MASTER

A framework proposal for harvesting service parts at Philips Health Tech

Kodhelaj, I.

Award date:
2015

Technische Universiteit Eindhoven
University of Technology

Department of Mathematics and Computer Science
Department of Industrial Engineering & Innovation Sciences

A Framework Proposal for Harvesting Service Parts at Philips HealthTech

Master Thesis

Iva Kodhelaj

in partial fulfilment of the requirements for the degree of
Master of Science in Business Information Systems

Supervisors:
Prof. Dr. C. Chituc (TU/e)
Prof. Dr. ir. G. J. J. A. N. van Houtum (TU/e)
Ing. D. Janssen (Philips HealthTech)
i.r. Erik Beunders (Philips HealthTech)

Eindhoven, August 2015

Abstract

Reverse Logistics (RL) has become a field of importance for all organizations due to growing environmental concerns, social responsibility and sustainable competitiveness. One of the activities of RL is the reuse of parts or products into other processes. This activity, like many others, needs the support of Information Technology (IT) in order to be enabled. IT has become a vital part of today's business environment. Almost all companies rely on computers and software to provide accurate information in order to effectively manage their business. The role of IT is crucial also for managing reverse logistics. Because RL processes span multiple functional areas, such as materials, finance, sales etc., an integrated information system solution is required. SAP Enterprise Resource Planning (ERP) systems provide a potential solution by integrating all facets of the business. However, these systems create high dependency among the shared users of the system. Implementing a reuse process in one of the participants of the system can have a great impact on the working ways of the others. To limit this impact it is necessary to align between all the involved stakeholders in the reverse supply chain. The current literature lacks a well-structured approach for implementing a reuse process flow in an existing SAP interface, while considering the impact on the other participants of the system. In this master thesis, we address this research gap by designing a comprehensive approach for setting up a reverse logistics activity in a servicing organization. We investigate options for enabling and supporting the process through SAP, and offer a thorough impact assessment to the other actors in the supply chain. In order to investigate requirements and solutions, both technical and business aspects of the problem are considered. The result of this project is a comprehensive approach which provides all the involved stakeholders with an efficient and practical solution for managing a reuse process.

Keywords: ERP, SAP, Reverse Logistics, Reuse, Repair, Harvesting, Process Modelling,

Acknowledgements

This master thesis is the result of my graduation project which completes the master program of Business Information Systems at Eindhoven University of Technology. This project would not have been possible without the support of many people, who deserve my deepest gratitude and appreciation.

Firstly, I would like to thank my first supervisor, Dr. Claudia Chituc, for her guidance, support and professionalism during the entire project. She taught me how to put structure into my thinking and writing, which proved to be a valuable lesson. Secondly, I would like to thank my second supervisor, Dr. Jan-Geert van Houtum, for his useful feedbacks on the design methodology followed. Also, thank you to Dr. Joos Buijs for accepting to be in my assessment committee.

During my graduate internship, I was fortunate to work with a great group of professionals at the SP&R department of Philips. I would like to offer my sincere gratitude to my Philips supervisor, Dave Janssen, for his continuous guidance, insights and encouragement. Working with him was both constructive and pleasant.

I would really like to thank the IGT unit manager, Erik Beunders, for always finding the time in his busy schedule to discuss all of my questions. Erik always had a good and simple story to explain a process. Also, I am indebted to the SP&R process engineer, Cengiz Altin, for his willingness to help and patience while sharing his SAP expertise with me.

Next, I would like to deeply thank my friends and fellow graduates for always being close to me not only during this project, but also through the two years of our master studies. They made sure I received my daily dose of laughter, and I will always cherish these times in my memories.

Finally, but most importantly, I am forever grateful to my parents, brother, and boyfriend, Roland, for their unconditional love, support and motivation. There is no achievement which would bring joy to me, if not shared with them.

Iva Kodhelaj August 2015

Contents

List of abbreviations

SP&R	Service Parts and Repair
SPS	Service Parts Supply
IP	Initial Production
MR	Magnetic Resonance
IGT	Image Guided Therapy
BIU	Business Innovation Unit
ERP	Enterprise Resource Planning
RMA	Return Material Authorization
FRU	Field Replaceable Unit
SLOC	Storage Location
QMS	Quality Management Systems
BMS	Business Management Systems
Q&R	Quality and Regulatory
F&A	Finance and Accounting
DMR	Device Master Record
DHR	Device History Record
RPO	Return Purchase Order
SWO	Service Work Order
BOM	Bill of Materials
IS	Information Systems
IT	Information Technology

List of figures

List of tables

Chapter 1 Introduction

The beginning is the most important part of the work.
-Plato

This introductory chapter starts with setting the context and providing the motivation for this study. Then a description of the problem is provided. The problem discussion is followed by the research objective and research questions of this project. Finally, an outline of the report concludes the introductory part.

1.1 Context and Motivation

This study is carried out at Philips HealthTech, which is a global leader in the delivery of products and solutions for the diagnosis and treatment of today's most prevalent diseases[1]. The company operates in more than 100 countries with the headquarters in Best, The Netherlands. This master thesis was designed and performed at the Service Parts and Repair (SP&R), an organization within the Imagining Systems (IS) business of Philips HealthTech. SP&R is responsible for repairing, reworking and upgrading parts of the imagining systems which are returned from the key markets as defective. The organization was formerly part of the initial production of the imagining systems. However, as the importance of the servicing business not only as a repair shop but also as a knowledge centre increased, an independent organization was created. The mission of SP&R involves accumulating knowledge and experience while offering services for Philips IGT (Image Guided Therapy) and Philips MR (Magnetic Resonance) products. The organization aims to apply this knowledge into improving products design, process efficiency, and ultimately the customer satisfaction.

Reusing parts is a common activity in the production of devices. However, this practice is not as largely applied in the service business as it is in the manufacturing business [2]. As the servicing activities gain prevalence in the operational world, their drive for adapting higher efficiency processes increases [3]. The motivation for reusing service parts in the repair process is twofold: economic and environmental. The recovery of used products is known to be economically more attractive than disposal [4]. The parts to be reused are functioning

[1] Philips Medical: http://www.medical.philips.com/

components of defective devices which are being disposed. By saving and reusing these parts, the demand for purchasing new parts as repair pool is reduced. For the business, this is a direct reduction in repair costs which might be translated to higher profit margins for the business, or lower prices for the end customer [5]. Additionally, harvesting spare parts tackles the obsolescing problem. Philips typically offers service time of 10-12 years after the last produced batches of one component [6]. During this time, technology and the product design can change considerably. If a product is no longer manufactured, there might be a lack of spare parts for repairing that product. Harvesting parts, addresses this problem by saving a pool of resources which are no longer being produced. In addition to serving the business interest, reusing parts represent an environmental initiative. By reusing parts which otherwise would have been disposed, the scrap rate is reduced. Lower volumes of disposed products signify less waste stream and lower environmental impact.

Nowadays, information technology (IT) plays a vital role in the continuity and success of any business. Many organizations are fundamentally dependent on their information technologies to effectively manage their business. Incorporating information technology solutions into the business has become a requirement in order to successfully operate. A business process now spans multiple participants and coordination can be complex. In order to optimize the process efficiency, companies should enable a transparent flow of information among the involved parties. One way that many corporations have adopted information technology on a large scale is by installing Enterprise Resource Systems (ERP) systems to accomplish their business transaction and data processing needs. Similarly, Philips has adopted SAP, the current market and technology leader in providing ERP systems [7]. Reusing parts in the repair process of medical devices requires the alignment of SAP for supporting the process and enabling the transactions between the stakeholders of the process.

In this project we conduct a comprehensive study about the business components that impact the reuse of parts in the servicing business. As a result, we offer an aligned solution which addresses the challenges derived from each component, and demonstrate how the process workflow can be enabled through SAP.

1.2 Problem Statement

The SP&R organization is responsible for offering repair services to parts of MR and IGT imagining systems. These parts have been previously distributed to the key markets (hospitals, clinics etc.) and after being defective, they are sent to this organization for service. The main activities of SP&R are repair, rework and scrap, but other activities also involve autopsy, root cause analysis, and testing. The forward and reverse distribution channels are managed and controlled by the Service Part Supply (SPS) organization, which is the customer of SP&R. The parts delivered for service at SP&R are also referred as Field Replaceable Units (FRU). As a current procedure, if the FRU is beyond economical repair the complete part is being discharged as scrap. However, these parts are often complex systems which are composed of many smaller components. It is often the case that even though the entire FRU cannot be repaired, some of its components are still functional. Disposing such parts not only creates unnecessary scrap but also prevents full utilization of the resources at hand, which can be considerably expensive in this industry. Therefore, there is the need for a process which enables the harvesting of such components from the defective FRUs, and reuses them as repair parts for the next FRU. In this project we address this business need by designing and integrating a harvesting process into the everyday repair process of the organization. Similar to any operations in today's organizations, the process should be aligned and supported by the information systems. The information system currently in use, SAP RMA (Return Material Authorization) does not support a process flow for harvesting of parts and reusing them in the repair process. To integrate such a process in the operations of the department, it is necessary that the current information system is adapted to accommodate the new process flow. However, modifying such large systems is not a trivial task. Currently, there is a lack of well-structured approach for implementing a reuse process flow in an existing SAP interface [7]. Furthermore, the constraints and challenges of such implementation are scarcely documented in the literature.

Another challenge derives from the shared use of the system by different organizations within the company. Every organization has its role in the system and is dependent on each other for a smooth flow of the process. Adapting a new process in one of these organizations would most likely affect at least one of the other ones. Integrating a new process in the existing operations of SP&R requires the adaptation of the current way of working not only at this organization but also at the other participants affected by the system. Therefore, it is necessary to have a clear assessment of the impact that implementing such a process has on other users of the system. Ideally, the impact of the change should be the lowest possible in order not to disrupt the working ways of the organizations which do not directly benefit from the implementation of the process. However, isolating this impact poses a challenge because of the high collaboration between the organizations.

Following the above observations, the problem addressed in this thesis can be summarized as follows:

> ***Problem statement:*** There is no comprehensive approach to guide Philips SP&R organization into implementing a harvesting process which is supported by SAP and is aligned with the other participants of the process.

1.3 Research Goal

As explained in the previous section, there is a lack of a standardized approach for adapting current SAP transactions to accommodate the harvesting process flow and for regulating the impact of such adaptation into the other participants of the process. Therefore, the goal of this research is the following;

> ***Research Goal***: To design a framework which serves as a comprehensive guide for setting up a harvesting process at the servicing organization of Philips HealthTech.

Since SAP is the system used through this research, one of the main goals of this project is to find a feasible solution for employing the flow of the harvesting process through SAP transactions. Specifically, the implementation needs to be supported by SAP RMA which is a process within the SAP MBP module for processing service materials. SAP RMA provides the functionalities for handling the material flow of the imagining systems parts which are returned from the customers. As this research work aims at providing a thorough analysis of the different options for implementation, firstly the main challenges and constraints of the system are investigated. Then, several options for accommodating the harvesting process in the system flow are identified.

While considering the technical options for the SAP environment, we keep focus on the practicability of the solution. The effect of such implementation on the other supporting departments is carefully considered. As mentioned earlier, ideally we aim to keep the impact of the harvesting process on the SAP interface of the other departments as low as possible. Therefore, in this project we also consider scenarios for regulating the transactions among the participants by business agreements and outside of the SAP system. Our aim is to provide a multidisciplinary approach for setting up a harvested process in the servicing organization. Therefore, whenever parts of the process are not feasible to be implemented in SAP, we explore alternatives for realizing those parts of the process through business agreements. The expected result of this project is a comprehensive framework for the feasible integration of a harvesting process in the current operational workflow of the SP&R department. Considering both technical and business related aspects, recommendations for the implementation of the process are provided.

1.4 Research Questions

To address the main research goal of this project, several research questions which break down the assignment are formulated. Sub-questions assist by structuring the work in order to answer the main research questions. The main areas of investigation and research questions of this project will be the following:

RQ1. What are the main components to be considered for setting up a harvesting process?
- What is the role of each component?
- What are the constraints and limitations originating from these components?
- How do these components interrelate with each other within the flow of the entire process?

RQ2. What are the options for supporting the harvesting process through SAP?
- What are the limitations of the current SAP RMA system?
- What are the requirements for adapting this process in SAP RMA?
- What are the effects of these options on the SAP system of the other supporting departments?

RQ3. How can the harvesting process flow be integrated to the current operations?
- What is the process flow in the shop floor control?
- What is the process flow through SAP transactions?
- What is the business case for undertaking such a project?

The last sub-question in the RQ3 concerns the rationale behind setting up a harvesting process in the organization. As described in section 1.1 Context and Motivation, there are economic and environmental benefits to reuse parts in the processes. However, the specific financial benefit to the company is not yet researched. As final part of this project we conduct a business case analysis for determining the profitability of the harvesting process. We explain in detail the approach taken to assess the economic attractiveness of harvesting spare parts given the current business model and environment of working. The profitability of the process is highly dependent on the flow of materials arriving at SP&R for service. The production of medical devices is part of a dynamic and evolving industry [8]. The business structure and the flow of products might change in the future; similarly the business case may evolve. Therefore, the highest priority of this project is the design of a framework for enabling the implementation of the process. The analysis on the actual profitability of the process is to be considered as supplementary work and not as the main focus of this project.

1.5 Report Outline

This section describes the structure of the thesis. The report starts with the current introduction chapter that provides a rationale for the research project, presents the problem description, the research objective, and the research questions of this project. Chapter 2 outlines the research and design methodology. In Chapter 3 the background theory and concepts are provided and the information gap in the literature is defined. In the next three chapters (4, 5, 6) the design of our framework is presented in the conceptual, detail and integration phases. In Chapter 7, we firstly validate the effectiveness and practicality of our design through testing scenarios conducted in the SAP testing environment. Secondly, we provide a business case for validating the financial profitability of the designed process. Lastly, we conclude this study with Chapter 8 which discusses the conclusions, limitation and future work.

For a systematic execution we identified five main phases of the project: orientation, analysis, design, validation and implementation[2]. During each project phase there are activities and deliverables. Below we show how the work conducted during these phases is mapped in the report structure. In addition to the complete project planning, in *Appendix A*, we provide in Figure 1 an illustration of the order, in which the research is presented in this document.

