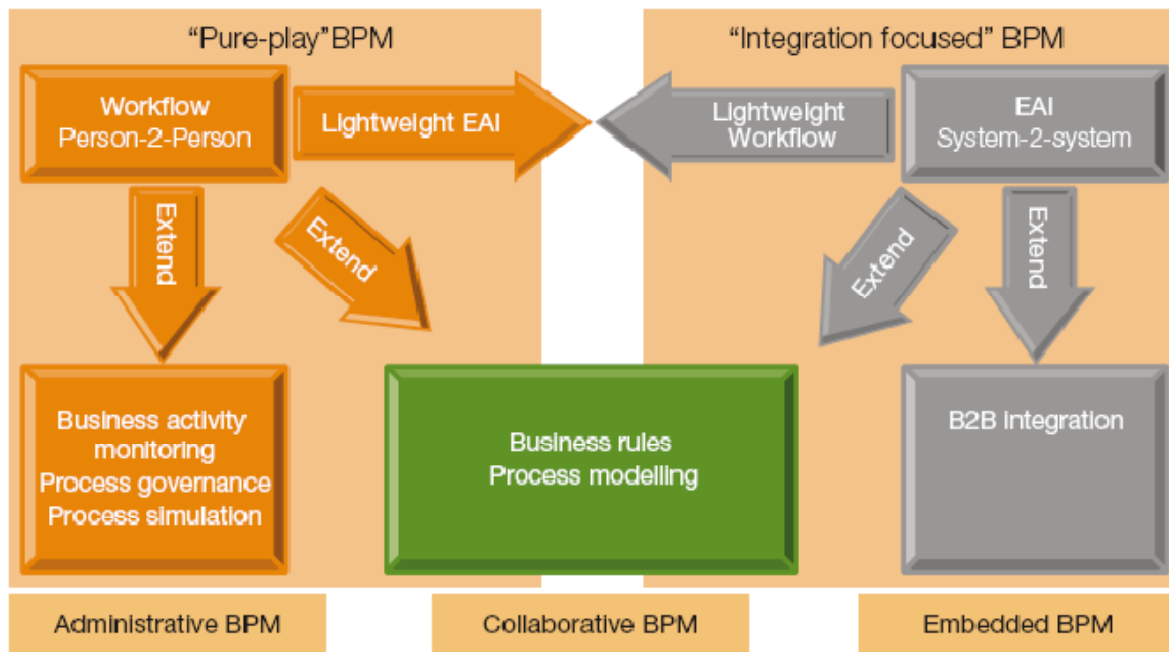


Figure 1 - Convergence of workflow & EAI

Now we enter the BPM suites, which is primarily a renaming of the combined space, putting the words EAI and workflow out of fashion. (Capgemini)

*A Business Process is a collection of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how the work is done within an organization, in contrast to a product's focus on what. A process is thus a specific ordering of work activities across time and place, with a beginning, an end and clearly defined inputs and outputs: a structure for action. (Sparx systems).*

There are a number of reasons for a company to adopt a Business Process Management initiative, one of which is to increase operational efficiency and reduce costs. In addition to that it provides insights into the weaknesses of the processes and minimizes the costs associated with daily work flows. Now to sum up the important incentives for organizations to adopt BPM, let's have a look at the points below:

1. Enhancing the process efficiency in different departments.
2. Executing processes based on BPM systems.
3. The use of BPM helps executing IT systems and applications like ERP and CRM.
4. Implementing EAI technologies or SOAs.
5. Making quality management systems for ISO certification.
6. Implementing standardization frameworks such as Zachman.
7. Implementing enterprise architecture management
8. Introducing process-based requirements analysis for software engineering and development process.
9. Using legislation-based compliance management that focus on business processes, e.g. Sarbanes-Oxley Act.

## 1.2 Understanding Business Process Management:

According to Melenovsky – 2006 and a white paper issued by SOFTWARE AG (Getting started with BPM) a number of myths and misconceptions that were associated with BPM. We will use these myths as a structure for elaborately understanding BPM and its functionalities.

### **Myth – 1: BPM is just a process improvement project.**

Correction: Process improvement is a continuous outcome from ongoing management of the business process; therefore BPM is not a project. The implementation of BPM takes place within one or more projects, but BPM is a process infrastructure.

### **Myth – 2: BPM is a technology.**

Correction: BPM is a management practice enabled by certain technologies.

**Myth – 3: BPM is all about process standardization**

Correction: Best practices can be adopted through better process management, besides; BPM provides agility, innovation and specialization.

**Myth – 4: BPM is a radical change to business.**

Correction: Depending on the change required, BPM provides the possibility for incremental change beginning with the current-state process. . However there's a lot of truth about the involvement of BPM in a radical rethinking of business processes. While most third party applications are limited to functional fields. An organization implementing BPM may undergo a major change from being a function-centric organization to process-centric organization. This change forces executives to associate accountability, compensation, performance evaluation, and business metrics to complete business process. For such organizations, it is important to follow change management measures and strategies. (E.g. giving employees enough time for consolidation, absorption, and training at every stage)

**Myth – 5: BPM is a package application**

Correction: Unlike the off-the-shelf software packages, BPM provides the tools to model the processes that flow across multiple functional applications and the tools necessary for their implementation, BPM is a cross-functional process bridge which creates an end-to-end, dynamic process.

**Myth – 6: BPM is very expensive.**

Correction: If we compare BPM to ERP and other client/server implementations, BPM is relatively less expensive and less risky as well.

**Myth – 7: BPM is only used for process modeling.**

Correction: It is indeed more beneficial for companies to use the full BPM capabilities by translating models into executable processes and manage their ongoing operations in addition to the process modeling and analysis tools. Furthermore, BPM provides the feedback possibility from the executing process to the underlying process model for future analysis and continuous improvements.

**Myth – 8: BPM is an all or nothing proposition.**

Correction: The incremental implementation of BPM contributes its benefits from the first day of implementation unlike the ERP systems of which, the ROI cannot be materialized unless full installation is complete. BPM benefit can be seen for example through the modeling tools, as business analysts can create standards based process diagrams that can be stored, shared, analyzed and implemented. These models can be more efficient than those done with Visio or PowerPoint as the BPM platform offers an integrated repository, change management, and reporting.

**Myth – 9: BPM is the same as EAI.**

Correction: Traditional Enterprise Application Integration is restricted to addressing issues of transaction and data integration without a focus on the overarching business process. BPM on the other hand is a framework for business process integration. As EAI is to applications, BPM is to business processes, as BPM adds higher level of integration capability to enterprise integration. Therefore BPM extends EAI to a higher order of abstraction.

**Myth – 10: BPM has no ROI.**

Correction: BPM is not the same as commercial-of the shelf- software applications, or a regular IT development project. Companies that are used to the traditional ROI calculations need to make provisions for BPM to calculate its ROI value. Within projects, BPM's value is in making the project more efficient (e.g. minimizing the time required to gather requirement and translating them to spec, developing new processes and promoting reuse). Moreover, BPM's value is in providing superior operations management capability. By combining these two value propositions, BPM provides real business agility.

### 1.3 So what is exactly Business Process Management?

*It is a management discipline which provides governance in a business environment, with the goal of improving agility and operational performance. (Melenovsky, 2006).*

It is composed of a collection of policies, methods, metrics, software tools and management practices to coordinate and continuously optimize the activities within an organization. Its goal is to control and continuously improve the organization business through coordinated active governance

of all aspects of the specification, design, implementation, operation, measurement analysis and optimization of business processes in order to deliver the required business objectives efficiently and effectively.

## 1.4 What is Business Process Modeling Notation (BPMN)?

BPMN: is a flow chart based notation for defining business processes. (white, 2006)

Business Process Modeling Notation was developed by the Business Process modeling Initiative. The primary goal of the BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes and finally to the business people who will manage and monitor those processes. BPMN will also be supported with an internal model that will enable the generation of executable BPEL4WS<sup>1</sup>. BPMN acts as a standardized connection filling the gap between the business process design and process implementation.

BPMN defines a business process Diagram (BPD), which is based on a flowcharting technique tailored for creating graphical models of business process operations. A business Process Model then, is a network of graphical objects which are activities (i.e. work) and the flow controls that define their order of performance.

BPMN defines the term process fairly specifically and defines a Business Process more generically as a set of activities that are performed within an organization or across organizations. Thus a business process, as shown in a Business Process Diagram may contain more than one separate process. Each process may contain sub-processes and would be contained with a Pool. The individual processes would be independent in terms of sequence flow, but could have message flow connecting them.

## 1.5 BPMN basics:

A BPD is made up of a set of graphical elements. These elements facilitate the development of simple diagrams that will look familiar to most business analysts (e.g. Flowchart diagram). The elements were chosen to be distinguishable from each other. Some of the BPMN shapes may already be

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<sup>1</sup> **BPEL4WS: Business Process Execution Language** (BPEL), short for *Web Services Business Process Execution Language* (WS-BPEL) is an OASIS standard executable language for specifying interactions with web services.

familiar to some business users who are acquainted with flow chart diagrams. For example, activities are rectangles and decisions are diamonds.

BPMN was developed to formulate business process models, while at the same time it should be sufficient for the reader to understand these models despite the complexity of the business processes. Therefore, the graphical characters were grouped into specific categories in such a way that the reader can easily recognize the basic types of these elements and understand the diagram. A further detail and variation is added for each category without conducting major changes for the basic shape of the element. (White)

### 1.6 Purposes and Goals of a Process Model:

The process model includes all the comprising activities in the end-to-end process, these activities are organized in a logical sequence according to the dependence of one activity on another and conforming to the information that is provided to it by other processes or activities. Although these process models are not time based and should not be confused with GNATT charts or PERT diagrams.

A process model can be very fine and detailed or very coarse and general depending on the degree of generality required. The more precise the model, the more specific it becomes to a particular process as practiced in one place. If it is less precise, it can be used with a high degree of generality.

#### Process Models can also be used for other purposes:

- Quality Assurance: A quality manual expresses activities to be undertaken, sequences of activities, roles and responsibilities and audit requirements. All of these can be expressed within a process model.
- Business Process Improvement  
A process model enables the capture of “As-Is” information about a process. This model can then analyzed and redeveloped as a “To-Be” process model that describes improvements.

#### BPMN Goal:

The primary goal of BPMN is to provide a notation that can be well understood by all business users:

- Business Analysts that create the initial drafts of the processes
- Technical developers responsible for implementing the technology that will perform those processes.
- Business People who will manage and monitor those processes. (IDM technical team, 2007)

## 1.7 Types of Sub models in a BPMN:

Business Process modeling is intended to deliver a wide variety of information to a wide variety of audiences, BPMN is designed to cover many types of modeling and allows the creation of end-to-end business process. The structural elements of BPMN will allow the view to be able to easily differentiate between sections of a BPMN Diagram.

There are three basic types of sub models within an end-to-end BPMN model:

### 1. Private (internal) business process

Private processes are processes taking place within a certain organization without interaction with outside parties. A good example of these processes is an employee's request for vacation. This process starts with an application form or letter to his supervisor and then goes back to him with approval or rejection. Private processes are also generally called workflow or BPM processes and in case of using multiple swim lanes, a private business process is contained within one lane.

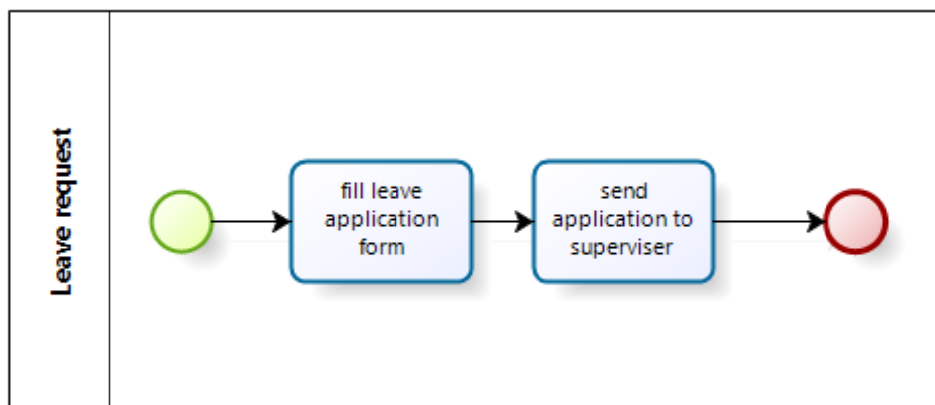


Figure 2 Private Business Process - Leave request

### 2. Abstract (public) processes

The abstract processes are the kind of business processes that include an interaction between two or more entities, in which the processes of one party are modeled with detail and the other party is treated like a blackbox. In other words, only the process of one party and the message flows with the other party are shown in these models. The purpose of this type of business process models is to emphasize the business activities of the process of the party which concerns us more than the other party. See the example below:



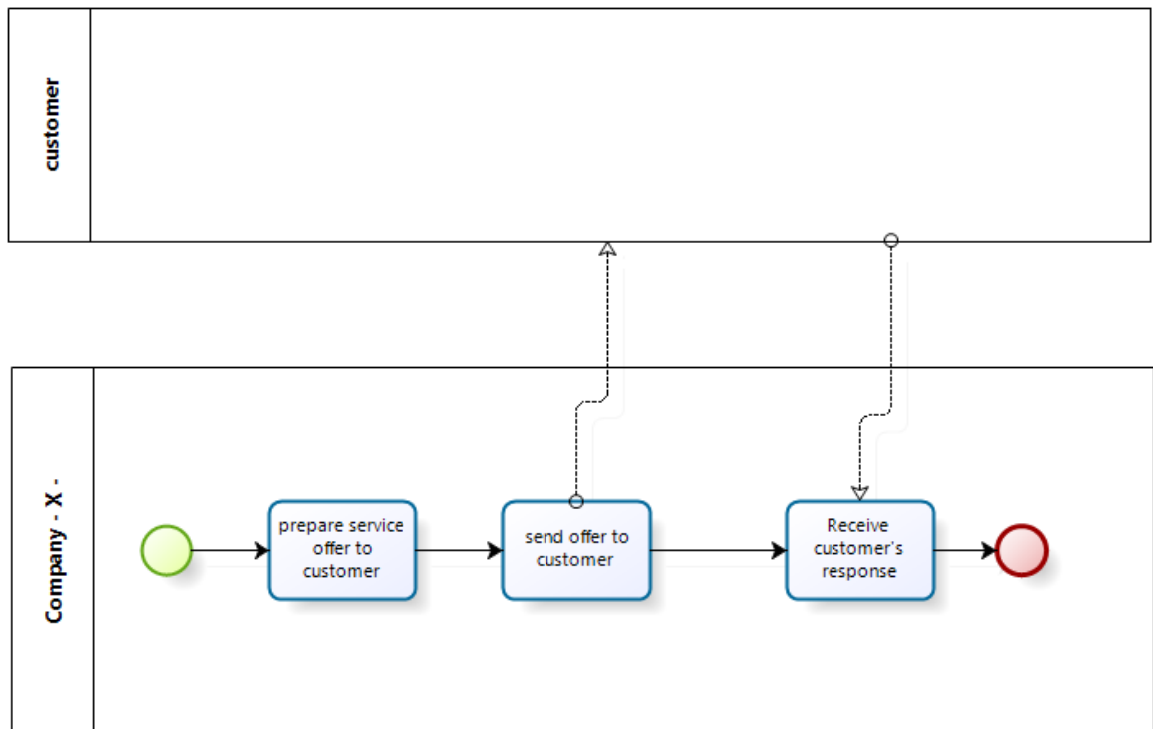


Figure 3 Abstract Business Process - Sending an offer to a client

### 3. Collaboration (global) process.

The collaborative process shows the interaction between two or more entities with giving a certain level of detail for the activities involved in the processes of both parties. The activities with the collaboration participants are considered as the “touch points”, however the actual and executable processes are prone to have more activity and detail than what is shown in the abstract processes (Object Management Group, 2008).

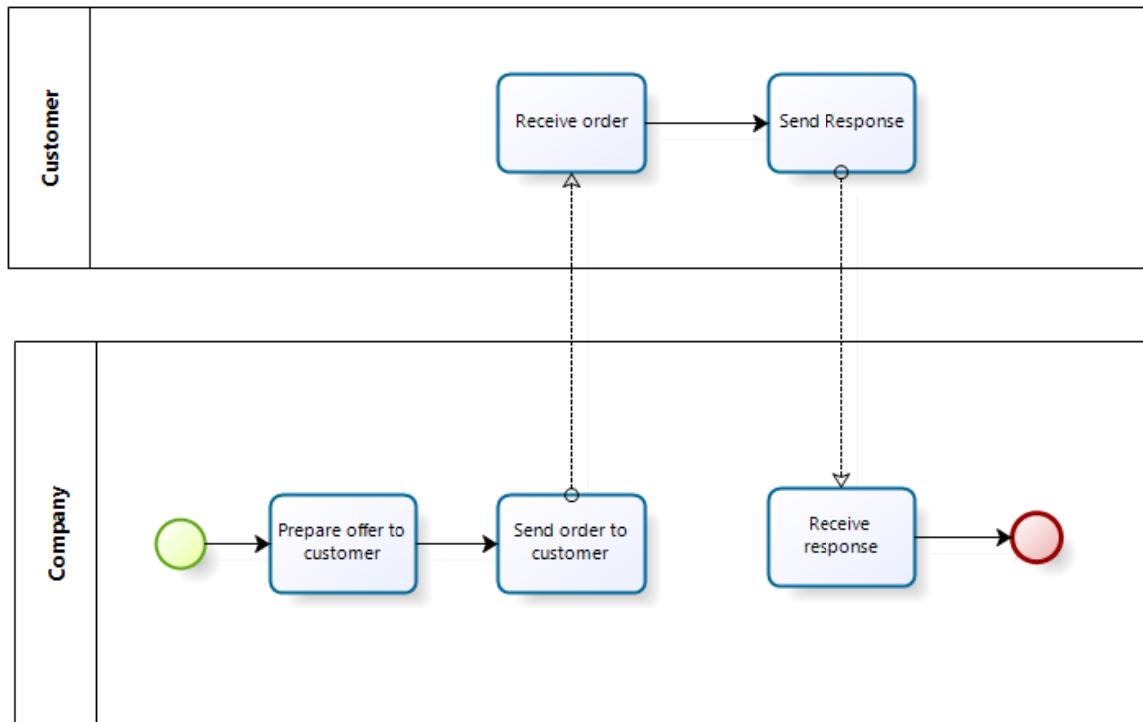


Figure 4 Collaborative Business process – Sending an offer to a client

### 1.8 BPMN Elements:

There are four principal types of elements namely actors, processes, connections and artifacts. Each of these elements acts for a given purpose in the process.

- Actors or roles of actors: Roles are the elements by which the process is performed. They also include the sub-actors who might be identified within the process flow as e.g. department of an organization.
- Processes: processes are divided mainly into two types; either atomic process which are also referred to as “tasks” they are the basic unit of the BPMN processes. The other type of processes is called “compound” process which can be further broken down to sub processes.
- Connections: are the elements that connect processes or the activities within and between processes, this includes the logical sequence of the activities or the messages passing between processes.
- Artifacts: either elaborate or annotate processes, elaboration refers to the expression of the data within or between processes. Annotation is providing further information.

## 1.9 BPMN components

The major components of the BPMN are processes and connections

### Flow Objects

There are three main flow objects in BPMN; they are Event, Activities and Message flows:

#### 1. Events:

An event is something that “happens” during the course of business process. It influences the flow of the process and usually has an incitement or a consequence. There is a variety of happenings that can be represented by events in the business process. The start of an activity, a message that is sent or arrived...etc all could be regarded as events. BPMN further categorizes events into three types:

##### 1. A Start Events:

The start event indicates where a particular process will start. In terms of sequence flow, the start event starts the flow of the process and thus will not have any incoming sequence flow. (i.e. no sequence flow can connect to start event).

The form of the start event symbol is a circle with an open center, so that markers can be drawn within the circle to indicate the different types of events. In order to be further distinguished from the intermediate and end events Bizagi business modeler represents the start event as a green circle.

#### Triggers of start events

There are many ways that business process can be started. The trigger for a start event is designed to show general mechanisms that will start that particular process. There are six types of start events in BPMN (Figure 5):

1. **None:** the modeler does not display the type of event; it is also used for sub processes that start when the flow is triggered by its parent process.
2. **Message:** A message arrives from a participant and triggers the start of the process.
3. **Timer:** A specific time-date or a specific cycle (e.g. every Monday at 9am) can be set that will trigger the start of the process.
4. **Conditional:** This type of event is triggered when a condition such as “Profit changes by more than 50%” or “Temperature above 250°C” becomes true.

5. **Signal:** A signal arrives that has been broadcast from another process and triggers the start of the process. Note that the signal is not a message, which has a specific target for the message. Multiple processes can have start events that are triggered from the same broadcasted signal.
6. **Multiple:** this means that there are multiple ways of triggering the process. Only one of them will be required to start the process. The attributes of the start event will define which of the other types of triggers apply.







 None	 Message	 Timer
 Conditional	 Signal	 Multiple

Figure 5 Start Events

### 1. B End events:

The end event indicates where a process will end. In terms of sequence flow, the end event ends the flow of the process and thus will not have any outgoing sequence flow—no sequence flow can connect from an end event.

The end event shares the same basic shape of the start event and intermediate event, a circle with an open center so that markers can be drawn within the circle to indicate the different types of the end event.

**Note:** BPD may have more than one process level (expanded sub processes). The use of start and end events is independent for each level of the diagram.

**Types of end events:** There are eight types of end events in BPMN; each represents a different motive by which the process ends. (Figure – 6).

1. **None:** It doesn't show a particular type of process end. When used in a sub-process, it causes the flow to go back to its parent process.
2. **Message:** This type of end indicates that a message is sent to a participant at the conclusion of the process.
3. **Error:** this type of end indicates that a named error should be created. The error will be caught by the error intermediate event with the same error code. If the process didn't contain an error intermediate event, the system which executes this process may define additional error like termination of the process instance for example.
4. **Cancel:** this type of end is used within a transaction sub-process. It implies that the transaction should be cancelled and shall trigger a cancel intermediate event attached to the sub-process boundary. Besides, it will indicate that a transaction protocol cancel message should be sent to any entities involved in the transaction.
5. **Compensation:** this type of end indicates that compensation is necessary.
6. **Signal:** This type of end indicates that a signal will be broadcast when the end has been reached. Note that the signal, which is broadcast to any process that can receive the signal, can be sent across process levels or pools, but is not a message as it has not specific destination or recipient.
7. **Terminate:** This type of end indicates that all activities in the process should be immediately ended. This includes all instances of multi-instances. The process is ended without compensation or event handling.
8. **Multiple:** This means that there are multiple consequences of ending the process. All of them will occur (e.g. there might be multiple messages sent).









			
None	Message	cancel	compensate
			
Conditional	Signal	Multiple	Terminate

Figure 6 End Events

### **1. C Intermediate events:**

Intermediate events refer to something that happens during the course of the process between its start and end. It affects the flow of the process but not directly ends it or starts a process.

Intermediate events can be used to:

- present where messages are expected or sent within the process
- present where delays are expected within the process
- Break the normal flow through exception handling
- Exhibit the extra work required for compensation

The intermediate event shares the same basic form of the start event and end event, a circle with an open center so that markers can be placed within the circle to indicate variations of the event.

An intermediate event is a circle that must be drawn with a double thick black line. The thickness of the line must remain double so that the intermediate event can be distinguished from the start and end events. In Bizagi, intermediate events are colored kaki green to be distinguished from other types of events. One use of intermediate events is to represent exception or compensation handling. This will be shown by placing the intermediate event on the boundary of a task or sub-process.

#### **Types of intermediate events:**

According to the cause that triggers necessity for an intermediate event, there are 10 types of intermediate events as follows: (Figure – 7):

- 1. None:** The “none” type is valid for the intermediate events that are in the main flow of the process. The modeler does not display the type of Event. It is used for modeling methodologies that use events to indicate some change of state in the process.
- 2. Message:** it is triggered when a message arrives. This causes the process to continue if it was waiting for the message or changes the flow for exception handling. When used to “catch” the message, then the event marker will be unfilled.

In normal flow, message intermediate events can be used for sending messages to a participant. When used to “throw” the message, the event marker will be filled. If it was used for exception handling it will change the normal flow into an exception flow.

3. **Timer:** A specific time-date or a specific cycle (e.g. every Monday at 9:00) can be set that will trigger this type of event. It can act as a delay tool when used in the middle of the flow. If used for exception handling, it will change the normal flow into an exception flow.
4. **Error:** This type event can only be attached to the boundary of an activity; hence it reacts to “catches” a named error, or to any error if a name is not specified.
5. **Cancel:** This type of intermediate event is used for a transaction sub-process. It must be attached to the boundary of a sub-process and shall be triggered if a cancel end event is reached within the transaction protocol “cancel” message has been received while the transaction is being performed.
6. **Compensation:** It is used for compensation handling—both activating and performing compensation. When used in Normal flow, this intermediate event indicates that compensation is necessary. Therefore, it is used to “throw” the compensation event, and the event sign must be filled. If the event identifies an activity, then that is the activity that will be compensated. Otherwise, the compensation is broadcast to all activities that have completed within the process, including the top-level process and including all sub-processes. Each completed activity that is subject to compensation will be compensated, in the reverse order of the completion of the activities. To be compensated, an activity must have a compensation intermediate event attached to its boundary.
7. **Conditional:** This type of event is triggered when a condition becomes true.
8. **Link:** A link is a mechanism for connecting two sections of a process. Link events can be used to create looping situations or to avoid long sequence flow lines. Link event uses are limited to a single process level (i.e., they cannot link a parent process with a sub-process). Paired intermediate events can also be used as “off-page connectors” for printing a process across multiple pages. They can also be used as generic “Go To” objects within the process level, There can be multiple source link events, but there can only be one target link event. When used to “catch” from the source link, the event marker will be unfilled and when used to through to the target link, the event marker will be filled. As shown in the table below.
9. **Signal:** This type of event is used for sending or receiving signals. A signal is for general communication within and across process levels, across pools and between business

process diagrams. A BPMN signal is similar to a signal flare that shot into the sky for anyone who might be interested to notice and then react. Therefore, there's a source of the signal, but no specific intended target. This is different than a BPMN message, which has a specific source and a specific intended target. This type of intermediate event can send or receive a signal if the event is part of a normal flow. The event can only receive or receive a signal if the event is part of a normal flow. The event can only receive a signal when attached to the boundary of an activity. When the signal event is used to throw a signal, the event marker will be filled; if it was used to catch a signal the event marker will be unfilled. As shown in the table below.

**10.Multiple:** This event means that there are multiple triggers assigned to the event. If used within normal flow, the event can “catch” the trigger or “throw” the triggers. When attached to the boundary of an activity, the event can only “catch” the trigger. When used to “catch” the trigger, only one of the assigned triggers is required and the event marker will be unfilled. When used to “throw” the trigger, all the assigned triggers will be thrown and the event marker will be filled.














						
None		Message (throw)	Message (catch)	Timer	Error	compensate
						
Signal (throw)	Signal (catch)	Link(throw)	Link (catch)	cancel	conditional	multiple

Figure 7 Intermediate events



## 2. Activities

An activity is work that is being performed in a business process. There are two main classifications of activities: atomic or non-atomic (compound) activities.

The types of activities that are a part of business process diagram are: Process, sub-process and task. Figure -9- shows the types of activities.

### Sub-process:

A sub-process is a compound activity; it indicates a process flow of other activities. A sub process is an activity object within the process flow which can unfolds to show another process inside of it. It has the same sign of the normal task activity which is a rounded rectangle. This rectangle can take a collapsed view which hides the sub-process inside of it; in this case a plus sign indicates the existence of the sub-process inside. Otherwise this rectangle can be expanded to show the interior process inside of it. See Figure-8 below for collapsed and embedded sub process.

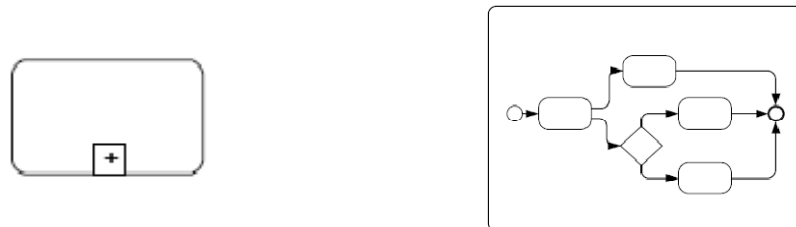


Figure 8 Collapsed sub-process (left) & Expanded sub process (right)

### Embedded Processes:

An embedded sub-process object is an activity that contains other activities (a process). The sub process's objects and activities are dependent on the parent process to start up and it is visible to the parent's global data. The embedded sub process only contains flow objects, artifacts and connecting objects without pools and lanes as this sub process is dependent on the parent process.

**Reusable Sub-process:**

A reusable sub-process object is an activity within a process that “calls” to another process that exists within a BPD. The process that is called is not dependent on the reusable sub-process object’s parent process. Reusable process exists in a separate diagram that can have multiple pools.

**Reference sub-process**

If two sub-processes share the exact same behavior and properties, then by one referencing the other, the attributes that define the behavior only have to be created once and maintained in only one location.

**Sub-process set as a transaction:**

A sub-process can be set to being a transaction (Transaction process has a special behavior controlled through a transaction protocol.) The boundary of the activity will be double lined to indicate that it is a transaction.

**There are three basic results of a Transaction:**

1. Successful completion: normal sequence flow that leaves the sub-process.
2. Failed completion (cancel): when a transaction is cancelled, then the activities inside the transaction will also be cancelled too, which could include rolling back the process and compensation for specific activities.

Note that the other mechanisms for interrupting a sub-process will not cause compensation. (e.g. Error, timer, and anything for a non-transaction process activity). A cancel intermediate event, attached to the boundary of the activity will direct the flow after the transaction has been rolled back and all compensation has been completed. The cancel intermediate event can only be used when attached to the boundary of a transaction activity.

There are two means that signal the cancellation of a transaction:

- A cancel end event is reached with the transaction sub-process. A cancel end event can only be used within a sub-process that is set to a transaction.
- A cancel message can be received via the Transaction protocol that is supporting the execution of the sub-process.

3. Hazard: this means that something went terribly wrong and that a normal success or cancel is not possible. Error intermediate event is used to show hazards, when they happen, the activity is interrupted (without compensation) and the flow will continue from the error intermediate event.

The behavior at the end of a successful transaction sub-process is different to some extent than that of a normal sub-process. When each path of the transaction sub-process reaches a non-cancel end event, the flow does not immediately move back up to the higher level parent process as does a normal sub-process. First the transaction protocol must verify that all the participants have successfully completed their end of the transaction. Most of the time this will be true and the flow will then move up to the higher level process. But in case that one of the participants ends up with a problem that causes a cancel or a Hazard, the flow will then move to the appropriate intermediate event, even though it had apparently finished successfully.






				
-1 - Task (atomic activity)	- 2- Embedded sub-process	-3- Transaction sub-process	-4- Standard loop process	-5- Multi instance loop process

Figure 9 Types of business activities

### 3. Sequence flow:

A sequence flow is represented with a solid line and an arrowhead and shows in which order the activities will be performed. The sequence flow may also have a symbol at its start; small diamond indicates that this flow is conditional while a diagonal slash indicates the default flow from a decision or activity with conditional flows.



Sequence flow

#### 4. Message Flow:

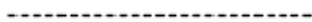
A message flow is used to transfer messages across pool boundaries



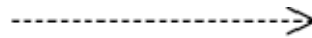
Message Flow

#### 5. Associations:

An association is used to associate information and artifacts with Flow Objects. Text and graphical non-flow objects can be associated with the flow object and flow. An association is also used to show the activities used to compensate for an activity.



Association



Directional association

#### 6. Gateways

Gateways are modeling elements that are used to control how sequence flow interacts as they converge and diverge within a process. The term (gateway) means that there's a gating mechanism that would either allows or disallows the flow.

##### Gateway types:

There are different types of gateways and each type has its own behavior in controlling the process flow. The gateways are diamond shaped and the type of the gateways and its behavior in the process flow depends on the signal inside the diamond shape.

**Exclusive:** Exclusive gateway restricts the type of the flow in such a way that only one path may be chosen out of the gateway incase of divergence and only one path into the gateways shall be permitted in case of convergence. It is used for data based decision and merging.

**Inclusive:** this type of gateways is inclusive gateway which represents a branching point where alternatives are based on conditional expressions contained with the outgoing sequence flow. In some sense it is a grouping of related independent yes/no decisions. All combinations of paths could be taken since the fact that the paths are independent. However *it should be designed so that at least one path could be taken.*

**Parallel:** is a decision in which all paths are possible and should go together or all paths merge to give the result.

**Event based:** An event based decision is taken as the result of the occurrence or non occurrence of a particular event. This decision represents a branching point where alternatives are based on an event that occurs at that point in the process. The specific event which is usually receipt of a message, determines which of the paths will be taken. Other types of events can be used, such as timer. *Only one of the alternatives will be chosen.*

**Complex:** it is used in situations where a decision may be based on the occurrence of complex decisions and situations. For instance, it may require a subset of 3 of a total of 5 data items to have achieved a particular value, or 4 out of a possible set of 6 events to have occurred.

				
Exclusive (data bases) gateway	Inclusive gateway	Event based gateway	Parallel gateway	Complex gateway

Figure 10 Types of gateways

## 7. Swimlanes (pools and lanes):

Each participant in the business process is represented in a swim lane which is a rectangle in which the activities and flow objects performed by this participant are contained inside of it.

**Pools:**

A pool represents a participant in the process. A participant can be a specific business entity. (E.g. a company) or can be a more general business role (e.g. a buyer, or manufacturer). In BPMN a pool is represented by a container for partitioning a process from other pools, when modeling business to business situations, although a pool need not have any internal details. (I.e. it can be a black box).

The interaction between pools is shown in message flow.

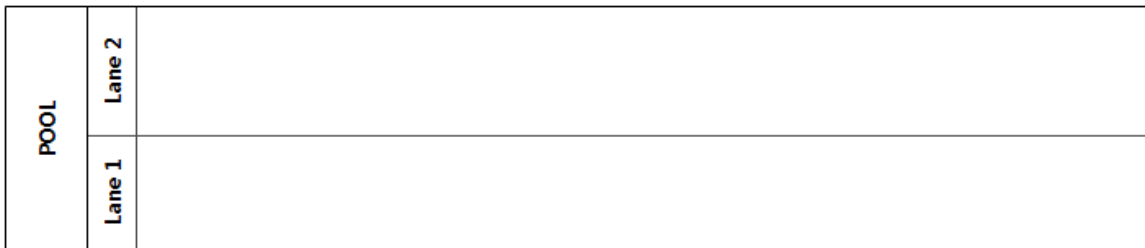


Figure 11 A pool with two lanes (swim lanes) inside of it

**8. Artifacts:**

Artifacts are means to show additional information about a process that is not directly related to the sequence flow or message flow of the process.

There are three standard artifacts offered by BPMN: Data objects, groups, and annotations.