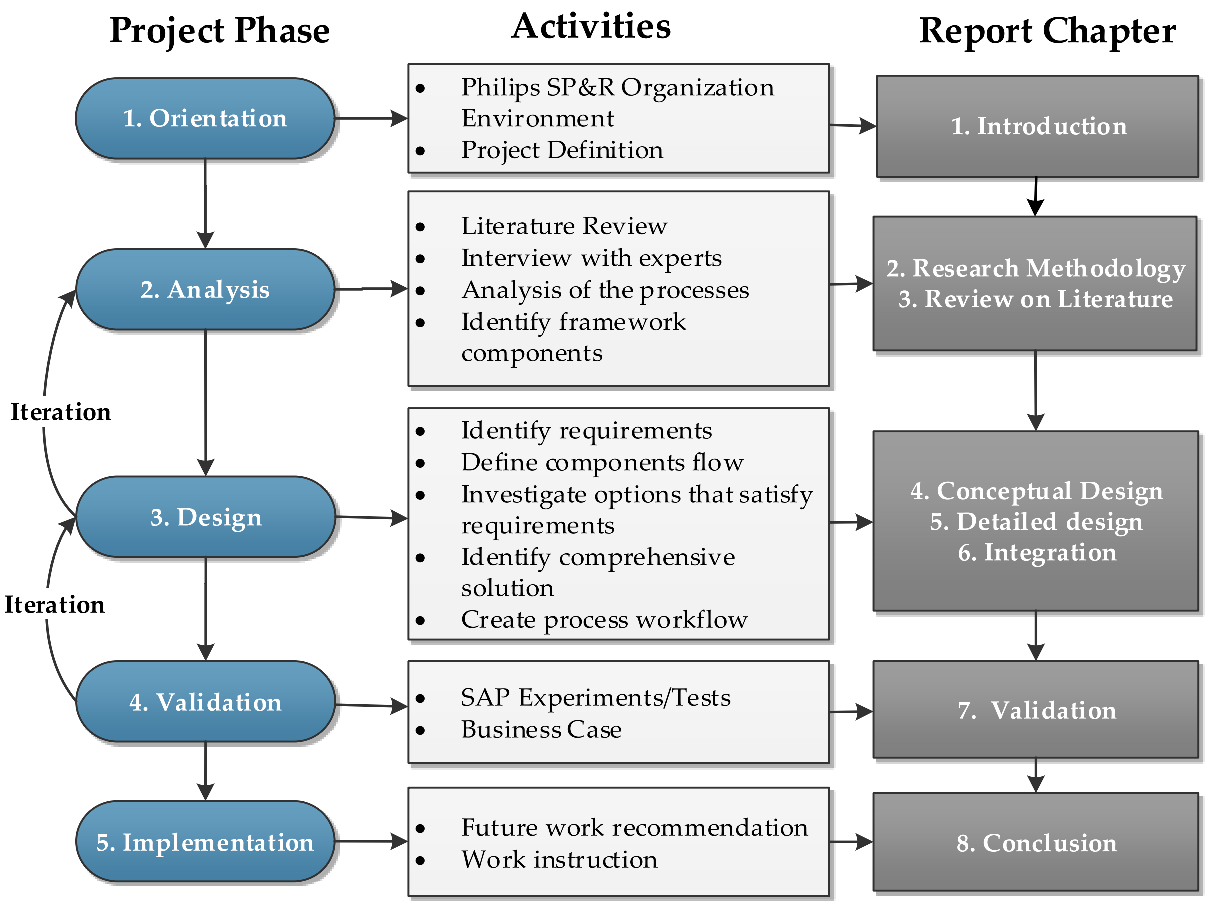


Figure 1. Project phases and activities mapped to chapter

[2] The technical implementation of the design is outside the scope of this project.

Chapter 2 Research and Design Methodology

If we knew what it was we were doing,
it would not be called research, would it?

-Albert Einstein

This chapter explains the research and design methodology followed in this report. The research methodology describes the steps and procedures followed to gather the necessary information for our research. The design methodology provides a systematic approach to the process of designing the framework. The data collected through the research methodology is used as input for the design phases of this project. Therefore, the research methodology answers the question *"How is the necessary information collected?"*, while the design methodology provides response to the question *"How is the collected data used in the design?"*

2.1 Research Methodology

In order to guide ourselves during this research project and provide optimal results, we use a scientific research methodology which prevents inconsistencies and provides various ways of validating our findings. The methodology used in this work is the well-known research framework of Hevner et al. [9] for the understanding, executing and evaluation Information Systems (IS) research. Design Science "addresses research through the building and evaluation of artifacts designed to meet the identified business need" [9]. An IT artifact can be a model, method, framework or instantiation that enables researches to develop and successfully implement information systems [10]. In our case, we contribute with a framework for implementing a harvesting process in the service business of the HealthTech industry.

According to Hevner et al., (2004) framework, the design of IS research lies in the intersection of people, organizations, technology and existing knowledge based foundations and methodologies. The visual illustration of the framework is presented in Figure 2.

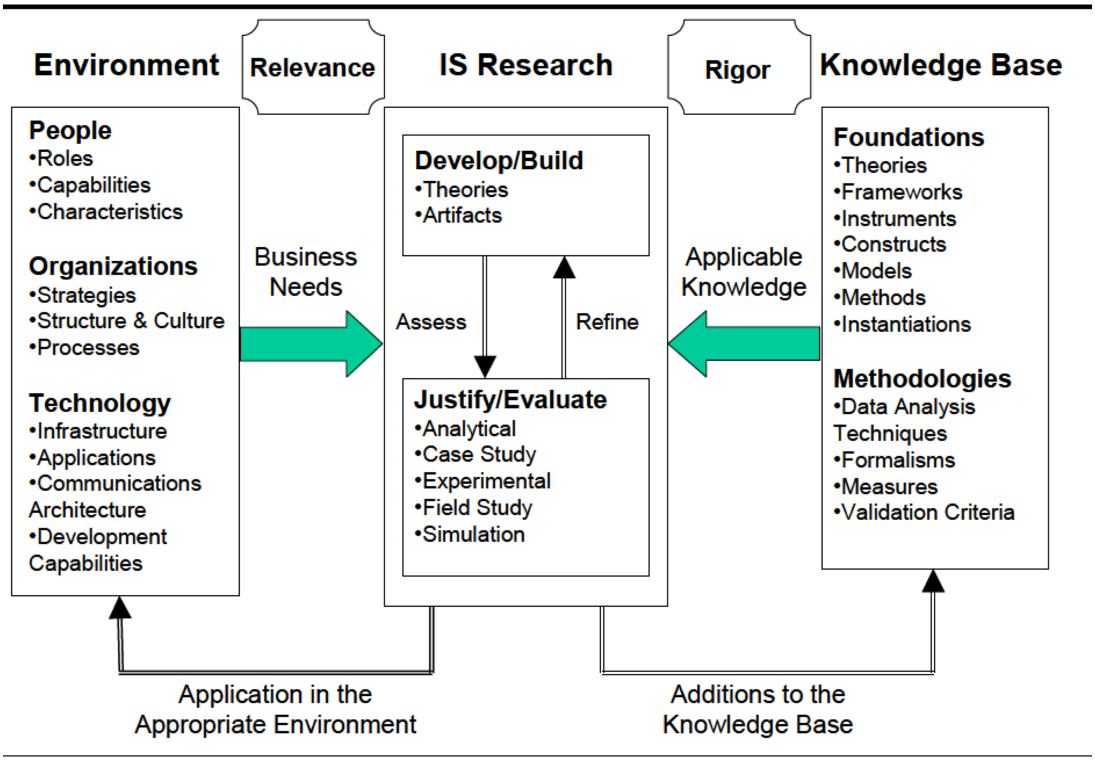


Figure 2. Information System Design Research Framework [9]

Hevner et al. (2004) identified three components of the design science research that interact with each other: the environment, IS research and knowledge base. The Environment represents the business needs and it is the context in which the phenomenon of interest resides. The problem originates in the environment which is comprised of the people, the organizations and technology at use. The knowledge based consists of the foundation that provides the required knowledge for the development of the IS research and methodologies. Finally, the IS research contains the research activities conducted in order to build and evaluate the artifacts which are designed to meet the business needs. It consists of building theories and artifacts, and then evaluating them with various methods. Hevner et al. (2004) offer five different evaluation methods: analytical, case study, experimental, field study and simulations. In this project we design an approach which includes technical recommendations for the support of a process through SAP. It is important to test the practicality and feasibility of our recommendations to the real environment. Therefore, in this project we use the experimental evaluation for checking the validity of our design.

Below we explain how we apply this research methodology into the project.

2.1.1 Environment

The business need for implementing a harvesting process derives by the environment in which this project is conducted. Within the environment we can detect the organization, the people working there and the technologies used. We explore and give a brief description of these three modules of the environment.

Organizations

SP&R is part of Philips HealthTech and it is located within the Imaging Systems group. The department is known for its good service which is reflected in the powerful mission: "Improve customer satisfaction through service excellence" [11]. The department is divided into two units MR and IGT. Both units are in the same facility, and they will both be considered for the harvesting process.

The supplier and customer of SP&R is the SPS organization, which is responsible for the logistics of the supply chain. Because of its close collaboration with SP&R, this organization is considered an important stakeholder in our project. SP&R does not generate any profit but it is a cost center. A cost center is part of a company that does not generate direct profit but receives money from the company to continue operating. Cost centers indirectly contribute to the profitability of an organization [12].

People

People are an important part of every organization. During this project we have continuous interaction with employees of different roles in order to gain a thorough understanding of the processes and the current ways of working. The staff composition in SP&R is quite diverse with an age range between 25-65 years old. The culture in the department is best characterized as a role-based culture [12]. There is a clear division of tasks among the employees. Additionally, coherent with the role of the organization many strict rules and procedures are followed during operations. The majority of the staff in the repair shop are technicians which handle the direct repair of the defective pats. The rest of the staff is composed by the engineers and two unit managers: MR and IGT.

Technology

Philips uses SAP ERP to integrate all facets of the business including activities such as inventory control, order tracking, customer service, finance and human resource. Depending on the business activity, there are diverse modules of SAP, such as such as SAP Materials

Management (MM), SAP Financial Accounting (FI), SAP controlling (CO) etc. There are several SAP systems being used in Philips HealthTech. The service organizations works with the SAP MBP kernel. The SP&R organization uses an environment within the SAP MBP kernel called SAP RMA (Return Material Authorization) which is used to process service materials.

SAP RMA is a crucial part of this research project. The process of implementing a harvesting process within the department requires that all materials and transactions are properly registered in SAP RMA, for an accurate, transparent and effective way of working. The main challenges of this project arise from the absence of the transactions which allow the harvesting process in SAP environment.

To tackle these issues and offer a solution, an extensive study of the SAP RMA is conducted. The current ways of working in the environment (SP&R) are analysed and the possibilities and limitations of the system are highlighted. The outcomes of this investigation serve as input for the design of our framework which is a solution for setting up a harvesting process in SP&R. The framework will address not only the IT (SAP RMA) issues but offer an aligned solution which integrates IT with the other supporting functions involved in the process.

2.1.2 Knowledge Base

The knowledge base provides the main source from and through which the IS research is accomplished [9]. From this knowledge base are drawn scientific theories and methods that provide foundations for rigorous design science research. There are two types of knowledge which are contained in the knowledge base: existing artifacts from previous research in the application domain of the research, and the experiences and knowledge of the experts working in the environment where the research is being carried out. In order to seize both of these sources of knowledge, we use two different approaches. Through an extensive literature study, we analyse and extract relevant information from scientific work in our area of interest. Additionally, we address the knowledge base from the experience and expertise of people by interviewing experts in the environment where the research is being conducted.

Document study

The first step performed during this research project was a literature study (Figure 1, Project phase 2). A literature review is an objective, thorough summary and critical analysis of the relevant available research and non–research literature on the topic being studied [13]. There are different sources of available literature reviewed and discussed to examine the topic of designing a framework for harvesting repair parts. Since harvesting is part of reverse logistics, an extensive literature study was conducted on the topic of reverse logistics and the business functions involved in it. Additionally, the information technology solutions which enable reverse logistics operations in businesses were researched and studied. Because the environment of this project uses SAP ERP, our investigation was focused specifically on the SAP module for return material authorization (RMA). In order to extract only the most relevant studies, a literature quality assessment was performed. The assessment is conducted by first creating a series of criteria which aims to reduce the pool of found references only to the most relevant ones. We categorized our assessment criteria into Relevance and Quality Screening criteria [14]. The aim of the Relevance Screening criteria is to determine which studies are considered to be the most relevant for the literature review research topic. The Quality Screening aims at assessing the quality of the studies. The articles which passed both criteria are the final studies which are used in our literature analysis. The methodology followed for the literature review and the findings are presented in Chapter 3.

In addition to the literature study, other topic related documents provided by Philips are used to investigate and gather relevant information. Two large documents databases, MR Quality Management System and IGT Business Management System, were proven to be highly relevant on providing information regarding existing procedures, quality requirements, and system constraints.

Interviews

Interviews are another technique used for collecting data in this research, as illustrated in Figure 1 (Project phase 1). There are three types of interviews: structured, semi-structured, and unstructured interviews. Structured interviews are conducted in a very standardized manner when each respondent is asked the same set of predefined questions. Usually this type of interview is the most beneficial if it is already known exactly what information is needed. Therefore, the structured interview is not explorative in nature. Semi-structured interviews have a more flexible nature and allow the interviewer to vary the list of questions depending on the profile and expertise of the interviewee. This type of interview allows more freedom to add questions that are deemed important during the interview and which were not initially determined [15]. The unstructured interview is conducted when the interviewer has no predetermined set of question but only a list of topics to be addressed. This type of interview is sometimes referred to as a "free flow" conversation, and it allows the interviewer to deviate the direction of the discussion according to what he considers appropriate [15]. Although this approach allows a high degree of freedom and spontaneity in the interview, it might endanger losing focus from the information that should be obtained. For the data collection of our project we use the semi-structured interviews. This method is considered to be the most beneficial because it combines structured questions in order to obtain the required information but it maintains a flexible nature which allows the opportunity to explore specific topics further.

Our project is a cross-disciplinary research which spans across many functions of the business: operations, quality and regulatory, information technology, finance, and purchasing. In order to be able to analyse the problem and design a framework which provides a comprehensive solution, it is necessary to gather information from all the involved functions. The different profiles of the interviewees and their roles in the organization allow for a various fields of expertise study belonging to our functions of interest. Therefore, interviews were conducted with experts in all the interested functions of the business in order to gather information and requirements belonging to each of those functions. The full representation of the interviewing phase which includes interviewee profiles, interview questions, and questions motivation is presented in *Appendix C* and *Appendix D.*

2.2 Design Methodology

The information collected through the research methodology is used in a systematic approach for the design of our framework. The design methodology used in this report consists of three phases: *conceptual design*, *detailed design* and *integration* phase [16], as illustrated in Figure 3.

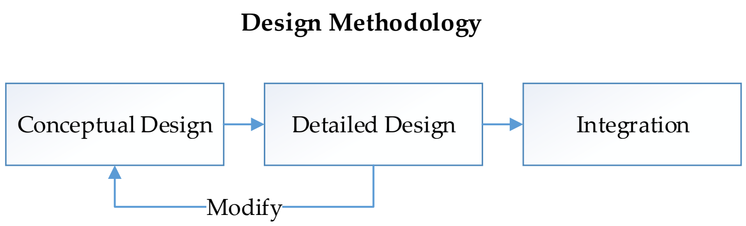


Figure 3. Visualization of the design methodology [16]

In the conceptual design phase the structure of the framework for harvesting repair parts is decided. In this phase the main components of the framework and their requirements are identified. Then the dependencies of the components with each other and the flow of information is analysed. The conceptual design provides an overview of the framework at an aggregate level. Since this design phase does not offer a detailed analysis of every component, the choices made at conceptual design might be modified after the detailed design phase. The detailed design phase consists of in-depth analysis of the components of the framework. In this phase the requirements for each component are investigated and options for satisfying the requirements are explored. The detailed design describes each of the options in detail and proposes the most feasible option as a solution to the components. This phase is the most crucial part of our design.

The integration phase combines all the steps and decisions taken in the previous two phases of the design. During this phase the chosen solution for each component is integrated in the framework. Therefore, a complete approach for harvesting repair parts in a multi-departmental environment is provided. The design is then instantiated by applying the framework into a process workflow. The process depicts the steps taken in the actual business by implementing the solutions offered. The integration phase finalizes the design of our framework which is later validated in Chapter 7 of the report.

Chapter 3 Literature Review

Knowledge has to be improved, challenged, and increased constantly, or it vanishes.

-Peter Drucker

Literature analysis enables to explore the knowledge base of the topic of research and integrate it on our project. This chapter presents the major definitions and concepts in the field of reverse logistics and their support by ERP information systems.

3.1 Approach

The methodology followed in this research is based on the systematic literature review which uses a rigorous and well defined approach to reviewing literature in a specific area [17].

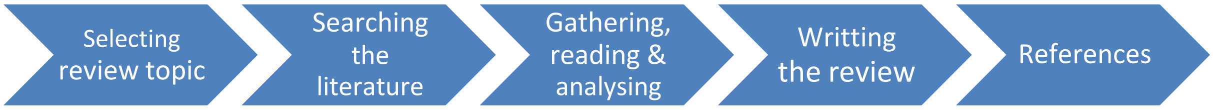


Figure 4. Literature Review Methodology [17]

Selecting a review topic is the first step while conducting a literature review. Specifying the topic of research is not only the first but also the most decisive step in the process, as it directly affects the evolvement of the project. The main task of this master thesis is to design a framework for setting up a harvesting process in the SP&R department of Philips HealthTech. The next step in the literature study methodology is researching the existing literature which is related to the topic being discussed. For finding and gathering relevant scientific documents many sources were used. According to Burnard Newell, comprehensiveness and relevance of sources is what reviewers need to consider [18]. Additionally, they outline that the results will be more focused if the topic or question being searched for is specific.

One of the most important steps on identifying relevant literature is searching by well-defined keywords. For this literature review we aimed at finding articles which were relevant for creating a framework on re-using service parts in the repair process. Therefore, some of the keywords which were used for this research are: Reuse parts, Remanufacturing, Quality Management Systems, Reverse logistics, Repair, Harvesting, Process Modelling, SAP RMA, Medical Devices Regulatory Compliancy, and Operational Compliancy.

In order to find information which combined more than one of these topics we used Boolean operators such as OR, AND, NOT. This type of operators resulted in queries such as:

(([service] AND [parts]) OR [service parts]) AND [reuse]

Because the term "harvested" is very commonly used in the agriculture and energetic industry, whenever we searched for the term we modified the query such that the articles of no interest were excluded:

([harvesting] AND [parts] NOT [energy] NOT [agriculture])

By using Boolean operators in the queries, more relevant literature was retrieved. However, the list of articles retrieved was very vast and not necessarily reliable. Therefore, a more elaborate search was conducted by restricting the usage of the databases used only to the most credible and trustworthy ones. Additionally, assessment criteria such as relevance and quality screening criteria were used to further restrict our finding to only the most relevant ones. A comprehensive electronic database search was initially performed to identify several electronic databases which are active in the field of business processes and supply chain managements. The search was first targeted at peer-reviewed journal articles and conference papers in order to identify only high quality studies. Certain filters were applied to the search mechanism such as English language, and articles written from 2000 to make sure to obtain recent scientific contributions.

In addition to database search and keyword search, forward and backward reference searching was applied to find more related relevant papers. The concept of forward and backward reference searching was introduced by Webster and Watson [19]. Forward reference searching is when a researcher identifies articles which have cited a particular article of work. The most relevant papers in a specific topic are the most cited ones. These papers are called cardinal papers, and they are often cited by many following works in that specific field. Forward searching identifies papers which have cited the cardinal papers. Backwards reference searching is identifying and examining the references cited in an article of interest. This is helpful in order to study the origins and developments of a theory, construct, or model of interest.

3.2 Recovery Systems

In the recent decades, the increasing concern over environmental issues, warranty obligations of used products, high cost of disposals and the economic benefits have been the driving motivations for the industry to pay considerable attention towards reuse, remanufacturing and recycling of used and discarded products ([4], [20], [21], [22]).

The traditional manufacturing paradigm is focused on obtaining profit by selling manufactured goods. The current changed paradigm implies considering various life cycle aspects of products, and optimizing their value and benefit [23].

The goal of value recovery is to retrieve components, assemblies, or whole modules from the product with the intent of reusing them in other products and process, by redirecting them to a second lifetime. Product recovery is not a new phenomenon. Waste paper recycling, and metal scrap are typical examples of product recovery that have been around for a long time. The recovery of used products is known to be economically more attractive than disposal [24]. It is estimated that product recovery activities can save 40-60% of the cost of manufacturing a completely new product, while requiring only 20% of the energy [24]. Thus, a remanufactured item with a lower price can be a great business strategy for increased profit margins. Additionally, a green corporate image further attracts environmentally conscious costumers, contributing to a larger market pie [25].

One of the most influential works on product recovery management was conducted by Thierry, Solomon, Van Nunen and Van Wassenhove in 1995 [22]. According to their framework, in order to optimize the value of products and reduce ecological waste, there are several tools that product recovery management (PRM) can use.

The five main recovery options to be used by PRM are repair, refurbishing, remanufacturing, cannibalization and recycling [22]. Each of these options is qualified in terms of level of disassembly, quality requirements and resulting product (Table 1). The decision on which product recovery option is selected depends on: technical feasibility; supply of suitable used products and components; demand for reprocessed products, components, or materials; and economic and environmental costs and benefits [22].

	Level of Disassembly	Quality Requirements	Resulting Product
Repair	To product level	Restore product to working order	Some parts fixed or replaced by spares
Refurbishing	To module level	Inspect all critical modules and upgrade to specified quality	Some modules repaired/replaced: potential upgrade
Remanufacturing	To part level	Inspect all modules and parts and upgrade to as new quality	Used and new modules/parts combined into new product:
Cannibalization	Selective retrieval of parts	Depends on process in which parts are reused	Some parts reused: remaining product recycled/disposed
Recycling	To material level	High for production of original parts: less for other parts	Materials reused to produce new parts

Table 1. PRM recovery Options [22]

The term "harvesting" which is used throughout this project is synonym for "Cannibalization" of the PRM recovery options. To be consistent with the terminology used at Philips HealthTech, and to convey a more benevolent notion, the term "harvesting" will be used in this project instead of "cannibalization".
Harvesting is one of the product recovery options which disassembles the selected parts for retrieval. The quality requirements for the harvested parts varies on the process in which these parts will be reused. After the parts of interest are reused, the rest of the product is recycled or scraped.

This research work is concerned with the harvesting process for service parts. Service parts inventories represent an important part of the assets for organizations with intensive equipment such as Philips Medical NL. The terms service parts and spare parts are often used as interchangeable and they refer to the same items. Spare parts inventories are different from manufacturing inventories as they are not intermediate or final products to be sold to the customer. Additionally, the policies which govern service parts inventories are different from those which govern work in progress (WIP) and other inventories [26]. In logistics, the service parts can be classified in two big groups: repairables and non-repairables. The repairable parts are those which are technically possible to be repaired and reused in the process as parts of a product. Since non-repairable service parts are not in our scope, from now and on we will only consider repairable service parts when addressing service parts.

Repairables usually take up a smaller portion of the number of items in inventories; however they are generally more expansive. This means that their share in the total service department is just as relevant compared to consumables [27]. Repairables are particularly important to companies which operate with heavily utilized and relatively expensive equipment [28]. For example, repairable inventory systems are common in the military and typically composed of high cost, long-life goods that are less expensive to repair than to replace [24].

3.3 Reverse Logistics

From a logistical perspective the recovery activities give rise to an additional goods flow in the supply chain management: from the consumers back to producers. The management of this flow opposite to the conventional supply chain is the main subject of the recently evolved field of study of "Reverse Logistics" (RL). The concept of reverse logistics has evolved over the years and authors have defined RL in different ways. The earliest definition of RL have been given by Murphy and Poist mentioning about the reverse flow of goods [29]. Other definitions have followed which added the term "environment" to the definition [30]. The concept has gone through various descriptions, but the most widely accepted definition of RL has been given by Rogers and Tibben-Lembke who defined RL as

> *"…the process of planning, implementing and controlling the efficient, cost-effective flow of raw material, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or for proper disposal"* [31]

During the last decade, Reverse Logistics has been stretching out worldwide, involving all the layers of the supply chain in various industries. Some actors in the chain have been forced to take products back; however, many others have proactively done so attracted by the value in used products [32]. One way or the other, Reverse Logistics has become a key competence in modern supply chains [33].

Drivers and Barriers

Adapting and implementing RL is a decision process which involves several factors and are useful for evaluating the RL effectiveness. A critical analysis of the factors affecting RL can provide valuable information for RL implementation. Rogers and Tibben-Lembke (1999) suggested that there are a number of factors affecting RL practices, and the presence or the absence of these factors can become drivers or barriers to the RL implementation. Many authors have investigated and categorized these factors.

Most of the authors claimed economic factors to be strong drivers to the RL implementation ([24], [4], [32]). Other factors found in the literature include extended producer responsibility, codes of conduct, environmental and green issues and legislations ([30], [5], [32]).

Similar to the drivers, the barriers of the RL implementation have been treated and discussed by many authors. Some of the most frequently resulted barriers to RL are strict regulations, resource constraints, asserted customer preferences, lack of commitment and most importantly: lack of proper technology ([34], [32], [35]).

3.4 Information Technology in Reverse Logistics

Many scholars have recognized reverse logistics as a very important area within the context of supply chain management. If managed correctly, RL can help firms gain competitive advantage [36]. Because RL is information intensive, many authors have undertaken research looking at how companies can boost their competitive advantage through their information technology capabilities.

A comprehensive study on Reverse Logistics, performed by the global consultancy firm PricewaterhouseCooper, revealed that the dissatisfaction with the information technology support is one of the main barriers to effective implementation of RL [33]. The study revealed a clear gap between the importance and satisfaction of IT in RL management. The best-in-class companies are able to align and integrate information systems, however the availability of appropriate software is a challenge [33]. It came forward that companies use systems which are interfaces rather than integrated. This lack of integration causes double data processing, manual transfer and puts pressure on the accuracy and quality of the data [33]. A conducted survey with more than 200 first class producers, highlighted that 68.2% of producers actually have ERP software in place for supporting reverse logistics operations; however, the functionality is often spread over many modules and it is not integrated [33].

It is important that companies are able to physically handle returns including activities such as stock selection, transportation, collection and handling. However, they must also develop data management capabilities i.e., be able to align the customer and manufacturer's data, create invoices, generate credits, detail accounts receivable and payable. But most importantly, companies should be able to strategically apply the information gathered through the information systems to the benefit of internal processes and to support supply chain-level planning [37]. Many firms are over concentrated on physical distribution and give little attention to the reverse logistics material management [36].

SAP RMA

Some of the systems that have evolved over the past few decades are MRP systems, ERP systems, RFID and ARPs which systemize the forward and reverse flow of products and materials across the supply chain. In this literature review, we dive deeper into the ERP systems, and specifically the RMA module of SAP ERP which handles the Returned Material Authorization.

One of the critical processes of an organizations supply chain (SCM) is the return material process. The control and tracking of returned materials plays a significant role in the medical devices manufacturing industry where products cost several hundred to several hundreds of thousands of dollars. Besides the direct financial loss to companies from repairing non-warranty items for free or replacing items never returned, there are also the serious issues of product quality and regulatory compliances. As a result, a poorly designed and implemented returned material process can have significant negative impacts on the organization's performance and future. Because this process crosses several functional areas such as materials, accounting, manufacturing, sales and service, an integrated information system solution is required. The SAP Enterprise resource planning system provides a solution with its return material authorization (SAP RMA) process.

The RMA process involves the physical flow of the material and the flow of the information concerning that material. The physical flow includes customer return (inbound logistics), repair/refurbishment cycle, and delivery of repaired item (outbound logistics). The information flow consists of customer contact date, transportation details, goods receipt, repair history, scrapped items, replacement product, quality data, etc. [38].

The major benefit of an ERP system is that a transaction can be uniformly managed from the point of inception to its final disposition [39]. The RMA process begins when the customer service personnel has determined that the material is defective and needs to be returned for repair. Raymond F. Boykin, a professor of Operations Management at California State University and a SAP expert, maintains that in a very general overview, the complete processing of the RMA involves connecting four processes:

a) RMA creation process
b) RMA material receipt process
c) RMA material issue process
d) Repair process

During these four core processes, Boykin identified several RMA issues such as material tracking, unplanned goods receipts, warranty information, replacements, and material revision level [40].