**Data objects:**

Data objects are considered artifacts because they do not have any direct affect on the sequence flow or message flow of the process, but they provide information about what the process does. That is how documents, data and other objects are used and updated during the process.

As an artifact, data objects generally will be associated with flow objects. An association will be used to make the connection between the data object and the flow object. In some cases, the data object will be shown being sent from one activity to another, via sequence flow. Or it can also be associated with message flow, they are not to be confused with the message itself, but could be thought of as the content of some messages. (Figure 12, left)

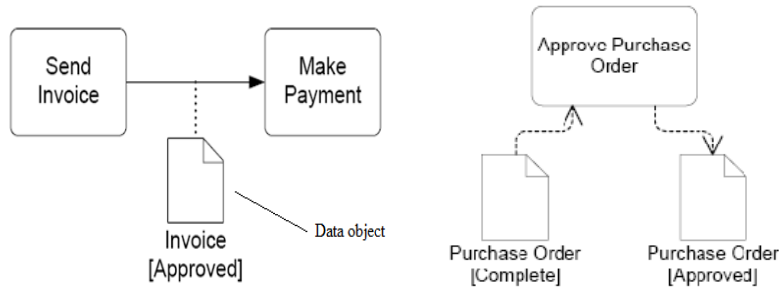


Figure 12 Data objects

Or the same data object can be shown as input and an output of a process (Figure 12, right) the direction of the arrow that's added to the association will determine whether the data is an input or an output object.

### Text Annotations:

Text annotations are means to provide additional information for the reader of the BPD. They are represented by an open rectangle that must be drawn with a solid black line. Text annotation object can be connected to a specific object on the diagram with an association but do not affect the flow of the process. (Figure 13)

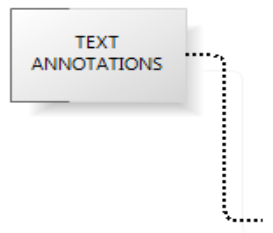


Figure 13 Text Annotation

### Groups:

The groups object is an artifact that's used to provide a visual mechanism to group elements of a diagram informally. A group is a rounded corner rectangle that must be drawn with a solid dashed black line. The group is different from an activity; it cannot connect to sequence flow or message flow. Groups are not constrained by restrictions of pools and lanes, which means that a group stretch across the boundaries of a pool to surround diagram elements, often to identify activities that exist within a distributed business-business transaction.

Groups are usually used to highlight certain sections of a diagram without adding additional constraints for performance as a sub-process would. The highlighted (grouped) section of the diagram can be separated for reporting and analysis purposes. Groups do not affect the flow of the process. Figure 14 below shows a sample of a group object.

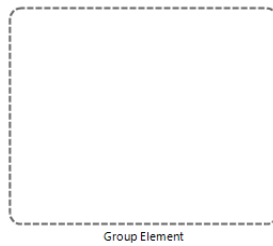


Figure 14 - Group

## 1.10 BIZAGI Business Modeler

Bizagi is a leading business process management provider based in England and has operations in different parts of the world. Bizagi business modeler is a product provided by this company for a standardized way of diagramming, documenting and sharing business processes. This modeler works with BPMN format as a world wide standard for business process diagrams. This program has been chosen for modeling the processes in this research.

## 1.11 Structured Expert Method for Business Analysis (SEMBA)

Capgemini the consulting company, have developed a structured approach for business analysis using the tools and functionalities of business process management. It consists of a clear framework of proven architectural approaches; resulting in a clear, simple and comprehensive methodology for Business Analysis.

In this research, namely in the case study that we shall see later on we have adopted a similar approach or in other words, part of the SEMBA method have been used for our analysis.

### **The SEMBA structure:**

This method is mainly composed of four phases:

#### **1. Focus and Direction**

In this phase the business analyst would determine his focus area and his vision and what sort of results he would like to see and how he can reach them. In our case here the focus shall only be on modeling the processes in order to find out the inefficiencies without the need to conduct execution and automation for them.



## 2. As-Is understanding:

Once we have determined our vision and orientation for the analysis, we need to understand the current state of the business process model and what is our final product or service and how it is being delivered to our customer (Customer can also be an internal customer inside the company; that is one department may serve another).

The Analysis does not necessarily give a single value or result as an answer but it is enough to show a picture on which the organization can have a good perspective on its process and how it is being run, who are the participants and how long does it take to finish certain activities...etc.

Afterwards, we can now determine where we think an improvement can be done for the business process model in order to optimize the process efficiency. The use of BPM tool like bizagi business modeler can help in describing business processes and what are the information needs and the roles taken up to conduct certain activities. The use of KPIs (Key Performance Indicators) can be very helpful to translate the performance into explicit measures like time and money.

## 3. Gap Analysis – Migration model:

In order to reach the To-Be state an analysis needs to be done for the change that is required to conclude a more efficient business process. According to the SEMBA approach there are two main methodologies that can assist facilitate the design of this migration model, as follows:

- Reference Models: SEMBA approach facilitates the use of reference models through various stages of the analysis. The benefit of these reference models is that it helps focusing on the problem areas and saves time in analyzing the As-IS stage.
- Best Practices: The use of best practices like examples, guidelines, techniques and check lists facilitates the analysis of different business models and allows the sharing of these practices between different analysts to deliver rapid solutions.

## 4. To-Be Model design

At this stage, the organization shall determine where it wants to be and how it wants its processes to be performed better and more efficiently, otherwise the company may need to conduct a change driver analysis in which it determines what change drivers it currently possesses as motives for better performance. In the article “Making the Case for Business Process Management in Time of Crisis” that was done by the Gartner

symposium business analysts, they outlined a number of potential change drivers as follows:

- Increasing work around processes and providing support for highly skilled workers to increase process efficiency.
- Decrease process costs and/or increase revenue.
- Focus on management of processes rather than control to deliver better value to the customer. This driver is more common for external processes where direct involvement of clients is included.
- Model driven processes: If the organization has already planned ahead how it sees its business processes in the future according to industry standards or best practices then this phase becomes easier to model or it can rely on certain ERP or WMS packages (this point is more compatible with our case study).
- Closing the gap between BPM design and execution: for organizations who are attempting to use execution functionalities of BPM programs, the designed model should be executable, therefore in some cases certain changes in the business process need to be done in order to migrate to the executable model.

## CHAPTER – 2 – WAREHOUSING AND WAREHOUSE MANAGEMENT

Warehouse Definition: it is a facility in which goods (raw materials or finished goods) are stored for a certain period of time in order to be picked and sent to a certain destination. It can also be referred to as a distribution center.

Warehouse management: is the process of regulation and liaising the receiving of goods in the warehouse, storing them and then picking them to be sent to an identified destination.

Warehousing is considered as an essential component of the business supply chain as it starts by purchasing and receiving the raw materials from suppliers, turning them into components and finally to finished products which shall then be distributed to the customers. In each stage of this process warehouse has a significant value and therefore warehouse management is a strategic competitive advantage for many companies. From this perspective we can see that the warehouse functions include:

- Goods storage to allow managing product flow and sustain longer production runs.
- Mixing point in which goods from different suppliers are combined and mixed to fulfill a customer's order.
- Customer service and sales branch
- A source for different components and raw materials for production
- A pre-final stage before goods are packaged and finished.
- Meeting fluctuating market conditions and uncertainties. (Seasonal changes, demand fluctuations, competitions).
- Surmounting time and space differences between producers and customers and supporting just in time inventory programs of customers.
- Serving in reverse logistics, providing temporary storage of materials to be disposed or recycled.
- Buffer location for trans-shipments or crossdocking.

### 2.1 Types of Warehousing

There are several ways in which warehouses are operated and managed. Below are the main two types:

1. **Public warehousing:** in this type of warehousing the client pays fees for the storage and management of goods inside the warehouse. It is also referred as "Third Party warehousing"  
For some companies, third party logistics is an option used to expand an already efficient supply chain. Other companies may opt for third party warehousing considering it to be the entire

logistics department and focus on developing the core technologies within the company. In many cases, the third party logistics provider has the necessary expertise and therefore logistics (warehousing and distribution) can be managed better than can be done in-house by the client. The main benefits out of this type of warehousing are:

**Cost reduction:** As many companies do not have the expertise or the technology to handle their inventory, third party warehousing becomes a cost effective option for them to avoid inefficient operations.

**Seasonality control:** Companies producing seasonal products finds it cheaper to store their products in third party warehouses than building their own ones. Example: a company that produces swim suits.

**Customer service:** third party warehouses can make more frequent deliveries to customers; can reduce lead times as these third party companies may have more than one distribution center in different geographical locations therefore they become closer to the client.

**Utilization and shipment consolidation:** third party providers can be dealing with a number of clients, therefore the goods shipment can be consolidated and the number of shipments can be reduced as compared to company that has clients in diverse regions each requesting a small number of goods.

**2. Private warehousing:** the storage and management of goods is completely performed in house by the manufacturer. Some companies own their entire warehousing facilities; other companies choose a mix of third party and private owned warehousing. The benefits of the private owned warehouses are:

**Control:** When the company has its own warehouse along with a capable management and technology the control over the goods movement becomes better and warehouse processes will be better integrated with other production facilities.

**Flexibility:** design of operations and flexibility becomes better as the company owns its warehouse and therefore does not require going through a prolonged routine with outside party if change is required.

**Costs can be less:** if the company can achieve an efficient throughput and utilization.

**Tax benefits:** depreciation costs of buildings and equipments lead to lower taxes to be paid to the government.

## 2.2 The value of warehousing in the economy

Companies need to have an accurate and scientific understanding of the value of the importance of warehousing. In order to reach to a scientific understanding, there needs to be awareness for the requirements of success of warehousing:

1. Professionalism: viewing warehousing as a necessity and a competitive strength (opposite to the thought of necessary evil”
2. Customer Awareness: appreciating the value of customers, understanding their requirements and doing the necessary steps to satisfy these requirements.
3. Measurement: setting up performance standards, warehouse performance shall be measured against those standards and following correct procedures to meet these standards.
4. Operations planning: warehouse management is planned in a proactive manner instead of reacting to external circumstances.
5. Logistics network: warehouses are viewed as part of the overall logistics network, not isolated operations.
6. Third party: the increase of inventory turnover along with the decrease in lead times and shorter product lives emphasize the use of third party warehouses.
7. Pace: shorter lead times, higher inventory levels and shorter product lives lead to higher pace in the warehouse.
8. Variety: More product types and more special requirements from the client will increase the variety of tasks performed in the warehouse.
9. Flexibility: the increase of the above two points (pace and variety) will result in a necessity for flexibility in the warehouse systems, people and equipments.
10. Uncertainty: minimizing uncertainty and maximizing discipline.
11. Integration: all warehouse activities from receiving to picking and shipping shall be integrated within the overall warehouse system.
12. Inventory management: real-time warehouse management systems should be used to manage the inventory. High degree of accuracy is necessary.
13. Space utilization: space should be efficiently and effectively utilized.
14. Housekeeping: high quality housekeeping should be employed.
15. Order picking: picking efficiency should be maximized and the quality and criticality of picking need to be well understood.
16. Team-based continuous improvement: team based processes unleash the power of people.

17. Continuous flow: focus on pulling products through the logistic system and not building up inventory.
18. Warehouse management systems: use of real time WMS systems to meet the requirements of today's market.
19. Total cost of logistics: the goal here is minimize the cost of logistics.
20. Leadership: keeping balance between the control aspects of management and confining the energy of change to create peak to peak performance of leadership.

## 2.3 Warehouse Operations

In a typical warehouse there are quite a rigorous number of operations that take place in every other warehouse. These operations define the functionality of the warehouse, although the way these operations and processes are performed may differ from one warehouse to another depending on a number of factors like the type of the warehouse (private or public), the type of materials stored, and the technology used to manage the warehouse...etc. The operations that take place in a typical warehouse are as follows:

1. Receiving of goods from a source
2. Storing the goods for a period of time
3. Picking the goods upon request
4. Shipping the goods to a specified destination

### 2.3.1 GOODS RECEIVING

The receiving process is the first step that a new warehouse would incur; it is simply receiving the goods from the source and storing them inside the warehouse. Although as much simple this process may seem to be as much important it is for the following process in the warehouse namely "goods picking".

A complete end-to-end inbound process is mainly composed of a number of sequential steps. However not all these steps are implemented in every receiving process in every warehouse but they should at least be considered for planning an effective receiving.

1. Appointment: the inbound trucker calls the warehouse operator to request an appointment and gives information about the load. The operator should give an appointment and assign the driver to an unloading time and location (unloading dock). It is obvious in this step that precision and time respect is quite important in this step. Running a scheduled truck dock

necessitate the ability to predict and measure the flow of work to allow the warehouse to hold the timetable which is set forward.

2. The warehouse operator confirms the information sent by the client in the form of an ASN “advanced shipping notification” with information received by phone from the trucker. In many warehouses nowadays, no receiving is done without the ASN. As this document is the best way to make sure that the correct merchandise has been delivered to the warehouse. In addition to that, the ASN contains a seal number that is used to check first to make sure that the merchandise hasn’t been tampered with.
3. Truck arrival: as the truck arrives to the warehouse, it is assigned to a certain receiving gate that has been initially booked for this truck according to the appointment schedule.
4. Securing the truck: this step is often neglected in many warehouses, despite its importance to make sure that no accidents would happen during the unloading process.
5. Seal is inspected and broken in the presence of the carrier representative. The seal number should match with the one noted on the ASN in the presence of the truck driver. In case of incongruity the goods should not be unloaded until the problem is resolved.
6. Inspection of the goods: this is an initial check which is done inside the vehicle to make sure that no clear damage or inconsistency is observed on the goods.
7. Unloading of goods which come in different forms; palletized, unitized or loose.
8. Unloaded materials are inspected before stored in the warehouse. In case of found damage, the goods are either returned directly or put on hold for further inspection by carrier or the client according to the conditions in the contract between the parties involved.
9. Correct disposal is done for the damaged goods. This is done according the conditions and agreement of the parties involved.
10. Load is stored in an assigned location: this is the last step in the inbound process and it is a very important and critical step, because of its influence on the other operations in the warehouse.

In many warehouses, the decision to putaway the material is left to the forklift driver or the worker as he/she travels in the warehouse to look for an empty location and places the load in it. The result is a poor storage pattern which wastes space as no one from management made the storage decision and therefore it is quite ordinary to find a certain item stored in random places in the warehouse. The efficient way to perform this step is by using storage plan in which certain criteria are taken into consideration to conclude an efficient configuration of goods in the warehouse. The use of warehouse management systems took a great part in making the proper storage patterns.

### 2.3.2 OUTBOUND OPERATIONS AND ORDER PICKING

According to the definition provided by Koster, Le Duc and Roodbergen in their article (Design and Control of warehouse order picking – a literature overview), order picking is the process of retrieving the previously stored goods from the warehouse according to a certain request or picking order. This definition stops at the moment that goods are picked from the storage locations although the full outbound operation would be extended to include goods check and/or preparation and finally loading in containers or trucks for shipping. Many literature studies have given an extensive attention to the order picking activity specifically more than other activities in the outbound process or other activities in the warehouse in general. The reason for this attention is that the order picking process is the most labor intensive process of the warehouse and it accounts for about 55% of the total warehouse operating expense. Any failure in the order picking process can lead to costly consequences.

Customer orders consist of order lines, each line represents a certain product with a certain quantity mentioned next to the line.

The types of picking vary from one warehouse to another or from one order to another in the same warehouse. The main driver for the variance is the size of the unit that is being picked and this is normally determined by the client. Literature showed five main types of picking according to this criterion:

1. Pallet picking: retrieval of full pallets from the storage racks
2. Layer picking: retrieval of full layers of cartons from pallets
3. Case picking : retrieval of full cartons from stored pallets
4. Split case picking: retrieval of inner packs from cartons in storage
5. Broken case picking: retrieval of individual items from storage

As will be seen later in the case study that was conducted in WEERTS Supply Chain, a warehousing company in Belgium, that the types of picking being implemented in this company are the first three; this depends on the requests that they receive from their clients. Some of the client request full pallet picking only, others request layer picks or case picks. Or sometimes a combination of the three picks can be found in the request orders. Another classification of the picking is decided internally by the warehouse company in order to choose the most efficient and suitable method for its operations. These types of picking are:



**Basic Picking:** in this case the orders are picked one at a time, which means that the worker will not pick any items from another order until the first one is finished. Items are placed in a staging area for check and inspection or in some cases they are placed directly in the truck or the shipping container.

**Batch Picking:** this type of picking is more common for piece picks (it's a specific type of picking in which cartons are opened and an individual number of pieces are picked from these cartons), as the picking worker travels inside the warehouse with a consolidated picking list (paper or electronic) containing several items of a number of orders. The items are picked together to minimize the travel time required for each order. Normally this worker has a special box or container for each product on the same cart or forklift and the picked items are picked and sorted by product first and then they are all taken to a staging area where they are separated by orders. The staging area is also called "Zone".

**Zone Picking:** in this type of picking, the picking area is divided into a number of zones and a picking worker is assigned to each of these zones who would only pick from his/her zone. Orders are passed from zone to another as one order is completed. This type of picking is also mostly common for piece picking and many warehouses use automatic conveyor systems to move orders from one zone to another.

**Wave picking:** it is a combination of batch picking and zone picking; as in this case the workers pick the requested items from their zones simultaneously and the picked items are consolidated in a staging area where they are later separated. This differs from the zone picking in that, as we saw above, the order has to be finished by one worker first and then passed to the next worker in the next zone. Wave picking is the quickest type of picking but it requires a considerable attention in the process of consolidation and separation.

In general, orders are received on "Day 1", during the night the orders are treated and the inventory is allocated. In the morning of "Day 2" the orders are released to the distribution center, the orders are then sent to the warehouse workers either in paper form pick lists or electronically to their handheld devices. The workers start preparing the orders according to the instructions that they have received from the warehouse management and the type of picking required. An average order is finished by the end of "Day 2" or during "Day 3" when all the requested items are picked, checked if necessary and finally loaded in the shipping containers or trucks. In some warehouses, a label is printed for each product or full case with a location address, product description and customer order

number. The picking worker reads the label on each line of an order, locates the item, picks the unit and applies the label to that unit.

**Replenishment:** As items are picked from their picking locations, their locations are refilled with new items brought from reserve storage locations. This process is called replenishment.

### **Principles of Picking**

There are certain principles that apply equally to the order picking process regardless of the size, the inventory, the customer requirements or the type of the systems used.

**Pareto's Law:** Pareto's law states that "small percent of the community carries a large percent of the wealth". This law applies to warehousing in that a small number of products account for the majority of the warehouse orders and a large number of products are less ordered, therefore in order to increase the efficiency within the warehouse operations it is important to place the products which are frequently requested closer to pick faces than the other slow moving items.

**Picking document need to be pre routed:** The sequence of line items to be picked in the picking document should take into account the route that the worker will take inside the warehouse to pick the required items in order to minimize travel time.

**Maintain an effective stock location system:** A stock location system should be used to locate the items and minimize the time required for the worker to find them in the warehouse.

**The Order picker must be accountable for order accuracy:** the picking worker should be responsible to pick the right items from the right location and make sure that no damages or missing units are present in the items picked. Even if the warehouse allocates an inspection employee to check the items before shipment, it is more efficient to avoid the error than to find it and correct it.

**Avoid counting:** it is quicker to use measure than to count items. Measurement can be by size, weight or in some warehouses where modern warehouse management systems provide real-time counting functionalities in which counting takes place simultaneously with the picking process.

**Minimize paper work:** Paper work is costly and inefficient. There are technologies that minimize or eliminate paperwork through the use of bar code scanners and voice recognition systems and radio frequency data terminals.

### 2.3.3 STOCK LOCATION AND INVENTORY MANAGEMENT

Stock location management is closely connected to inventory management although the two terms refer to two different operations.

Inventory management: is the process of managing the quantity of inventory of goods in the warehouse to make sure that demand is always met. On the hand, Stock location is the process of making sure that when demand is initialized the requested goods are reached efficiently and accurately. Therefore these two processes are strongly connected to each other.

In stock location management, each location in the warehouse where stock is stored is given a unique address. This address can be an alphanumerical combination in order to give a wider possibility of expansion in the future and to be able to cover more locations in the warehouse and at the same keeping the address short and easily read for the personnel. An example of this that I found in the Book of Tompkins Smith; “the warehouse management handbook” is as follows

<b>2</b>	<b>AA</b>	<b>01</b>	<b>B</b>
<b>Work Area</b>	<b>Aisle</b>	<b>Bay</b>	<b>Level</b>

**Figure 15 : Location numbering scheme example**

This example shows that the warehouse has been divided into a number of work areas; the one shown in the address above is work area number 2. In each work area there are a number of aisles, AA for example. The aisle AA is composed of a number of Bays – 01 – and the latter contains several levels. Our stock is located at level B.

#### **Stock location methodologies**

There are a number of methodologies used to locate stock inside the warehouse; these methodologies may differ from one warehouse to another according to its size and the complexity of its operations. Now we will go through each of these methodologies and highlight the advantages and disadvantages of them.

**Informal system:** in this method the goods are stored randomly in the warehouse without any rule or configuration conditions. This is normally used for small warehouses where the number of goods is small. No registry is made for the goods location, in this method the only registry is inside the heads of the workers who place the goods inside the warehouse. It is the most inefficient way of stock location, as the workers will have to travel between the aisles to look for the requested stock and to check if a sufficient quantity is available.

**Fixed location system:** this methodology states that every part has its fixed location and each location is reserved for a certain part. In other words, every product is assigned to a unique location inside the warehouse. This methodology is easy to establish and maintain and shows a systematic way of storage although it has a negative impact which is that when larger quantities are delivered to the warehouse of a certain product, there might not be a place to fit them in their specified locations whereas other locations in the same warehouse are empty but they are simply reserved for another product!

**Part Number system:** this methodology is a derived version of the “Fixed location system”, it is based on the fact that each part has a certain number and the sequence of placement is based on this number, for example A123 is placed before B123. It is suitable for a company which has an even frequency of operations and a limited number of goods. The advantage of this method is that it is easy to retrieve material from reserve stock to pick faces and it facilitates finding the stock in the warehouse, but the same inefficiency is present here as that in the fixed location system due to the poor space utilization and lack of flexibility in case of larger demands.

**Commodity system:** In this method, the stock is grouped according to the product type like the way we see the products in a supermarket, detergents are grouped together, and dairy products are together. This method presents a logical way of arranging stock in the warehouse; it increases the picking efficiency and shows a flexible way of storage, although intensive training should be given to workers to avoid picking the right category but the wrong specific product. The space utilization can still be improved since that some products are difficult to be grouped due to their exceptional characteristics.

**Random location system:** when this method is applied, products of the same product might be located in various locations inside the warehouse, regardless of their specifications or characteristics. The goods are distributed according to the space available but precise records of location, product and quantity should be kept in order to avoid any discrepancies. The use of Warehouse Management

Systems plays a significant role in this type of storage. The main advantage of this methodology is its flexibility and capability to store a vast range of products with variant quantities. It also facilitates the storage expansion issue as result of the flexibility of this method. The main disadvantage is that the picking process can be very inefficient when this method is employed, as the picking worker will have to conduct several tours in the warehouse in order to gather a given quantity of a certain product. For some warehouses where technology is not the favorite dish of their employees, keeping track of detailed records and maintaining them can be a significant problem.

**Combination Systems:** As the name implies, this method is a combination of all of the above mentioned methodologies. It provides wider spectrum of possibilities for the warehouse personnel to choose the most efficient and suitable combination for their warehouse operations. It provides flexibility, best use of all methodologies, better control and chances to expansion based on the warehouse requirements. Customization is an essential part of this methodology. The use of Warehouse management systems played a significant role in making these combinations and facilitated their implementations. The disadvantage is that it may cause confusion if employed by less trained or experienced personnel. Attention should be paid not to compromise space utilization when making combinations.

### **Product Location assignment**

Regardless of which methodology was used from the above mentioned ones, it is imperative now to determine how to further organize the goods in the warehouse. One of the most common ways is the ABC analysis method, which divides the inventory into three categories.

“A” items: are items with high movement velocity, they are the items that account for most of the movements in the warehouse (Pareto’s law above). These items should be located in locations where picking and replenishment are done easily. They occupy the “golden zone” of the warehouse.

The “B” and “C” items have less movement frequency but it is still important to place these items in proper positions, taking into account that the “B” items are considered as more fast movers than the “C” items. In addition to the frequency of the movement of the items, another aspect should be taken into consideration when conducting the ABC analysis is the cost per unit. Therefore companies should consider which is the best option and aspect to be used for classifying its products when doing the ABC analysis. A given example of this found in the literature is whether a company would choose a one cent bolt with 100 units moved per month or a 1000 dollars tool that is moved once a year.

### **Inventory Control**

It's the process of continuously tracking and managing the amount of inventory in the warehouse. It is important to have a good knowledge of the products, their quantities and the lead times required in order to properly manage inventory. The objective of inventory control is maximizing profits while maintaining customer service; this is not an easy balance as the warehouse must always have the required quantity to satisfy the customer's demand. The data used to do an inventory control is demand, current inventory balance and supplier lead times, cost of shipment and cost of holding inventory. The costs of holding inventory include the opportunity cost of money, the cost of storage space and the cost of handling and maintenance.

### **Physical Counting**

It's the process by which the warehouse is shut down for given period, no more transactions are conducted and no more goods enter or leave the warehouse. During which a counting process takes place for the entire warehouse inventory. This process has long been utilized for cost accounting and tax purposes. Although this process has proved to be inefficient because the warehouse has to be frozen from all activities, which lead to delays to customer demands. In addition to that, it's common that the less experienced worker are assigned to do the counting which lead to miscounts and inconsistencies resulting from pack factor conversion or errors in physical counting or unfamiliarity with the products. Errors were also found when experienced workers conducted the counting too due to the long hours and the big amount of inventory. When the counting is finished, the results are entered into the system and it's very common to find inaccuracies which are most often adjusted in the system. The end result is an inaccurate inventory count.

### **Cycle counting**

It's the best alternative to the physical inventory counting. It involves counting a small percentage of the inventory on a regular basis. Cycle counting is a systematic method of inventory counting throughout the year; it includes a dynamic audit that provides real-time inventory accuracy of merchandise. It's a method for auditing inventory accuracy and reconciling errors on a cyclical basis rather than once a year.

The advantages of Cycle counting are as follows:

1. It provides more accurate data.
2. Reduces human errors through correctly including receiving, putaway and storage, picking orders. Training is quite essential to meet the zero error bench mark.
3. Replaces the annual inventory physical count. Since the process is done on real-time basis, this leads to less out of stock situations and helps finding misplaced stock in the warehouse.
4. It improves the overall performance in the warehouse as stock can be measured without the need to freeze the warehouse operations. Besides, this leads to better customer service through high in-stock rates and less out of stock conditions.
5. Continuous improvement through spreading a culture of accuracy in the warehouse and it optimizes business opportunities through data driven knowledge.

Best Practices for Cycle counting

1. Count the entire inventory in a regular and disciplined manner. It's recommended to count the whole inventory four times a year.
2. One person should be in charge of the cycle count process and should be trained and assigned as a team leader. The warehouse workers should be trained on procedures and the value of inventory accuracy. It's recommended to include the training program for the new workers and employees' general training.
3. Counting strategy should be determined ahead. Counting would either be by physical area or by category. In case of physical area the warehouse is divided to a number of zones and a consistent counting pattern should be employed to make sure that all the stock is counted within a given time period. Or counting can be done by category through dividing the stock according the types of products and each group is counted within a specific period of time.
4. Discrepancies to be tracked and traced. Investigation should be done for any discrepancies and continuous improvement should be taken into account. Problems should not be neglected and corrective actions should be identified for each problem.

## **2.4 Warehouse Management Systems – (WMS)**

The use of warehouse management systems for managing warehouse operations is considered a paramount key success factor for today's warehouses. It is mainly used to meet the two objectives of warehousing; first is to maximize the use of space, equipment and labor, and exceeding the customers' expectations.

The WMS provide a real-time work environment and helps in reducing the warehouse operating costs through improving labor productivity by reducing the travel times associated with performing a task or a number tasks, resulting in increased labor productivity. The productivity is also improved by increasing removing the unproductive or non-value added steps performed by employees. For example reducing the time required for searching a certain item between the aisles of the warehouse. These non value added steps can be removed by an approximately 100% real-time and accurate WMS technology.

The second benefit of WMS is the reduction of lead times through benefiting from the real-time environment. These reductions involve both order processing and inventory management. These benefits will reflect more customer satisfaction and a quicker turn on inventory which by the end result in financial benefits for the warehouse owner.

Along with the warehouse management systems, the development of Auto ID technologies, these technologies refer to all the technologies associated with printing and writing a bar code, including the printer and the radio frequency equipment. The use of these technologies along with the warehouse management systems lead to the highest accuracy levels of information in the warehouse.

In order to understand Auto ID technology, it is important to understand that it is an information accuracy enabler. It enables information to be accurately transmitted through different steps of any process. To make real-time data transfer to be 100% accurate, it's best accomplished through the use of Auto ID systems. Barcode is one the most widely used Auto ID technology. Barcodes serve in passing information quickly and accurately leading to a reduction in the time consumed by product being in a pipeline. Moreover, the use of bar codes reduces the amount of non value added processes which are associated with inaccurate information transfer.



## 2.5 The Serial Shipping Container Code (SSCC)

According to the article “An introduction to the Serial Shipping Container Code” by GS1<sup>2</sup> the definition of SSCC is as follows:

*It is an identifier or a “license plate” that provides access to information stored in computer files, which are transferred through electronic business transactions.*

The SSCC is composed of 18-digit number, it is considered as a critical element when exchanging information electronically about the movement and location of logistics units. Data exchange and tracking of logistics units is an application of the GS1 systems which formerly referred to as EAN (European Article Number).

### **The advantages of SSCC are as follows:**

1. SSCC identifies items with a number that is unique worldwide.
2. It links bar coded information on an item and the information that is communicated between trading partners via electronic business transactions.
3. It uses a globally accepted standard provided by GS1 organization; therefore its language is standardized, understood and used by many industries.
4. It applies to the entire supply chain from, from raw materials supplier to manufacturer to distributor and finally to end user.
5. It can be used inside the company or between the company and its trading partners.
6. Includes a common vendor numbering scheme that uses GS1 standards so that the number cannot be duplicated.

The SSCC is employed in electronic messages like the Advanced Shipping Notification (ASN). When used in electronic business transactions, information about the products which are contained in a certain pallet, box or truck are linked to the SSCC and then scanned by the receiving company to speed up the trade items through the supply chain.

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<sup>2</sup> GS1: is a non-profit organization dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand globally and cross sectors. GS1 standards are the most widely used supply chain standards around the world. ([www.GS1.org](http://www.GS1.org))

## 2.6 SKU

Before ending the chapter, it is important to give a brief definition for an important terminology used in warehouses and logistics. The term SKU stands for “Stock Keeping Unit” and it refers to part numbers, product numbers or product identifiers. It can take a numerical format or an alpha numeric string used to identify products. SKUs can be universal following a global standards format or can be local to a specific firm.

## 2.7 RedPrairie

RedPrairie is privately held productivity solutions providing company. With headquarters in Brookside – USA, Redprairie has over 25 sales and services offices around the world. It delivers services in the fields of process and performance management, workforce, inventory and transportation. In the field of warehouse management solutions which falls under the category of inventory solutions. RedPrairie provides a warehouse management system that optimizes all operations from before an inbound shipment arrives to the warehouse until and after the outbound shipment has left it. RedPrairie enable agile, productive and lead distribution operations leading to lower distribution costs and improved return on investment.

## CHAPTER 3 – CASE STUDY

### COMPARISON STUDY BETWEEN OLD IN-HOUSE BUILT WMS AND NEW REAL-TIME BASED WMS IN WEERTS SUPPLY CHAIN USING BPM DIAGRAMS

#### WEERTS SUPPLY CHAIN (WEERTS S C) Company overview

Weerts Supply chain is a privately owned Belgian company specialized in the field of logistics. It is a market leader in the Benelux region and its operations may extend beyond. The company has 235.000 square meters of temperature controlled warehousing capacity in and around Liege – Belgium.

#### The company's vision:

*“Convince potential customers of our capabilities to achieve their objectives. Through the analysis of data, use of experience, creation of a healthy social climate WSC sets up partnerships with each of its customers to better master their objectives and create the necessary basis for long term relationships bearing in mind that an improved ratio between Quality and Price stimulates a firmer commitment from all parties”*

In addition to warehousing activities, the company owns co-packing and value added services (e.g. flow pack and shrink-wrap) that are performed inside the company's facilities. For some strategic reasons the company stopped working in the transportation field and focused only on warehousing.

KRAFT food forms the main client of WEERTS supply chain although; there are many other clients who have smaller shares among WEERTS' activities. This case study will focus on the operations between KRAFT and WEERTS. WEERTS supply chain has long been working with an in-house built warehouse management system which is provided by its IT service provider SMIW. As we will see in our case study below that this system is old fashioned and kept WEERTS S. C restrained with its limited capabilities and caused many efficiency problems in its operations, therefore the company has decided to replace this old WMS with a new and modern system provided by RedPrairie. This new system is developed to be in line with the new requirements of today's business, providing real time work base and high tech solutions.

Our case will focus on drawing up a comparison between the company's operations during the old fashioned warehouse management system and compare them to the To-Be situation after the installation of RedPrairie WMS through the use of BPMN models. Processes shall be modelled end to end in each situation (before and after the new WMS) and bottlenecks and inefficiencies shall be identified for each process. Then in chapter 4 I have made a what-if analysis for various productivity levels to provide bench marks in which the company can maximize its profit. Finally in chapter 5 I

have developed a gap analysis to compare the old situation to the new one in productivity levels as well functionalities and efficiency in the previously explained processes.

### Case study Methodology:

As a start point for my case study, I have had a meeting with company's CEO and its Commercial and Marketing manager who have explained to me the situation in the company, after this meeting I have decided to use BPMN tools to make the comparison study and to assess the BPMN value for such analysis.

I started making interviews with the employees to have an insight about how the processes were being performed with the old system; in addition to that I have also accompanied the workers in the warehouse to see how tasks are being executed. On the other hand, I have used and relied on RedPrairie's documents and manuals and attended operations room meetings with the company's management and RedPrairie's representatives and consultants to learn how the processes are foreseen to be implemented after the installation of RedPrairie's WMS. When the installation and integration started I have also participated in system integration training sessions.

### Summery of the parties involved in the operations:

**Warehouse Manager (WEERTS S. C):** is the party in charge of storage and management of goods.

**The client (KRAFT):** the warehouse services are provided for the goods of this company.

**Transportation Company:** is the carrier company who's in charge of transporting the goods into and from the warehouse. (e.g. Jost)

**WMS manager (SMIW/SoftLog WMS):** Is the company in charge of managing the old warehouse management system)

**JDC:** is a sub contractor for WEERTS and is in charge of the implementation of the actual value added services and copacking inside WEERTS' facilities.