3.5 Conclusion

Over the past 20 years, conference and journal paper on product recovery and reverse logistics have been considerably increasing. This suggests that the research on the topic is increasing, and as more research is conducted the overall concepts of recovery and what it involves has become clearer. The work of Thierry et al. (1995) was one of the pioneer analysis of product recovery management and issues related to product recovery options. Thierry et al. (1995) identified the various options for product recovery and clearly distinguished between each of them. Similarly, literatures on Reverse logistics have been reviewed by many researchers in the past. Fleischmann et al. (1997) studied RL from the perspectives of distribution planning, inventory management and production planning. Pokharel and Mutha (2009) reviewed 164 articles on important RL features such as product acquisition, pricing, collection of used products, RL network structure, the integration of manufacturing, and remanufacturing facilities of location of facilities for inspection and consolidation activity.

Additionally, the impact of information systems in supply chain management and RL in specific have long been recognized ([4], [41], [32]). The performance indicators and the success of such information systems to the service of reverse logistics have been greatly discussed and argued. Moreover, the issue of the lack of integration between different modules of the system has been recognized [33]. However, little research has been performed on the adaptation and implementation of such information systems to the reverse logistics of a specific form of product recovery. There is no reference in the literature about the main challenges faced by the ERP system while trying to align between different participants of a reverse logistics process, and recommendations on how to address these challenges. In this thesis, we fill this research gap by proposing a comprehensive framework for supporting reuse of spare parts in the repair process of a Philips organization through SAP, and enabling the alignment with the various participants of the reverse supply chain.

Chapter 4 Conceptual Design

Thinking fragments reality, it cuts it up
into conceptual bits and pieces.

-*Eckhart Tolle*

This chapter presents the conceptual design of our framework. First, an analysis of the main findings collected from the environment and the requirements of the entire process are presented. Second, an operational framework is presented which will serve as a basis for the design of the conceptual framework. By analysing the current environment, we map the existing organizational structure of Philips into the base framework and identify the main components of our framework and their interaction. Last, the flow of information in the conceptual framework is described.

4.1 Requirements Elicitation and Analysis

A various number of data sources are needed to extract and analyse the inputs for this study. Due to the diverse nature of the information required, it is not possible to use one central dataset containing all relevant information. Instead, numerous sources from various departments and levels of the organization are used. At this initial phase of the work, the aim of the investigation is to identify the requirements of the overall system.

Identifying requirements is a crucial and arguably the most important step in a project design [42]. Requirements are essential to understand not only what is expected from the system, but also what are the boundaries and challenges of setting up a harvesting process in the current environment. Also, by outlining the requirements, a better understanding is gained about the various areas from which these requirements arise. This information is an important input on determining which will be the main components of the framework. Requirements elicitation requires that conclusions are drawn through a well-planned and deliberate search [43]. It is an active effort to extract information from stakeholders, documents and other relevant sources for the subject. In order to elicit requirements, a proactive approach involving different techniques should be adapted. Some of the various techniques of requirements elicitation involve: document analysis, meeting discussion, interview, group meetings, workshop, questionnaires, and prototyping [44]. For this research work, the techniques used to elicit the requirements are document analysis, meeting discussions, interviews and group meetings. For the input of this analysis, internal company documents were investigated. The information form the document study is then complemented from interviews and discussions with the field experts *Appendix C.*

During this research, a large number of requirements from different areas of the business were elicited. A full list of these requirements and the importance assigned to them is presented in *Appendix E*. By evaluating the role of the requirements and their dependency on each other, it was determined that all the requirements can be grouped into four main requirements, which also represent the main areas from which the requirements are derived. These main requirements are crucial for the operation of the whole system and addressing these requirements becomes the main priority for the design. For the conceptual design phase, we present the main requirements in an aggregate manner. More details and specifications about these requirements will be analysed in the detailed design phase. Below we present the requirements of the overall system and explain the rationale behind such requirements.

R1. The process should be compliant to quality and regulatory standards

Medical devices are identified as unique products requiring strict regulations [45]. The special nature of medical devices is due to their potential harm to the users in case of malfunction or misuser. Because of the potential severity of the consequence of introducing inferior or unsafe product to the market, manufacturers of medical devices are held to a higher standard than manufacturers of many other products [46]. In accordance with the market expectations, Philips HealthTech is also a highly regulated business. The company operates globally in many countries; therefore, its operations are regulated by different regulatory standards throughout the world. For example, because Philips HealthTech operates in the United States of America, all its operations should be compliant with the Foods and Drugs Administration (FDA), which is the largest federal agency of the United States Department of Health and Human Services. FDA is responsible for protecting and promoting public health through the regulation and supervision of all types of food and drugs, but also medical devices manufacturers [45]. For its operations in Europe, Philips is under the regulatory umbrella of the International Organization for Standardization (ISO Standards). FDA 820 and ISO 13485:2003 quality system regulation are the most prevailing ones in the medical manufacturing industry. Compliance to these quality standards provides high degree of assurance that a manufacturer will consistently produce medical devices that are safe, perform as intended, comply with customer and regulatory requirements and have the appropriate level of quality [47].

In addition to the FDA and ISO standards, Philips has its own quality management systems which specify and describe all processes occurring within the organization [11]. In the imagining systems group, the operations for the manufacturing of MR devices follow the MR QMS (Quality Management Systems), while the production of IGT devices is regulated by the

IGT BMS (Business Management Systems). Despite the slight difference in their name (QMS vs. BMS), these systems are similar in their purpose to provide a standardized way of operating medical devices. SP&R department does not manufacture medical devices, but offers repair services. Because in SP&R both MR and IGT machines are repaired, the processes related to the repair of these machines are standardized by the QMS and BMS, respectively [11]. Therefore, every new process implemented in our environment must be compliant to these quality standards. Because of its high importance, compliancy to quality and regulatory standards is identified as the main priority requirement for the harvesting process.

R2. The process flow should be recorded in SAP RMA

This requirement also represents one of the main goals of this research work. Information technology is essential for end-to-end control and transparency along the reverse chain. Aligning and integrating the information system with the process is a fundamental requirement. The harvesting process aims at extracting spare materials from non-repairable devices which are being scrapped. By saving those materials, a new stock of second hand materials is created. Like any other material, this stock constitutes inventory and should be recorded as such in the SAP system. The saved materials would later be used as substitute parts in repairing other devices. Therefore, a material which was about to be scrapped, is saved in stock and then used in another product. Registering this flow of material is important not only for inventory management but also for material traceability. Since the harvested materials have been previously distributed to the market, it is important to keep track of where these products are being reused and how many times. In this way, the risk of using one material more times than allowed by its design specifications is avoided. Given the importance of the alignment between the information system and the process, enabling the harvesting process flow through the SAP RMA interface is considered a main requirement.

R3. The harvested materials should be financially evaluated

One of the most important aspects of any project is the financial accuracy. The rationale behind reusing materials is to reclaim value from the returns [33]. Therefore, it is important that this value is correctly captured and reflected in the financial statements of the company. From an accounting point of view, having accurate valuation of the inventory directly affects two main financial statements: the income statement and the balance sheet [48]. Below we briefly explain the purpose of each financial statement as defined by GAAP (Generally Accepted Accounting Principles), and point out the impact that inaccurate inventory valuation has on them.

The income statement summarizes a company's revenues and expenses at the end of a period which might be quarterly or annual. This statement is divided in two parts: the operating and non-operating sections. In the operating items of the income statement are represented revenues and expenses which are directly linked to business operations, such as manufacturing devices. The non-operating section includes revenues and expenses which are not related to the company's main business, such as the one time investment of buying new offices. The valuation of inventory affects directly the income statement. The inventory value of a company is recorded in the operating sections as cost of goods sold. Having inaccurate valuation of cost of goods sold will induce erroneous gross profit and net income.

The balance sheet presents a company's assets, liabilities and shareholder's equity at a specific point in time. It is called balance sheet because two sides of the statement balance out: the sum of liabilities and shareholders' equity is equal to assets. The value of inventory is reflected in the balance sheet under the accounts of working capital, total assets and owner's equity. Hence, inaccurate valuation of the inventory will incorrectly record all these three accounts, and create errors in the final results of the balance sheet.

Because of the high importance that accurate inventory valuation has on the financials of a company, correctly evaluating the harvested materials becomes a main requirement for the system.

R4. The process should be aligned with the customer

Similar to forward flows, managing Reverse Logistics is not the activity of just one department. In order to optimize the reverse chain, collaboration of all relevant departments is fundamental. The parts which arrive at SP&R for repair are brought by the customer of the department. Similar to any repair shop, the customer brings and owns the device to be repaired. After the repair shop has offered the service, the part is delivered back to the customer. In our environment, the role of the customer is covered by the SPS department. Since the parts to be repaired are officially owned by SPS, so are the materials which would be harvested from these parts [11]. The aim of SP&R is to later reuse these parts in the repair process. Even though the harvested materials will be extracted from devices which are about to be scrapped, it is necessary to align with the official owner of those parts for the appropriation to take place. Therefore, finding an appropriate scheme to align with the customer is a requirement of the overall harvesting process.

At this phase of the conceptual design we aim to determine the main components of the framework. Therefore, we limit to the presentation of the main requirements of the overall system. These requirements are used as input to understand the main decision areas within the framework. After the components of the framework and their interaction is determined, we proceed by mapping more specific requirements to the blocks of the framework.

4.2 Base Framework

The main objective of this thesis is to develop a comprehensive framework for setting up a harvesting process in the service organization. The use of frameworks is a thorough method that provides an overview of all possible decision areas that influence organizational performance. To build the framework we use a holistic approach, which implies that all the aspects involved in setting up harvesting are considered. Even though holistic approaches are difficult to manage because of the complexity, they are the most beneficial approach as they take in consideration all the different dimensions of the initiative [49].

The first step of the conceptual design has a focus on identifying the key decision areas of the framework. For this purpose we use existing frameworks as a reference for building our own. Wolf-Pany provides an overview of the main elements that contribute to operational efficiency in his operational framework [50]. This framework provides a comprehensive view on product development and service delivery. The framework consists of six blocks: policies, standards, process, procedures, training, and tools or methods (Figure 5). Below we explain the role of each block according to Wolf-Pany.

Policies involves the laws and regulations that govern the operations. Policy statements are usually used to enforce the use of organizational processes. Therefore, the policies constrain the organizational processes by identifying required or acceptable ways of doing a certain process.

Standards are the operational definitions of the final or intermediate work products. The standards define the level of quality that the product must be compliant to. Standards constrain organizational processes by setting acceptance criteria on the output of those processes.

A process describes that activities that the organization conducts in order to build the products or deliver the services. Processes should specify ways to develop products or deliver services which conform to the standards and policies. The processes describe *what* happens in the organization. On the other hand, procedures explain *how* the processes are implemented. Procedures usually include step-by-step instructions for executing an entire process or just a part of it. Therefore, processes are implemented by specific procedures.

The training block addresses the knowledge and skills required to execute a process or use a procedure. Training is used to support the use of processes and procedures. In the final block are located tools and methods. These elements are needed to implement a procedure. Tools can, for example, be new equipment or resources for supporting a procedure.

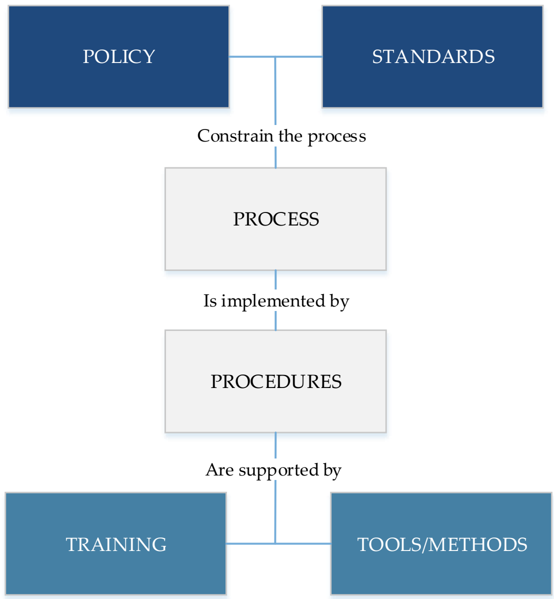


Figure 5. Operational Framework (adapted from [50])

Even though all the elements are fundamental to the operation of the framework, the heart of the operational framework is the process. The process itself is constrained by the policies and standards of the organization. The process is translated into work instructions by the procedures. In order to be implemented, the procedures need to be supported by skills of the people using the procedures and the tools and methods which enable the procedure. The Wolf-Pany framework serves as a comprehensive guideline through the operational setup of an organization. Pointing out the main actors of the framework and defining their relationship provides a basis for constructing the framework of the harvesting process.

4.3 Environment Decision Areas

In addition to the Wolf-Pany's operational framework [48], data collected from the environment is used as input in order to frame the main decision areas which are the components of the framework.

As explained in the methodology chapter (Chapter 2), document study and semi-structured interviews are used to collect information from the experts working in our organization. In addition to eliciting requirements, another goal of these interviews is to gain insight on the organizational setup of the business, the functions involved in the repairing process, and the dependences of each function on each other. Specifically, we are interested on the stakeholders involved in the current repair process. Since harvesting is closely linked to the repair process, the stakeholders in the new process remain the same as in the repair process. From the data collected, the main actors in the repair process are identified to be the following: SP&R itself, SPS, Quality and Regulatory, purchasing and the finance department. Below we explain the role of these departments and their interaction with each other (Figure 6).

SP&R is naturally a key stakeholder in the process, since the process of harvesting, the main element of the framework takes place within this organization. SPS represents the customer which brings the defective devices to SP&R. The financial interaction between these two departments is managed by the finance department. Finance controls all the economical transactions within Philips HealthTech. Even though this department is in charge for the financial alignment of many departments within the company, for our project we focus on the role that finance has with regard to SP&R operations. Since finance serves as a facilitator between our organization and the customer, this department is a fundamental function of the system.

The purchasing department is responsible for assuring that SP&R has enough available materials to repair the defective medical parts. The purchasing of these materials is of course reflected in the financials of the company, and therefore is closely linked with the finance department. Within the context of reverse chain supply, the customer of the repair shop is also the supplier which brings the materials for repair. Since purchasing is responsible for the material supply in the shop, it also interacts with the customer, SPS. Therefore, purchasing has close interaction with all three department: SP&R, finance and SPS.