**Destination:** in the outbound process (local and export), destination refers to the party to whom the goods are sent.

## 3.1 Inbound process

Definition: it is the process in which the goods arrive to the warehouse; it's mainly composed of three stages: Goods unloading from the trucks, Goods check and control and finally Goods putaway and storage in the warehouse.

### 3.1.1 Old system - Process Explanation:

*Refer to Appendix 1 for old process BPM diagram and related sub processes.*

#### 1. Goods Reception

The inbound process starts by a request for an appointment sent by the transporter. The appointment is either requested by telephone or by e-mail. This appointment request includes only date and time for the incoming trucks.

The inbound manager prepares / updates the inbound slot schedule according to the requested appointments (tool = MS Outlook Agenda). This schedule is divided into 10 hours starting at 8:00 am and finishes at 6:00 pm. During each hour a maximum of 2 trucks can be unloaded. Therefore A total of 20 trucks can be discharged per one working day. The Purchase orders are automatically downloaded from the KRAFT's SAP into the WMS.

As the schedule is finished, a paper copy of it is sent to the dock responsible for each incoming truck on that day along with the name of each client. Then through phone coordination between the inbound manager and the dock responsible some of the trucks are decided to stop in the inbound manager's zone and others stop in the zone of the dock responsible, the dock responsible or the inbound manager will be in charge of the follow up of the unloading process in his zone according to this decision.

(This step is only intended to determine who's in charge of the follow up of unloading the truck; although this does not mean that the unloading has started at this stage).

After the truck has been stationed the truck driver then hands over the CMR document<sup>3</sup> to the inbound manager, the inbound manager verifies the info in this document with the data he receives from KRAFT SAP (this info includes the type of SKU, PO number, quantity). Afterwards, the truck unloading takes place in the warehouse.

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<sup>3</sup> CMR Document is consignment note to confirm that the carrier has received the goods and that a contract of carriage exists between the carrier and the trader. It includes the date and place where this document is written, the name of sender, the carrier, the receiver (consignee), weight and description of the goods, charges related to the goods.

(<http://www.businesslink.gov.uk/bdotg/action/detail?type=RESOURCES&itemId=1078039470>)

### **Pallet checking**

After the goods have been unloaded, controller checks the quantity and the quality of the goods and compares his check output to the data mentioned in the delivery note<sup>4</sup> (external – no damages allowed to the packaging material, product ID must be correct, goods expiry date is still valid). In case that any discrepancies were found regarding the quantity of the received goods, then the client will be informed about the variance and the receiving continues for the remaining goods.

If damages were found in the arriving goods, a picture is taken for the damage and the receiving process continues. The client is informed about the damage and a copy of the taken picture is sent to the client.

In case that the arriving goods have an expired date (very rare case), then the goods receiving is cancelled and the client is informed about the situation.

## **2. Goods Putaway**

The putaway and storage process is the process in which the goods are taken from the shipdocks (*location in the warehouse near the shipping gates where which goods are placed in the warehouse before final storage or before being loaded in the trucks in the outbound process*). A worker in charge of scanning the truck unloading, scans the label on each pallet, searches an empty location inside the warehouse in a random way, places the pallets in that location and scans the rack where which this pallet was placed. The scanner only saves the two codes (*Product ID = SSCC-label + rack location*).

This scanner is physically taken to the inbound manager who places the scanner on a special cradle connected to his workstation (PC) and transfers the information of the scanned pallets from the scanners into the WMS (*putaway/storage scanning application is NOT working online but in batch*). A signal automatically announces the delivery of the shipment in the clients ERP/SAP system when the information is loaded by the inbound manager into the WMS. At that moment the inbound process ends. Note that the inbound manager has to upload the information into the WMS system before the end of the working day, or next day's morning in worst case scenario.

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<sup>4</sup> Delivery Note: is document accompanying the shipment of goods that lists quantity, description, grade of the goods.

### Exceptional cases

- If a truck arrives without appointment, the inbound manager will check his schedule if there's an available slot for the truck to unload during that day (between 8:00 to 18:00), if no slot was available in the schedule the truck will have to wait till the next day. The waiting truck is unloaded at 7h00 the next day because no appointments are given at that time.  
Note: The maximum unloading allowed is 2 trucks per gate per hour, therefore available space and time would refer to the term "SLOT".
- If a truck arrives later than the appointed time, the inbound manager will check if there's still slot available for the truck to discharge its load during the day, if not then it should wait till the other day's morning.
- If more trucks arrive than what was scheduled, the inbound manager will check if there's a slot available for the extra truck(s) to discharge at that moment, if not then the truck will have to wait till the next day.
- If in any of the above cases the client requested that the truck should be discharged on the same day of its arrival, then a special request shall be made and extra bill will be charged by Weerts to this client.

### Problems identified

- The Putaway location is searched on the basis of the weight of the pallet or if the pallet contains open boxes, in these two cases the pallets should be placed on the floor (*case-picking locations*), otherwise the location is searched randomly and placed wherever place is available (*reserve locations = full pallet locations*). This method of putaway is very inefficient as the worker spends long time traveling in the warehouse looking for a location which means energy consumption as well.
- The scanners used in the putaway process are very old and they break down from time to time, besides when the scanner breaks down, the inbound manager will have to go to each location (rack), check the pallets stored in that location writes down the rack number and matches it against the pallet number and then manually enters the information into the system.

### 3.1.2 New System process explanation

*Refer to Appendix 2 for new process BPM diagram and related sub processes.*

Through the use of the new WMS in collaboration with RedPrairie Company for warehouse and productivity solutions, we can notice that there have been some major changes in the processes of goods inbound, although many of the operations involved in the inbound remained unchanged. First let's take a look at the reception of goods in the warehouse; we can see in this process that it is mainly divided into two main procedures: Goods Reception and Goods Putaway, before we delve into the explanation of these steps, one important point has to be highlighted that KRAFT and WEERTS agreed upon in their new contract that will be effective almost simultaneously with the kick-off of the RedPrairie WMS. It's a bonus/malus system; the truck has to be ready for unloading within 2 hours from the time of its arrival if this is the case a bonus is paid to WEERTS for good performance; otherwise a malus (penalty) is charged for the delay.

The new inbound process starts in the same manner as the old process, by a request from the transport company for a location to stop the arriving truck. Then the inbound manager checks the purchase order that is downloaded automatically into the WMS and using the info coming in this PO. Once the order is opened to be processed it's status in the systems is set to "released" and a message is sent to the client stating the current status of the order.

The inbound manager specifies the location where the truck should be parked according to the type of the goods loaded in that truck. The type of goods that the WMS takes into consideration at this stage is whether the goods are intended for copacking and value added services or finished goods ( goods intended for direct outbound from the warehouse).

Subsequently, the inbound manager checks if the arriving trucks are on time and according to the time schedule.

#### **Truck Arrival Process**

If the arriving truck is on time and according to the announced schedule by the transportation company, the inbound manager should allow the truck to park near the unloading gate at the warehouse within a maximum of 2 hours from the time of the arrival of the truck. In this case WEERTS will receive a bonus for not letting the truck wait longer than the allowable duration. If the inbound manager fails to provide an empty unloading gate within 2 hours, a penalty (malus) is charged against WEERTS for the delay.



As explained earlier in the old process, if the truck does not arrive on time, the inbound manager will have to take special considerations for each case. (*Refer to the “Exceptional issues” section above in the old process*).

As the truck arrives and parks in its specified location, the inbound manager receives the CMR document from the truck driver, and verifies the data in the CMR with the data that came earlier with the PO from the SAP. This data includes the type of stock, the quantity, the SKU, the PO order number).

## 1. Goods Reception:

### • Goods Unloading

The goods reception process starts first by unloading all the pallets from the truck to the dock location. And then the reception process starts at the warehouse using the handset scanner (RDTs). Once the receiving starts the status changes in the WMS from “Released” to “in Progress”.

There are mainly three types of goods receiving procedures involved in this process, any of these types could possibly be implemented, depending on the information that we have from the client.

Below are the three possible types:

- **EAN128 receiving on RDT processes:** In this type of receiving, the pallets are identified with EAN128<sup>5</sup> barcodes and received against the PO number that’s downloaded earlier from the SAP. The worker scans the barcodes on each pallet and confirms the reception processes until all pallets are received. The batch number of each pallet is also identified at the receiving process, this batch number contains the manufacture date and expiry dates. The Expiry date will be used in the putaway algorithm in order to avoid having mixed expiry dated products in the same location.

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<sup>5</sup> EAN 128: EAN stands for International Article Number (earlier European Article number) and is a product identification for trade goods. The EAN is a number, which consist of 8 or 13 digits, are managed centrally and are given away on the demand of the producer. 128 is the logistic code for the trade. (<http://www.laendmarks.com/index.php?id=157&L=1>).

- **Pre Advice receiving on RDT:** In this case the pallets are not labeled with the EAN128 tag. Therefore the operator will have to create a label ticket by identifying the SKU, the quantity of SKUs in each pallet, the Batch number, the production and expiry dates. After this label ticket has been created and printed out, the worker sticks this ticket on each pallet. The receiving is done subsequently based on the new pallet labels and the information in the PO.
- **Blind Receiving:** This type of receiving is considered a rare case that is treated exceptionally; in this case the arriving goods are not included in the PO mentioned above (e.g. goods coming from another client).

In addition to that, pallets are not identified with EAN128. In this case, the worker will have to enter the data manually field by field which differs from the above two types as the data used to be downloaded from the SAP system. In addition to that the worker will also have to prepare the label ticket and stick it on the palette.

At the reception of each palette regardless which type of receiving was used, each receipt will be reported back to SAP. The maximum time allowed for unloading is 2 hours in which the bonus/malus rule is also applicable.

## 2. Pallets Check

Meanwhile the pallets are being received using one of the receiving methods; the controller checks the pallets for the quality and quantity. The same procedure and conditions mentioned earlier in the old inbound process is used for the goods check in the new process too. The checking is done during the receiving process and not after all the pallets has been received. Once all the pallets have been unloaded and checked the status changes from “in progress” to “complete” in the WMS and a signal is sent to the client about the status update. Weerts considers the putaway process as an internal process that does not require the intervention of the client. In addition to that the client added a bonus/malus item in the latest contract with Weerts, in which the receiving of the goods should last not more than two hours, therefore splitting the putaway process from the other inbound activities gives more time for Weerts to perform processes.

## 3. Putaway:

After all the pallets have been received and checked, the putaway of pallets starts in the warehouse. When the worker scans a palette for putaway, the WMS determines (calculates) a location for this palette according to certain algorithms initially installed in the system and

selected by the system administrator. In our case (WEERTS S. C.) the putaway criteria that are used in the configuration of the putaway algorithms are listed below (e.g. Product category Like BE11 for confectionary and BE12 for coffee.)

The goods are taken to this location and the data are uploaded to KRAFT SAP. This last step marks the end of the inbound process.

## **ADDITIONAL INFORMATION**

### **Criteria used for Putaway algorithms:**

- Product Category
- Storage conditions
- Outcome ABC-analysis (fast-slow movers)
- Double Stack possible Y/N (Biscuits LU)
- case Pick Location becoming available Y/N
- Drive In (only for high volumes of same SKU/Batch-lot/Expiry date)

### **Product Categories**

- BE11 : Confec
- BE12 : Coffee
- BE13 : Cheese
- BE15 : Convenient Meals
- BE16 : Other Groceries
- BE17 : Biscuits (BE95 = SAP Plant Kraft for LU products)

## 3.2 Outbound – Local process

**Local Outbound activities:** are the operations including all fulfillment activities, warehousing and transportation to customers inside Benelux.

### 3.2.1 Outbound Old Process explanation

*Refer to Appendix 3 for old process BPM diagram and related sub processes.*

Outbound is the process of sending goods from the warehouse to a certain destination requested by the client. According to WEERTS S.C. if the destination is inside the Benelux region, the outbound process is treated as local outbound. Otherwise if the outbound is intended to be for countries outside the Benelux then the outbound process is treated as export.

#### The old outbound process procedures

The process of local outbound takes approximately two days to be finished. It starts with a request order which arrives to WEERTS S. C. on daily basis at around 14h00. The following procedures explain the processes involved in this process:

- 1. Receiving order:** An order is sent by the client (KRAFT) to the WMS manager (SMIW) who by then reformulates the order and informs the outbound manager to check his WMS interface for the received order. The order comes in the form of a group of documents called (The Big/Rush File).
  - If the order is meant to be finished within approximately 48 hours, it's called **BIG FILE ORDER**. It is received by Weerts S.C. on Day 1 between 14h00-15h00 and must be shipped out of Weerts' warehouse within 48hrs (= Day 1 + 2days).
  - If the order is meant to be finished within approximately 24 hours, it's called **RUSH FILE ORDER**. Rush File from Kraft SAP is received by Weerts S.C. on Day 1 between 12h00-13h00 and must be shipped out of the Weerts warehouse within 24hrs (= Day 1 + 1 day)

**The big file documents are:****a. Replenishment documents**

- Palettes that require replenishment<sup>6</sup>
- Palettes that require replenishment BIS<sup>7</sup>

- a. Picking list
- b. Global list (F-table)
- c. Pallet labels (etiquettes)
- d. SSCC (only for the client who request it)

**2. Document preparation:** The outbound manager prints out the documents, arranges them and hands them over to the team leader to start with the preparation of order.

Both of the files are treated in the same way in terms of sequence of procedures, but rush file orders are more urgent than big files orders.

**Preparation of order**

Before the preparation of a new order the team leader needs to make sure that all the previous orders in hand are finished and ready to leave the warehouse.

Afterwards he starts the preparation process of the new order. He hands over the order picking and replenishment documents to the workers, the latter will start picking and replenishment process accordingly. The picking is done according to single criterion – FEFO – first expired first out – the goods with nearest expiry date are picked first, this process is determined by the WMS. During the picking process, the picking worker replenishes a new pallet if necessary before leaving the location.

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<sup>6</sup> *Replenishment: is the process of placing the palettes that require certain preparation on the ground to be ready for individual picking of parcels.*

<sup>7</sup> *Replenishment BIS: in case that some pallets are required to be replenished (brought down from the racks to the ground, but no space was available then the BIS specifies which pallets should be put on hold until the required space on the ground is provided.*

- In case that there was an error in the location of a listed pallet, the worker has to search the surrounding area of the pallet, if it was found then it would be picked up or replenished for case or layer picking. If the missing pallet was not found, the team leader would have to inform the outbound manager who would verify where the error is and what the reason is. Meanwhile the worker continues his replenishment and picking process.
- The worker notes the pallet number on the picking and replenishment document and sticks a preparation paper on the picked pallets.
- After the worker has finished his picking and replenishment tasks, the controller would then start the checking process. In which he verifies if the picked pallets and articles correspond to the ones mentioned in the preparation document, in terms of article type, quantity, client, zone, and pallet type.
- Quality check stickers are put on the inspected palettes. The controller then takes the preparation documents to his office, signs them and then fills the F-distribution order (global list). This list is filled in manually on paper.
- Then the controller would scan each palette and preparation document and stores them on his PC. Finally he gives the F-table check order to the Team leader.
- If an error is found, the controller would have to file this error and asks the worker to correct it.
- The team leader would then check the F-table check order, if an error was reported on the F-table; the team leader would discuss it with the responsible worker and checks if training is required for this worker. The target worker(s) for training are then assigned to certain training program.
- At last the team leader would update the archive and fills in the PAL document in WMS and informs the administration that the order is ready and PAL is filled.

**PAL file check:** This document is a spreadsheet contains information about the latest status of the goods picked along with more details about the quantities, expiry date, destination...etc.

- The Administrator (outbound assistant) would check PAL file, and sends it via WMS to the transport company (JOST) and the goods at that moment would be ready to leave the warehouse.

- If an error was found in the PAL file, the team leader would be asked to correct the error and notify the administration.
- If the goods were ready for loading before 18h00 then WEERTS workers will do the loading into the truck, otherwise the truck driver will be in charge of that.

**Problems identified:**

1. The order process is performed in an inefficient way, as the order comes first to (SMIW) the company that manages the WMS and then someone from this company would have to inform the outbound manager about the order. In this case WEERTS S. C. is completely dependent on the WMS manager.
2. The replenishment and picking documents are all prepared and classified manually by the outbound manager and then they are manually handed over to the team leader so that he can start the picking process.
3. Picking lists are manually distributed to workers and then they are recollected when the picking is finished.
4. Due to the fact that the storage of palettes is done randomly according to the space available in the warehouse, the picking and replenishment work is being performed in an inefficient way. The new system should be able to solve this problem in such a way that the worker knows exactly where the palette is and palettes are grouped together according to certain criteria, this would lead to more efficient and less time consuming picking process.
5. A common error taking place in this process is that the worker does not find a certain pallet as noted in his picking list, and then he/she would have to search for the palette in the surrounding racks.
6. The current way the control check is being performed is inefficient as the controller has to hand in a paper of copy of the checking documents to the team leader. Paper work can also be replaced by real time data transfer between the controller's handheld and the team leader's PC, which means that the team leader would only need to verify the controller's result and update the archive.

### 3.2.2 Outbound New Process explanation

*Refer to Appendix 4 for new process BPM diagram and related sub processes.*

The outbound process has undertaken a revolutionary change through the use of the new system, as we will see in the lines below that it has become much more efficient and less time consuming. One of the most important efficiencies in the new process is that the orders are downloaded directly from the client's (KRAFT) SAP system. There's no need to wait for a third party (a WMS manager) to be able to obtain the orders from the client's SAP.

The agreement of Bonus/Malus between KRAFT and WEERTS applies here too, but there's a slight difference in the outbound processes. If the orders were not ready by the specified time, big file or rush file accordingly, a penalty (malus) will be charged against WEERTS, otherwise if they were done on time or earlier a reward (bonus) will be paid to WEERTS.

Now let's have a look at the outbound processes in light of the new WMS by RedPrairie:

The outbound orders are still coming in the form of big file and Rush file explained earlier.

#### 1. Order creation in WMS.

Outbound orders are downloaded from the KRAFT SAP to WEERTS WMS, along with the outbound orders the client sends the transportation plan in an excel sheet, this plan includes the following information: Transport Company, Delivery Date, SAP Delivery Number + Customer Order Number, Load number and Drop number. According to this transportation plan, the picking process will be performed. WMS will update the corresponding orders already existing in the WMS and assign them to a consignment and put a load sequence on these orders. (The goods that are planned to be delivered first are the last goods to be placed in the truck – LIFO). Once the orders can be consulted via the WMS interface, a counter is started that these orders would have to be finished within 48hours for big file and 24 hours for the rush file.

2. **Merge Rules:** When orders have been downloaded into WMS, they need certain criteria other than those specified by SAP to be used to identify or separate one group of orders from another. These criteria are called "Merge Rules". One of these merge rules that shall be set up in the WMS is a SHIPDOCK; it is used to start the allocation and the creation of pick tasks. A Shipdock will be set up for each order and given a certain name or number (i.e.



orders are linked to a specific shipdock on which a truck will be assigned {allows scanning the pallets on a truck to confirm the loading process}).

Another merge rule that shall be set up is the work group. It serves in differentiating between the Big File and Rush File. It assigns the work group field for each order; undoubtedly Rush file orders are treated more urgently than big file orders. Work groups are assigned by the WMS according to this rule.

Once merge rules are configured in the WMS, the identified conditions shall be automated in this task by the WMS without any human intervention, except for the case that change of rules was necessary.

3. **Allocation of orders:** Allocation of orders is used to create picking tasks; using these allocation rules the right stock shall be picked. In our case here allocation will be according to FEFO (First Expiry First Out). If stock does not have an expiry date, Production date shall be used instead. When the manufacture date is registered at receipt time, then this date will be used for FEFO, otherwise the receipt date will be used. This task is not always automated; human intervention (outbound manager) is sometimes required to set which orders shall be treated before the others if the expiry date algorithm was not intended to be used. Special orders are also treated at this stage, if the client sends a special order that needs to be finished on the same day, the outbound manager will see if the special order has arrived before 15h00 or not. Orders coming before 15h00 are entered manually into the WMS and given higher priority in the "allocation of orders" process and a special request invoice (extra charges) is sent to the client. If the client's special request was sent after 15h00, then the order is postponed to the next day and it shall be added to the rush file orders of that day. There are two ways in which orders' allocation is performed:

- *System Allocation : the system selects the stock based on FEFO*
- *Manual allocation : the operator selects the stock from a spreadsheet with the available stock (only in very specific occasions which may lead to overruling FEFO)<sup>8</sup>*

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<sup>8</sup> WEERTS SOLUTION SUMMERY – REDPRAIRIE WMS Document, 4.2.3 Allocation (Step 3) Page 56

4. **Clustering** : RedPrairie WMS provides the functionality of creating computerized work lists, which act by automatically grouping replenishment and picking tasks based on certain predefined rules.

Pallets from pallet storage areas are not always full pallets (for example double stack pallets only take half height). If possible layer picks and carton picks should be picked on top of each other till full pallet loads are built, WMS includes such a functionality that is based on grouping picks for a pallet load into electronic lists. The restrictions of WEERTS's customers are based on maximum volume, weight, number of cases...etc.

It's better to explain this functionality with an example: Suppose there's a customer who made a request for 1 carton picked pallet of confectionery + 1 carton picked pallet of biscuits + 1 carton picked pallet of coffee + 1 carton picked pallet of spaghetti sauce and 1 full pallet of chocolate. The customer requests that pallets should be of maximum 1 meter height.

**Discussion:** Let's assume that the height of each of the carton picked pallets is 50 cm, the client's condition is a maximum height of 1 meter for each pallet, which means that the carton picked pallets are all meeting up the condition. Although, in order to be efficient and to save space when filling the truck container, the pallets has to be placed on top of each other; the chocolate pallet will be placed separately because it's already of 1 meter height. The other carton picked pallets has to be arranged in certain conditions so that when placed on top of each other, fragile goods do not get damaged. The confectionery pallet for example can be placed on the coffee pallet or vice versa (both pallets form 1 meter height). While the spaghetti sauce and biscuits have to be treated exceptionally due to the heavy weight of the sauce pallet. Therefore the biscuits pallet has to be placed on top of the spaghetti sauce.

The clustering task requires human intervention (Outbound manager) in order to specify the succession of picking for each order

5. **Print Pick-lists for Back-up:** After clustering of tasks has been completed, the system is now ready to give order to start the physical picking process. In order to avoid bottlenecks in case of technical problems, the outbound manager prints out a paper copy of the pick lists. This paper copy is kept for spare and shall only be used during technical troubles that prevent the electronic pick lists from appearing on the worker's handset.

6. **Order Preparation:** The Worker in the warehouse receives the electronic picking lists on his RDT handset from the outbound manager's workstation (PC) and starts the physical order preparation in the warehouse.

Before starting the new order, the worker has to finish all the pending and ongoing orders from the previous day. Then he/she would start checking the type of picking required, as there are three possible picking options:

- Full Pallet Picking from storage locations: As the name implies, it is the picking process from storage/reserve locations
- Case-Picking (Carton picking) from pick faces (picking single cases from a full pallet in a box-pick location)
- Line picking: in this type of picking a layer of cases is picked and placed on a single pallet and then another pallet is placed on top of it to receive a new layer of cases.

7. **Print out and put palette labels:** When pallets are picked and completed, pallet labels are printed from the worker's RDT handset and are put on each pallet. Each label carries a unique SSCC number which identifies each pallet from another in the process of truck loading.

8. **Control Check:** In this process a controller starts checking the number of picked pallet if it matches with the pick lists created by the wms. The controller also makes sure that the same pallet identified in the WMS have actually been picked, in addition to quality checks to ascertain that no defected cases or pallet are on the shipdock.

In case that errors or defects were found in one pallet, this error will be saved on the controller's RDT handset for reference and the controller shall ask the worker to correct the error or replace the defected item.

If no errors or defects were found, the controller puts quality check stickers on the checked pallet.

9. **Cross checking** – (Check if major errors exist). The final step in the order preparation process is done by the team leader who makes sure that no errors were done in the whole preparation process in general. If errors were found, the team leader would discuss these errors with the worker; send him/her to training if necessary. Afterwards the team leader updates the archive and ends the order preparation process.
10. **Update order status to “picked”**: At this point the WMS automatically updates the status of the order preparation from “in progress” to “picked” which triggers an automatic message to the client’s SAP. The message is sent in an EDI format via a mediator called DESADV.

**11. Shipdock Reassignment by Consignment:**

In order to be sure that all pallets for the consignment are loaded to the correct door, the outbound manager would have to perform shipdock reassignment on PC. When the truck arrives to the warehouse, the driver will be instructed to dock the truck to a specific door.

*“Each Dock door will be defined as a unique location with a unique check string. A barcode containing the check string will be attached next to the door. Later during vehicle loading the trailer ID will automatically be created as a location and it will inherit the check string form from the corresponding dock door”<sup>9</sup>*

**12. Vehicle loading by consignment:**

At this point we have the entire pallets ready to be shipped out of the warehouse; they are placed in stages on the shipdock. Each palette has an SSCC number as well as a WMS pallet ID. This process is performed by the worker who enters a consignment (load number) and a trailer ID in his handset, the system proposes a pallet, the operator looks for the pallet and puts it in the truck, the worker confirms the task by scanning the barcode attached to the loading door.

Afterwards the system proposes the next pallet according to the load sequence.

Once truck loading is finished, a message is sent to the outbound manager’s PC showing that the loading is finished.

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<sup>9</sup> WEERTS SOLUTION SUMMERY --- REDPRAIRIE WMS Document, 4.2.8 Shipdock Reassignment by Consignment – Page 71.

### 13. Shipping Confirmation

Once all the goods have been loaded in the truck, the outbound manager changes the order status from “Picked” to “Shipped” in the WMS; the stock is confirmed in the WMS.

Consequently shipment ITL (=shipping confirmation file) is created along with a shipping manifest and shipping documentation.

14. The WMS verifies the duration that took to complete whole order preparation process. If it took more than 48 hours, a malus (penalty) will have to be paid by WEERTS supply chain, otherwise if it took 48 hours or less a bonus will be granted to WEERTS supply chain.

**Note:** The above process is the process of outbound for the Big file orders, the Rush file order process is exactly the same except for the duration. As the duration of the rush file is 24 hours instead of 48 hours.

### 3.3 Outbound Export Process

**Export Outbound processes:** are all the operations including fulfillment activities, warehousing and transportation to customers outside Benelux.

#### 3.3.1 Export Outbound Old Processes

*Refer to Appendix 5 for old process BPM diagram and related sub processes.*

**1. Receiving order:**

The process starts by a request e-mail from the client - KRAFT sent to the export manager; the e-mail includes shipping instructions and delivery note document.

**Shipping instructions:** is a document showing the details of the export order in terms of address of shipment, customer name (the recipient), order number ....etc.

**2. Document preparation:**

- a. The export manager checks and prints out the shipping instructions, and he prepares the shipping documents along with the pallet labels. Then the picking lists are printed out of the WMS, these documents are prepared by the export manager using the data entered by the inbound manager when the receiving is done earlier for the corresponding pallets.

**Picking list:** is a document that lists the items that need to be picked and transferred out of the warehouse, based on the shipping instructions.

**Pallet label:** it's a document that shows the PO and the address of the recipient, this document is stuck on the pallet when it's ready for shipment.

**3. Article selection process:**

The export manager then manually selects the articles that are valid for export according to the expiry date of each article. Three possibilities are identified in this process:

- If the expiry date of an article is 9 weeks or more then, this article is considered valid for export and can be picked according to FEFO.
- If the expiry date is less than 9 weeks but article is still valid, then the article status is checked whether it was intended for export only or for export and Benelux outbound. Export only articles are either blocked in the WMS as well as physically or they are sold to another destination according to KRAFT's decision. While articles intended for export and Benelux outbound would have their status changed to Benelux outbound only.
- If the article's expiry date is passed, KRAFT is contacted who would either advise to block this article or would take some other action.

#### 4. Quantity Check:

Requested articles are then compared against the existing ones. In case of variance KRAFT is contacted to adjust the request to the existing quantity.

#### 5. Recap Picking:

An empty packing list is then printed. The recap picking, pallet labels and picking list are given to the picking worker to start the physical picking process at the warehouse.

**Packing list:** is an empty form given to the picking worker to fill it in during the picking process.

#### 6. a. Picking and order preparation processes:

The picking worker starts the picking process, prepares the order for shipment, fills in the packing list and gives it back to the export manager.

**b. Fax recap picking to the client:** Meanwhile, the export manager faxes the recap picking list to KRAFT as a means of confirmation that the enlisted goods are being picked.

**Recap Picking list:** is a short summary of all the items that shall be picked for that order. This document is printed out of the WMS and sent to the client (KRAFT) as a verification that the enlisted items are being picked at the warehouse. The items in this list should be the same items in the delivery note that's sent from the client

**7. Truck/ container loading:**

- a. It takes  $\pm 48$  hours for the order to be completed and set ready for loading; therefore the truck arrives to the warehouse after two days from the date of request e-mail.
- b. When the truck arrives, the driver has to submit a delivery note, a CMR and a copy of the recap picking list. The export manager faxes the CMR to the customs.
- c. The truck or the container is being loaded up in the warehouse, once done the worker gives the filled packing list to the export manager.
- d. The export manager then faxes KRAFT documents (CMR, the verified recap picking list, the delivery note and the packing list) to KRAFT.

**8. Archiving:**

Finally the export manager archives all the documents.

**Problems identified**

- The request and document preparation is complicated; many processes can be shortcut through the use of the new WMS.

Points to highlight:

- Order can be loaded up to the export manager's work station
- Documents can be synchronized between the WEERTS and KRAFT database.
- Expiry date and quantity of existing articles can be shown on KRAFT's database, this would cut the time and effort required to check each article manually by the export manager. In addition to the e-mail and fax correspondence between the two parties regarding exceptional actions.
- Picking worker can have handheld PDAs which would automatically shows the request and the sequence of picking process.
- Picking list should take into account the alphabetical order of aisles where articles are stocked as well as the expiry date, if so the physical picking of articles will become more efficient as the worker is currently driving back and forth between aisles in a rather random way in order to perform the picking.
- Packing list can be filled and sent via the use of PDAs as well.
- KRAFT document faxing can be replaced with EDI messages between the WEERTS' WMS and Kraft's SAP.



### 3.3.2 Export Outbound New Processes:

*Refer to Appendix 6 for old process BPM diagram and related sub processes.*

The new export outbound process in WEERTS S.C. has become quite analogous to the local outbound processes in the warehouse, except for the fact that orders are not coming via EDI transfer between KRAFT's SAP and WEERTS'WMS, the reason is that the client (KRAFT) does not have enough resources to change this order process.

Below is the new sequence of activities involved in the export process using REDPRAIRIE WMS:

#### 1. Receiving Order:

As in the old export procedure, the process starts by a request order sent via e-mail from KRAFT to the export manager of WEERTS S. C. The e-mail attachment includes the shipping instructions document and the delivery note. The export manager then prints out the attached documents.

#### 2. Prepare Export order:

The export manager prepares the export order manually in the WMS according to the information received in the order e-mail.

#### 3. Set Required Merge rules

Here the export manager would set a merge rule which facilitates the confirmation of the picking process as follows; the merge rule will be setting up a shipdock assigned to each order. The truck or container will be parked at the gate corresponding to this shipdock. When pallets are loaded into this truck/container they can be scanned for confirmation (i.e. the pallet label is scanned with the worker's RDT handset and then the shipdock's gate is scanned against it to confirm the loading of this particular pallet has been loaded inside the truck/container).

#### 4. Allocation of orders

As mentioned earlier in the local outbound process, the allocation of orders will be used to create picking tasks.

In the outbound export process the allocation of orders that shall be identified, is the validity rule of the articles in the warehouse.

In order to consider an article ready for the export, it should be valid for at least 9 weeks. Having the article valid for this period it shall be picked according to FEFO.

Articles that are valid (expiry date not passed), but have less than 9 weeks validity will be checked if their original status is export only or export and Benelux outbound; export only articles will be blocked automatically by the WMS and the client will be contacted to see if their status should be kept as blocked or they could be changed to Benelux local outbound.

If the article's original status is Benelux and export, then it shall be changed to Benelux only automatically by the WMS. Finally if articles are for export only then they shall be blocked by the WMS and kept in the warehouse until further instructions are given by the client.

**Note:** This task is not always automated; human intervention (export manager) is sometimes required to set which orders shall be treated before the others, if the expiry date algorithm was not intended to be used.

#### 5. Clustering:

Same explanation in the local outbound process applies here. In short this functionality in the WMS allows creating electronic pick lists which allows setting up pallets of different heights.

#### 6. Print out picking documents:

Picking documents are printed out for back up, in case there was an error in the WMS, the picking process can still be performed manually using the paper lists.

#### 7. Picking of pallets process:

When the picking list is ready, it's sent to the worker's RDT scanner electronically. The worker will start the picking process according to the instructions that appear on the RDT screen. The RDT handset will show the exact location of the pallet that needs to be picked; therefore there will be no waste of time when the worker needs to look for the required pallet as before. Once all the pallets have been picked and prepared, the picking worker would have to stick pallet labels (etiquettes) on each pallet. Finally when all the order preparation is finished, a message is sent from the worker's RDT to the export manager that the pallets are picked and ready to be loaded.

**8. Pallets' status:**

When the export manager receives the information from the export worker that all the pallets are now picked and ready for loading, the status of the pallets is changed into "picked" in the WMS and an update is sent to the client via EDI between Weerts' WMS and Kraft's SAP.

**9. Truck/container loading:**

As mentioned earlier in the old process the truck arrives after two days from the day of the request for the order to be prepared and set ready for loading. Once it arrives, the driver has to handover the CMR document and the delivery note to the export manager, the export manager sends the CMR document to the customs via fax.

The export manager then sends a message to the export worker to start the truck/container loading process. As mentioned earlier in the order allocation process, the shipdock's gate will have a bar number registered in the WMS, therefore each pallet is scanned using the RDT against this bar number to confirm that it has been loaded inside the truck or the container.

**10. Confirmation:**

After the loading process is finished in the warehouse, the export manager receives a confirmation message on his work station (PC) from the worker's RDT handset.

The export manager then sends confirmation to the client that goods have been loaded inside the container. The latter message transfer is done via EDI message between WEERTS' WMS and KRAFT SAP.

**11. Archive:** after all the processes have been finished, export manager will archive all files and related documents in a special folder.

### 3.4 Inventory management process

Inventory management: is the process in which quality and quantity checks are performed for the goods inside the warehouse, in order to avoid return of goods from clients which costs the company extra unnecessary costs.

It's an interior process and does not include interaction with external entities like clients or suppliers in most of the cases. It's considered a very important process because the company works in a bonus-malus system in which the service level is measured on a 99.7%<sup>10</sup>, if the company can achieve a service quality at this level or above it, it wins a bonus and if it was less than this percentage a malus is charged on the company.