The operations of these four departments are constrained by the policies and standards of the medical devices industries. At Philips HealthTech this responsibility is held by the Quality and Regulatory (Q&R) department. The Q&R is a key stakeholder in any processes implemented in our environment, because they regulate and control if everything is compliant with the highest standards of quality. The first requirement of the entire system, *R1. The process should be compliant to quality and regulatory standards*, arises from this function of the business. Therefore, the policies and standards which constrain the process, as referred by the operational framework [50], will be represented in our framework by the Q&R department.

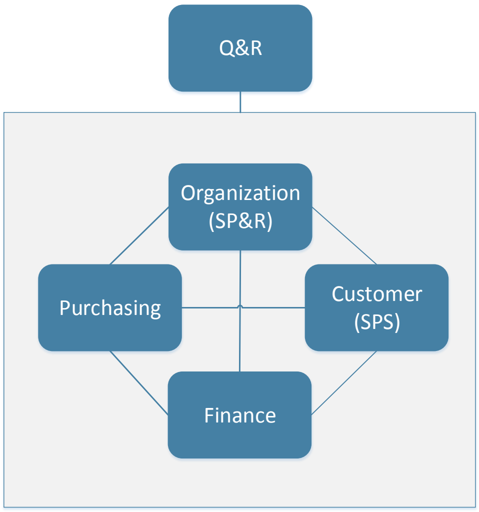


Figure 6. Harvesting Process Stakeholders: a simplified representation

In order to implement a process, the process needs to be supported by training and tools/methods [50]. In our case, the main tools required to support the process is the IT system used in the environment, SAP RMA. Because IT is crucial for the implementation of any process, the decisions taken in this step are fundamental. The second requirement of the system, *R2. The process flow should be recorded in SAP RMA,* derives from this decision area. This main requirements, reinforces the observation that IT is a main component of the conceptual framework.

The next two requirements of the system, arise from the finance and purchasing area, respectively. The financial constraints require that any material in the inventory is evaluated to a price, in order to correctly reflect the real inventory value in the financial statements. Therefore, the requirement number three "Harvested materials should be financially evaluated", makes the finance function another fundamental component of the system.

The last requirement (R4), which calls for an alignment with the official owner of the harvested materials, originates from purchasing. As outlined in the requirement, it is necessary to take steps and decisions which align the process with the customers. These steps concern the flow of materials from one party to another and the appropriation of these materials. In our framework the area responsible for these steps and decisions is purchasing.

After the process is created, it needs to be supported by proper training of the employees. We consider this phase to be the final step in the implementation of a process. In addition to proper training, other activities are required for the execution of the process, such as implementation of the IT changes which enable the process in SAP, and written employee work instructions for the new process.

4.4 Conceptual Framework

From the base framework (Figure 5) and the analysis of the environment *(Section 4.3)*, a conceptual framework is developed which defines the main decision areas of the process and their relationship, portrayed in Figure 7. The main components of the framework are the following: Organization, Quality and Regulatory, Purchasing, Finance, Information Technology, Process, and finally the Implementation. Below we explain the role of each component and the information flow in the framework.

The first step for designing and implementing a process starts in the organization where the business need for the process arises. Analysing the environment is fundamental in order to identify ways of meeting the business need. After the business need is identified, it is important to determine the attractiveness of the project by conducting a business case. A business case aims at determining the economic rationale behind investing in such a project, and it is a helpful tool to be used by the management for decision making. The outcome of the organization components is the identification of the process which needs to be implemented in the company and the financial motivation behind it. This information is used as input in the next component of the framework: Quality & Regulatory. Once a project is determined to be initialized, the next step is elicitation and analysis of the requirements for designing and implementing the process. In the HealthTech industry, the strictest requirements arise from the quality and regulatory standards, which aim to assure high product quality and safe work environments. Meeting these standards becomes a priority for any process. Therefore, the Quality & Regulatory component of the framework is placed in the second place.

The outcome of the Q&R element of the framework is an identification of all the requirements required for the process. This requirements will directly affect the following elements in the framework because they pose constrains on the way the following components operate.

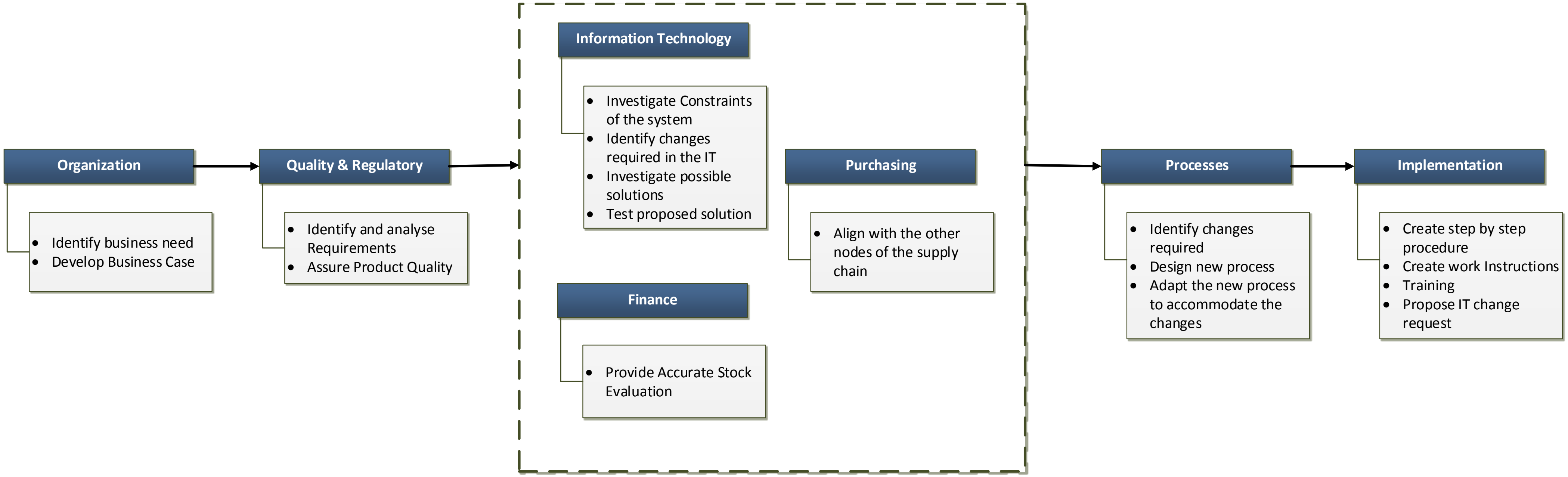


Figure 7. Conceptual Framework for setting up a harvesting process at SP&R

The following element in the framework is a group of three components: Purchasing, Finance, and IT. These components are gathered within the same group because of the high level of interaction among them. Purchasing and Finance are constantly interacting to support the economic functions of the business. Additionally, every interaction needs to be supported by the information technology. The possibilities and limitations of the IT system, affect the way purchasing and finance operate. These three areas need to be aligned with each other and the decisions taken in them would directly affect the process. The information technology component is responsible for providing SAP support for the harvesting process. Within this area, the constraints of the current system should investigated, new changes required for the process should be identified and solutions to address the issue should be proposed. Finally, the proposed IT solutions should be tested in the working environment.

The main role of finance is to provide accurate financial evaluation which is transparently reflected in the financial statements. With regard to the harvesting process, the main role of finance is to provide accurate evaluation of the harvested materials. The purchasing component of the framework is responsible for aligning with the other nodes in the supply chain.

The role of the process is to offer a complete operational flow for harvesting parts in SP&R. In this component the decisions taken during the previous components of the framework are integrated into an overall process flow. The repair process is changed to accommodate the new harvesting process.

After the process has been designed in alignment with the previous five elements (Organization, Quality & Regulatory, Finance, Purchasing and IT) the new process needs to be implemented. For implementing the process, it should be translated in a procedure which is a step by step instruction [50]. Additionally, some supporting activities such as training of the employees, writing work instructions for each role, and submitting an IT change request need to be executed.

4.5 Concluding remarks

The beginning of this chapter started with the presentation of the main requirements for the whole system. Using a reference operational framework and information regarding the organizational setup of the environment, we constructed a comprehensive conceptual framework. The framework includes all components which should be considered during the implementation of a harvesting process and the flow of information among them. The four main requirements of the system, R1, R2, R3 and R4 were identified as originating from four areas of the framework: Q&R, IT, Finance and Purchasing, respectively. The first requirement, *R1. The process should be compliant to quality and regulatory standards*, is a fundamental requirement, and yet a quite ambiguous one. Since the rules and regulations of a healthcare company are very vast, we conducted a thorough research about the more detailed requirements within requirement R1. From our investigation, it resulted that most requirements regard safety and product quality standards to be applied in the physical shop floor. These requirements include practical activities, such as labelling the harvested stock in order to avoid confusion between different stocks of material. Because such requirements are easily realizable in the day to day operations, we concentrate our efforts into requirements which cannot be satisfied without the support of SAP RMA. From the investigation of all the Q&R requirements, analysis of the current SAP RMA environment, and discussion with the field experts it is pointed out that the most challenging requirement concerns stock segregations. Specifically, it is a Q&R requirement to "Segregate the harvested stock from the new buy stock, in the physical environment and in the SAP RMA system"([45], [51], [52]). This requirement dictates the clear isolation of second hand materials from the new materials in order to avoid mix-up. While fulfilling this requirement in the physical shop is easy, doing so in the SAP is not a trivial task. Currently the department stocks only new-buy materials, and the SAP system records and treats all materials in the same way. With the introduction of second hand materials in the system, there should be a clear isolation between the two statuses of material. Details about the challenges and possibilities of this requirement are discussed in the following section. However, it is important to note that this requirement of the Q&R component of the framework has now become a requirement for the IT. As described by the framework, requirements of Q&R directly affect the following components of the framework. Therefore, considering that stock segregation in SAP RMA is the most important requirement originating from Q&R, we can translate requirement R1 of the system into a more specific IT requirement "SAP RMA Stock Segregation".

Requirement R2, regards the process flow to be supported by the SAP RMA. The current repair process is currently being supported by the system. As explained in Chapter 1, the aim of the department is to harvest materials from parts which arrive at the shop floor for repair but which are beyond economical repair. Therefore, the harvesting process is either a subprocess or a different process flow within the current repair process. The main obstacle for enabling the harvesting process flow in SAP RMA is the same as explained from requirement R1. Having a clear separation in SAP between the new materials and the second hand ones, is a priority.

Requirement R3 and R4 of the entire system are specific enough to remain the same. As identified earlier, evaluation of the harvested materials (R3) is a requirement which belongs to the finance component of the framework. Alignment of the harvesting process with the customer (R4) regards the purchasing function. Even though these last requirements fall into areas different than IT, in order to have a comprehensive solution the SAP RMA system should enable these requirements. Therefore, we look into these requirements from an IT perspective and research options to solve them in the SAP environment.

From the identified requirements, it is clear that the main components to be addressed in the design of our solution are IT, Purchasing and Finance. Even though each of these areas have their own requirements, they must all be aligned in order to have a comprehensive solution (Figure 8). In the next chapter we proceed by analysing in detail the three main components and their requirements. We investigate options which satisfy the requirements and discuss their feasibility to entire system.

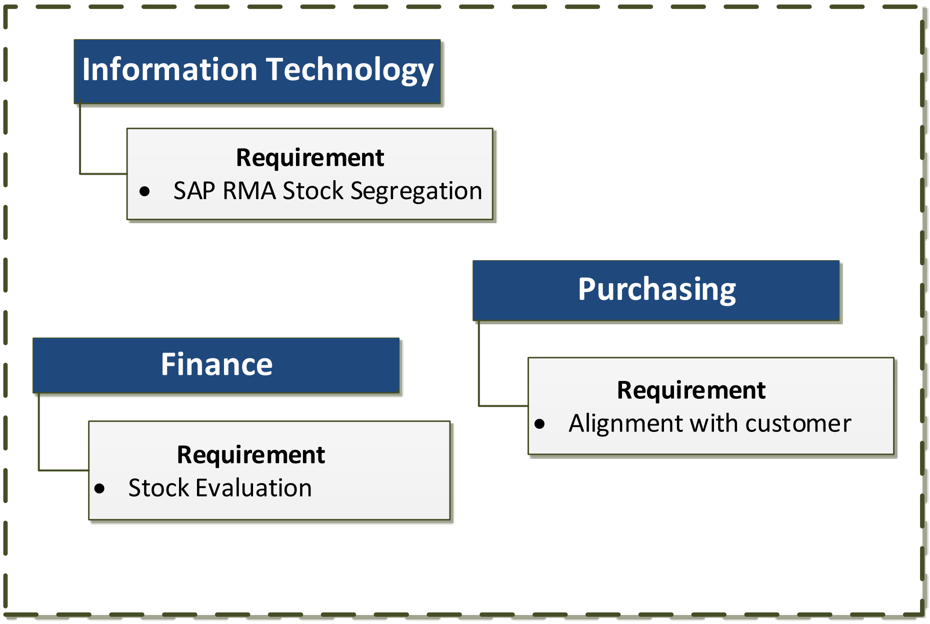


Figure 8. Identified requirements per framework component

Chapter 5 Detailed Design

The devil is in the details.
-Gustave Flaubert

The previous chapter presented the conceptual design of a comprehensive framework for harvesting parts. The framework defined the main components and the interaction among them. Three main requirements were identified arising from the components of IT, Purchasing and Finance. This chapter analysed each of the requirements and provides several options which address the issue. Afterwards, the options provided are discussed, and a pros and cons analysis is provided to better understand the implications of each option. Finally, we propose the most feasible approach which meets the requirements of the components.

5.1 Information Technology

SAP Stock Segregation

As stated in the Conceptual Design chapter, the requirement for the information technology is to clearly segregate between harvested stocks and new stock in SAP. In order to address this requirement, it is necessary to present and analyse the current SAP RMA system. In this section we explain the levels of SAP hierarchy structure (Figure 9), and its importance for addressing the requirement.

The Material Management module (MM) is a core component of the SAP software. The functionality within MM is the engine that drives the Supply Chain. The highest hierarchical level of the SAP is the *client*. All areas of an organization that are integrated into the SAP R/3 production system should be included under one client [51]. In one client there is a common set of rules and also common tables, master files, and databases. Usually one company is one client of SAP, and in our case the client is Philips.
Below the client level is located the *company code*. SAP defines a company and a company code separately. A company can contain one or more company codes, but it must use the same chart of accounts and the same fiscal-year breakdown [51]. The company code will represent legally independent companies. Philips uses only one company code.

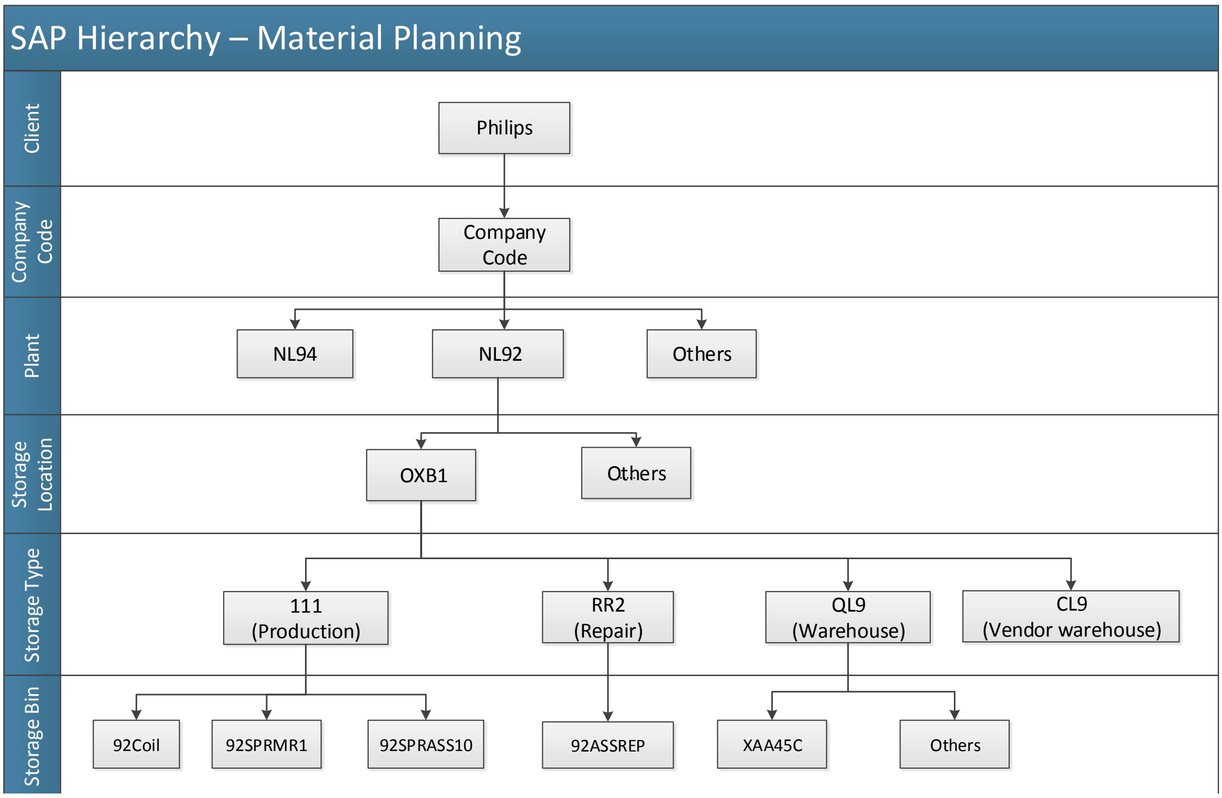


Figure 9. SAP storage hierarchy (Philips HealthTech, Best)

One level lower than the company code are located several *plants*. A plant is a location that holds valuated stock or contains service and maintenance facilities. The plant is always defined by a four-character. The operations of Philips HealthTech are located within NL92 plant and Figure 9 extends the hierarchy within this plant.
Below the plant level are located the storage locations (SLOC). Storage Location is a place where stock is physically kept within a plant. There will be always at least one storage location defined for one plant. SLOC is the lowest level of location definition and organizational structure within the MM module. However, it is not the lowest level in the SAP system, since the Warehouse Management (WM) module provides the opportunity to extend and manage inventory at a bin level (Warehouse → Storage Type → Storage Sections → Storage Bins). It is possible to create storage locations automatically (for each plant where this is needed) when an inward goods movement for a material is performed (SAP ERP, 2015).
The storage location OXB1 is shared by different operations in Philips HealthTech. Within this storage location are located many storage types which belong to materials for repair (storage type RR2), new materials used by the other department called Initial Production (storage type 111), and materials belonging to the warehouses (storage type QL9 and CL9). At the bottom of the hierarchy are located the storage bins, which are the lowest level of inventory. These bins are used by SP&R, Initial Production and the warehouses which are shared functionalities of

these two departments. Initial Production deals with the manufacturing of the IGT and MR machines. Naturally, the stocks used by the initial production contain new materials which are used to manufacture new products (Q&R requirement). The other storage bins located within OXB1 are used as Philips internal warehouses or warehouses for the products purchased by third party vendors.

MRP and Availability Check

Material requirements planning (MRP) is a production planning and inventory control system. An MRP integrates data from production schedules with that from inventory and the bill of materials (BOM) to calculate purchasing and shipping schedules for the parts or components required to build a product. A BOM is a list of parts needed to produce a system or assembly. There are three primary functions of an MRP system. First, the system helps ensure that the appropriate materials are available for production and the necessary products are available for customers to avoid shortages. Second, MRP reduces waste by maintaining only the lowest possible materials and product levels in stock. Last, an MRP system helps plan manufacturing functions, delivery schedules and purchasing [52]. When an MRP system is functioning, it reduces material waste while also avoiding product shortages. The three major inputs for an MRP system are the master production schedule, the product structure records, and the inventory status records. These are the three basic inputs which are required for the MRP to function.

During the order processing, the *Availability Check* tells the user if there are enough materials available for finishing the order. Every material can be set to be tracked by checking the availability check field in the material master data. There are two available check methods: checking against the planned independent requirements and the Available To Promise (ATP) check. The SAP RMA environment uses the ATP check, therefore in this report we further explore this option and disregard the other checking method. The ATP availability check is carried out using two main elements: the checking rule and the checking group. The combination of checking rule and checking group defines the scope of the check. In our environment, the scope of the check is set on the storage location level. This means that whenever a material needed for an order, the availability check will look into every stock of materials located within the storage location, independent of the storage type or storage bin. Therefore, whenever operations within the storage location OXB1 require a material in the SAP order, the availability check will look for that material into every bin located within OXB1. The checking rule first overlooks into the bins of the department which is executing the order, and then into the other storage bins. This means that any stock, including used harvested stock, can be picked up by any of the operations located within OXB1, such as Initial Production.

Currently, SP&R and Initial Production have only new materials stocks in their storage bins. Both SP&R and the Initial Production can access whatever stock is located in their storage bins. The current situation is presented in Figure 10. Current situation. For ease of understanding, the storage location OXB1 is referred as SLOC1, and Initial Product is referred as IP. The visual presentation depicts both departments being able to access their own and each other's stock.

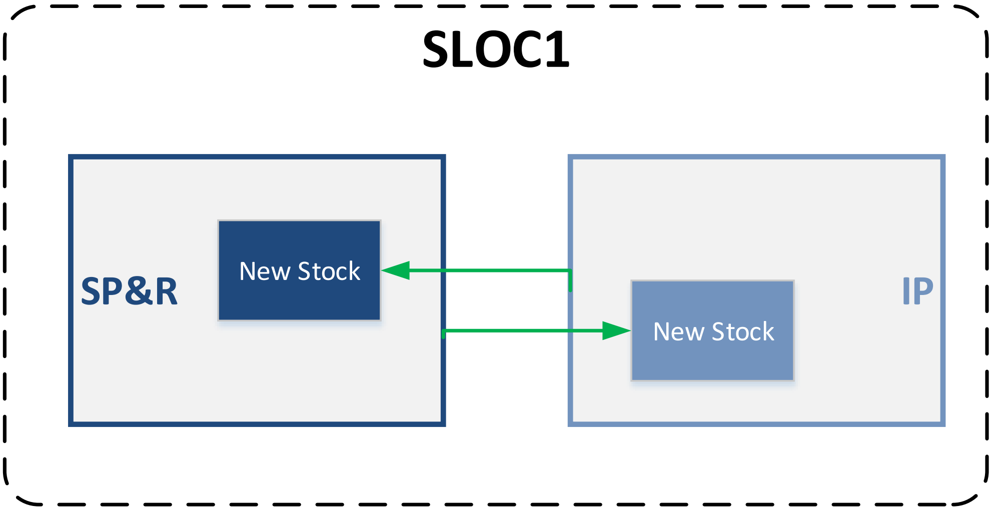


Figure 10. Current situation

For implementing a harvesting process it is necessary to have both new stock bin and harvested stock bin. When materials are extracted from components which can no longer be repaired, a new pool of second hand materials is created. If these harvested materials are located next to the other stocks owned by SP&R, the IP would be able to access that stock. Specifically, whenever an order issued by IP requires a material which is out of stock in their bin, the SAP availability check will look for that material into every other bin of the storage location. If the material is found in the harvested bin, a TO (transfer order) is automatically issued by SAP which transfers the material from SP&R bin to the bin owned by IP. With the current configurations, there is no way for SAP to recognize this stock as second hand one and to prevent it from displaying as available material through the availability check. The problem that arises in this case is that IP, which is allowed to use only new materials to manufacture products (Q&R requirement), might accidently pick up the harvested materials Figure 11.

To prevent this issue, it is necessary to segregate between the new and harvested stock, not only physically but also in SAP. Therefore, the main concern to be addressed is:

How can SP&R store and use the harvested stock in SAP while ensuring that it is not accidentally used by the Initial Production?

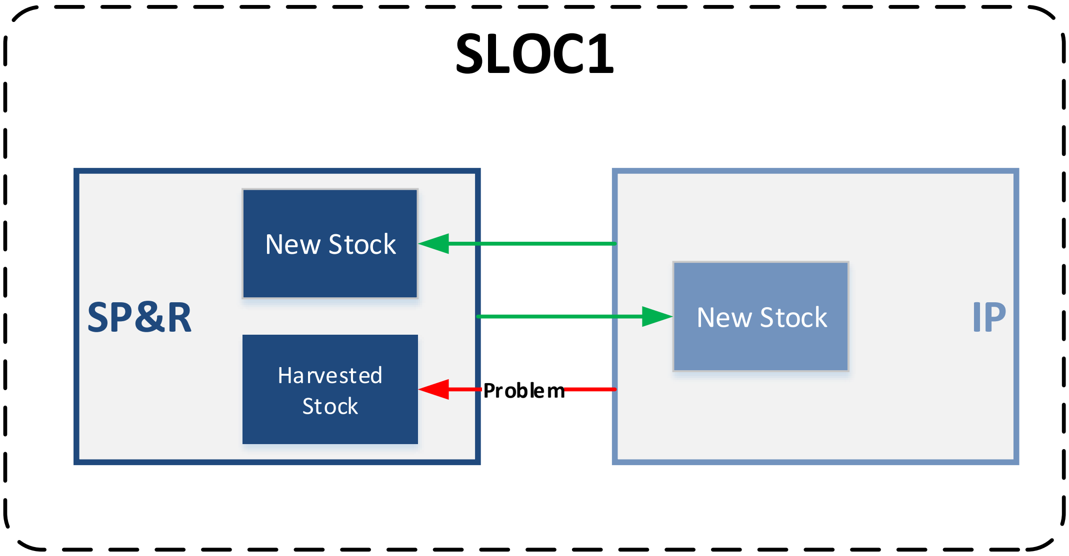


Figure 11. Issue of Initial production accessing harvested stock

To solve this issue we research into possible options for segregating the harvested stock from the new stock in SAP, so that any possible mix-up is avoided. We analyse the identified options and outline the benefits and drawback of each. Finally, we use a decision making matrix in order to evaluate the options against each other and be able to select the most feasible solution. By analysing the documents on SAP structure and manuals, reviewing the existing literature and discussing with SAP experts at the environment, the following options have been identified for addressing the issue.

5.1.1 Blocked Stock

In SAP the stock can exist in one of two statuses: unrestricted and blocked [53]. The unrestricted stock is available and can be used by any operation. Materials located in the unrestricted stock are visible to SAP availability check and can be accessed whenever those materials are required in a service work order. On the other hand, the blocked stock is displayed in the inventory but it is not accessible by SAP. Usually the blocked status is used for damaged stock or for stock which is in reserve on request of a specific customer. Materials which are blocked, cannot be used by SAP in a service order. Therefore, one way to prevent the risk of IP to use materials from the harvested stock when is to assign the status “blocked” to the bin. The functionality of changing the stock statuses is an existing process in SAP RMA and it requires no IT changes. Therefore, this process is easy to adopt and it requires no validation, since it is a currently existing process within SP&R. A blocked stock does not show up in the SAP availability check; therefore, it can’t be consumed by any operations. This means that neither Initial Production, nor SP&R can access this stock. The visual presentation of the blocked stock scenario is shown in Figure 12.

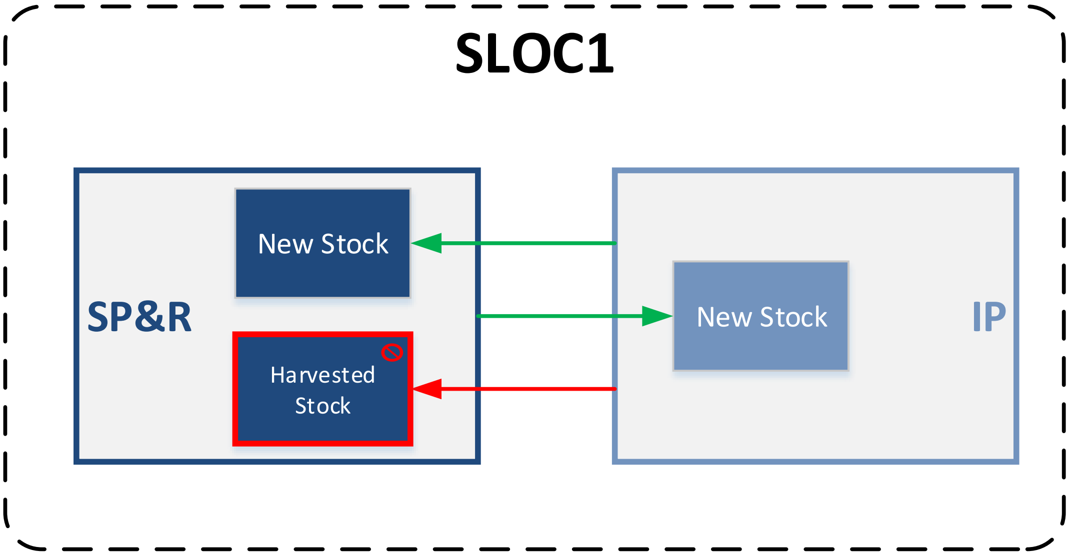


Figure 12. Presentation of the blocked stock scenario

However, for reusing the harvested materials in the repair process it is necessary that SP&R has access to this stock. In order to use the blocked bin, the status of the stock must be changed from blocked to unrestricted. Once the stock is unrestricted, it can be used by SP&R and the materials can be consumed in an SAP order. To prevent this stock from being consumed from the IP, the status of the stock should immediately be changed again from unrestricted to blocked stock The process of transferring the stock from one status to another, can't be done automatically; therefore, manual transactions are required every time the materials in the harvested stock need to be used. Only certain people in the repair floor have authority to change the status of the stocks (i.e. service parts controllers). This means that in cases when the required volume of harvested materials in an order is high, changing the status of stock can become a bottleneck in the process.