In General there are two types of inventory check that WEERTS performs in the warehouse:

1. **Frequent checks:** this kind of check is performed frequently at the warehouse without necessarily having a request from the client, and consequently if there were no discrepancies found in the check, the results are not sent to the client, they are simply archived and stored.
2. **Annual checks:** The client (KRAFT) sends a request e-mail to WEERTS to inform WEERTS about the intended date for the inventory check. Both parties have agreed that this processes should be performed during March, because it has been noticed that the least amount of orders arrive during this month. Nevertheless KRAFT should confirm to WEERTS the exact date of the process. After the check is finished, the results have to be sent to the client and then archived and stored.

#### 3.4.1 Inventory Management procedures old Process explanation

*Refer to Appendix 9 for old process BPM diagram and related sub processes.*

1. **Process start:**

The process starts by a request from the inventory manager<sup>11</sup> to the assigned workers (inventory control workers) to start the inventory count.

All the workers in the warehouse should finish their ongoing tasks (goods receiving and putaway, picking and replenishment....etc.).

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<sup>10</sup> **99.7%:** This percentage is measured with a KPI tool in the form of an excel sheet. The following equation is used to calculate this percentage:  $\text{service level} = (\text{No. of errors found} / \text{No. of lines "layers" inspected})$ .

<sup>11</sup> **Inventory Manager:** job position is held by the same person as the outbound manager in WEERTS' office.

**2. Block the WMS:**

In the mean time that the workers in the warehouse should finish all their ongoing tasks, the processes managers (inbound, outbound, copacking and export) should finish their tasks and should block their WMS interfaces from receiving new orders.

**3. Interface verification between WEERTS and KRAFT systems:**

The inventory manager makes sure that KRAFT and WEERTS have the same amounts and details of the stock (same theoretical figures in WEERTS WMS and KRAFT's SAP).

**4. Print check lists:**

The inventory manager selects which articles or locations will be checked and by whom and prints out the corresponding pick lists. Each worker would have his/her name written on the lists of materials that he/she should check.

**5. Give inventory control lists to the assigned workers:**

The inventory control list is handed over to the assigned workers to start the physical count process.

**6. Physical count:**

The worker starts with the physical count in the warehouse and fills in the inventory check form. Once filled, this form will be checked by the inventory manager, if there were variances between the actual physical count and the WMS count, the worker is requested to double check the physical count.

7. **Comparison of Stock:** If variance persisted after the second physical check, the inventory manager would check if a certain pallet was reported missing in a certain location but it was found in another.

As in the example below:

Pallet Number	Description	Location	discrepancy	Quantity
777888	Chocolate bars cote d'or	B225	-1	19
777888	Chocolate bars cote d'or	B221	+1	20

If variance persisted despite the checks above, the quantity will be adjusted in the WMS and the error will be investigated.

If no variances were identified the inventory management procedure is terminated at this point and shall be sent to the client if it was an annual check, otherwise it would only be saved and archived.

### 3.4.2 Inventory Management new process explanation

Refer to Annex 10 for new process BPM diagram and related sub processes.

Physical counting in the warehouse requires stopping all other warehouse activities so that the correct amount of stock can be counted without mixing the reserved stock for outbound or the newly stored stock before being registered in the warehouse.

The new inventory management process that WEERTS would perform using RedPrairie WMS is called *Physical Inventory Counting*; this process is composed of multiple cycle counting which can be done in the warehouse without interrupting the other processes.

This process divides the warehouse into multiple storage locations in the WMS and performs separate counting for each location. Due to the fact that RedPrairie reserves the stock in the system by the time the order is downloaded from the client's SAP (Big file or Rush file), and the same thing goes with the incoming stock as the pallets are entered in the stock by the time that they are scanned for receiving after being unloaded from the truck, therefore the process of inventory check can be done without interrupting the other processes in the warehouse, in other words the inventory check can be done without blocking the system.

The procedures involved in this new process:

**1. Assign inventory control worker:**

The inventory manager assigns a worker or more (this is an operational decision taken at the company) to start performing the inventory control process at the warehouse. The assigned worker will receive the commands from WMS on his RDT handset which will be in contact with the inventory manager's PC on real time basis.

**2. Perform inventory check**

The inventory check process is performed at the warehouse according to the orders that the worker receives on his RDT. The WMS starts with a certain pallet number (SSCC number) that appears on the screen of the worker's RDT handset and the inventory manager's PC at the same time (real time). The worker moves towards this pallet following the coordinates given by the WMS, he then checks if the pallet physically exists or not (quantity check), if the pallet was missing, the worker would adjust this information in the WMS using his RDT handset, the worker also checks if the pallet or any of its contents is physically damaged. Once the worker confirms that the check is finished for this pallet on his handset, the WMS shows the SSCC

number of the next pallet. The sequence that the WMS uses is preconfigured earlier by the inventory manager who makes sure that the sequence of the pallet numbers to be checked is according to their physical location in the warehouse. There are two different ways that can be configured for the check:

- 1. Normal sequence of pallet check (fig 16 Left):** Here the worker starts with the first location in the rack; he/she checks the top placement and all the way down to the bottom (floor) placement. Once checked and confirmed, the system shows the next location in the same row and the same top to bottom sequence is followed. When the entire row is checked and finished, the system shows the last location in the opposite row and then the same sequence is followed backwards.
- 2. Zigzag sequence of pallet check: (Fig 16 Right):** Here the worker starts with the first location in the rack; he/she checks the top placement first and all the way down to the bottom (floor) placement. Once it's finished the system shows the location in the opposite row in front of the first one, and the same sequence of top to bottom check is followed. When the second (opposite) location is checked the system shows the location in the first row that's next to the first checked location as shown in the figure below. The same process continues in a zigzag manner until both rows are checked.

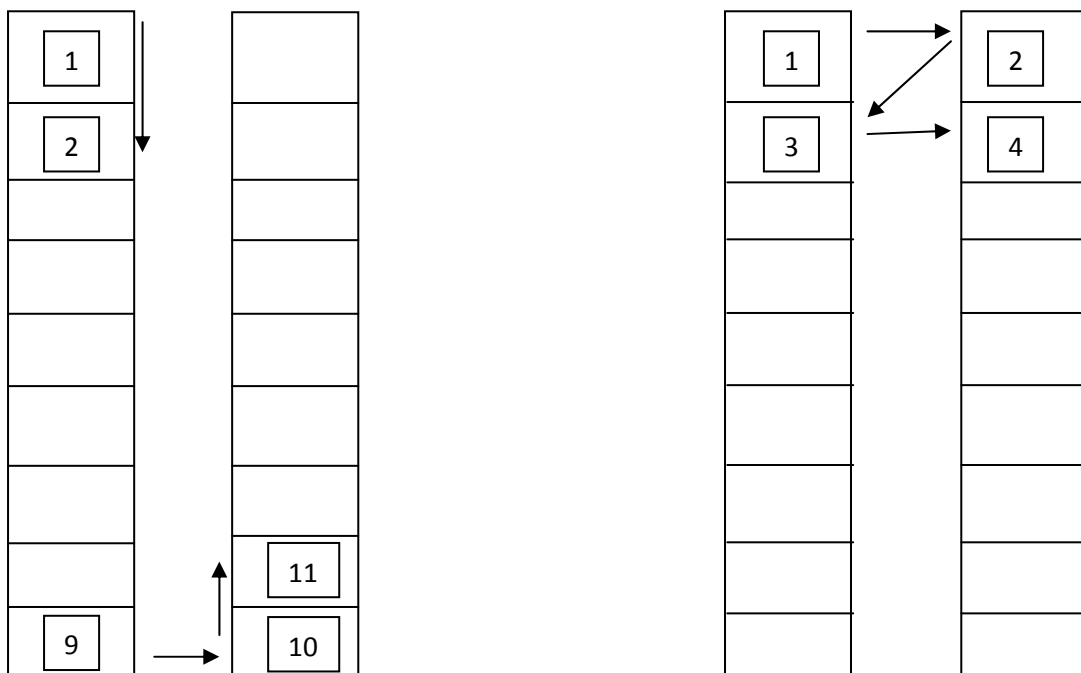


Figure 16 (Left) Normal sequence flow (Right) Zigzag sequence flow



### 3. Check Discrepancies:

If discrepancies were found (difference between physical quantity and theoretical quantity in the WMS or damaged pallets or goods) they shall be registered and the damaged pallets shall be blocked in the WMS till the entire warehouse is checked. Afterwards, the inventory manager would inform the client about these discrepancies. The result of the inventory check shall be saved and archived.

In case that the control check was an annual check, the inventory manager has to send the results to the client regardless if discrepancies were found or not.

## 3.5 Value added activities and Copacking

**Value added services:** are the processes in which a certain value is added to the stock upon the client's request, such as preparation of promotion packs, product displays...etc.

The VAS is composed of multiple activities which include fabrication of displays to be installed in supermarkets for certain promotional offers or special displays during the holiday season (E.g. Christmas holiday product displays, Easter holiday product displays)

Products copacking: are promotional offers in which a number of product units are packed together and a promotion sticker is stuck on them. (E.g. three chocolate bars are packed together and sold for the price of two).

### 3.5.1 Value Added Services and Copacking old process explanation

*Refer to Appendix 7 for old process BPM diagram and related sub processes.*

The activities involved in this process are as follows:

#### 1. Request for Price:

The process starts by a request e-mail from the client (KRAFT) asking for a price for a certain kind of service (e.g: copacking). The e-mail includes some specifications regarding the type of the value added service. The copacking/VAS manager sends an offer e-mail in the form of a price proposal.

## 2. Copacking Order:

Once the client agrees to WEERTS's price, an order is sent via e-mail explaining the quantity and the type of goods for which the value added services are required. Besides, the client sends an excel sheet called (*optic plan*) via e-mail; this sheet mainly includes the purchase orders of the goods required to be processed (e.g. copacked), the type of services required, the expected starting date of the production process, the expected date of termination, and empty columns that has to be filled in by WEERTS for the actual date of termination, the actual quantity produced on time and the actual quantity produced after being delayed and the date of delay. In addition to supplementary information that is beyond the scope of this paper.

The copacking responsible starts the production planning according to this request and the *optic plan* but holds the order on standby until all the purchase order documents are sent via fax. The fax is normally followed by the request e-mail within one hour, if it took longer the copacking responsible contacts the client who would either cancel the order or ask for more time. The process remains on standby until the copacking responsible receives the fax from the client.

## 3. Production documents: Upon receipt of the order documents by fax, the copacking responsible prepares the production documents which include:

- a. Two copies of delivery notes.
- b. A form for checking the bar codes
- c. A document for damaged stock registry.
- d. Picking lists: these documents are taken from the WMS system but received as a paper copy from the SMIW. (The big file and rush file packages contain special picking lists for the copacking and VAS).
- e. Pallet labels (Etiquettes) are then created and printed out.

The POs and Delivery notes are sent by the EDI messages between KRAFT's SAP and WEERTS' WMS. Although these documents are sent separately from each other as each one serves in a different way.<sup>12</sup> In order to have a link between these documents, a list is sent from the client via fax or e-mail linking each PO to the corresponding delivery note.

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<sup>12</sup> The purchase orders are intended for making the inbound of materials to the warehouse and the delivery note (Bon de livraison) is a document for picking out the orders from the warehouse, but the problem is that there's no link between each PO along with its corresponding Delivery Note (BL). The standard features of RedPrairie WMS does not support this functionality of linking POs to Delivery Notes, therefore this feature can only be added after customizing the purchased version of the WMS, which means extra costs shall be incurred on WEERTS, therefore this idea was disregarded.

**4. Order picking:**

The copacking manager gives the picking lists to an assigned worker(s) in the warehouse who would start picking the goods listed in these lists and take them to the copacking area. The picking process is done on a random basis as the worker travels randomly in the warehouse to pick the articles on the list.

**5. Give order for production process:**

All the production documents are then photocopied and then handed over to JDC.

**6. Production and value added services work:** Once the JDC receives the order, it starts with the production process of the value added services. When the production is finished, a production form is filled in with the quantity produced and the expiry date of the materials and returned back to the copacking manager.**7. Data Entry and Archiving:** Finally the copacking responsible verifies the data in the production form with the requested order documents fills in the optic production planning with the actual data then enters the data into KRAFT SAP. Every Friday afternoon the copacking manager sends the filled optic production sheet back to KRAFT via e-mail.**8. Goods receiving:** In order to let the finished goods restored in the warehouse, an inbound receiving process is performed by the copacking manager. By which the finished goods are returned back to the warehouse. The receiving is done here manually using paper lists on which the worker notes down the pallet number and the location. Then these paper lists are handed over to the copacking manager who would enter this data in the WMS.**9. Archiving:** finally the copacking manager archives all the documents for reference.

**Problems identified:**

1. The order processes is prolonged and can be short cut through the use of automated commands between WEERTS supply chain's WMS and KRAFT's SAP.
2. Manual preparation of picking lists is inefficient and time consuming.
3. Copacking sub contractor may have access to the WMS interface to receive orders through this system instead of receiving paper orders.
4. Fax use can be replaced by a shared data base between Weerts and Kraft or EDI messaging between the two parties.

### 3.5.2 Value Added Services and Copacking new Process explanation

*Refer to Appendix 8 for new process BPM diagram and related sub processes.*

As all other processes in the warehouse, the Value added services process has been dramatically changed with the usage of the new software from RedPrairie. The main change as will be seen shortly below is the process of picking goods from the warehouse and the process of returning the goods to the warehouse. Below are the steps of the new VAS and Copacking process:

#### **Request for a price:**

As in the old process, the VAS/copacking process starts with a request e-mail from the client (KRAFT) for a price quotation for a certain type of service. The copacking manager prepares the price quotation and sends it back to the client.

#### **1. Production planning**

If the client agrees to this price, a production order is sent via e-mail along with a production plan (same as above in the old process). The copacking manager will start the production planning according to the deadlines specified by the client. Afterwards, the order is held on standby until the corresponding POs and delivery notes are sent from the client.

#### **2. Picking materials from the warehouse:**

This process is exactly analogous to the outbound process explained earlier local outbound process. It's mainly composed of the following:

- a. Creating outbound order based on the delivery notes that are sent from KRAFT SAP.
- b. Allocation of orders: orders are allocated to workers or work groups to create pick tasks.
- c. Clustering: tasks are clustered to separate full pallet picking from case (carton) picking.
- d. Print pick lists: pick lists are printed for back up in case of system error or shut down.
- e. Execute picking process: here picking is done from the warehouse rack to a virtual shipdock configured in the WMS for COPACKING.

#### **3. Give order to JDC and start VAS/Copacking process:**

After the goods have been picked from the warehouse, the copacking manager gives an order to the VAS subcontractor (JDC) to start the production process. The order is given to JDC in paper documents as the subcontractor does not have access to WEERTS' WMS.

Once the production has been finished the subcontractor sends back a production report indicating the materials, the quantities and the expiry dates of the raw materials as well as the finished goods.

#### 4. Verification of data:

The copacking manager receives the production report and verifies if no errors were performed during the production process. In case that an error was found, the contractor is asked to correct the error and resend the production report.

#### 5. Goods Receiving

After the production process has been completed, the finished goods shall be treated as new goods entering the warehouse, therefore regular goods receiving process shall be performed. The process is analogous to the normal goods receiving process explained earlier and it's composed of the following:

- a. Perform pre advice receiving: based on the POs received from the client KRAFT pre advice receiving is performed, the new pallets has to be identified based on the SKUs, their quantity, their batch numbers, production and expiry dates.
- b. Print pallet labels: based on the information in the above point, pallet labels with unique barcode shall be printed for each pallet. The worker has to stick each label on its corresponding pallet.
- c. Pallets are then scanned for putaway and stored back in the warehouse.

**6. Status update:** After the pallets have restored in the warehouse, the copacking manager sends a status update to the client's SAP system using his WMS interface.

**7. Archiving:** finally and after all the processes have been terminated the copacking manager archives documents related to this process.

## Chapter 4 - What-if analysis

According to Martin Murray, in his article about the measures of warehouse productivity, he mentioned the following:

*Warehouse productivity is a number of measurements that management will analyze to monitor the performance of their warehouse operations. The basis for many of the measures used in warehouse productivity is based on how much it costs to perform an operation<sup>13</sup>*

Therefore in order for management to be able to measure its performance inside the warehouse this performance has to be translated in terms of costs and profits. In this chapter what-if analysis has been developed to be used as a tool for measuring and monitoring the performance of different productivity levels for each warehouse operation and comparing the current productivity with the targeted levels. I have used Microsoft excel as a tool to perform this what-if analysis, although it is also possible to use BPMN softwares that contain simulation functionality to do this analysis like the one developed by IBM (*websphere business modeler advanced*)<sup>14</sup>

In addition to comparing different productivity levels, according to a request from the management, I have added columns of different price conditions that the company might charge its clients. Given that the values of cost and price are not realistic but are estimated to be close from the real values for reasons of confidentiality. Refer to appendices 11, 12 and 13 for the what-if analysis sheets of inbound, outbound and export respectively.

### 4.1 Parameters:

For each process analysis a set of parameters have been developed, these parameters affect the productivity levels of the activities. The values of these parameters are fixed and do not change regardless of the productivity levels. If the management took the decision to deliberately change them, their change will consequently affect the outputs in the tables underneath

- Old prices: these are the old prices charged to the client before signing the new contract.
- New prices: these are the new prices charged to the client after signing the new contract.
- Working hours: the number of working hours per worker per day. Given in decimal form for ease of calculations. Example: 7.5 = 7 hours and 30 minutes
- Salary cost/hour: the estimated average salary per worker per hour

<sup>13</sup> Measures of warehouse productivity – Martin Murray

<sup>14</sup> IBM products website: <http://www-01.ibm.com/software/integration/wbimodeler/advanced/features/>

- Additional cost: this refers to the additional costs incurred during the operation, including machine costs and energy ...etc.
- Activity percentage: this refers to the cost percentage of each activity involved in the whole operation. These percentages are used in the company's costing system.
- Assumed number of articles per line: is the assumed number of articles in each layer picked (outbound process).
- Price per line picked: is the price charged per line (layer of articles), calculated by multiplying the number of articles per layer times the price per article picked (outbound process).

## 4.2 Analysis tables

The same methodology was used for the analysis of all the processes, in which each process is subdivided into a number of activities. Each activity is analyzed individually using six case scenarios corresponding to different productivity levels. The tables are generally composed of the following items:

1. Assumption: this refers to the different case scenarios from A...to ...F.
2. Time required to perform an activity: this refers to the time required by one worker to perform an activity, for example the time needed to unload the pallets from the truck in the inbound process (measured in seconds). Or the time required to picking one pallet from the warehouse rack and placing it on the loading dock in the outbound process (measured in minutes).
3. Productivity level: this refers to the number of units moved (unloaded, checked, loaded...etc) per hour. In each activity analysis table there's a productivity column in which the values are calculated by dividing 3600 seconds per hour by the time required to perform that activity per unit. If the time used to measure the productivity was in minutes then 60 min/hour is divided by the time required to perform that activity. Examples:
  - Inbound unloading: Pallets unloaded per worker per hour =  $3600 \text{ second} \div 20 \text{ second/ pallet} = 180 \text{ pallets/hour}$
  - Outbound full pallet picking: Pallets picked per worker per hour =  $60 \text{ min/hour} \div 1.5 \text{ min/ pallet} = 40 \text{ pallet/hour}$ .

The same method applies to measuring the productivity of all the activities.



4. Working hours per day: as mentioned earlier they refer to the number of working hours per worker per day, it has been added inside the table to ease calculations and comparisons.
5. Productivity per day: this column does not enter in the calculations of the profit or loss per activity but it's been calculated to give a view to the managers about possible daily levels of productivity of each case scenario (assumption). It is calculated by multiplying the number of working hours per worker per day by the number of hourly activity levels found above.

Example: Outbound line picking (productivity level per day) = 25 No. of lines picked/hour x 7.5 hours/day = 187.5

6. Salary cost: is the average salary cost per hour multiplied by the cost percentage of the activity.

Example: salary of unloading pallets (inbound process) = €25/hour x 16.67% = €4.17/hour

7. Additional cost: this refers to the costs of equipment, energy and maintenance involved in the performance of the activities. It is also multiplied by the cost percentage of the activity.

Example: Additional cost of unloading pallets (inbound process) = €4.625/hour x 16.67% = €0.77/hour

8. Total cost per hour: this refers to the sum of the total cost of salary and additional costs per hour.

9. Cost per unit: it is calculated by dividing the cost per hour by the productivity level per hour. It is written in different titles in the table referring to the units used for the measurement (pallets, articles...etc.).

Example: Cost per line in the outbound process = €14.81/hour ÷ 25 lines/hour = €0.59/line picked.

10. Price per unit (old and new): this refers to the unit price multiplied by the cost percentage of the activity.

Example: €1.81/line picked x 50% = €0.90/line picked

11. Profit per activity: this refers to the profit gained from a certain activity at a certain productivity level. (negative values refer to the losses)

Example: Profit per line picking at assumption C of outbound process is €0.90 – €0.59 = €0.31/line picked.

Note: the profit has been calculated for two possible price levels –old price and new price – this can be changed to any price level according to the agreements between the company and its client.

### 4.3 Inbound Operations

The inbound is the process of receiving and storing goods in the warehouse. Here it has been divided into three main activities forming up the whole process from beginning to end. These activities include the unloading of goods from the trucks, the goods check and the goods putaway inside the warehouse.

#### 1. Pallets Unloading

The first activity inside the warehouse in the inbound operation is the unloading of pallets from the truck and placing them together in a special location for inspection before being putaway in the warehouse.

#### 2. Goods Check

It's a an activity forming the second main step in the inbound process, in which the goods and pallets are inspected by an operator to make sure that there are no damages in them before they are putaway inside the warehouse.

#### 3. Goods putaway

it's the last activity involved in the inbound process. It involves the transportation of goods from the reception dock and placing them in the proper position inside the warehouse.

#### 4. Total profit of inbound

After the profits have been calculated individually for each activity, this table sums up all the profits together to show the total profit obtained or lost from the inbound process for each productivity level given the costs and prices explained earlier.

The table is divided into two main sections. One of them refers to the old price and the second one refers to the second price. It includes the following items in each of the sections:

- a. Assumption: As usual the first column in each table refers to the case assumed in terms of productivity level.
- b. Total cost per unit of inbound: this refers to the total cost per pallet of all the activities comprised in the inbound process. Assumption "A" for example refers to the costs of assumption "A" in the unloading, goods check and putaway activities summed up together.
- c. Total price per unit of inbound: this refers to the total price per pallet of all the activities comprised in the inbound process. Assumption "A" for example refers to the prices of assumption "A" in the unloading, goods check and putaway activities summed up together.
- d. Total profit of inbound per unit: this refers to the resulting profit (or loss) from subtracting the total cost per pallet per inbound from total price per pallet per inbound.

### 4.4 Outbound Operations

Outbound is the process in which the goods are picked inside the warehouse and prepared for shipping to the clients. The outbound process is mainly composed of two activities. The outbound process is mainly composed of two activities:

#### 1. Picking of units:

it is the process of collecting the units in the warehouse and placing them on the loading dock. There are three different types of picking depending on the signification of units requested by the client:

- a. **Case picking (column picking):** in this type of picking, cases are picked individually and placed together on one pallet. It's possible to have more than one type of product on the same pallet.
- b. **Line Picking:** in this type of picking, products are picked and placed on one pallet forming one layer and then another pallet is placed on top of them and other type of products are

picked and placed on it. It is possible to have several layers (lines) placed on top of each other according to the order.

- c. **Full pallet picking:** in this type of picking pallets are fully picked from the warehouse racks and set for shipment.

## 2. Loading of pallets

It is the process of loading the pallets from the loading dock to the truck containers. Note that no matter the type of units used in the picking activity the loading is always done with pallets.

## 3. Total profit of outbound for the old and new price possibilities:

These two tables show the total profit or loss resulting from summing up both activities for each assumption. Below is the explanation of the columns of these tables:

- a. **Assumption:** this refers to the assumption taken in the above tables; each assumption refers to the sum of the corresponding assumptions in the above tables.  
Example: Assumption (A) = Assumption (A) picking + Assumption (A) loading
- b. **Total cost per unit of outbound:** is the total cost per unit of picking and loading for the corresponding assumption.
- c. **Total price per unit of outbound:** is the total price per unit of picking and loading for the corresponding assumption.
- d. **Total profit per unit of outbound:** is the total profit or loss per unit. Found by subtracting the total unit cost from the total unit price.

## 4.5 Export operations

There are special requirements that need to be fulfilled before loading the goods in the export containers.

### 1. A Line picking:

As mentioned earlier, line picking refers to picking the articles and placing them in the form of layers. It is assumed that each layer or line contains 10 articles, although this is liable to change according to the size of the box.

**1. B Case picking (column picking):**

This refers to the picking of individual articles and placing them in the form of columns on the pallets.

**2. Box restacking:**

In the export process different type of pallets are used from the ones that are used in the local outbound, therefore it is mandatory to switch pallets for each order before sending them for export.

**3. Carton covers:**

According to the requests of the client, it is sometimes necessary to add carton covers on the prepared pallets before leaving the warehouse.

**4. Pallet sealing:**

According to the requests of the client, it is sometimes necessary to add plastic or metal seals around the pallets before leaving the warehouse.

**5. Airbags:**

According to the requests of the client, it is sometimes necessary to add protection airbags around the pallets before leaving the warehouse.

**6. Loading pallets:**

is the process of loading the prepared pallets in the export containers.

**7. Total profit of export:**

As can be seen above that not all the above activities are performed for each export order, therefore calculation of the total profit per export shall be done only for the activities that are constantly required. The profit of the other activities shall be calculated too but it won't be added automatically to the summation table. If a certain activity is required, the user must first fill in the cost of this activity in the parameters table on top and then manually includes it in the formula of the summation table.

The cost percentages of activities are divided as follows:

Column picking or line picking = 33.33%

Box restacking = 8.33%

Additional and optional activities (carton covers, seals, and airbags): each one of these activities

costs around 8.33% of the total export process.

Loading of pallets = 33.33%

*Note: In all the tables above, the cells highlighted in the red rows refer to the current productivity level at the company. The rows highlighted in blue refer to the level intended to be achieved by the management.*<sup>15</sup>

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<sup>15</sup> These figures have been obtained after meeting with the management and explaining this what-if analysis sheet.

## Chapter – 5 – Gap Analysis

Gap Analysis is used for the identification of the gap between the current (old) state and the desired (future) state of the company. It can be simply defined with two questions; where are we now? And where do we want to be?

Gap Analysis serves in determining whether a company or an organization is making its best use of resources to come up with the most efficient productivity levels or there is a waste or misuses of resources. By looking at the outcomes, the organization can identify the gap in the allocation of resources and the investments between the current level and the optimized level of performance. This gives an insight to management about the areas where more attention should be paid and where there is a room for improvement through outlining the foundation for measuring the investment in human resources, in time and money<sup>16</sup>. It can also be used as a tool for measuring the added value of a new system installed in a company, through identifying a number of indicators and measuring the fulfillment of certain activities and business processes before and after the installation of the new system. This is quite analogous to our case, as the company WEERTS S.C used to use a number of indicators for measuring its performance levels before the installation of the new WMS from RedPrairie. As we have previously seen in the What-if analysis that the relationship between the cost and the time consumed to achieve a certain activity is directly proportional, therefore we shall use this relationship after being converted into productivity terms (e.g. Pallets unloaded/hour) as a performance measure for the company to compare the old system to the new one. These measurement means or indicators are called KPIs (Key Performance Indicators).

### 5.1 Performance Management

According to the famous management quotes:

*“When you can measure what you are speaking about and express it in numbers, you know something about it” --- Lord Kelvin*

*“You cannot manage what you cannot measure” --- Anon<sup>17</sup>*

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<sup>16</sup> Reference: [http://en.wikipedia.org/wiki/Gap\\_analysis](http://en.wikipedia.org/wiki/Gap_analysis), Gap Analysis – Charles A. Dana Center – Middle school principal seminar – Austin Texas.

<sup>17</sup> Performance measurement management – Department of Trade and industry - UK

Performance management is the process in which the organization chooses certain indicators and uses these indicators to compare its current performance level to the desired level. It plays an important role in the cycle of never-ending improvement as it serves in:

- Identifying and observing the progress against specified bench marks or desired outcomes
- Determining opportunities for improvement
- Comparing the current performance against standards (external and internal).

## 5.2 Key Performance Indicators

A Key performance indicator is a measurement means used by an organization to measure its success or the success of a certain activity. It can be used to monitor the current performance levels and compare it to certain bench marks or intended levels to outline the progress of the related activity.<sup>18</sup>

In WEERTS S.C. these KPIs were structured in an excel sheet that is filled by an allocated employee on daily basis, he's in charge of collecting data from the process managers (inbound manager, outbound manager...etc) and use this data in filling his KPI sheet. These KPIs were used to measure the performance of WEERTS and compare them to the desired outcomes which were specified by the management and they can also serve in measuring the client's satisfaction.

## 5.3 Comparison between WEERTS performance before and after the RedPrairie WMS:

Now in the big outset we shall discuss two important questions to identify the value of the new WMS installed in WEERTS S.C by RedPrairie. Through developing a comparison between the processes of the company before and after the new WMS and with the aid of the BPMN diagrams a number of differences have been identified, these differences shall be discussed in the first question:

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<sup>18</sup> Warehouse Key Performance indicators – Vijay Sangman



### ***What are the obstacles that were controlled by the new system?***

In order to reply to the first question, an insightful comparison needs to be made between the old WMS and the new WMS for all of the warehouse processes by identifying the weak points that were observed in the old WMS and comparing them to the way they have been tackled by the new WMS from RedPrairie.

The use of the BPMN diagrams gives us the opportunity to investigate the processes from two different perspectives, the first is by explaining “What needs to be done to perform this process?” this leads to a tactical high level analysis of the activities forming each process. The second perspective is by investigating the process from a more detailed operational level showing “*How the process is being performed?*” Therefore each of the processes we have explained earlier will be discussed from those two perspectives to see if the installation of a new WMS system has changed what process is composed of or it only changed the way the processes are performed (HOW).

#### **5.3.1 Inbound Processes:**

##### **Tactical level**

When we look at the inbound process from a tactical point of view, we see that this process is composed of four main activities that are the same regardless the type of WMS used in the warehouse (old or new). The inbound process is mainly composed of the following activities:

**Order receiving:** This refers to all the activities in which the orders are sent by the client in general.

**Unloading:** When the goods arrive to the warehouse they unloaded from the trucks.

**Checking:** after the goods are unloaded from the trucks they are checked in terms of quantity and quality.

**Putaway:** Finally the goods are stored away in the warehouse.

**The figure below shows a tactical level inbound process.**

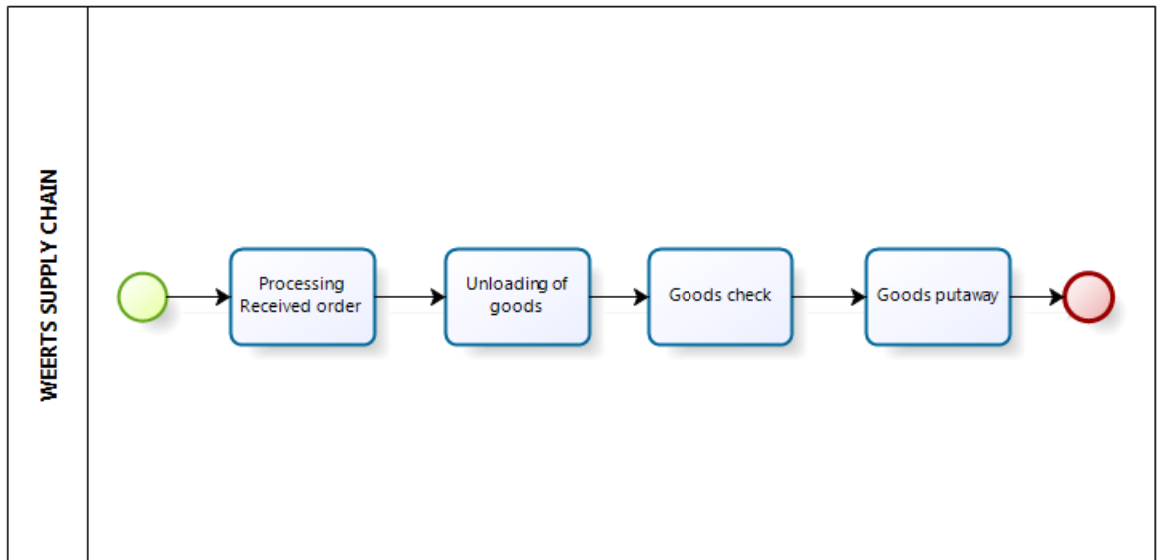


Figure 17 Tactical level of the inbound process

### Operational Level

On the operational level which shows how the activities in each process are being performed, the differences between the old process and the new process of inbound shall be explained separately in each stage of the processes.

- A. Goods Receiving: One of the differences that I would like to highlight at the first phase of the inbound process is that the decision where the truck should be stopped is solely decided by the inbound manager. This change is not related to the installation of the new WMS but it's one of the changes that go simultaneously with the implementation of the new WMS. BPMN diagram shows the difference between the old process and the new process at this level. This change has been taken into consideration as it has been noticed that the process of coordination between the dock responsible and the inbound manager is time consuming and inefficient, therefore the decision was taken that the inbound manager will be the only person in charge of determining the location where the truck should be parked for unloading and he will be in charge of the administrative work and the unloading follow up.
- B. In the new system –RedPrairie – the pallets are unloaded from the truck and scanned for receiving, during this process the status changes from “released” to “in progress”. This gives the possibility for the inbound manager to know the status of the process while sitting on his desk as the (RDT) scanner used by the workers in the warehouse is connected to the WMS

This functionality did not exist in the old system as the inbound manager needs to go himself to the unloading location or send someone on his behalf to check the status of the process.

- C. After all pallets have been unloaded and checked, the putaway process starts. A quite considerable difference is observed in this activity between the old WMS and the new one.

As we have seen earlier, during the old system the worker has to take the Pallet with his/her forklift and travels between the alleys of the warehouse looking for an empty location. The search is done in a random manner, the only criteria that is taken into consideration during the old process is the weight of the pallet and/or whether the pallet contains open boxes. In these two cases the pallets should be placed on the floor otherwise they are placed on the racks. Once the pallets are placed in a certain location, they are scanned with a handheld scanner and the location where they are placed is scanned as well. (A bar code is available for each storage location in the warehouse).

Then the scanners have to be taken to the inbound manager who connects them to his computer and transfers the location data to the WMS. Finally a notification of inbound process termination is sent to the client.

The new putaway process goes completely in an opposite way. Once the worker decides to start with the putaway activity, the system requests the worker to scan the pallet and then according to predefined criteria by the company (e.g. Expiry date, type of product...etc.) the system's algorithm decides a specified location in the warehouse to place the pallets in it. Once the worker places the pallet in the specified location he/she should scan the pallet and the location for confirmation. The inbound manager can observe the progress of the process from his computer in real time basis without the need to wait for the worker to bring the scanners to him.

- D. Another difference between the old process and the new process is that the receiving process status changes to "complete" once the unloading and the check is done in the warehouse without the need to wait until the putaway is performed unlike the old process which is only considered complete and the status update is sent to the client after the putaway is completely done and the storage data are brought back to the inbound manger.

The status changes from "released" to "in progress" and then to "complete" facilitates the management and the follow up of the process for the inbound manager to have control on each stage of the process in real time basis. When the inbound process status "complete" is sent to the client after the goods have been unloaded and checked, this gives more time for WEERTS to perform the putaway process without the pressure of the client.

### 5.3.2 Outbound process

#### Tactical Level

The tactical level of the outbound process is composed of four main activities regardless whether this process was performed using the old WMS or the new one, from a high level perspective, the activities are the same but the way they are performed has been mainly changed. Below we will first look at these activities from a high level tactical point of view and then we will study the detailed operational level where the major differences have been identified.

The tactical activities of outbound are:

**Processes Orders (Big file or Rush file):** this implies to all the sequential activities to make the order ready to be picked.

**Picking and preparation:** these are all the activities included to pick the pallets or cases from the storage racks and placing new pallets from the storage racks on the ground placements for future individual picking.

**Checking:** Before leaving the warehouse, the goods have to be checked in terms of quality and quantity.

**Loading:** Once all the goods are picked and checked, they are ready for to be loaded into the trucks.

The figure below shows a tactical level of the outbound process:

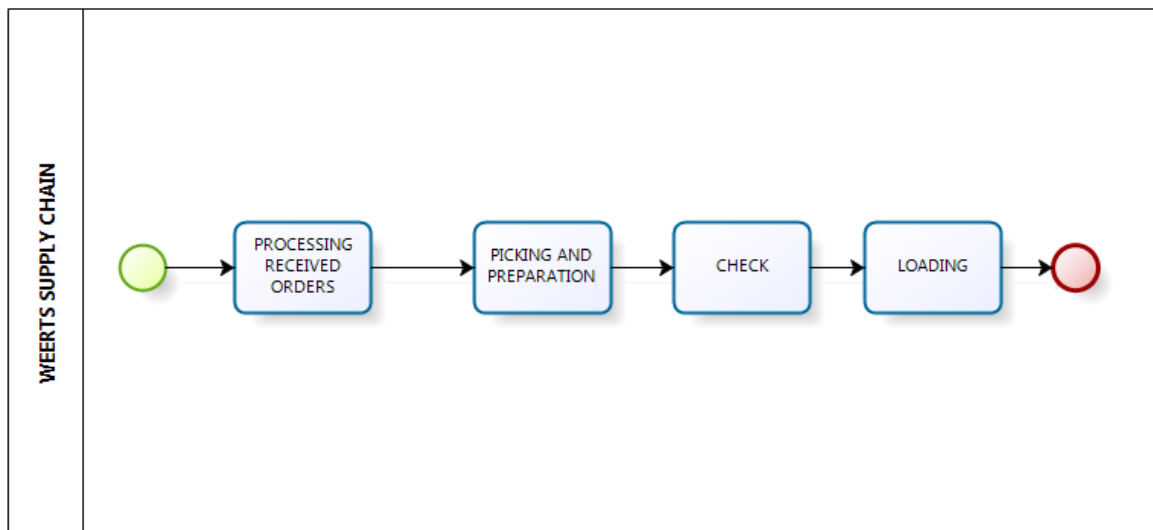


Figure 18 Tactical level of outbound process

## Operational Level

On the operational level we see that the outbound process underwent major changes after the installation of RedPrairie, which lead to more efficiency in the process activities. We will examine those changes according to the sequence of the flow of activities for the whole end to end process.

### 1. Receiving outbound orders:

The orders coming from the client: Before the installation of REdPrarie, the orders (big file and rush file) used to come from the Kraft's SAP to SMIW the third party manager of the WMS in WEERTS, the latter had to wait for the orders to be transferred from the SMIW's computers to WEERTS's computers and once the order was sent to WEERTS, SMIW's representative had to call WEERTS and inform them that the order is now transferred to their computers.

We can see from the above situation that WEERTS is totally dependable on a third party in receiving its orders from the client, this has always lead to inefficiency problems, delays in executing the orders, and in some extreme cases the orders were not transferred to WEERTS on time. It also gave higher hand to the WMS supplier in the outbound process. After the installation of RedPrairie, the flow of messages from the client's SAP system come directly to WEERTS' computers and enters the RedPrairie data base. The main advantage that WEERTS gained is the efficient flow of orders from its client to its system without relying on third parties.

### 2. After the orders have been downloaded, in the old WMS the outbound manager has to prepare a paper picking document and hands it over to the workers in charge in the warehouse. This procedure has been replaced now by real time data transfer between the outbound manager's computer and the picking worker's RDT scanner. This change in the way the picking is performed increased the efficiency of the transfer of the internal orders between the outbound manager and the workers inside the warehouse. The main advantages in this change are:

- A. Faster flow of orders between the outbound manager and the workers in the warehouse.
- B. Less room for errors: as orders now are electronically transferred to a number of workers simultaneously, whereas before the orders used to be on printed documents that are given first to the team leader who distribute them to a number of workers to conduct the picking.

- C. The cost of printing is not to be neglected, as each big file or rush file order is printed on approximately 400 pages therefore the cost of printing which includes the cost of paper itself, the cost of the ink cartridges, the cost of electricity consumed by the printers and the cost of maintenance to the printing machines is now reduced thanks to the electronic transfer of information.
3. The method in which the goods are putaway and stored in the warehouse directly affects the process of picking for the outbound orders. When the goods were stored in a random way without being related to a certain order or criteria, the picking process was done randomly too as the worker may have to pick one pallet or item in one section of the warehouse then drives to a another section to pick the following item on his picking list and then returns to the first location to pick another item, this random way of putaway and picking lead to losses in time and energy and therefore in money. The new system works according to certain criteria predefined by the company, leads to more efficient execution of the processes, for example ABC algorithm maybe defined as a criteria for putaway which facilitates picking process. This algorithm divides the goods into three categories A=fast movers, B=medium movers and C=slow movers, when implemented the goods that have high turnover rates - class A- are placed nearer to shipping dock and those that have medium turnover rate are placed in the middle of aisles and similarly the goods with low turnover are placed at the back end of the aisles. This along with the other criteria that are taken into account by the WMS have lead to more efficient and faster picking process.
  4. The grouping of pallets according to the predefined criteria along with the systematic way of storage of items in the putaway process has eliminated the previously common error of not finding a certain pallet in presumed location.
  5. The use of the merge rules functionality in the new WMS has opened new possibilities to increase the efficiency of the warehouse processes. The use of the SHIPDOCK rule explained earlier in the outbound process, has organized the order preparation process and it is used to confirm the loading process of the goods inside the trucks. The treatment of the big file and the rush file has become more efficient as the system automatically assigns the tasks to certain groups to conduct the picking of articles and pallets for the big file orders apart from the rush file orders through relating the time required for finishing the order with a sufficient number of workers.

6. The use of the clustering functionality made meeting the special requirements requested by some clients easier, for example some orders where certain types of articles need to be placed on top and others need to be placed on bottom when loaded in the trucks were done in an improvised manner in which the picking workers along with the controller were in charge of arranging them, this led to many errors and problems with the client, therefore the automation of these tasks through the clustering functionality have facilitated this process and lessened the chance for errors.
7. The control check process is now done in real time basis, in which the controller checks the picked pallets and articles and confirms the situation in his RDT scanner, in case problems were found the worker in charge is called and asked to correct the error and then the status is confirmed in the controller's scanner which is connected to the WMS system, therefore previous complicated paper work process has been eliminated and replaced by the real time data transfer.

Note: there were contractual changes between WEERTS and other stakeholders of the supply chain in addition to the changes of the WMS, for example in the old outbound process the loading of pallets was done either by WEERTS workers if the time of loading was before 18:00 hours otherwise the truck driver will be in charge of loading the pallets into the truck. In the new contract, WEERTS is in charge of this procedure no matter what the time of loading is, as can be seen in the outbound BPMN diagrams.

8. In the new process, the client is given better view on the progress of the process flow as the status is updated and sent to the client when the goods are fully picked, during which an EDI message informing the client that the goods are picked. Then when the goods are loaded inside the trucks another message is sent that the goods are "loaded" and shipped out of the warehouse. During the old WMS system the client had less visibility on the process flow and the only message that was sent to the client was when the whole process is complete and that the goods are ready to leave the warehouse.

### 5.3.3 Export process:

#### Tactical level

The export process is mainly composed of four activities that are quite similar to the normal outbound process from a tactical point of view. These activities are the same on the high tactical level but as we will see later below that the way they are performed is different, the figure below shows the tactical level activities of an export process:

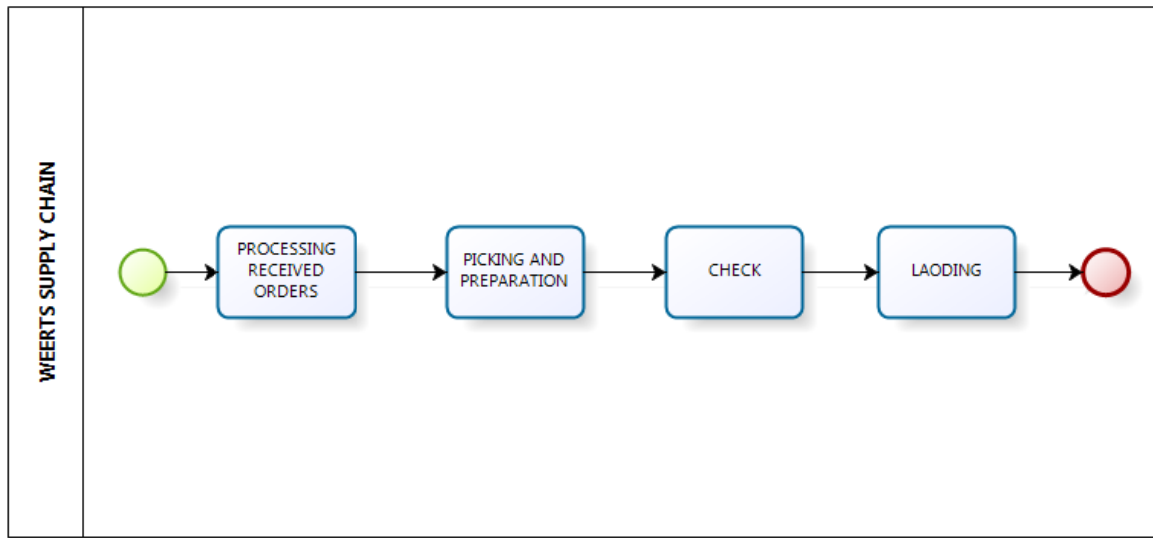


Figure 19 Tactical level of export process

#### Operational level

Apart from the fact the export outbound orders shall still be coming via e-mail, there have been many changes in the export process with the new WMS.

1. Like the local outbound process, the merge rules functionality helps relating each order to a certain gate in order to make sure that the picked items of a certain order have been loaded up in the right truck/container.
2. The selection of articles: After the order documents have been printed out of the order e-mail and the picking documents are printed out of the old WMS, the export manager has to manually tick off the items whose expiry date is within less than 9 weeks from the date of the order. After the New WMS has been installed, this activity is done automatically by the WMS through the allocation of orders functionality. This leads to better efficiency as the export manager can focus on more important tasks while this activity is automatically done by the system.



3. The picking of pallets inside the warehouse: This picking process is considerably more efficient than the previous procedure in the old WMS, as the RDT handset will show the exact location of the pallet that needs to be picked, therefore there will be no waste of time when the worker needs to look for the required pallet as before. Once all the pallets have been picked and prepared, the picking worker would have to stick pallet labels (etiquettes) on each pallet. Finally when all the order preparation is finished, a message is sent from the worker's RDT to the export manager that the pallets are picked and ready to be loaded. Note that this difference between the picking of pallets before and after the installation of RedPrairie WMS is quite analogous to the picking process in the local outbound operation.
4. The client has better visibility on the status of the order inside WEERTS facility, as it changes from "picked" to "shipped". Messages about each of these statuses are sent via EDI to the client's SAP system.
5. The real time data flow between export manager's computer inside the office to the worker's scanner has increased the efficiency of the process considerably as there's less room for errors, the process goes faster and the follow up takes place in real time between the worker and the manager.

#### 5.3.4 Copacking and Value Added Services

##### Tactical Level

The tactical level of the copacking and value added services is composed of five main activities which if were looked at from this tactical point of view, it will be noticed that these activities are the same whether an old WMS was used or a new one. These activities are:

**Processing received orders:** this refers to all the activities that include receiving an order from the client and the required administrative work to prepare this order.

**Production planning:** this refers to all the preparation of the production plan for the order to be prepared to the customer.

**Picking and preparation:** this refers to picking the material from the warehouse and sending them to the workshop for conducting the value added services.

**VAS and Copack:** this refers to all the activities included to produce a value added product according to the requests of the client.

**Receiving and Putaway:** once the new products (Value added products) are finished they are received and stored back in the warehouse.

The BPMN diagram below shows the value added services process in a tactical level.

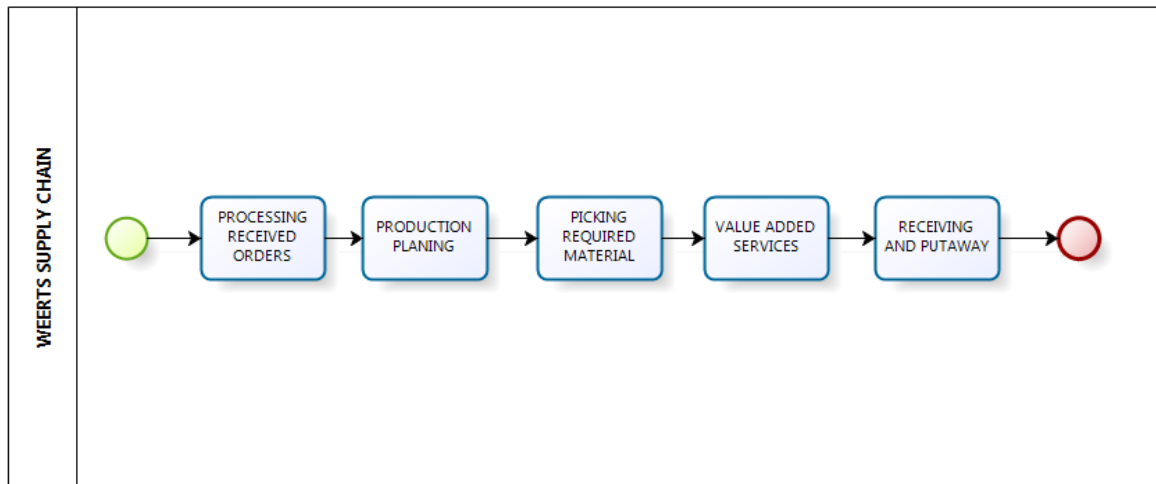


Figure 20 Tactical level of VAS and Copacking

### Operational Level:

As we saw above that the tactical level activities of VAS and Copacking process are unchanged regardless of the type of WMS used to manage these processes. But when we look into the operational detailed level of how these processes are being undertaken, we can observe that there are many changes inferred by the new WMS improving the way these processes are performed. However since that the activities in this process are composed of picking (outbound) and receiving and putaway (inbound), therefore the same points that we have discussed above in the inbound and outbound process apply here, therefore it would be unnecessary to list these differences again.

### 5.3.5 Inventory Management

#### Tactical Level

By studying the BPMN diagrams for the inventory management process I came to the conclusion that the inventory management process is the only process in this case study that has been changed in terms of tactical level procedures; “What needs to be done” as well as operational level procedures “How it should be done” after the installation of the new WMS. As we will see in the two BPMN diagrams below, that the old inventory management process was previously composed of two main tactical level activities which are:

1. Stop all warehouse activities: this refers to stopping all the other processes in the warehouse including the inbound, the outbound...etc.
2. Conduct the inventory management process: after all the other warehousing activities are stopped, the inventory management and control is performed.

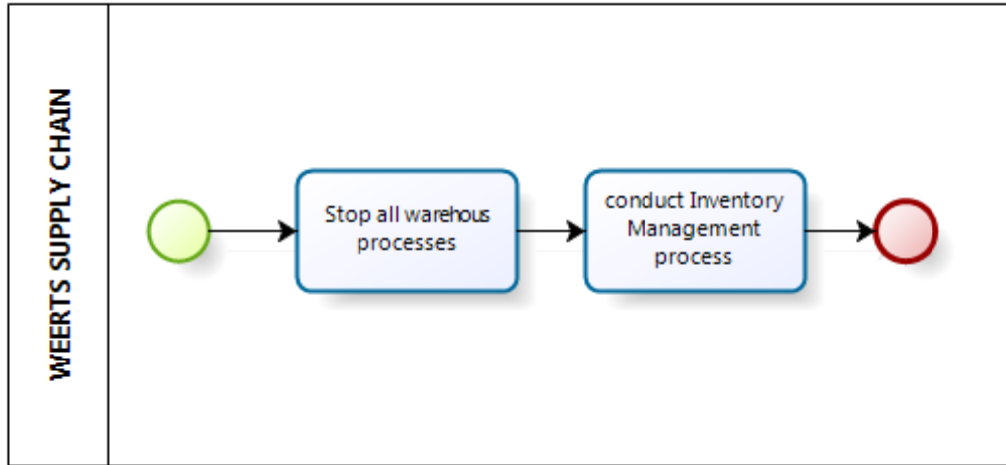


Figure 21 Tactical level of the old inventory Management process

After the installation of the new WMS, the inventory management processes became simpler at the tactical level as well as at the operational level. The new process is composed of only one main activity at the tactical level which is simply – conducting the warehouse management process – right away without a predecessor or a successor, as can be seen in the BPMN diagram below:

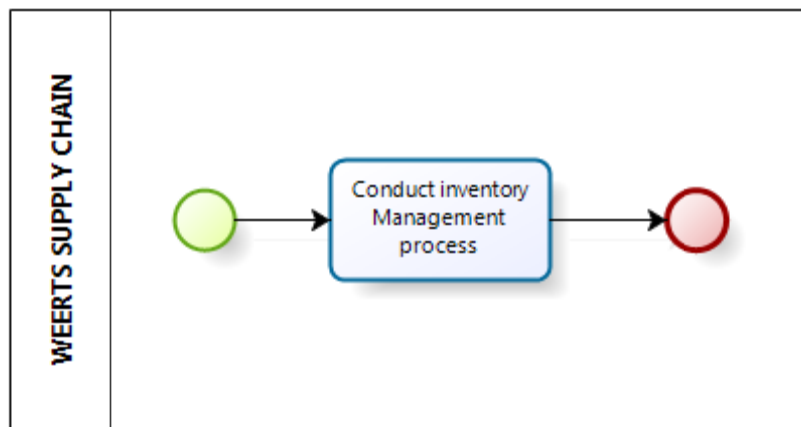


Figure 22 Tactical level of the new warehouse management process

### Operational Level

By analyzing the BPMN diagrams of the inventory management process at the operational level, it has been noticed that major differences been incited after the installation of the new WMS, inferring “How” the new process is performed. Below are the observed benefits.

1. After the installation of the new WMS from RedPrairie, the process of inventory management and control can be done without the need of blocking the system from receiving more orders from the client as used to be the situation before. Delays were caused to WEERTS because of that and exceptional pressure is required to catch the up the delayed orders when the check is complete. As the new WMS gives the possibility of conducting the control process during other process are still taking place inside the warehouse without interference with these processes.
2. The new inventory management process is more accurate and efficient as the system gives orders to the control worker on his RDT handset and if more than worker are required to perform the process according to the management decision, then the work can be divided in the WMS and allocated to the assigned workers in an efficient manner.
3. The new inventory management process is paper free as all orders and communication is done between the inventory manager’s computer and the worker’s RDT handsets on real time basis.
4. Due to the systematic way of the inventory storage that is guided by the system, there is less room for discrepancies between the physical count and the system count which makes the inventory management process go faster and smoother.
5. The RDT handsets are provided with cameras which gives the possibility for the control worker in the warehouse to take a picture for any damage and upload the picture to the company’s website<sup>19</sup>.

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<sup>19</sup> This functionality is not provided by Redprairie’s version that is installed in WEERTS, although the RDT scanners that were bought does contain a camera and they are connected to internet, therefore it is possible to use this functionality as a separate service.

## 5.4 Gap Analysis sheet

### ***What is the change in time and cost due to the new system?***

As we have seen in the beginning of this chapter that a set of performance indicators was used by WEERTS S.C to measure its performance levels, therefore we shall use these KPIs to draw a comparison in their levels and values before and after the installation of RedPrairie WMS and after it.

The KPIs that we shall use in our case here are related to the productivity levels and the time consumed to achieve a certain task, as this time has a reflection on two important measures; the first would be the cost of a certain activity to the company which means that the lower the cost is the more profit the company makes in this activity. The second measure that is affected by time, is the client's satisfaction because as we have seen above, after the installation of the new WMS the client has more visibility on the progress of the processes in the warehouse of WEERTS, therefore the shorter time consumed to perform a certain activity the more satisfied the client will be according to the bonus/malus rule.

The Export Process shall be considered as part of the outbound in general as it includes the same main activities (receiving orders, picking, loading) although there are some additional activities in the export like changing the pallet type, or covering the cartoons with airbags for protection but these activities will not be useful for the comparison as they still need to be done manually and in the same way regardless of the type WMS used in the company.

The inventory management process is done less often in the company than the other activities; therefore the processes that we shall use to draw out our comparison are the outbound process and the inbound process. This would also include the outbound and the inbound that is needed for the copacking and the value added services.

Now before moving to the explanation of the gap analysis sheet items, an important point has to be emphasized regarding the percentages that were used to calculate the cost per activity. Referring back to the "what-if" analysis sheet, the percentages used to calculate the cost and productivity of unloading, checking and putaway were: 16.67%, 16.67% and 66.67% respectively. These percentages were given by the company and they are used in the costing system. They are now referred to as – situation A – in the gap analysis sheet. On the other hand – situation B – refers to the percentages that were calculated based on the current productivity levels of each activity in the inbound process

which gives us a more detailed insight on the configuration of activities in the whole inbound process. These actual levels of productivity are identified by the red rows in the “what-if” analysis sheet that we saw earlier. Table 1 below shows how the new percentages – situation B – were calculated.

Activity	Actual time consumed (seconds)	Percentages
Unloading one pallet	60	33%
Checking one pallet	20	11%
Putaway one pallet	103	56%
Total	183	100%

Table 1 Calculation of situation B percentages of inbound process

Another point that requires attention here is that the KPI sheet that is used by the company contains only the total number of hours used in the inbound process per week without breaking it down by the activities comprising the whole process, therefore the above percentages were used to calculate the time consumed in each activity of the inbound.

In the outbound process, the percentages used by the company to allocate the costs to activities were 50% picking and 50% loading regardless of the type of picking that was done, given that each outbound process is composed mainly of picking activity plus loading activity. However the calculations which were based on the actual productivity levels of each activity as we saw earlier in the red rows of the outbound process in the “what-if” analysis have shown different percentages for each type of picking. Table 2 below shows the actual percentages per activity for different types of picking in the outbound process.

Outbound process			Total
Outbound with case picking only	Time to pick a case	Loading time needed	
	14.4	90	104.4
	Picking percentage	time to finish and load pallet	
	14%	86%	100%
Outbound with line picking only	time to pick a line	time finish and load a pallet	
	180	90	270
	Picking percentage	Loading percentage	
	67%	33%	100%
Outbound with Full Pallet picking only	time to pick a pallet	time to load a pallet	
	162	90	252
	Picking percentage	Loading percentage	
	64%	36%	100%

Table 2 Actual percentages calculated in the outbound process

In addition to that, the outbound process is more complicated than the inbound as each outbound order may contain different types of picking activities (case picking, line picking and/or full pallet picking) and after the picking is finished a concurrent loading is performed for all the pallets without differentiating the pallets that were fully picked from those that were done by case picking or line picking activities. Due to these inconsistencies from one outbound process to another it is not possible to calculate the total weekly productivity of the outbound process as a whole, as each outbound process maybe composed of different levels of the three types of picking, therefore the productivity levels are taken individually. The KPI sheet that the company uses contains only individual values for each activity of outbound.

#### 5.4.1 Inbound Process comparison

The table is generally divided into two sets of rows comprising the situation and the values before and after the installation of the new WMS. The values taken are for 10 weeks before the installation and 10 weeks after the installation, each row represents the values of a certain week. Due to a user error that was done by one of the employees in the company the values of 2011 were defected and this lead to an inconsistency in the values of these items, therefore I have used arbitrary values

assuming the same number of pallets were received as those in the corresponding week in the inbound process before the installation of RedPrairie. The time needed to perform an operation was assumed to be less and therefore productivity is higher and cost is lower. Despite the assumed values still this sheet can be used for benchmarking of KPIs and compare their values from one period to another.

The columns in the analysis sheet correspond to the following:

1. Week Number: this corresponds to the week number of the year, the weeks that I have selected were from Week 15 -2010 which is the first week the KPI excel sheet was used in WEERTS and then nine more weeks of 2010. The same weeks were chosen in 2011 starting from Week 15 and all the way to week 24.
2. There are three sets of columns with three different colors; each set represents an activity in the inbound process. The purple refers to "Unloading", the blue refers to "Checking" and the green refers to "Putaway".
3. Total pallets Unloaded: this corresponds to the total number of pallets unloaded during that week.
4. Working hours spent: this refers to the total amount of working hours spent to unload the above pallets, regardless of the number of workers used. As can be seen on the excel sheet that there are two columns carrying different values for the number of hours spent. These values are based on the percentage used to calculate the working hours. The formula used in this calculation is:  
$$\text{Time spent on unloading} = \% \text{ unloading (A or B)} \times \text{Total time spent on inbound (hours/week)}.$$
5. Unloading productivity: this is an amount calculated by dividing the number of pallets unloaded per week by the number of working hours spent to unload those pallets during that week.
6. Cost of Unloading: it refers to the cost of the unloading activity, calculated by multiplying the total cost per hour (including labor cost and machinery) by the time spent on the unloading activity.
7. In the same way the productivity and cost of check activity and the putaway were calculated for each week. And then compared to their values after RedPrairie was installed.



Example showing the calculation of time spent for unloading, productivity and cost: Week 15 – situation – A –.

Time spent on unloading = total working hours of the inbound for that week (55.29) x 16.67% = 9.22 hours.

Unloading Productivity Pal/hr = pallets unloaded/week (1428 pallets) x time spent on unloading (9.22 hours) = 155 pal/hr

Cost of unloading = total cost per hour (€ 29.63) x time spent on unloading (9.22 hours) = € 273

- 8. Time spent on inbound: this is the total time spent to perform all the inbound activities in the warehouse (excluding administrative works) during each week. The value is calculated by the amount of working hours that the workers have to fill in their time sheets. This data is taken from the company’s KPI sheet.

The charts in figure 23, 24 and 25 below show the differences between the inbound costs before the installation of RedPrairie WMS and after it was installed. These charts are based on the above sheet calculations and only (situation B) which refers to percentage values of calculation that were calculated earlier.

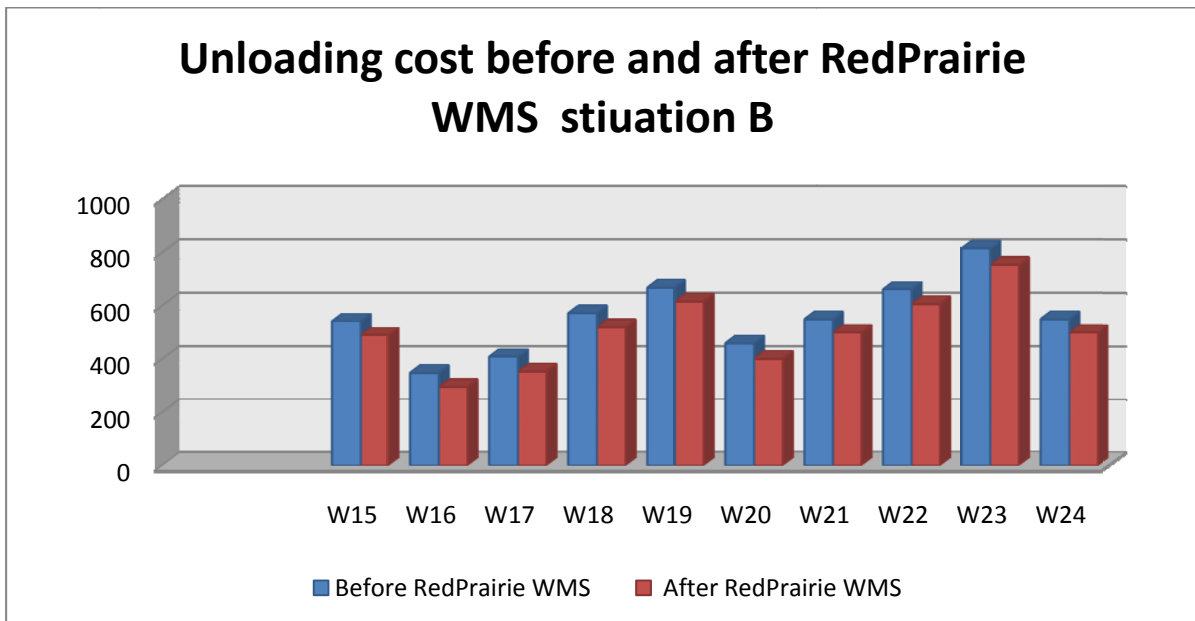


Figure 23 Unloading Cost Gap Analysis

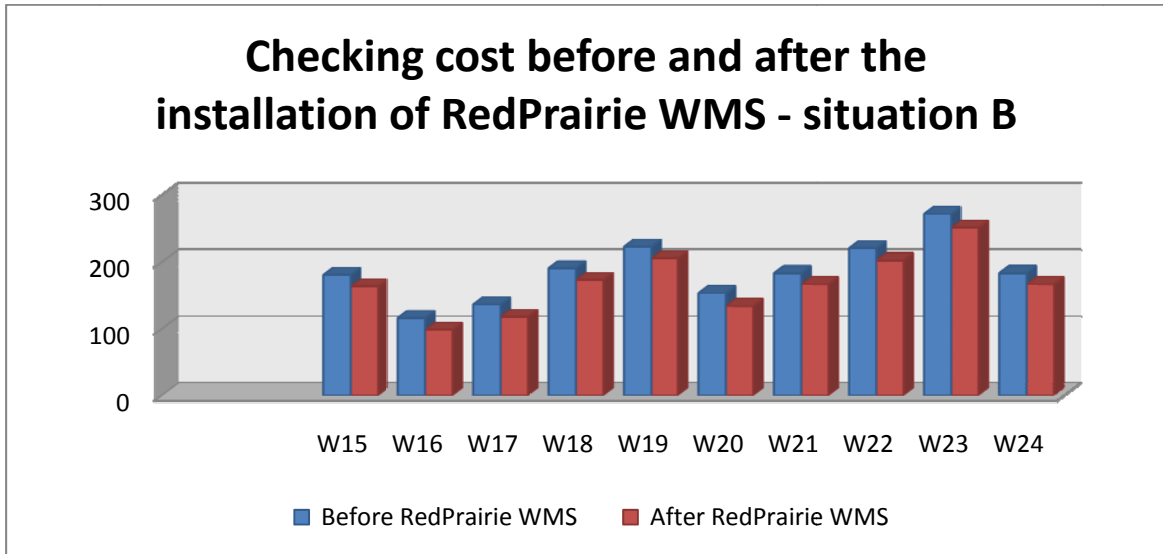


Figure 24 Checking Cost gap analysis

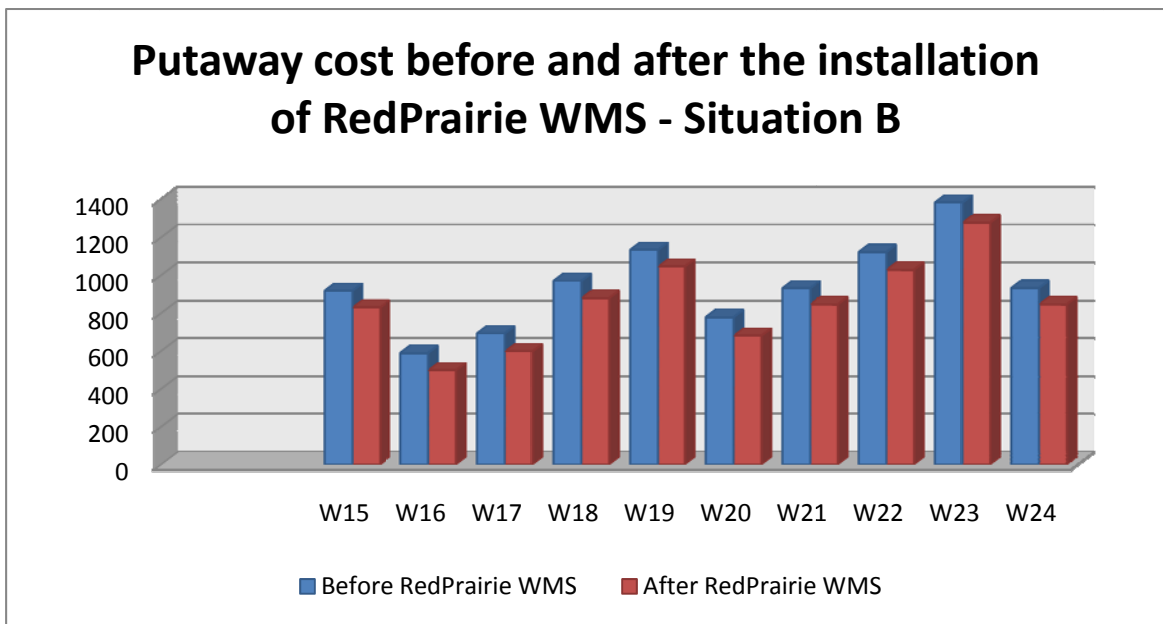


Figure 25 Putaway cost gap analysis

### 5.4.2 Outbound Process comparison

Like the inbound process table, it is divided into two sets of rows. Each row refers to a certain week as we will see below. Due to the same reason mentioned earlier regarding the error in filling in the KPI sheet, the values that were filled-in in the rows after RedPrairie's installation are arbitrary values assumed on the fact that this new WMS is more efficient and therefore the time required to perform an activity is shorter and productivity is therefore higher leading to less cost per activity.