Additionally, the financial value of all stocks is calculated by considering all the available and visible stocks in SAP. The value of materials in blocked stock are not visible to the financial calculations [38]. Thus, the value of the harvested materials would be excluded from the inventory. This results in a financial inaccuracy.

Using the blocked stock solution to make the harvested stock inaccessible by the Initial Production has several benefits and drawbacks which we summarize below:

Benefits

- This options prevents Initial Production from consuming harvested stock materials
- Operating with blocked stock is a current existing procedure in the RMA; therefore, no IT change would be required
- It is a quick approach to implement

Drawbacks

- All changes from one status of the stock to the other should be done manually
- Only a few people in the department have SAP authority to make the transfer transactions; therefore, it exists the risk of slowing down the process
- The financial value of the blocked stock would not be calculated

The blocked stock option addresses the problem of Initial Production consuming the harvested stock by making this stock inaccessible. However, for SP&R to access this stock, manual transactions are required in order to transfer materials from the blocked status to unrestricted. Additionally, the concealed value of materials in the blocked stock makes this option financially inaccurate.

5.1.2 Batch Management

Another option for addressing the requirement of segregating the harvested stock from the new stock in SAP is through the Batch Management (BM) functionally. BM is an SAP functionality for inventory management. When using batch management, products can be allocated in groups under the same conditions. For instance, the same product (same 12NC number) can be located in a batch called *New* and in a batch called *Harvested,* which point to the new products and the harvested products, respectively. Batches allow for products to be treated separately from other groups. In operations where only new products can be used, it can be specified in SAP that the product should be consumed from batch *new*. When SP&R needs to use the harvested products in one of its orders, SAP would pick up from the specified batch: harvested. In this way the new products and the harvested products would be clearly segregated in SAP orders. However, even though the products could be easily identified as new or harvested, the IP would still be able to pick up the products from batch harvested. This happens because both of the batches are relevant for the MRP material availability check, and if required in an order they could be consumed in SAP transaction (Figure 13).

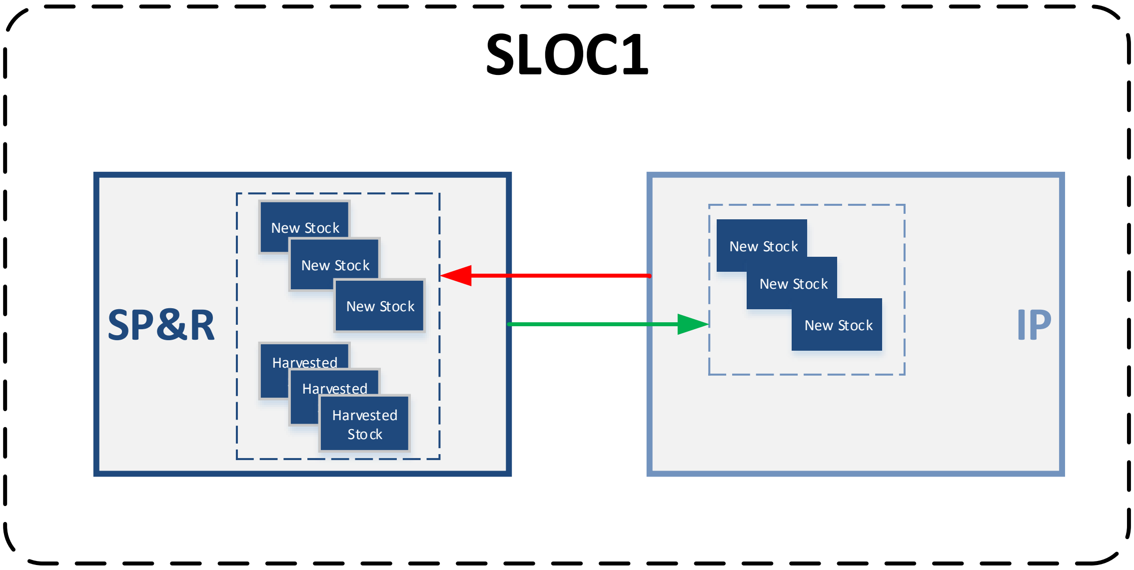


Figure 13. Presentation of batch management

Batches ca be implemented on the client level, plant level and material level [56]. If BM is activated in one level, then all materials located under the same level will have the batch functionality; thus, they can be found in different conditions. If materials are assigned as batch on the client level, that would result on all materials located within that client to be recorded in different batches. All operations of Philips are located within one client (Figure 9), therefore activating batch management on the client level would have a huge impact and bring implications to the whole organization worldwide. Naturally, this option is not further considered.

If the batch functionality is assigned on the plant level, then all the different materials located within the plant would be batch. Our goal is to have a harvested batch for the materials which are potentially interesting to harvest (defined in Chapter 7. Business Case), and not for all the materials used in the department. By activating BM on a plant level, all materials located within plant NL9, also those used by Initial Production, would be registered in different batches. However, if the batch functionality is activated on both the plant and material level, then only the specified materials located in the plant would be found in batches. The MRP availability check includes all materials located in batches, regardless of which batch they are located in. This feature is a benefit for SP&R because by calculating the harvested batch in MRP, an accurate calculation and planning of the materials can be made. On the other hand, the materials would also show in the MRP availability check done by the Initial Production. This signifies that the harvested stocks, which are second hand parts to be used only within SP&R, would be recorded as available materials for Initial Production to access. Therefore, the material planning of Initial Production would be inaccurate as it would mistakenly include the harvested materials.

Assigning a material to different batches is done though the materials master data in SAP. Activating batch management is not a reversible action [56]. This signifies that the material assigned to different batches, would always be located in the system in batches. This poses an issue in case SP&R decides in the future to exclude one material from the list of materials to be harvested. Even if not being harvested anymore, that material would still be recorded in SAP as located both in new batch and harvested batch. This implication makes the batch management option not a flexible solution. We summarize the benefits and drawbacks of this option below.

Benefits

- The harvested batch and new batch are clearly segregated in SAP.
- The functionality can be implemented on the material level; therefore, not all materials under the same plant have to be in batches.
- Harvested batch is relevant stock for MRP. This is a benefit from SP&R perspective as it induces accurate material planning for SP&R.

Drawbacks

- Initial Production can still consume materials from the harvested batch.
- If the batch functionality is applied to one material, all orders within the same plant using that material will use batches (Initial Production as well).
- Harvested batch is relevant stock for MRP. This is a drawback from Initial Production perspective as it induces inaccurate material planning for this department.
- Batch activation is not reversible.

If the potential harvesting materials are located in different batches, new and harvested, the segregation between these two stocks would be realized. However, this option does not prevent the Initial Production from picking up and consuming the harvested materials in their production orders.

5.1.3 New Storage Location

The issue of the other department (IP) being able to access the SP&R harvested stock originates from the fact that both these departments share the same storage location (SLOC). As explained earlier, the MRP availability check will look in every bin located within the same SLOC and both departments can access each other’s storage bins. The first two options discussed, blocked stock and batch management, address the problem by trying to make the stock inaccessible (blocked stock), or by segregating the harvested and the new stock (batch management). However, both options have many drawbacks and fail to completely solve the issue. The blocked stock option requires multiple manual transactions in order to use the stock; thus, it is a time consuming and not practical for everyday operations. The batch management solution succeeds on segregating harvested stock from new stock within SP&R but it fails on actually preventing the Initial Production from using the harvested stock.

Other options to address the issue deal with the actual origin of the issues: shared storage location. We explore the possibilities of creating a new storage location where SP&R can store and use the harvested stock for their own use, without being dependent on the Initial Production. We identify two scenarios within the option of creating a new storage location which are explained below.

Option 1. Transferring entire SP&R operations to a new Storage Location

As explained in section MRP and Availability Check, the MRP planning and availability check scope is within the storage location. One way to avoid the risk of IP using the harvested stock is to isolate this stock from the MRP and availability check of the current storage location (called here SLOC1). Transferring entire SP&R, the operations and the stocks, to a new storage location (called SLOC2) would enable this department to have its own SAP location and be independent from the other functions. The stocks which are located in a new SLOC2, cannot be accessed by IP as they are not included in the MRP view. Every storage location should have its own MRP view in order to manage the material planning within that location. If the two departments, SP&R and IP, are located in two different storage locations then their MRP views will not include each other's stocks. However, for the current operations of both departments, it is important that they are able to access each other's new stock, as illustrated in Figure 10. If SP&R is transferred to a new location, neither SP&R nor IP could access each other's new stock because these stocks would be excluded from the MRP (Figure 14). This creates an issue for the everyday operations where the new materials need to be accessible from both departments.

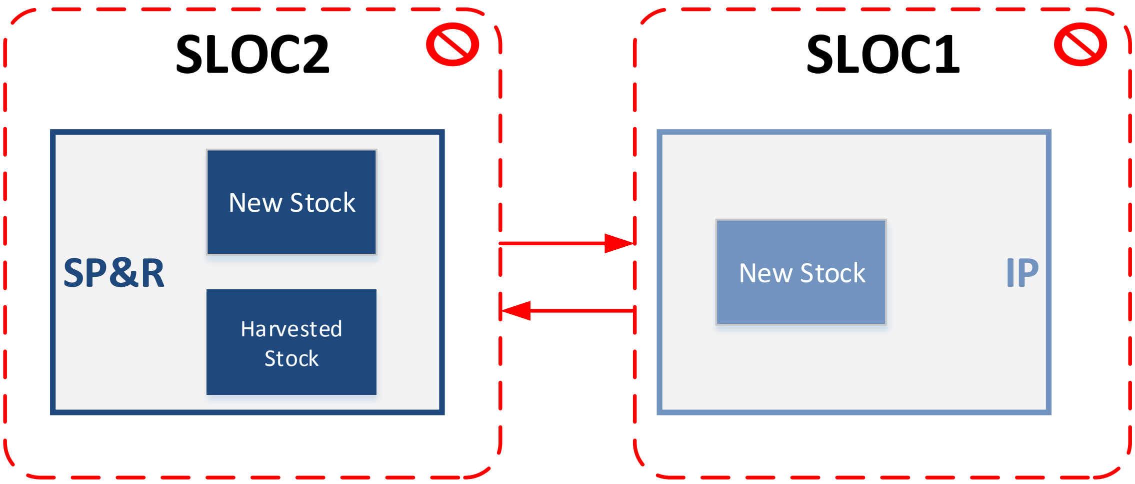


Figure 14. Transferring SP&R operations to a new Storage Location

Locating the SP&R department in a new SAP location avoids dependence from the other organizations; therefore, it would be an interesting possibility in case independence is required in the future business needs of SP&R. However, for the current situation, transferring all the SP&R operations into a new storage location is a complex project which would impact all the transactions between SP&R and the other organizations. Because of the high impact on the SAP kernel, this option also represents a very high business investment.

Option 2. Locating only the harvested stock in a new Storage Location

Transferring all SP&R operations and stocks to a new storage location can have a high impact on the entire SAP hierarchy structure. However, since the harvested stock is the only part that needs to be segregated from the rest, we can consider locating only the harvested stock in the new SLOC2. If a new storage location is created and the harvested stock is registered there, then this stock is excluded by the MRP and availability check of SLOC1. This means that if an order within the SLOC1 requires materials which are not found in that storage location, the SAP will not look into other storage locations. Therefore, the stock located in SLOC2 cannot be accessed or even seen by the IP which is located in SLOC1. In order to make sure that SP&R can still access the stock it is necessary to create a new MRP view for SLOC2. This means that when a new material is added, an extra MRP view should be created for that material to make sure that whenever the material is in demand, the new location is also looked into. The visual illustration of this option is presented in Figure 15.

Additionally, enlisting the new SLOC2 as being accessible only by SP&R would allow that this department still consumes the materials in the harvested stock whenever they are needed in the production orders. The transfer of materials from SLOC2 to SLOC1, where they can be used by SP&R, can be done automatically. In the production order material line can be stated that this specific material should be picked up from SLOC2. Reasonably, whenever a material is required in the SP&R production order, the harvested version will be the first one to be consumed from SLOC2. If that material is not found in the harvested stock, then the SAP will look into the new stocks located in SLOC1. This checking rule is set up by assigning the harvested stock the default one to be used in the production orders.