The columns in the outbound analysis sheet refer to the following:

1. Week Number: this corresponds to the week number of the year, the weeks that I have selected were from Week 15 – 2010 which is the first week the KPI excel sheet was used in WEERTS and then nine more weeks of 2010. The same weeks were chosen in 2011 starting from Week 15 and all the way to week 24.
2. There are four sets of columns in the outbound process table; each set represents a certain activity in the outbound process. The purple, the blue and the green refer to the types of picking taking place including case picking, line picking and full pallet picking respectively. The orange row refers to the pallets loading activity.
3. Articles picked: this column refers to the number of articles picked individually, i.e. individual boxes picked and placed on a pallet.
4. Time of picking: this refers to the total number hours required to pick cases and place them on pallets per week.
5. Case picking productivity: this refers to the productivity level for this picking activity, it is calculated by dividing the number of articles picked per week by the total working hours required for article picking during that week.
6. Cost of article picking: is the cost of article picking during that week, it is calculated by multiplying the time required for picking by the hourly cost times the percentage of this activity from the outbound process. Note that the costs are calculated on different levels using different percentages; situation – A – refers to the percentages that were taken from the company as given values, while situation – B – refers to the percentages that were calculated based on the current productivity levels as explained above.
7. In the same way the productivity and the cost of line picking, full pallet picking and loading of pallets in trucks or containers were calculated. With regards to the loading activity we can see that there are four cost columns with different values. The first column (Cost of Loading – A –) this refers to the cost of loading when the percentage of loading activity makes 50% of the whole outbound process as in situation –A- for all the types of picking identified. Each column of the other three cost columns refer to the

loading cost when the percentage of loading is calculated based on the actual productivity level and it completes the corresponding percentage of the picking activity.

The charts in figure 26, 27, 28 and 29 below show the differences between the outbound costs before the installation of RedPrairie WMS and after it was installed. These charts are based on the above sheet calculations and only (situation B) which refers to percentage values of calculation that were calculated earlier.

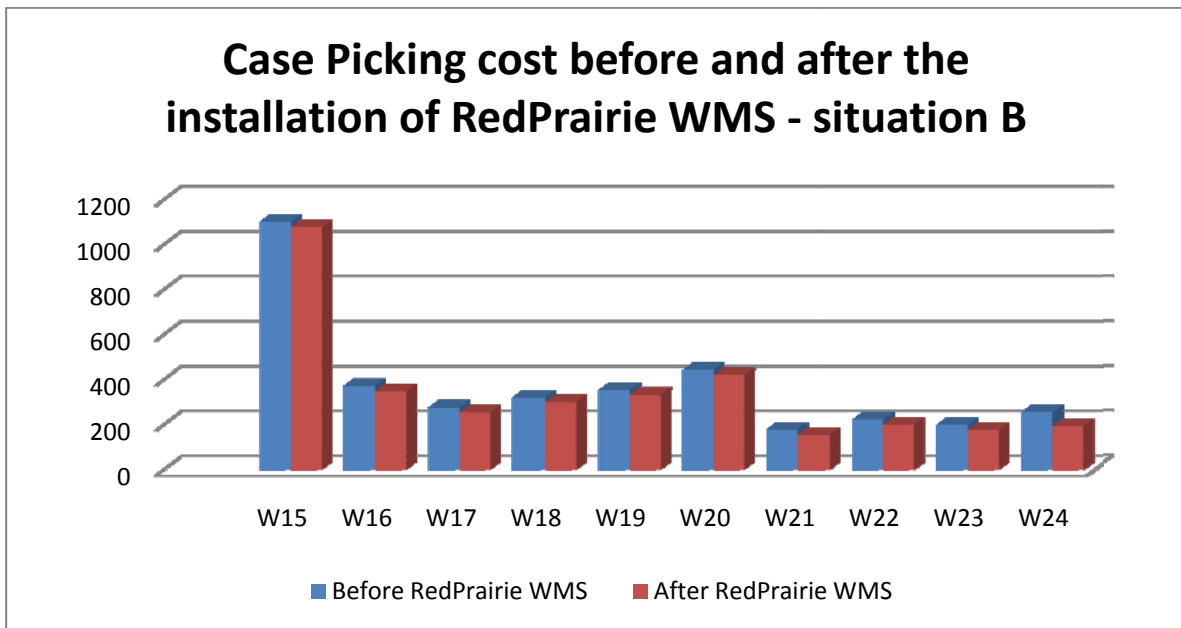


Figure 26 Case picking cost gap analysis

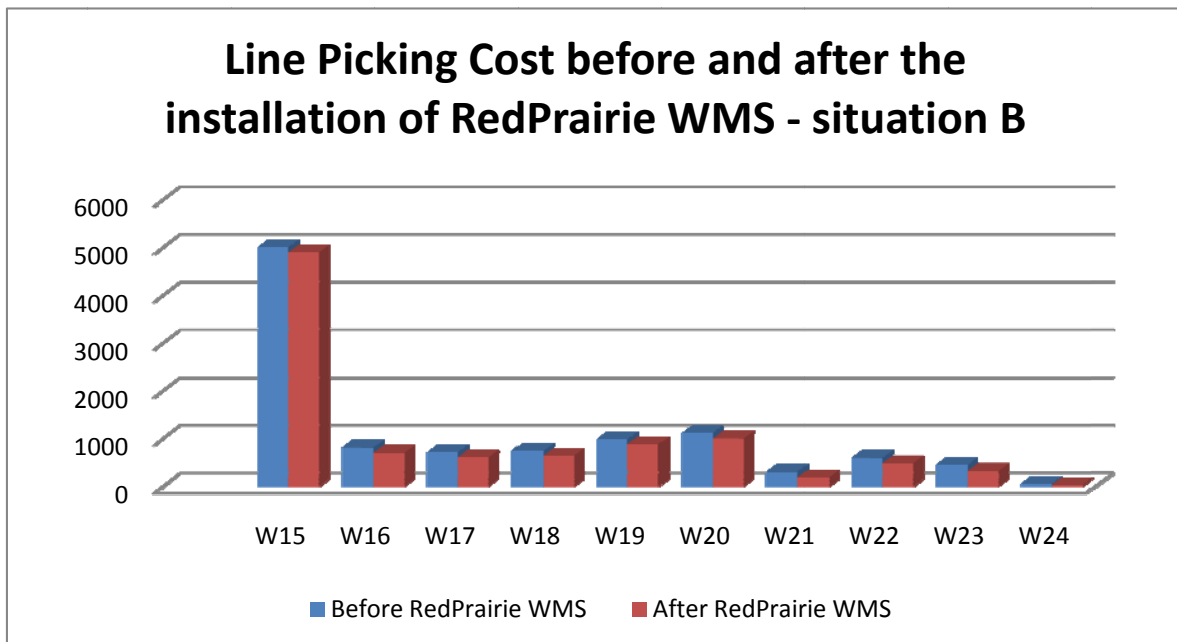


Figure 27 Line Picking cost gap analysis

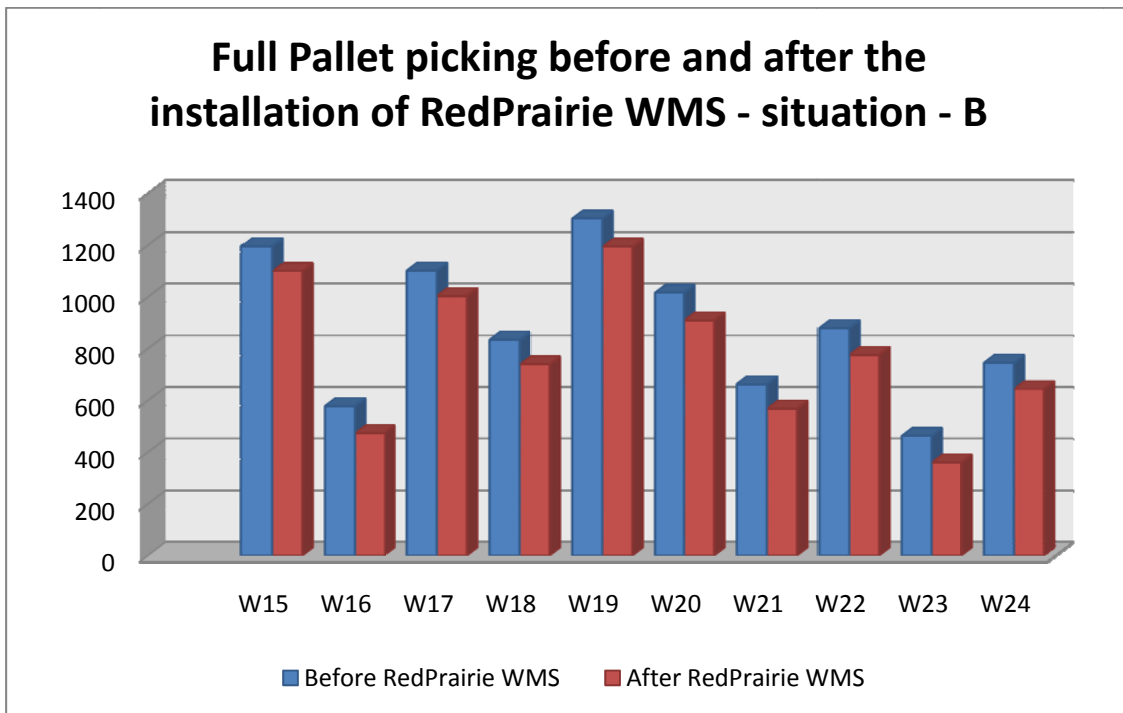


Figure 28 Full pallet cost gap analysis

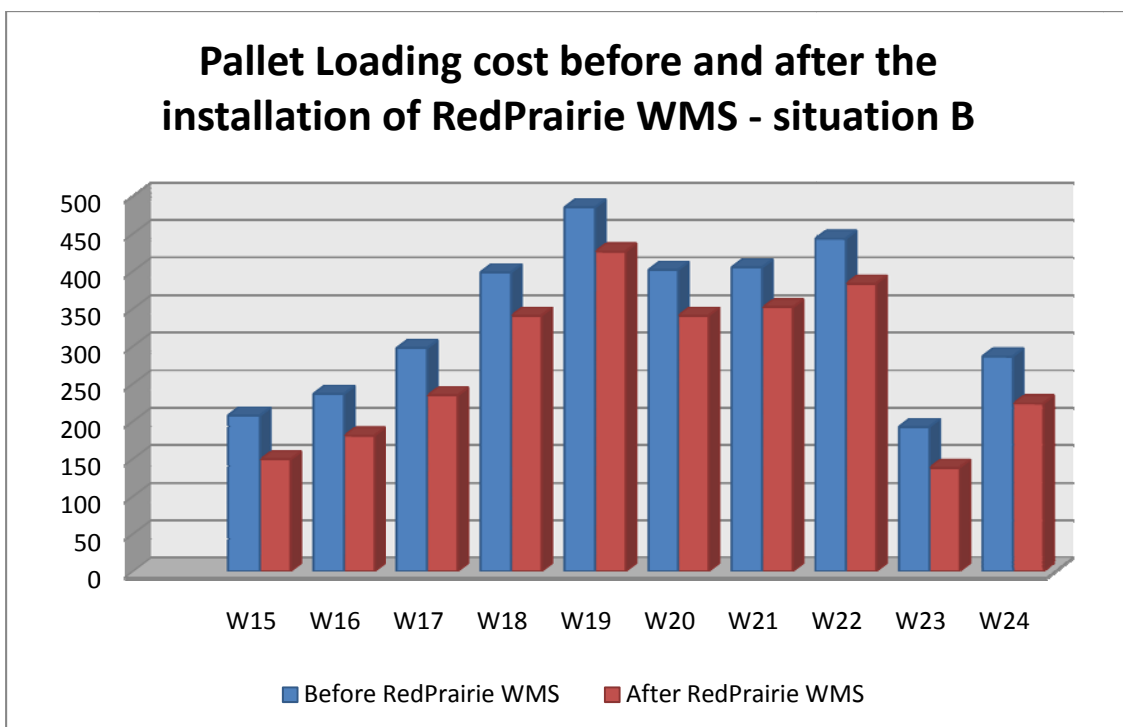


Figure 29 Pallet loading cost gap analysis



## Chapter – 6 – Conclusion and recommendations

By studying these As-Is models that I have developed with BPMN, I have been able to identify the road blocks and the points where inefficiencies were taking part place in each process. Based on these models, along with studying the processes of the new warehouse management system from RedPrairie, I have been able to set up the To-Be models. These models where quite helpful to demonstrate how the processes are going to be in the future.

While setting up the To-Be models, I used drafts of these diagrams to discuss certain activities with the employees in charge and then take their input to be discussed with the management and with the consultants during the integration process, until the final version has been developed. This means that the use of BPMN diagrams were helpful in providing migration models to be used for discussion and analysis with the stakeholders.

The use of BPMN diagrams helped in making gap analysis between the two situations, (i.e. before the installation of RedPrairie WMS and after it). This gap analysis was based comparing each process with it how it should be done after the new WMS is installed. Two levels of BPMN diagrams were used to compare each process; tactical and operational. It has been noticed that all the processes were not changed at the tactical level (except the inventory management process) but when we investigated them at a more detailed operational level we saw that there were major differences between the old model and the new one.

No empirical values were possible to be used in these diagrams. The use of empirical values for the gap and what-if analysis that we saw earlier in this thesis were done separately using Excel sheets. It is therefore, intriguing to make further research in the future weather BPMN technology can be used for empirical analysis, not necessarily with Bizagi software but maybe with another BPMN tool like the one provided by IBM, which wasn't possible to use it in this case study as this tool is for professional use and is costly that cannot be used for an academic purpose.

Further recommendation and not related to BPMN issue, is to make a "What-if" analysis if ERP system was used for managing the warehouse operation in WEERTS Supply Chain instead of a sophisticated WMS like the one provided by RedPrairie, specially that the main client of WEERTS supply chain is KRAFT food which use SAP for managing their operations and given that one of the major problems that were faced by the installation team is integrating the message transfer between SAP and RedPrairie WMS. Therefore would it be a wiser solution for WEERTS to use SAP modules instead and save all the time lost in the integration problems and the extra costs of consultancy?

Would it be less costly on the long run as well as the short run? This is my recommendation for further research to be done in WEERTS Supply Chain.

The Gap Analysis sheet can be used on continual basis, as long as the company guards its KPI values and notes them down in an efficient manner. The company can choose one week as a bench mark even by assuming certain level of productivity and can compare its productivity levels with reference to that level in order to continuously improve its performance.



## References

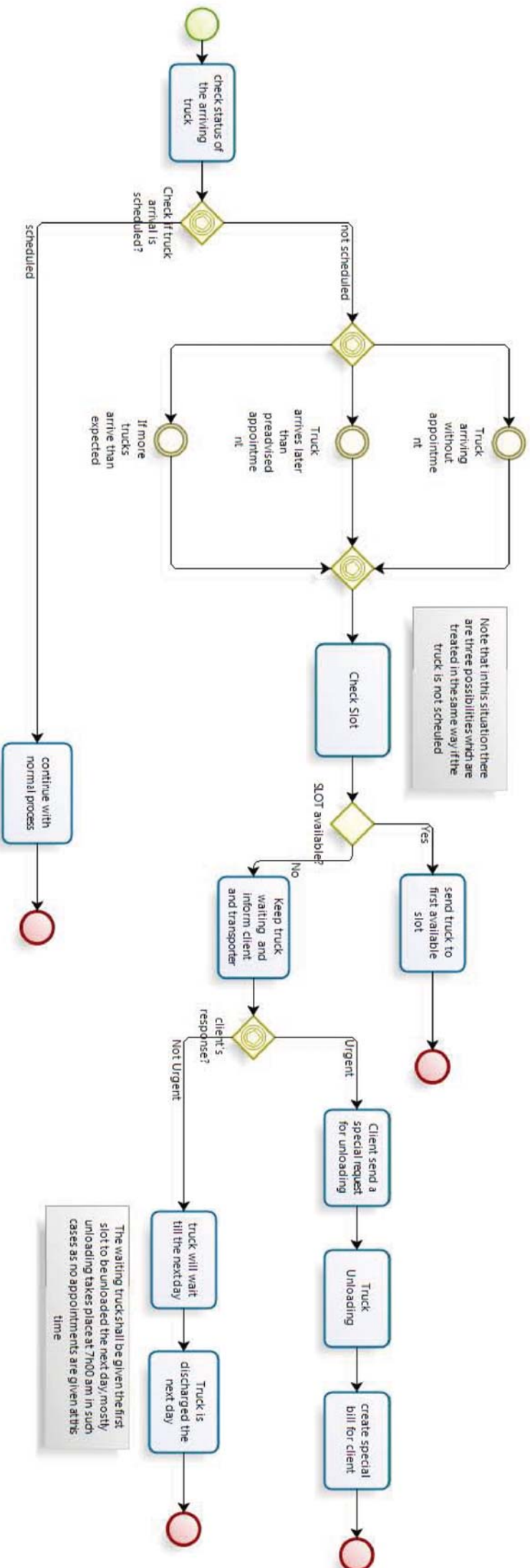
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- Bizagi website: <http://www.bizagi.com/>
- Weerts supply chain website : <http://www.weerts.be/>

## Appendices

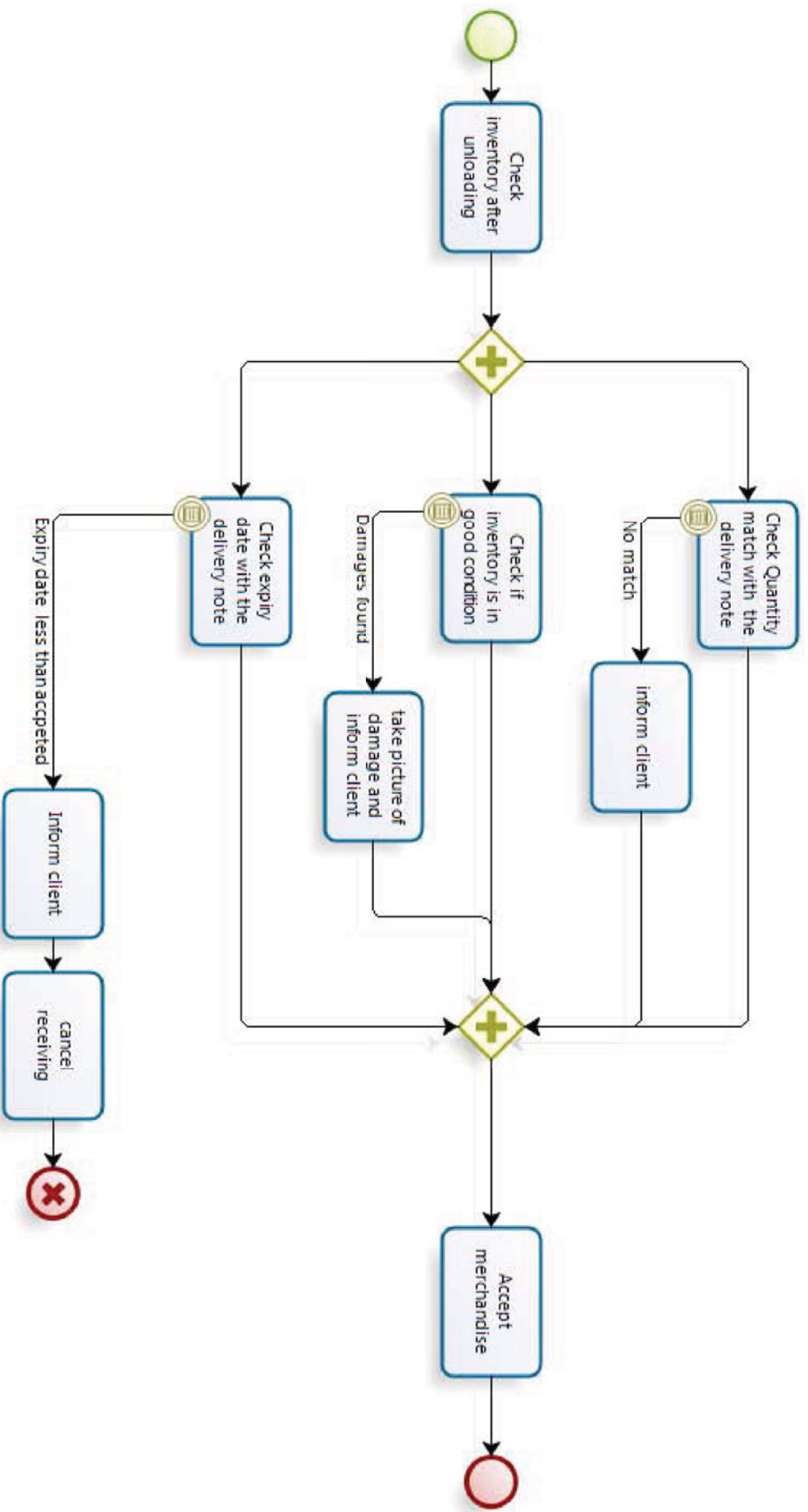
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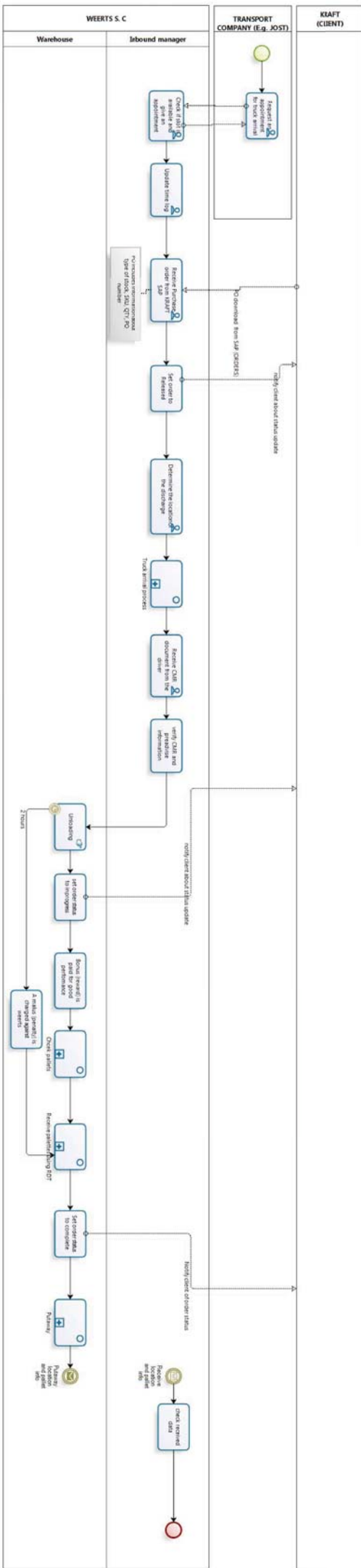


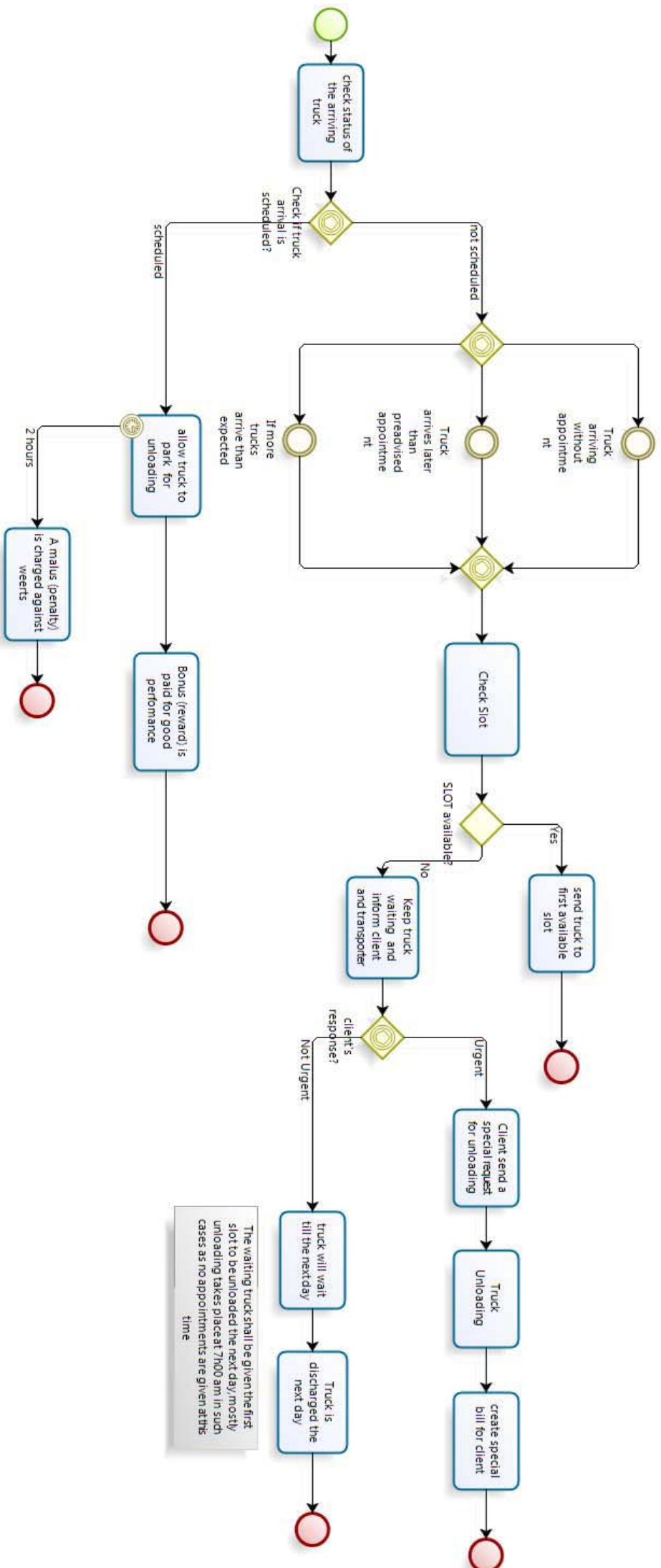


Old inbound process/truck arrival sub-process

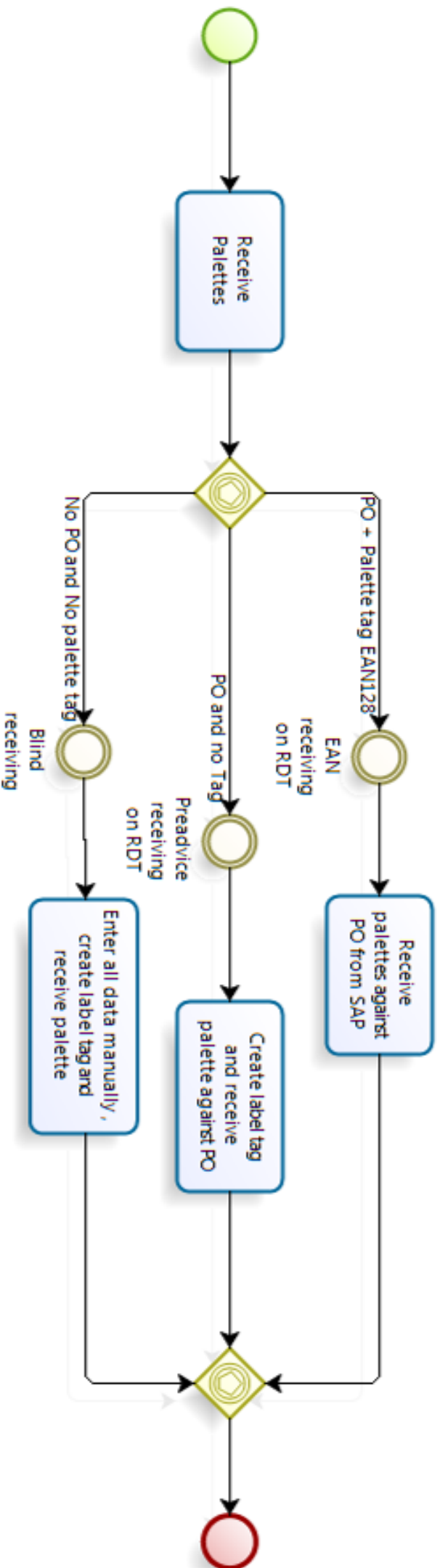


Old inbound process/Pallets check sub process



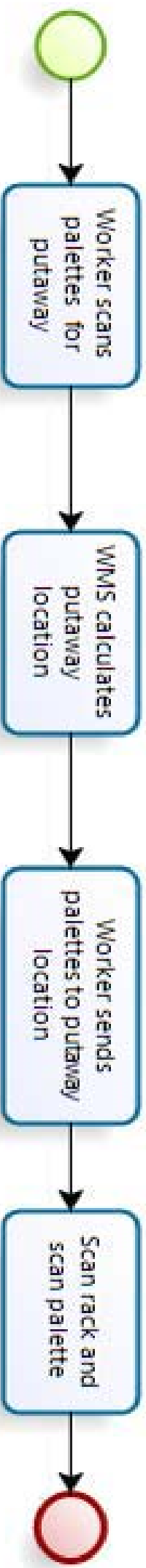


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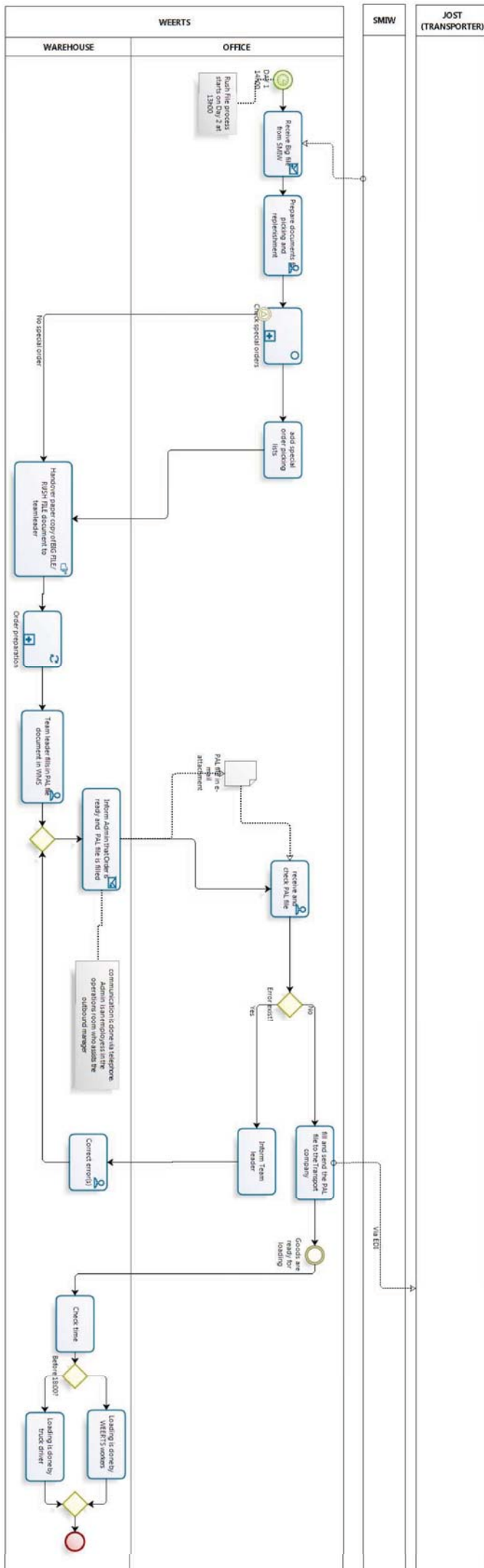


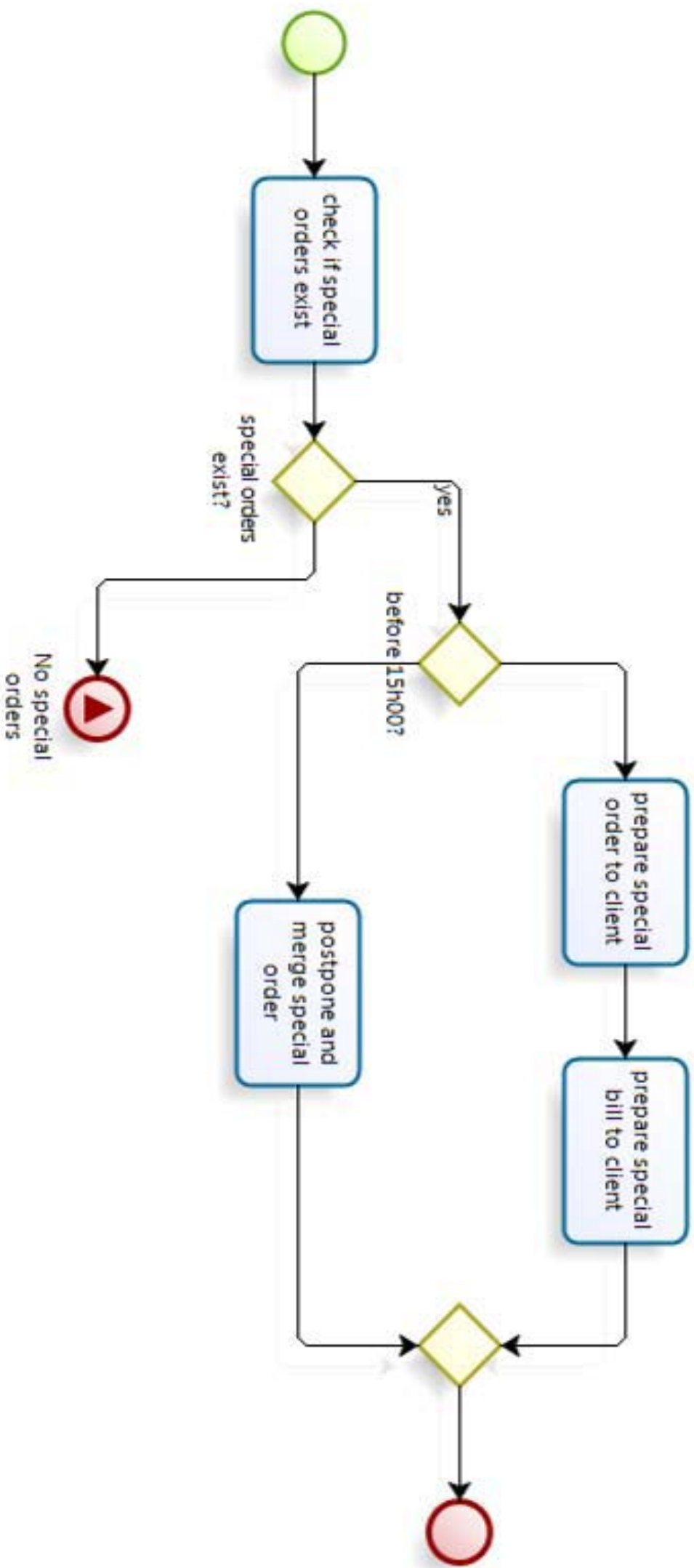
New inbound process/Receiving pallets with RDT sub-process





## New inbound process/putaway sub process

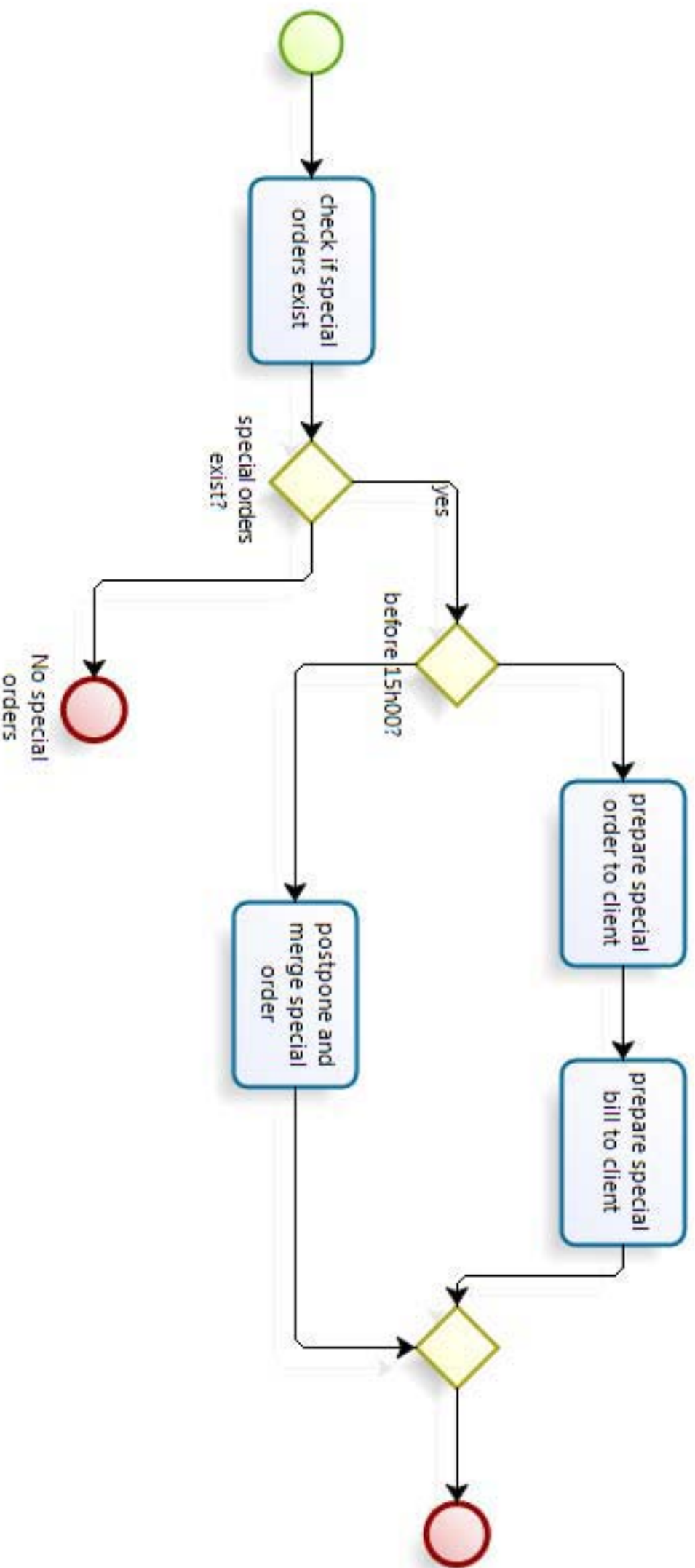




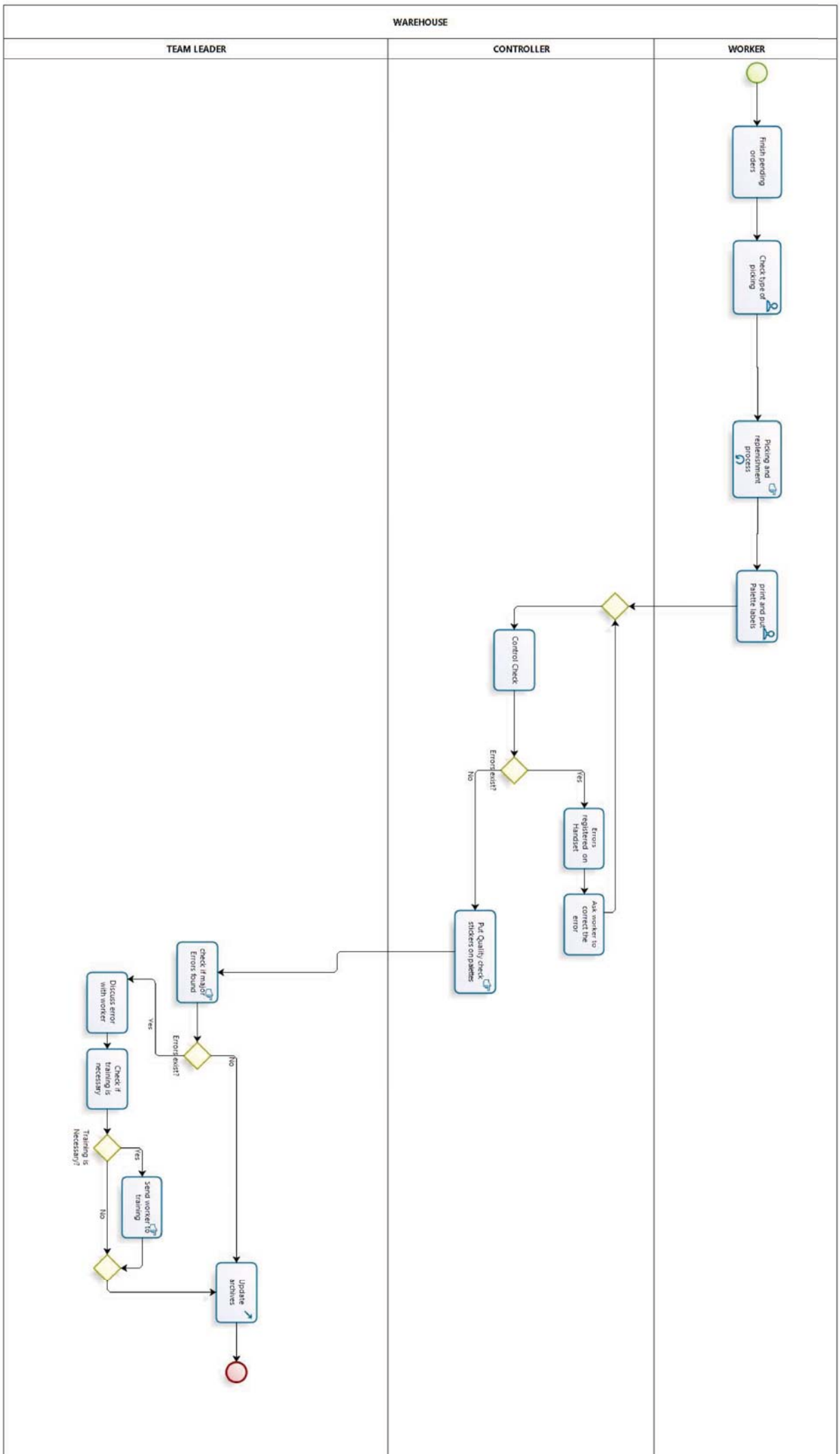
Old outbound process/special orders sub-process







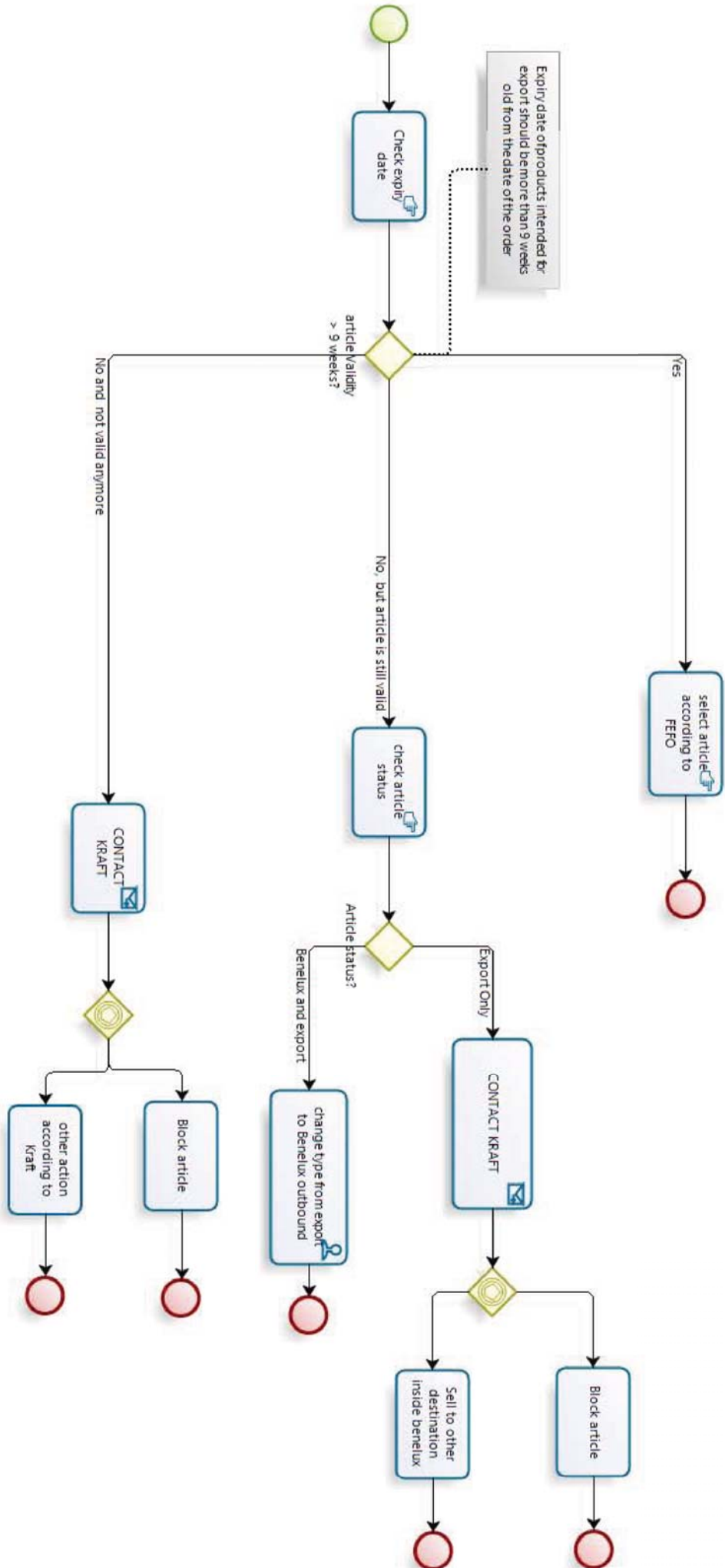
New outbound process/ allocation of orders sub-process

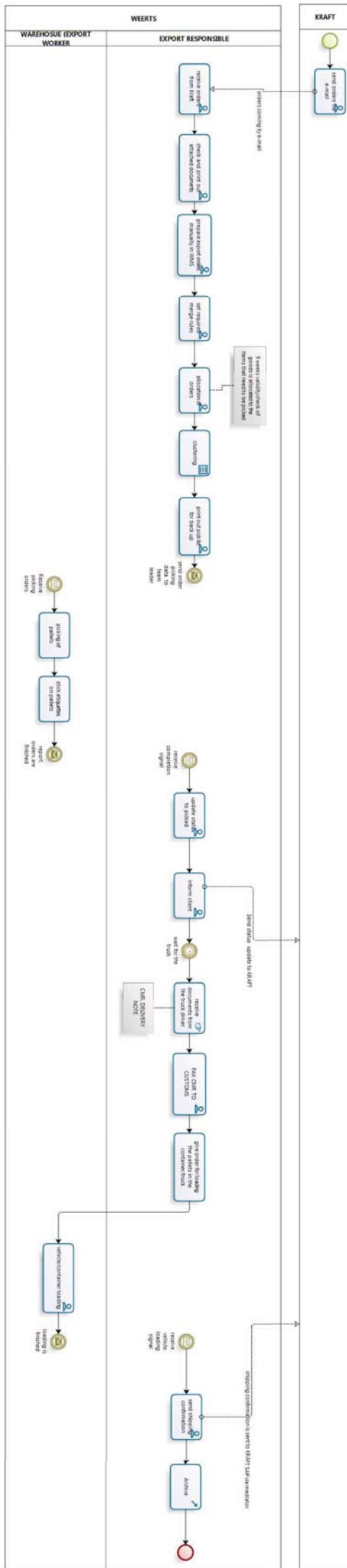




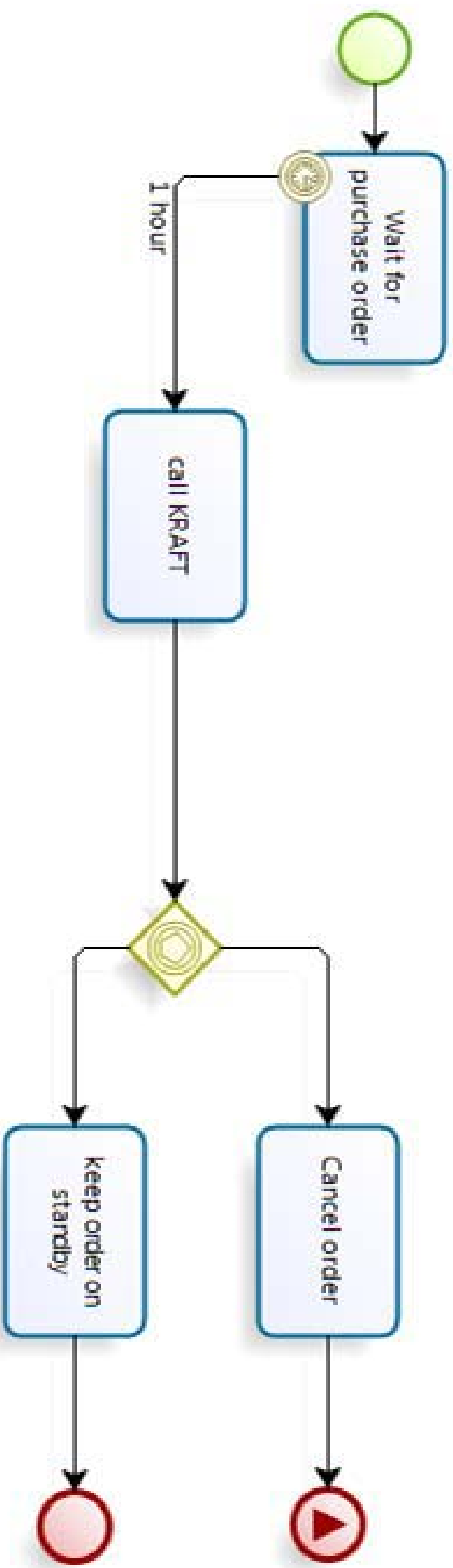


# Old Export process/ article selection sub-process



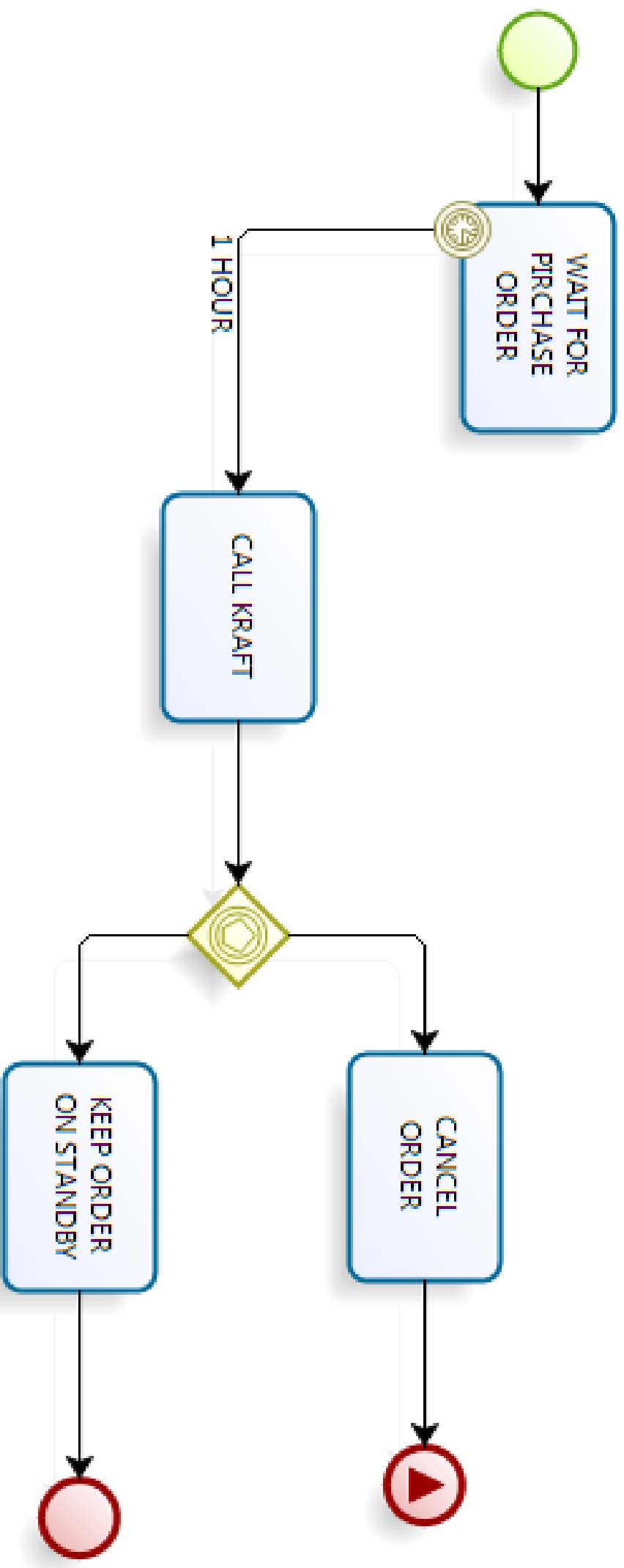




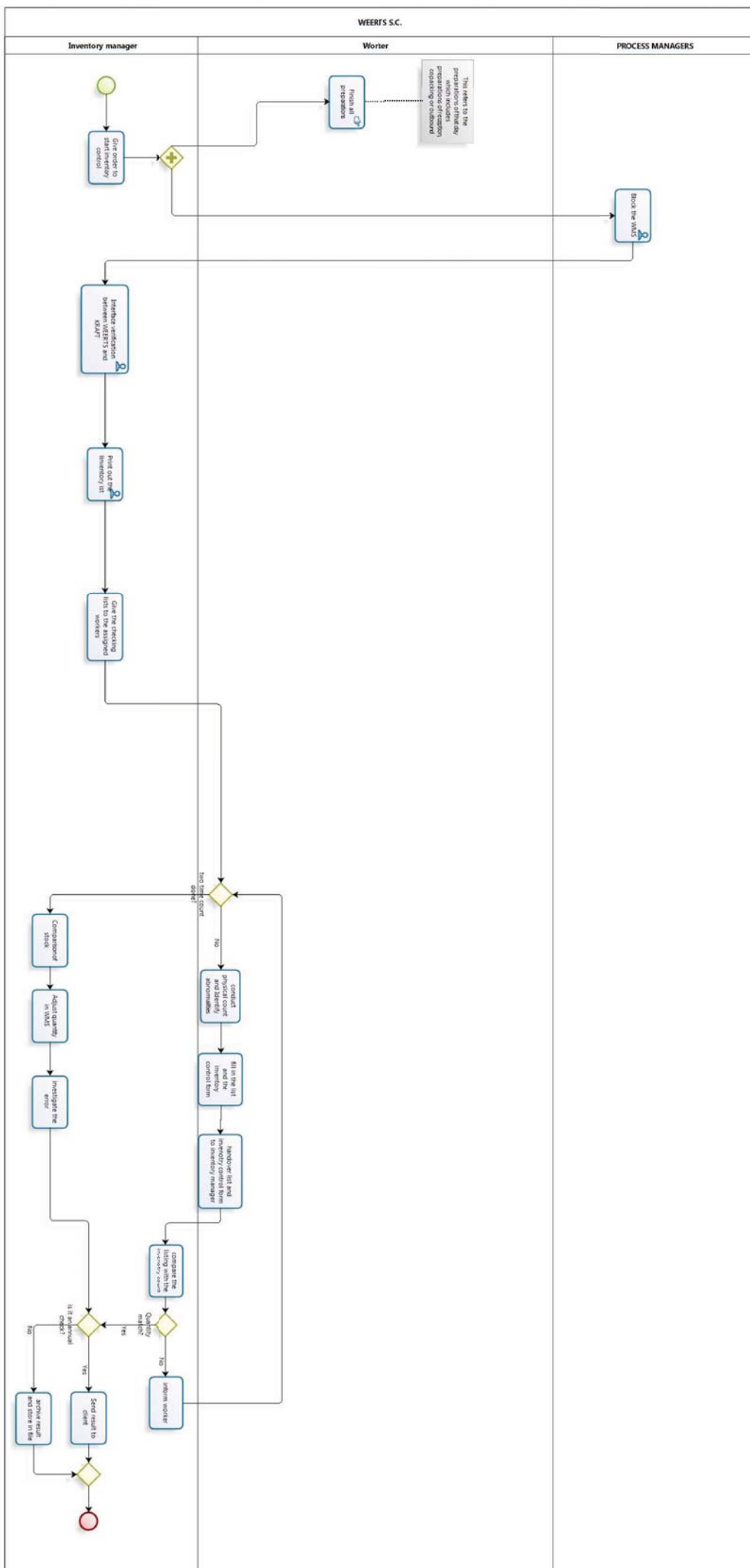


Old Copacking & VAS / waiting for the PO sub-process

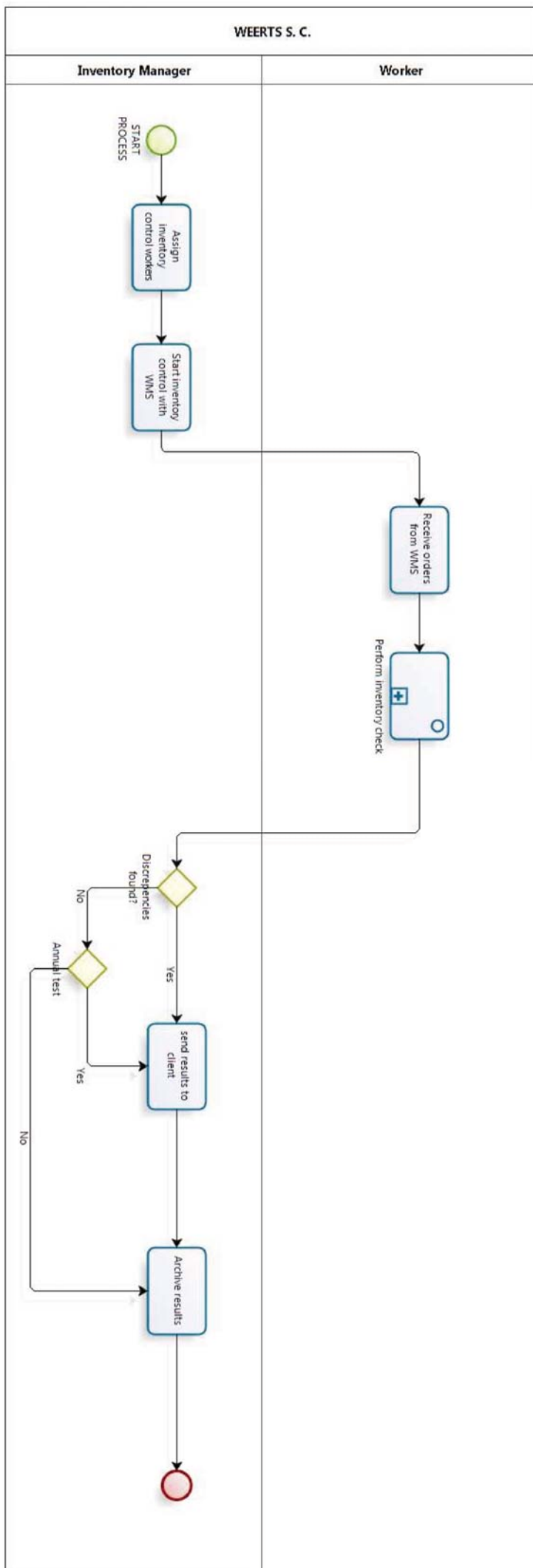




New Copacking & VAS process / Waiting for the PO sub-process

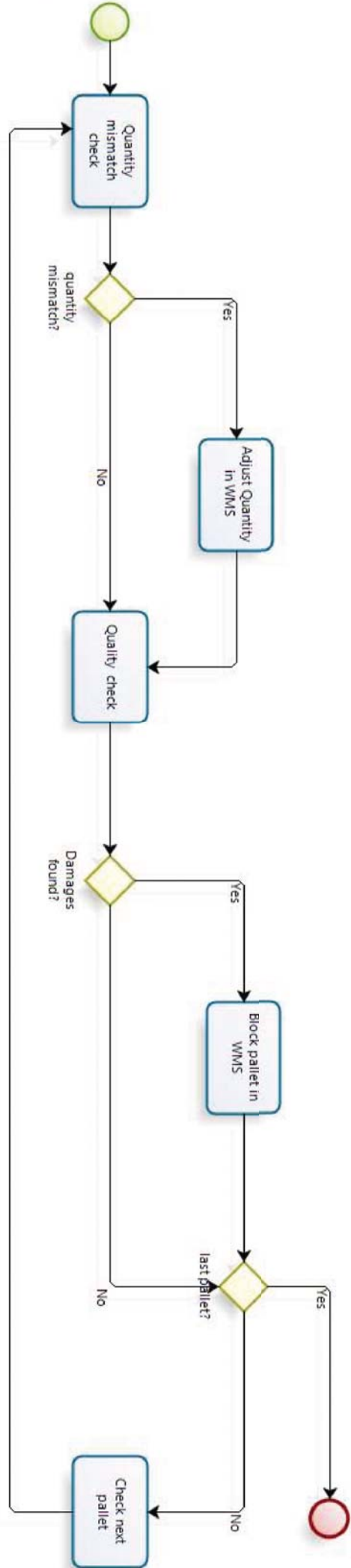


Appendix -10- New Inventory management process





# New Inventory Management process/inventory check sub-process



Appendix - 11  
What-if Analysis - inbound process

Parameters							
Old Prices		New Prices		Activity Percentage			
Unloading and checking	€ 0.85253	Unloading and checking		Working Hours	7.50	Unloading %	16.67%
Putaway	€ 1.7051	Putaway		Salary cost/hour	€ 25.00	Check %	16.67%
Total	€ 2.55758	Total	€ 0.74	Additional <sup>1</sup> cost/hour	€ 4.625	Putaway %	66.67%

PALLETS UNLOADING

Assumption	Time of pallets unloading (seconds) per pallets	Productivity pallets unloaded per worker/ hour	Working hours/day	productivity per day	Salary cost/hour <sup>2</sup>	Additional cost/hour <sup>3</sup>	Total cost/hour	cost/ pallet	Old Price		New price	
									Price / pallet	profit / pallet	Price/pallet	Profit/pallet
A	20	180	7.5	1350	€ 4.17	€ 0.77	€ 4.94	€ 0.03	€ 0.43	€ 0.40	€ 0.12	€ 0.10
B	30	120	7.5	900	€ 4.17	€ 0.77	€ 4.94	€ 0.04	€ 0.43	€ 0.39	€ 0.12	€ 0.08
C	40	90	7.5	675	€ 4.17	€ 0.77	€ 4.94	€ 0.05	€ 0.43	€ 0.37	€ 0.12	€ 0.07
D	50	72	7.5	540	€ 4.17	€ 0.77	€ 4.94	€ 0.07	€ 0.43	€ 0.36	€ 0.12	€ 0.05
E	60	60	7.5	450	€ 4.17	€ 0.77	€ 4.94	€ 0.08	€ 0.43	€ 0.34	€ 0.12	€ 0.04
F	70	51	7.5	386	€ 4.17	€ 0.77	€ 4.94	€ 0.10	€ 0.43	€ 0.33	€ 0.12	€ 0.03

GOODS CHECK

Assumption	Time of pallets check (seconds) per pallet	Productivity pallets checked per worker/hour	working hours/day	productivity per day	salary cost/hour	Additional cost/hour	Total cost/hour	cost/pallet	Old Price		New price	
									Price / pallet	profit / pallet	Price/pallet	Profit/pallet
A	10	360	7.50	2700	€ 4.17	€ 0.77	€ 4.94	€ 0.01	€ 0.43	€ 0.41	0.12	0.11
B	20	180	7.50	1350	€ 4.17	€ 0.77	€ 4.94	€ 0.03	€ 0.43	€ 0.40	0.12	0.10
C	25	144	7.50	1080	€ 4.17	€ 0.77	€ 4.94	€ 0.03	€ 0.43	€ 0.39	0.12	0.09
D	30	120	7.50	900	€ 4.17	€ 0.77	€ 4.94	€ 0.04	€ 0.43	€ 0.39	0.12	0.08
E	35	103	7.50	771	€ 4.17	€ 0.77	€ 4.94	€ 0.05	€ 0.43	€ 0.38	0.12	0.08
F	40	90	7.50	675	€ 4.17	€ 0.77	€ 4.94	€ 0.05	€ 0.43	€ 0.37	0.12	0.07

GOODS PUTAWAY

Assumption	Time of pallets putaway (seconds) per pallet	Productivity pallets putaway/hour	working hours/day	productivity per day	salary cost/hour	Additional cost/hour	Total cost/hour	cost/pallet	Old Price		New price	
									price/pallet	Profit/pallet	price/pallet	Profit/pallet
A	50.0	72	7.50	540	€ 16.67	€ 3.08	€ 19.75	€ 0.27	€ 1.71	€ 1.43	€ 0.49	€ 0.22
B	60.0	60	7.50	450	€ 16.67	€ 3.08	€ 19.75	€ 0.33	€ 1.71	€ 1.38	€ 0.49	€ 0.16
C	70.0	51	7.50	386	€ 16.67	€ 3.08	€ 19.75	€ 0.38	€ 1.71	€ 1.32	€ 0.49	€ 0.11
D	90.0	40	7.50	300	€ 16.67	€ 3.08	€ 19.75	€ 0.49	€ 1.71	€ 1.21	€ 0.49	€ 0.00
E	103.0	35	7.50	262	€ 16.67	€ 3.08	€ 19.75	€ 0.57	€ 1.71	€ 1.14	€ 0.49	-€ 0.07
F	120.0	30	7.50	225.00	€ 16.67	€ 3.08	€ 19.75	€ 0.66	€ 1.71	€ 1.05	€ 0.49	-€ 0.17

TOTAL PROFIT OF INBOUND

Assumption	OLD PRICE			NEW PRICE SINGLE STACK		
	Total cost per unit of inbound	Total Price per unit of inbound	Total profit of inbound per unit	Total cost per unit of inbound	Total Price per unit of inbound	Total profit of inbound per unit
A	€ 0.32	€ 2.56	€ 2.24	€ 0.32	€ 0.74	€ 0.42
B	€ 0.40	€ 2.56	€ 2.16	€ 0.40	€ 0.74	€ 0.34
C	€ 0.47	€ 2.56	€ 2.08	€ 0.47	€ 0.74	€ 0.27
D	€ 0.60	€ 2.56	€ 1.95	€ 0.60	€ 0.74	€ 0.14
E	€ 0.70	€ 2.56	€ 1.86	€ 0.70	€ 0.74	€ 0.04
F	€ 0.81	€ 2.56	€ 1.75	€ 0.81	€ 0.74	-€ 0.07
Current situation	€ 0.67	€ 2.56	€ 1.88	€ 0.67	€ 0.74	€ 0.07
minimum required	€ 0.59	€ 2.56	€ 1.97	€ 0.59	€ 0.74	€ 0.15

Minimum assumption required	
Current situation	

- Machine costs including energy for charging the batteries>>Info ORI €740/mois
- Total salary cost/hour x percentage of activity
- Total machine cost x percentage of activity, Avg cost of truck + energy = 740€/hr

**Appendix - 12**  
**What-if Analysis - outbound process/case picking**

Parameters							
Old Prices		New Prices (case picking)			Activity Percentages		
case picking	€ 0.18096	Case Picking	€ 0.15	Working hours	7.5	Column Picking	50.00%
				Salary cost	€ 25.00	pallet loading	50.00%
				Additional cost	€ 4.625		

**COLUMN PICKING (CASE PICKING)**

Assumption	Time to pick one article (SECOND)	Productivity Articles picked/hour	Working hours/day	productivity per day	Salary cost/hour	Additional cost/hour	Total cost/hour	Cost/article	Old price		New price	
									Price/article	Profit/article	Price/article	Profit/article
A	8.00	450	7.50	3375.00	€ 12.50	€ 2.31	€ 14.81	€ 0.03	€ 0.09	€ 0.06	€ 0.08	€ 0.04
B	9.00	400	7.50	3000.00	€ 12.50	€ 2.31	€ 14.81	€ 0.04	€ 0.09	€ 0.05	€ 0.08	€ 0.04
C	9.47	380	7.50	2851.11	€ 12.50	€ 2.31	€ 14.81	€ 0.04	€ 0.09	€ 0.05	€ 0.08	€ 0.04
D	11.00	327	7.50	2454.55	€ 12.50	€ 2.31	€ 14.81	€ 0.05	€ 0.09	€ 0.05	€ 0.08	€ 0.03
E	13.00	277	7.50	2076.92	€ 12.50	€ 2.31	€ 14.81	€ 0.05	€ 0.09	€ 0.04	€ 0.08	€ 0.02
F	14.40	250	7.50	1875.00	€ 12.50	€ 2.31	€ 14.81	€ 0.06	€ 0.09	€ 0.03	€ 0.08	€ 0.02

**PALLETS LOADING**

Assumption	Time to load one pallet (minutes)	Productivity pallets loaded/hour	Working hours / day	productivity per day	Salary cost / hour	Additional cost / hour	Total cost/hour	Cost/pallet	Old price		New price	
									Price/pallet	Profit / pallet	Price/pallet	Profit / pallet
A	1.00	60	7.50	450.00	€ 12.50	€ 2.31	€ 14.81	€ 0.25	€ 0.09	-€ 0.16	€ 0.08	-€ 0.17
B	1.50	40	7.50	300.00	€ 12.50	€ 2.31	€ 14.81	€ 0.37	€ 0.09	-€ 0.28	€ 0.08	-€ 0.30
C	2.00	30	7.50	225.00	€ 12.50	€ 2.31	€ 14.81	€ 0.49	€ 0.09	-€ 0.40	€ 0.08	-€ 0.42
D	2.50	24	7.50	180.00	€ 12.50	€ 2.31	€ 14.81	€ 0.62	€ 0.09	-€ 0.53	€ 0.08	-€ 0.54
E	3.00	20	7.50	150.00	€ 12.50	€ 2.31	€ 14.81	€ 0.74	€ 0.09	-€ 0.65	€ 0.08	-€ 0.67
F	3.50	17	7.50	128.57	€ 12.50	€ 2.31	€ 14.81	€ 0.86	€ 0.09	-€ 0.77	€ 0.08	-€ 0.79

TOTAL PROFIT OF OUTBOUND IN CASE OF COLUMN (ARTICLE) PICKING (OLD PRICE)				TOTAL PROFIT OF OUTBOUND IN CASE OF COLUMN (ARTICLE) PICKING (NEW PRICE)			
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Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit of outbound per unit	Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit of outbound per unit
A	€ 0.28	€ 0.18	-€ 0.10	A	€ 0.28	€ 0.15	-€ 0.13
B	€ 0.41	€ 0.18	-€ 0.23	B	€ 0.41	€ 0.15	-€ 0.26
C	€ 0.53	€ 0.18	-€ 0.35	C	€ 0.53	€ 0.15	-€ 0.38
D	€ 0.66	€ 0.18	-€ 0.48	D	€ 0.66	€ 0.15	-€ 0.51
E	€ 0.79	€ 0.18	-€ 0.61	E	€ 0.79	€ 0.15	-€ 0.64
F	€ 0.92	€ 0.18	-€ 0.74	F	€ 0.92	€ 0.15	-€ 0.77
Current situation	€ 0.43	€ 0.18	-€ 0.25	Current situation	€ 0.43	€ 0.15	-€ 0.28
minimum required (C)	€ 0.29	€ 0.18	-€ 0.10	minimum required (C)	€ 0.29	€ 0.15	-€ 0.14

**Appendix - 12**  
**What-if Analysis - outbound process/Line picking**

Parameters							
Old Prices				New Prices			
Price per article picked	€ 0.1810	Price per article picked	€ 0.15	salary cost	€ 25.00	Line picking	50.00%
Assumed No. articles/line	10	Assumed No. articles/line	10	Additional cost	€ 4.625	Loading	50.00%
Price per line pick	€ 1.81	Price per line	€ 1.50	Working hours	7.5		

**LINE PICKING**

Assumption	Time to pick one line (minutes)	Productivity No. of lines picked/hour	Working hours / day	productivity per day	salary cost/hour	Additional cost / hour	Total cost / hour	cost/line	Old Price		New Price	
									price/line	profit/line	Price/line	Profit/line
A	1.00	60	7.50	450.00	€ 12.50	€ 2.31	€ 14.81	€ 0.25	€ 0.90	€ 0.66	€ 0.90	€ 0.66
B	2.00	30	7.50	225.00	€ 12.50	€ 2.31	€ 14.81	€ 0.49	€ 0.90	€ 0.41	€ 0.90	€ 0.41
C	2.40	25	7.50	187.50	€ 12.50	€ 2.31	€ 14.81	€ 0.59	€ 0.90	€ 0.31	€ 0.90	€ 0.31
D	2.73	22	7.50	164.63	€ 12.50	€ 2.31	€ 14.81	€ 0.67	€ 0.90	€ 0.23	€ 0.90	€ 0.23
E	3.00	20	7.50	150.00	€ 12.50	€ 2.31	€ 14.81	€ 0.74	€ 0.90	€ 0.16	€ 0.90	€ 0.16
F	4.00	15	7.50	112.50	€ 12.50	€ 2.31	€ 14.81	€ 0.99	€ 0.90	-€ 0.08	€ 0.90	-€ 0.08

**PALLETS LOADING**

Assumption	Time to load one pallet (minutes)	Productivity pallets loaded/hour	Working hours / day	productivity per day	Salary cost / hour	Additional cost / hour	Total cost/hour	Cost/pallet	Old price		New Price	
									Price/pallet	Profit / pallet	Price/pallet	Profit/pallet
A	1.00	60	7.50	450.00	€ 12.50	€ 2.31	€ 14.81	€ 0.25	€ 0.90	€ 0.66	€ 0.75	€ 0.50
B	1.50	40	7.50	300.00	€ 12.50	€ 2.31	€ 14.81	€ 0.37	€ 0.90	€ 0.53	€ 0.75	€ 0.38
C	2.00	30	7.50	225.00	€ 12.50	€ 2.31	€ 14.81	€ 0.49	€ 0.90	€ 0.41	€ 0.75	€ 0.26
D	2.50	24	7.50	180.00	€ 12.50	€ 2.31	€ 14.81	€ 0.62	€ 0.90	€ 0.29	€ 0.75	€ 0.13
E	3.00	20	7.50	150.00	€ 12.50	€ 2.31	€ 14.81	€ 0.74	€ 0.90	€ 0.16	€ 0.75	€ 0.01
F	3.50	17	7.50	128.57	€ 12.50	€ 2.31	€ 14.81	€ 0.86	€ 0.90	€ 0.04	€ 0.75	-€ 0.11

**TOTAL PROFIT OF OUTBOUND IN CASE OF LINE PICKING (OLD PRICE)**

Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit per unit of outbound
A	€ 0.49	€ 1.81	€ 1.32
B	€ 0.86	€ 1.81	€ 0.95
C	€ 1.09	€ 1.81	€ 0.72
D	€ 1.29	€ 1.81	€ 0.52
E	€ 1.48	€ 1.81	€ 0.33
F	€ 1.85	€ 1.81	-€ 0.04
Current situation	€ 1.11	€ 1.81	€ 0.70
minimum required	€ 0.84	€ 1.81	€ 0.97

**TOTAL PROFIT OF OUTBOUND IN CASE OF LINE PICKING (NEW PRICES)**

Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit per unit of outbound
A	€ 0.49	€ 1.65	1.16
B	€ 0.86	€ 1.65	0.79
C	€ 1.09	€ 1.65	0.57
D	€ 1.29	€ 1.65	0.36
E	€ 1.48	€ 1.65	0.17
F	€ 1.85	€ 1.65	-0.20
Current situation	€ 1.11	€ 1.65	0.54
minimum required	€ 0.84	€ 1.65	0.82

**Appendix - 12**  
**What-if Analysis - outbound process/full-pallet picking**

Parameters					
Costs		Prices (full pallet)			
Salary cost	€ 25.00	Old Price	€ 2.4249	Working hours	7.5
Additional cost	€ 4.625	full pallet	€ 1.07	pallet Picking %	50.00%
				pallet loading %	50.00%

**FULL PALLET PICKING**

Assumption	Time to pick one pallet (minutes)	Productivity pallets picked / hour	Working hours / day	productivity per day	Salary cost/hour	Additional cost / hour	Total cost/hour	Cost/pallet	Old price		New price	
									Price/pallet	Profit / pallet	Price/pallet	Profit/pallet
A	1.50	40	7.50	300.00	€ 12.50	€ 2.31	€ 14.81	€ 0.37	€ 1.21	€ 0.84	€ 0.54	€ 0.16
B	2.50	24	7.50	180.00	€ 12.50	€ 2.31	€ 14.81	€ 0.62	€ 1.21	€ 0.60	€ 0.54	-€ 0.08
C	2.70	22	7.50	166.67	€ 12.50	€ 2.31	€ 14.81	€ 0.67	€ 1.21	€ 0.55	€ 0.54	-€ 0.13
D	3.00	20	7.50	150.00	€ 12.50	€ 2.31	€ 14.81	€ 0.74	€ 1.21	€ 0.47	€ 0.54	-€ 0.21
E	3.50	17	7.50	128.57	€ 12.50	€ 2.31	€ 14.81	€ 0.86	€ 1.21	€ 0.35	€ 0.54	-€ 0.33
F	4.00	15	7.50	112.50	€ 12.50	€ 2.31	€ 14.81	€ 0.99	€ 1.21	€ 0.22	€ 0.54	-€ 0.45

**PALLETS LOADING**

Assumption	Time to load one pallet (minutes)	Productivity pallets loaded/hour	Working hours / day	productivity per day	Salary cost / hour	Additional cost / hour	Total cost/hour	Cost/pallet	Old price		New price	
									Price/pallet	Profit / pallet	Price/pallet	Profit / pallet
A	1.00	60	7.50	450.00	€ 12.50	€ 2.31	€ 14.81	€ 0.25	€ 1.21	€ 0.97	€ 0.54	€ 0.29
B	1.50	40	7.50	300.00	€ 12.50	€ 2.31	€ 14.81	€ 0.37	€ 1.21	€ 0.84	€ 0.54	€ 0.16
C	2.00	30	7.50	225.00	€ 12.50	€ 2.31	€ 14.81	€ 0.49	€ 1.21	€ 0.72	€ 0.54	€ 0.04
D	2.50	24	7.50	180.00	€ 12.50	€ 2.31	€ 14.81	€ 0.62	€ 1.21	€ 0.60	€ 0.54	-€ 0.08
E	3.00	20	7.50	150.00	€ 12.50	€ 2.31	€ 14.81	€ 0.74	€ 1.21	€ 0.47	€ 0.54	€ 0.21
F	3.50	17	7.50	128.57	€ 12.50	€ 2.31	€ 14.81	€ 0.86	€ 1.21	€ 0.35	€ 0.54	-€ 0.33

**TOTAL PROFIT OF OUTBOUND (FULL PALLET PICKING) ASSUMING THE OLD PRICE**

Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit of outbound per unit
A	€ 0.62	€ 2.42	€ 1.81
B	€ 0.99	€ 2.42	€ 1.44
C	€ 1.16	€ 2.42	€ 1.26
D	€ 1.36	€ 2.42	€ 1.07
E	€ 1.60	€ 2.42	€ 0.82
F	€ 1.85	€ 2.42	€ 0.57
Current situation	€ 1.04	€ 2.42	€ 1.39
minimum required (C)	€ 0.62	€ 2.42	€ 1.81

**TOTAL PROFIT OF OUTBOUND (FULL PALLET PICKING) ASSUMING NEW PRICE**

Assumption	Total cost per unit of outbound	Total price per unit of outbound	Total profit of outbound per unit
A	€ 0.62	€ 1.07	€ 0.45
B	€ 0.99	€ 1.07	€ 0.08
C	€ 1.16	€ 1.07	-€ 0.09
D	€ 1.36	€ 1.07	-€ 0.29
E	€ 1.60	€ 1.07	-€ 0.53
F	€ 1.85	€ 1.07	-€ 0.78
Current situation	€ 1.04	€ 1.07	€ 0.03
minimum required (C)	€ 2.42	€ 1.07	-€ 1.35

CARTON COVERS INSTALLATION

Assumption	Time to install one cover (minutes)	Productivity covers installed/hour	working hours/day	productivity per day	salary cost/hour	Additional cost/hour	total cost/hour	cost/pallette	Price/pallette	Profit/pallet
A	3.00	20	7.50	150	€ 2.08	€ 0.00	€ 2.08	€ 0.10	€ 2.06	€ 1.96
B	4.00	15	7.50	113	€ 2.08	€ 0.00	€ 2.08	€ 0.14	€ 2.06	€ 1.92
<b>C</b>	<b>5.00</b>	<b>12</b>	<b>7.50</b>	<b>90</b>	<b>€ 2.08</b>	<b>€ 0.00</b>	<b>€ 2.08</b>	<b>€ 0.17</b>	<b>€ 2.06</b>	<b>€ 1.89</b>
D	6.00	10	7.50	75	€ 2.08	€ 0.00	€ 2.08	€ 0.21	€ 2.06	€ 1.85
E	7.00	9	7.50	64	€ 2.08	€ 0.00	€ 2.08	€ 0.24	€ 2.06	€ 1.82
F	8.00	8	7.50	56	€ 2.08	€ 0.00	€ 2.08	€ 0.28	€ 2.06	€ 1.78

PALETTE SEALING

Assumption	Time to seal one palette (minutes)	Productivity palettes sealed/hour	working hours / day	productivity per day	salary cost/hour	Additional cost/hour	total cost/hour	cost/palette	Price/pallet	Profit/pallet
A	1.00	60	7.5	450	€ 2.08	€ 0.00	€ 2.08	€ 0.03	€ 0.82	€ 0.79
B	2.00	30	7.5	225	€ 2.08	€ 0.00	€ 2.08	€ 0.07	€ 0.82	€ 0.75
<b>C</b>	<b>3.00</b>	<b>20</b>	<b>7.5</b>	<b>150</b>	<b>€ 2.08</b>	<b>€ 0.00</b>	<b>€ 2.08</b>	<b>€ 0.10</b>	<b>€ 0.82</b>	<b>€ 0.72</b>
D	4.00	15	7.5	113	€ 2.08	€ 0.00	€ 2.08	€ 0.14	€ 0.82	€ 0.69
E	5.00	12	7.5	90	€ 2.08	€ 0.00	€ 2.08	€ 0.17	€ 0.82	€ 0.65
F	6.00	10	7.5	75	€ 2.08	€ 0.00	€ 2.08	€ 0.21	€ 0.82	€ 0.62

AIRBAG INSTALLATION

Assumption	Time to install one airbag (min)	Productivity Airbags installed/hour	working hours / day	productivity per day	salary cost/hour	Additional cost/hour	Total cost/hour	cost/palette	Price/pallet	Profit/pallet
A	5.00	12	7.5	90	€ 2.08	€ 0.00	€ 2.08	€ 0.17	€ 4.12	€ 3.95
B	6.00	10	7.5	75	€ 2.08	€ 0.00	€ 2.08	€ 0.21	€ 4.12	€ 3.91
<b>C</b>	<b>7.00</b>	<b>9</b>	<b>7.5</b>	<b>64</b>	<b>€ 2.08</b>	<b>€ 0.00</b>	<b>€ 2.08</b>	<b>€ 0.24</b>	<b>€ 4.12</b>	<b>€ 3.88</b>
D	8.00	8	7.5	56	€ 2.08	€ 0.00	€ 2.08	€ 0.28	€ 4.12	€ 3.84
E	9.00	7	7.5	50	€ 2.08	€ 0.00	€ 2.08	€ 0.31	€ 4.12	€ 3.81
F	10.00	6	7.5	45	€ 2.08	€ 0.00	€ 2.08	€ 0.35	€ 4.12	€ 3.77

LOADING PALLETES

Assumption	Time to load one palette (minutes)	Productivity Palletes loaded/hour	working hours / day	productivity per day	salary cost / hour	Additional cost / hour	Total cost / hour	cost / palette	price/Pallet	profit/pallet
A	1.00	60	7.50	450.00	€ 8.33	€ 1.54	€ 9.88	€ 0.16	€ 0.60	€ 0.44
<b>B</b>	<b>1.50</b>	<b>40</b>	<b>7.50</b>	<b>300.00</b>	<b>€ 8.33</b>	<b>€ 1.54</b>	<b>€ 9.88</b>	<b>€ 0.25</b>	<b>€ 0.60</b>	<b>€ 0.36</b>
C	2.00	30	7.50	225.00	€ 8.33	€ 1.54	€ 9.88	€ 0.33	€ 0.60	€ 0.27
D	2.50	24	7.50	180.00	€ 8.33	€ 1.54	€ 9.88	€ 0.41	€ 0.60	€ 0.19
E	3.00	20	7.50	150.00	€ 8.33	€ 1.54	€ 9.88	€ 0.49	€ 0.60	€ 0.11
F	3.50	17	7.50	128.57	€ 8.33	€ 1.54	€ 9.88	€ 0.58	€ 0.60	€ 0.03

**Appendix - 13**  
What-if Analysis - outbound export process

Parameters		Costs		Pricing of Extra requirements		COLUMN PICKING %	
Line Pricing	€ 0.1810	Additional cost	€ 4.63	Box restacking	€ 0.17	LINE PICKING %	33.33%
Price per article pick	10	Salary cost	€ 25.00	carton covers	€ 2.06	BOXES RESTACKING %	8.33%
Assumed No. articles/line	€ 1.81	Total cost	€ 29.63	sealing of pallets	€ 0.82	CARTON COVERS INSTALLATION %	8.33%
Price per line pick	7.5	Additional cost (box restacking)	€ 0.00	airbag installation	€ 4.12	PALETTE SEALING %	8.33%
Working hours	7.5	Additional cost (carton covers)	€ 0.00			AIR BAG INSTALLATION %	8.33%
		Additional cost (sealing)	€ 0.00			LOADING OF PALETTES %	33.33%
		Additional cost (airbag)	€ 0.00				

LINE PICKING

Assumption	Time to pick one line (min)	Productivity No. of lines picked/hour	Working hours / day	productivity per day	salary cost/hour	Additional cost / hour	Total cost / hour	cost/line	price/line	profit/line
A	1.00	60.00	7.50	450.00	€ 8.33	€ 1.54	€ 9.88	€ 0.16	€ 0.60	€ 0.44
B	2.00	30.00	7.50	225.00	€ 8.33	€ 1.54	€ 9.88	€ 0.33	€ 0.60	€ 0.27
C	2.40	25.00	7.50	187.50	€ 8.33	€ 1.54	€ 9.88	€ 0.40	€ 0.60	€ 0.21
D	2.73	22.00	7.50	165.00	€ 8.33	€ 1.54	€ 9.88	€ 0.45	€ 0.60	€ 0.15
E	3.00	20.00	7.50	150.00	€ 8.33	€ 1.54	€ 9.88	€ 0.49	€ 0.60	€ 0.11
F	4.00	15.00	7.50	112.50	€ 8.33	€ 1.54	€ 9.88	€ 0.66	€ 0.60	-€ 0.06

CASE PICKING

Assumption	Time to pick one article (SECOND)	Productivity Articles picked/hour	working hours/day	productivity per day	salary cost/hour	Additional cost / hour	Total cost / hour	cost/article	price/article	profit/article
A	8.00	450	7.50	3375	€ 8.33	€ 1.54	€ 9.88	€ 0.02	€ 0.06	€ 0.04
B	9.00	400	7.50	3000	€ 8.33	€ 1.54	€ 9.88	€ 0.02	€ 0.06	€ 0.04
C	9.47	380	7.50	2851	€ 8.33	€ 1.54	€ 9.88	€ 0.03	€ 0.06	€ 0.03
D	11.00	327	7.50	2455	€ 8.33	€ 1.54	€ 9.88	€ 0.03	€ 0.06	€ 0.03
E	13.00	277	7.50	2077	€ 8.33	€ 1.54	€ 9.88	€ 0.04	€ 0.06	€ 0.02
F	14.40	250	7.50	1875	€ 8.33	€ 1.54	€ 9.88	€ 0.04	€ 0.06	€ 0.02

BOXES RESTACKING

Assumption	Time to restack one article (seconds)	Productivity Articles stacked/hour	working hours/day	productivity per day	salary cost/hour	Additional cost/hour	Total cost /hour	cost/article	price/article	profit/article
A	3.00	1200	7.50	9000	€ 2.08	€ 0.00	€ 2.08	0.002	€ 0.17	€ 0.17
B	4.00	900	7.50	6750	€ 2.08	€ 0.00	€ 2.08	0.002	€ 0.17	€ 0.17
C	5.14	700	7.50	5253	€ 2.08	€ 0.00	€ 2.08	0.003	€ 0.17	€ 0.17
D	6.00	600	7.50	4500	€ 2.08	€ 0.00	€ 2.08	0.003	€ 0.17	€ 0.17
E	7.00	514	7.50	3857	€ 2.08	€ 0.00	€ 2.08	0.004	€ 0.17	€ 0.17
F	8.00	450	7.50	3375	€ 2.08	€ 0.00	€ 2.08	0.005	€ 0.17	€ 0.17

TOTAL PROFIT OF EXPORT - LINE PICKING

		ADDITIONAL ITEMS							Total
Line picking	Boxes restacking	Instalilling carton covers	Palette sealing	Airbag installation	Additional items/3	Loading pallettes			
<b>A</b>									
Total Costs	€0.16	€0.00	€0.10	€0.03	€0.17	€0.10	€0.16	€0.43	
Total Prices	€0.60	€0.60	€2.06	€0.82	€4.12	€2.54	€0.60	€3.74	
<b>Profit</b>									
<b>B</b>									
Total Costs	€0.66	€0.00	€0.28	€0.21	€0.35	€0.28	€0.58	€1.51	
Total Prices	€0.60	€0.17	€2.06	€0.82	€4.12	€2.39	€0.60	€3.60	
<b>Profit</b>									
<b>C</b>									
Total Costs	€0.40	€0.00	€0.17	€0.10	€0.24	€0.17	€0.33	€0.90	
Total Prices	€0.60	€0.17	€2.06	€0.82	€4.12	€2.39	€0.60	€3.60	
<b>Profit</b>									
<b>D</b>									
Total Costs	€0.45	€0.00	€0.21	€0.14	€0.28	€0.21	€0.41	€1.07	
Total Prices	€0.60	€0.17	€2.06	€0.82	€4.12	€2.39	€0.60	€3.60	
<b>Profit</b>									
<b>E</b>									
Total Costs	€0.49	€0.00	€0.24	€0.17	€0.31	€0.24	€0.49	€1.23	
Total Prices	€0.60	€0.17	€2.06	€0.82	€4.12	€2.39	€0.60	€3.60	
<b>Profit</b>									
<b>F</b>									
Total Costs	€0.04	€0.00	€0.28	€0.21	€0.35	€0.28	€0.58	€0.89	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.60	€3.06	
<b>Profit</b>									

TOTAL PROFIT OF EXPORT - CASE PICKING

		ADDITIONAL ITEMS							Total
Case picking	Boxes restacking	Instalilling carton covers	Palette sealing	Airbag installation	Additional items/3	Loading pallettes			
<b>A</b>									
Total Costs	€0.02	€0.00	€0.10	€0.03	€0.17	€0.10	€3.60	€3.73	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									
<b>B</b>									
Total Costs	€0.02	€0.00	€0.14	€0.07	€0.21	€0.14	€2.16	€2.33	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									
<b>C</b>									
Total Costs	€0.03	€0.00	€0.17	€0.10	€0.24	€0.17	€0.00	€0.20	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									
<b>D</b>									
Total Costs	€0.03	€0.00	€0.21	€0.14	€0.28	€0.21	€0.89	€1.13	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									
<b>E</b>									
Total Costs	€0.04	€0.00	€0.24	€0.17	€0.31	€0.24	€3.06	€3.34	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									
<b>F</b>									
Total Costs	€0.04	€0.00	€0.28	€0.21	€0.35	€0.28	€2.16	€2.48	
Total Prices	€0.06	€0.17	€2.06	€0.82	€4.12	€2.39	€0.00	€2.45	
<b>Profit</b>									



Index			
Situation A	refers to the percentage values obtained from the company		
Situation B	refers to the values based on the percentages based on calculations		
Activity/ Time consumption percentages	A	B	Hourly Costs
Pallets unloading	16.67%	33%	€ 25.00
Pallets check and inspection	16.67%	11%	€ 4.63
Pallets putaway	66.67%	56%	€ 29.63
			Total cost per hour

Week number	Total pallets unloaded	VALUES BEFORE THE INSTALLATION OF REPAIRS												
		Unloading			Checking									
		situation A		situation B		situation A		situation B						
	Time spent on unloading - A -	Unloading productivity pal/hr - A -	Cost of unloading - A -	Time spent on unloading - B -	Unloading productivity pal/hr - B -	Cost of Unloading - B -	Total pallets checked	Time spent on checking - A -	Inspection productivity pal/hr - A -	Cost of checking A -	Time spent on checking - B -	Inspection productivity pal/hr - B -	Cost of Checking - B -	
W15	1428	9.22	155	€ 273	18.25	78	€ 541	1401	9.22	152	€ 273	6.08	230	€ 180
W16	1064	5.92	180	€ 175	11.72	91	€ 347	1091	5.92	184	€ 175	3.91	279	€ 116
W17	563	6.95	81	€ 206	13.76	41	€ 408	533	6.95	77	€ 206	4.59	116	€ 136
W18	1577	9.73	162	€ 288	19.27	82	€ 571	1528	9.73	157	€ 288	6.42	238	€ 190
W19	1876	11.38	165	€ 337	22.54	83	€ 668	1508	11.38	132	€ 337	7.51	201	€ 223
W20	865	7.82	111	€ 232	15.48	56	€ 459	1048	7.82	134	€ 232	5.16	203	€ 153
W21	1958	9.35	209	€ 277	18.51	106	€ 548	1776	9.35	190	€ 277	6.17	288	€ 183
W22	1765	11.27	157	€ 334	22.51	79	€ 651	1763	11.27	156	€ 334	7.44	237	€ 220
W23	1986	13.89	143	€ 412	27.51	72	€ 815	1680	13.89	121	€ 412	9.17	183	€ 272
W24	1696	9.36	181	€ 277	18.53	92	€ 549	1356	9.36	145	€ 277	6.18	220	€ 183
VALUES AFTER THE INSTALLATION OF REPAIRS														
Week number	Total pallets unloaded	Unloading						Checking						
		situation A		situation B		situation A		situation B		situation A		situation B		
			time spent on unloading - A -	Unloading productivity pal/hr - A -	Cost of unloading - A -	time spent on unloading - B -	Unloading productivity pal/hr - B -	Cost of Unloading - B -	Total pallets checked	time spent on checking - A -	Inspection productivity pal/hr - A -	Cost of checking A -	time spent on checking - B -	Inspection productivity pal/hr - B -
W15	1428	8.33	171	€ 247	16.50	87	€ 489	1401	8.33	168	€ 247	5.50	255	€ 163
W16	1064	5.00	213	€ 148	9.90	107	€ 393	1091	5.00	218	€ 148	3.30	331	€ 98
W17	563	6.00	94	€ 178	11.88	47	€ 352	533	6.00	89	€ 178	3.96	135	€ 117
W18	1577	8.83	179	€ 262	17.49	90	€ 518	1528	8.83	173	€ 262	5.83	176	€ 173
W19	1876	10.50	179	€ 311	20.79	90	€ 616	1508	10.50	144	€ 311	6.93	218	€ 205
W20	865	6.83	127	€ 202	13.53	64	€ 401	1048	6.83	153	€ 202	4.51	153	€ 134
W21	1958	8.50	230	€ 252	16.83	116	€ 499	1776	8.50	209	€ 252	5.61	317	€ 166
W22	1765	10.33	171	€ 306	20.46	86	€ 606	1763	10.33	171	€ 306	6.82	259	€ 202
W23	1986	12.83	155	€ 380	25.41	78	€ 753	1680	12.83	131	€ 380	8.47	198	€ 251
W24	1696	8.50	200	€ 252	16.83	101	€ 499	1356	8.50	160	€ 252	5.61	242	€ 166

Total pallets putaway	Putaway						Total time spent on inbound hours/week	
	situation - A -			situation - B -				
	Time spent on putaway - A -	Putaway productivity - A -	cost of Putaway - A -	Time spent on putaway - B -	Putaway productivity - B -	Cost of Putaway - B -		
1401	36,86	38	€1,1092	30,96	45	€917	55,29	
1091	23,67	46	€701	19,88	55	€589	35,5	
474	27,80	17	€824	23,35	20	€692	41,7	
1528	38,93	39	€1,153	32,70	47	€969	58,4	
1508	45,53	33	€1,349	38,25	39	€1,133	68,3	
1048	31,27	34	€926	26,26	40	€778	46,9	
1776	37,40	47	€1,108	31,42	57	€931	56,1	
1763	45,07	39	€1,335	37,86	47	€1,121	67,6	
1680	55,57	30	€1,646	46,68	36	€1,383	83,35	
1366	37,43	36	€1,109	31,44	43	€932	56,15	
<b>Putaway</b>								
Total pallets putaway	situation - A -			situation - B -			Total time spent on inbound	
	Time spent on putaway - A -	Putaway productivity - A -	cost of Putaway - A -	Time spent on putaway - B -	Putaway productivity - B -	Cost of Putaway - B -		
	1401	33,33	42	€988	28,00	50		€830
	1091	20,00	55	€593	16,80	65		€498
	474	24,00	20	€711	20,16	24		€597
	1528	35,33	43	€1,047	29,68	51		€879
	1508	42,00	36	€1,244	35,28	43		€1,045
	1048	27,33	38	€810	22,96	46		€680
	1776	34,00	52	€1,007	28,56	62		€846
	1763	41,33	43	€1,225	34,72	51		€1,029
	1680	51,33	33	€1,521	43,12	39		€1,277
	1366	34,00	40	€1,007	28,56	48		€846

Situation A		Situation B		Activity	
refers to the percentage values obtained from the company					
refers to the values based on the percentages based on calculations					
Activity	A	B	Activity	A	B
Percentage case picking	50%	14.00%	Pallet Loading	50%	86%
Percentage Line picking	50%	67.00%			33%
Percentage Full pallet picking	50%	64.00%			36%
			Hourly Cost		
			Cost of worker per hour		€25.00
			Cost of machine		€4.63
			Total cost per hour		€29.63

Week Number	Total number of cases picked	Time spent on case picking hours/week	case picking productivity	Cost of case picking - A -	Cost of case picking - B -	Total Number of lines picked	Time spent on line picking hours/week	Line picking productivity	Cost of Line picking - A -	Cost of line picking - B -	Total number of full pallets picked	Time of full pallet picking	full pallet productivity	Cost of full pallet picking - A -	Cost of full pallet picking - B -	PALETTES LOADED
W15	825	265.3	3.1	€ 3,929.68	€ 1,100.31	1794	252.85	7.10	€ 3,745.97	€ 5,019.60	508	63.1	8.05	€ 934.83	€ 1,196.58	813
W16	1345	89.6	15.0	€ 1,327.42	€ 371.68	9403	41.5	226.58	€ 614.82	€ 823.86	659	30.5	21.61	€ 451.86	€ 578.38	724
W17	1325	66.3	20.0	€ 982.23	€ 275.03	9064	36.3	249.70	€ 537.78	€ 720.63	1278	58.1	22.00	€ 860.75	€ 1,101.76	1331
W18	1539	77	20.0	€ 1,140.76	€ 319.41	9493	38	249.82	€ 652.97	€ 754.38	968	44	22.00	€ 651.86	€ 834.38	1060
W19	1702	85.1	20.0	€ 1,260.76	€ 353.01	12597	50.4	249.94	€ 746.68	€ 1,000.55	1512	68.7	22.01	€ 1,017.29	€ 1,302.77	1519
W20	1888	106.6	17.7	€ 1,529.28	€ 442.20	9819	56.7	172.17	€ 840.01	€ 1,125.61	1302	53.6	24.29	€ 794.08	€ 1,016.43	1242
W21	853	42.7	20.0	€ 632.60	€ 177.13	3917	15.7	249.49	€ 232.60	€ 311.68	770	35	22.00	€ 518.53	€ 663.71	800
W22	1069	53.3	20.1	€ 789.64	€ 221.10	7670	30.7	249.84	€ 454.82	€ 609.46	1021	46.4	22.00	€ 687.42	€ 879.89	1103
W23	947	47.4	20.0	€ 702.23	€ 196.62	5763	23.1	249.48	€ 342.23	€ 458.58	536	24.4	21.97	€ 361.49	€ 462.70	806
W24	1223	61.2	20.0	€ 906.68	€ 253.87	780	3.1	251.61	€ 45.93	€ 61.54	865	39.3	22.01	€ 582.23	€ 745.25	1080

VALUES AFTER THE INSTALLATION OF REDPRIMAIRE

Week Number	Total number of cases picked	Time spent on picking hours/week	case picking productivity	Cost of case picking - A -	Cost of case picking - B -	Total Number of lines picked	Time spent on line picking hours/week	Line picking productivity	Cost of Line picking - A -	Cost of line picking - B -	Total number of full pallets picked	Time of full pallet picking	full pallet productivity	Cost of full pallet picking - A -	Cost of full pallet picking - B -	Total number of pallets loaded
W15	825	260	3.2	€ 3,851.90	€ 1,078.53	1794	247	7.26	€ 3,659.31	€ 4,903.47	508	58	8.76	€ 859.27	€ 1,099.87	813
W16	1345	84	16.0	€ 1,244.46	€ 348.45	9403	36	261.19	€ 535.34	€ 714.68	659	25	26.36	€ 370.38	€ 474.08	724
W17	1325	61	21.7	€ 903.72	€ 253.04	9064	31	292.39	€ 459.27	€ 615.42	1278	53	24.11	€ 785.20	€ 1,005.05	1331
W18	1539	72	21.4	€ 1,066.68	€ 298.67	9493	33	287.67	€ 488.90	€ 655.12	968	39	24.82	€ 577.79	€ 739.56	1060
W19	1702	80	21.3	€ 1,185.20	€ 331.86	12597	45	229.93	€ 666.68	€ 893.34	1512	63	24.00	€ 933.35	€ 1,194.68	1519
W20	1888	101	18.7	€ 1,496.32	€ 418.97	9819	51	192.53	€ 755.57	€ 1,012.46	1302	48	27.13	€ 711.12	€ 910.23	1242
W21	853	37	23.1	€ 548.16	€ 153.48	3917	10	391.70	€ 148.15	€ 198.52	770	30	25.67	€ 444.45	€ 568.90	800
W22	1069	48	22.3	€ 711.12	€ 199.11	7670	25	306.80	€ 370.38	€ 496.30	1021	41	24.90	€ 607.42	€ 777.49	1103
W23	947	42	22.5	€ 622.23	€ 174.22	5763	17	339.00	€ 251.86	€ 337.49	536	19	28.21	€ 281.49	€ 360.30	806
W24	1223	46	26.6	€ 681.49	€ 190.82	780	2	390.00	€ 29.63	€ 39.70	865	34	25.44	€ 503.71	€ 644.75	1080

Pallets Loading					
Time of Loading	Pallets loading productivity	Cost of loading - A -	Cost of loading - B- (Case pick)	Cost of loading - B- (line pick)	Cost of Loading -B (full pallet pick)
		A -	B- (Case pick)	B- (line pick)	(full pallet pick)
19.5	41.69	€ 288.89	€ 496.90	€ 190.67	€ 208.00
22.2	32.61	€ 328.89	€ 565.70	€ 217.07	€ 236.80
27.9	47.71	€ 413.34	€ 710.94	€ 272.80	€ 297.60
37.4	28.34	€ 554.08	€ 953.02	€ 365.69	€ 398.94
45.5	33.38	€ 674.08	€ 1,159.42	€ 444.89	€ 485.34
37.7	32.94	€ 558.53	€ 960.66	€ 368.63	€ 402.14
38	21.05	€ 562.97	€ 968.31	€ 371.56	€ 405.34
41.6	26.51	€ 616.30	€ 1,060.04	€ 406.76	€ 443.74
18.1	44.53	€ 268.15	€ 461.22	€ 176.98	€ 193.07
26.9	40.15	€ 398.52	€ 685.46	€ 263.03	€ 286.94
Pallets Loading					
Time of Loading	Pallets loading productivity	Cost of loading - A -	Cost of loading - B- (Case pick)	Cost of loading - B- (line pick)	Cost of Loading -B (full pallet pick)
14	58.07	€ 207.41	€ 356.75	€ 136.89	€ 149.34
17	42.59	€ 251.86	€ 433.19	€ 166.72	€ 181.34
22	60.50	€ 325.93	€ 560.60	€ 215.11	€ 234.67
32	33.13	€ 474.08	€ 815.42	€ 312.89	€ 341.34
40	37.98	€ 592.60	€ 1,019.27	€ 391.12	€ 426.67
32	38.81	€ 474.08	€ 815.42	€ 312.89	€ 341.34
33	24.24	€ 488.90	€ 840.90	€ 322.67	€ 352.00
36	30.64	€ 533.34	€ 917.34	€ 352.00	€ 384.00
13	62.00	€ 192.60	€ 331.26	€ 127.11	€ 138.67
21	51.43	€ 311.12	€ 535.12	€ 205.34	€ 224.00

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