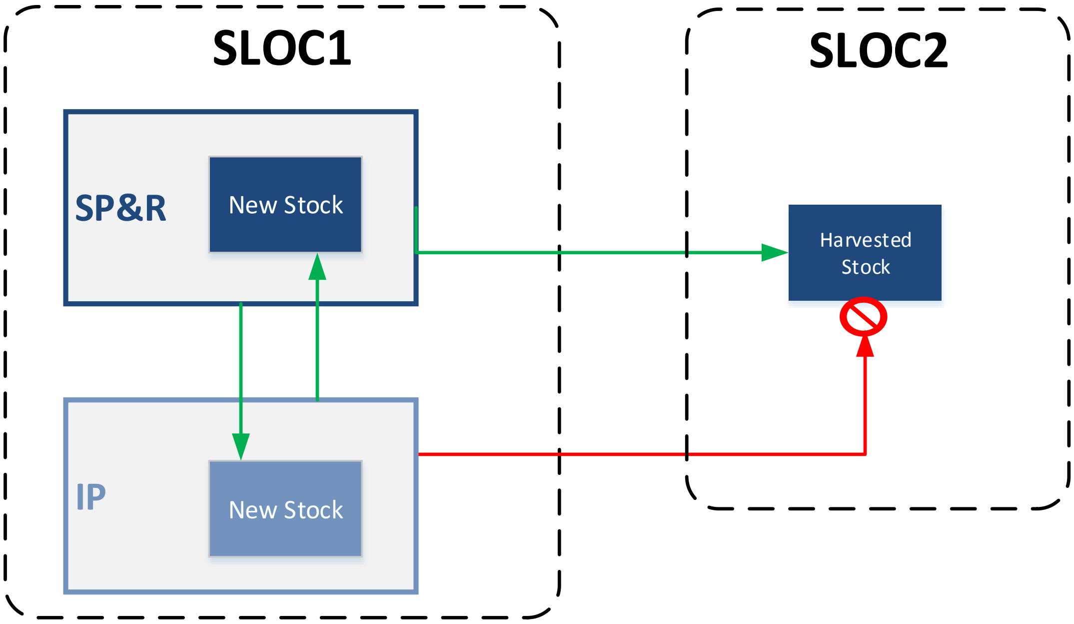


Figure 15. Locating the harvesting stock in a new Storage Location

Additionally, having only the harvested stock in a new storage location is easily manageable from the financial point of view. Stock reports in SAP can be run per storage location; therefore, the value of harvested materials will be easily calculated and recorded.

Creating a new storage location where only stocks are located, is a considerably smaller project and lower investment than a new storage location for the entire department (Option 1).

The benefits and drawbacks of the two options involving a new storage location are presented in Table 2.

	PROS	CONS
Transferring entire SP&R operations to a new SLOC	• Harvested Stock is excluded from MRP of SLOC1 therefore initial production won't be able to consume this stock • In the long term, a new storage location may be a good solution for segregating SP&R from Initial production	• The new stock will also be excluded from MRP, implications for initial production and SP&R since either could access the New stock of each other • All order processes of SP&R will need to be transferred to the new SLOC2 • Very complex project with impact on the kernel
Locating only the harvested stock in a new SLOC	• The harvested stock excluded from MRP, therefore no risk of being picked by the Initial Production • The transfer can be done automatically • Easy financial reporting through the stock reports per SLOC • Relatively small IT change request	• A new MRP view must be created for the new SLOC

Table 2. Pros and cons of the new storage location options

Above we have presented four options which address the issue of segregating the harvested stock from the new stock. Each of the options have benefits and drawbacks which allow for a clear comparison between the main features of each option. In addition to the qualitative analysis, we use a decision making matrix in order to quantify the value of each option in comparison to the other ones. For this approach, we use criteria, weights and scores.

The criteria are the determining factors to be considered while considering the options. The selection of criteria was based on models for evaluating IS design. Specifically, one of the most cited models for measuring information systems success is the DeLone and McLean Information Systems Success Model [41]. The model consists of six categories of IS success: systems quality, information quality, use, user satisfaction, individual impact and organizational impact.

Within each of these categories of the IS success we identified criteria which impact the decision for the most feasible option. The SAP designs which are being compared are parts of a large ERP system which is being used by a global company. The systems are used to accomplish the business goals and there is little impact that the system can have on an individual level, or the vice versa. Therefore, for our comparison there are no criteria used within the "individual impact" block. Instead, we add a block which is considered very relevant for the design choice in our environment: Implementation. This block is related to the practicalities of implementing and maintaining the system. We present the criteria elicited from each block of the DeLone and McLean Information Systems Success Model, and the added criteria from the "Implementation" block in Table 3.

After identifying the main criteria according to which a comparison between the design options can be performed, the next step is assigning weights to the criteria. Weights are used to display the level of importance that each criteria has to the choice of design options. In order to allocate weights, we looked at the criteria form a problem solving perspective. The highest weights were allocated to the criteria which are directly linked to offering a solution to the problem under discussion: segregating between two types of stock in order to avoid mix up. Therefore, the criteria which were considered the most important are Effectiveness, Efficiency and Mix Up prevention. These criteria were assigned the weight of 5 which is the highest in the rate scale (1 to 5). On the other hand, criteria which have a lower role on addressing the issues, such as implementation speed, ease of customization and maintenance, were assigned a lower weight of 3. All the criteria selected are considered important in order to have a well-rounded design choice; therefore, no weights lower than 3 were assigned.

Block	Criteria	Description
Systems Quality	Effectiveness	The degree to which the option is successful on segregating harvested and new stock
Information Quality	Ease of financial reporting	The degree of simplicity in reporting all the stocks to finance
Use	Efficiency	The speed with which the workers can complete their tasks
User Satisfaction	Ease of Use	The level of simplicity to which the employees can complete their tasks
Organizational Impact	Impact segregation	The degree to which the other business functions can continue working unaffected by the change
	Mix up Prevention	How successful is this option on preventing unintended use of the harvested stock from the initial production
	Long term perspective	How effective this option is for handling long term business needs

Implementation	Ease of customization	The level of simplicity in adapting the existing IT landscape to accommodate the new process
	On budget	Lower cost of implementing and operating the solution
	Implementation speed	The speed at which the option can be implemented and ready to operate
	Maintenance	How easy it is to maintain and support the solution

Table 3. Criteria description

After selecting the criteria and defining the weights, the next step in the decision making matrix is the allocation of scores. Each option is assigned *a score from 1 to 10*, where 1 is low points in that criteria, and 10 is maximal point. For example, a score 10 in the criteria *Effectiveness* signifies that this options highly effective, while a score 1 presents that the options is almost not effective.

The way of performing the score allocation to each option input from field experts was collected. The decision making matrix was discussed during interviews with five SAP experts within Philips HealthTech. The aim of these discussion was not only to allocate scores to the options, but also to gain insights if the list of criteria and allocations of weights was complete and accurate, respectively. The insights and feedbacks collected during these interviews are incorporated in the decision making matrix. As a results, the order to fill the right score allocation to the criteria of each option, the decision making matrix was discussed and send to five SAP experts within Philips HealthTech. Their collective feedback was feedback was collected and used in the decision making matrix (Table 5).

Option	Definition
1	Blocked Stock
2	Batch Management
3	Transferring entire SP&R operation to a new SLOC
4	Locating the harvested stock in a new SLOC

Table 4. Options definition

Decision Factors		Options			
Criteria	Weights	1	2	3	4
Effectiveness	5	7	7	10	10
Ease of financial reporting	4	9	9	10	10
Efficiency	5	5	9	8	8
Ease of Use	4	9	8	8	9
Impact segregation	3	9	9	4	9
Mix up Prevention	5	7	2	10	10
Long term perspective	4	2	6	10	9
Ease of customization	3	10	7	3	7
On budget	4	9	7	2	7
Implementation speed	3	10	7	2	7
Maintenance	3	4	4	8	8
Accumulated Score		330	286	311	373

Table 5. Decision Making Matrix

The results of the score allocation indicate that the option with the most desirable outcomes and feasibility to implement is option 4: Locating the harvested stock in a new SLOC. In the rest of this report we continue with integrating this option in the conceptual framework for harvesting spare parts. Finally, we validate and test the technical feasibility of this option (Chapter 7. Validation).

5.2 Finance

One of the important aspects of any project is the financial impact. The harvesting process aims at extracting spare parts and reusing them in the repair process, thus by creating a stock with harvested parts. In section 5.1 we presented and discussed options of registering this stock in SAP in such a manner that it is segregated from the new materials stock. One of the main system requirement is that of having financial evaluation for all materials which are harvested. Therefore, when these materials are recorded in the system, they should be associated to a price. What follows is the question of evaluating the harvested stock: *What is the value to be associated to the harvested stock?*

The harvested materials are second hand materials which have been previously distributed to the markets; therefore, the quality of the material is naturally different from the new bought materials. It is important that all materials in stocks are correctly displayed and evaluated in SAP. In order to have different prices for the same material registered in SAP it is necessary that those materials have different evaluation type. The current status of SAP RMA does not allow having different prices for the same registered material. One material, which is presented in SAP through a 12 digit number (called 12NC), can have only one price associated to it [38].

Having different prices for the same 12NC can be realized only through the *Split Evaluation* functionality of SAP [54]. Below we investigate the possibility of implementing Split Evaluation within the SAP RMA.

Split evaluation is used to manage stocks of the same material which are different in terms of value. For some materials it is necessary to differ in the valuation of various stocks because of several reasons such as: different origins of the materials, different grades of quality, different statuses for the material, differentiation between in-house production and external procurement, and differentiation between different deliveries. In our case, the differentiation should be made because of the different grades of quality between the new materials and the harvested ones.

Split evaluation allows organizations to track the stock of different valuation. It refers to the valuation type on a material master data. Split evaluation is applicable when a valuation category is assigned to a material. The assignment or non-assignment of a valuation category is almost irreversible; in order to reverse the action a new 12NC serial number would have to be created for the material [55]. The valuation category field specifies which criterion should be used as the basis for differentiating between the various partial stocks. A valuation category contains multiple valuation types which specify an individual characteristic of a partial stock (Figure 16). Each valuation type represents a different value. The system administrator can define as many valuation types as required. For example, if material A is found in different grades of quality it has assigned the valuation category Q for quality. Within this valuation category there are different valuation types such as: New and Harvested. Each valuation type has a different value, i.e. the cost of the "New" stock is 100% of the buy price and the cost of the "harvested" stock is 70% of the new buy price. In Figure 16 we present an example of split evaluation where many evaluation types are differentiated by type of procurement, quality of product and origin of product. These differentiations are respectively linked to valuation category P, Q, and C.

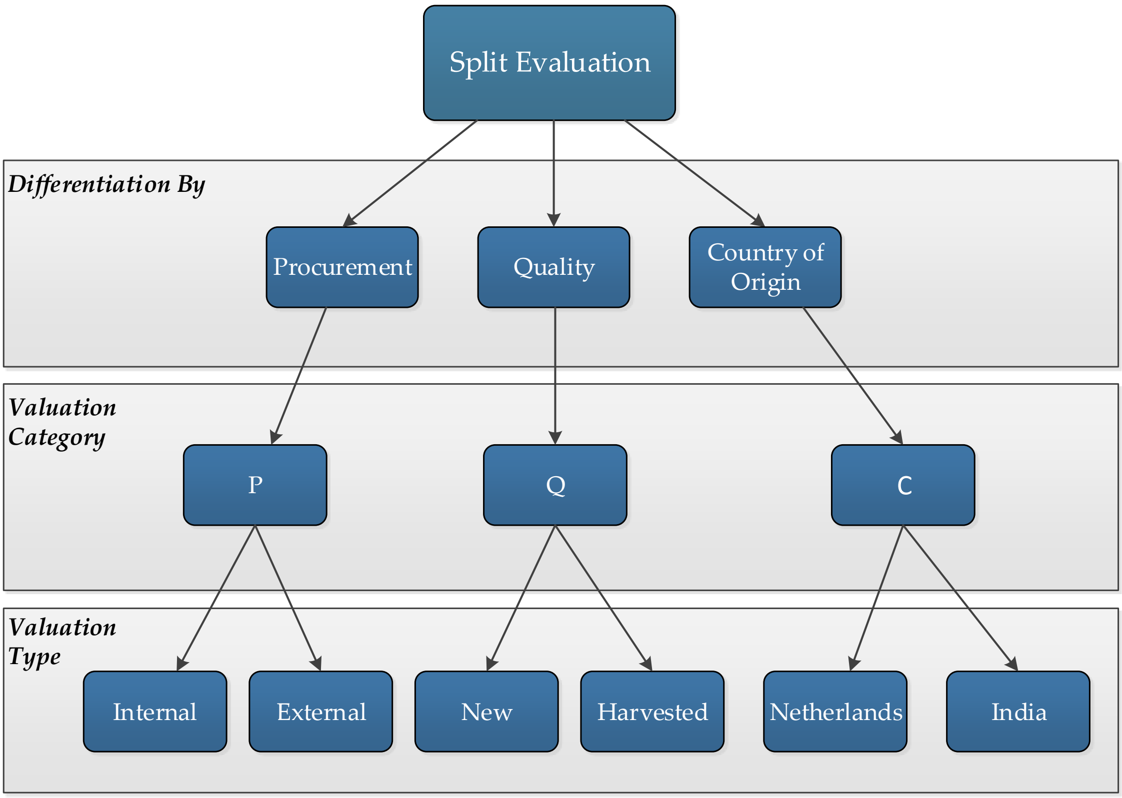


Figure 16. An example of Split Evaluation

The stocks of a material subject to split valuation are managed separately for each valuation type. Each SAP transaction that requires materials, such as goods receipt, goods issue, invoice receipt, etc., is carried out at the level of the partial stock with the valuation type. When a transaction is processed, it must always be specified which partial stock is being used. When material A is used in one transaction, it must be specified whether A is being taken from stock "New" or "Harvested", which then determines the price which will be recorded for that material. The financial reports are calculated for each stock separately, which allows the finance department to have an accurate evaluation of how much value of harvested stock and new stock is possessed [55]. Together with the partial stocks, the total stock is also updated. The calculation of the value of total stock is the sum of quantities in all the partial stocks. Partial stocks are also referred to as batches of materials. In order to implement split evaluation for one material it is necessary to have that material found in different batches [57]. Therefore, in order to have split evaluation it is required to activate batch management.

As explained on previous section (5.1.2 Batch Management), batch management is a functionality which can be activated on the material level, plant level and client level. Since the harvested process will involve only some materials which can be harvested and not all of them, it would be more practical to activate batch management on the material level; in this way only specific materials would be batch. However, split evaluation can be activated only on the plant level [54]. Since it is required to have batch management in order to activate split evaluation, it would be necessary to activate batch management also on the plant level. This means that all the materials located under the NL92 plant would be located in batches. As discussed on the previous sections of the report, batch management presents many inconveniences to the current way of operating. Other departments located in the plant, such as initial production, which don't need split evaluation of materials, would be prompted with added work and complexity of material planning without receiving any benefit. Additionally, activating both batch management and split evaluation to the entire products within the plant is a costly change request without the possibility to reverse. For these reasons, the split evaluation of materials is not considered to be a feasible solution for the evaluation of harvested and new stock.

Instead, other options were researched with the financial department for having an accurate reporting of the value on stock without necessarily having registered different prices for the stocks "new" and "harvested" in SAP. Another alternative for aligning finances is through *periodic adjustments* to the value of the "harvested" stock in the financial statements. If the harvested stock is clearly segregated in SAP from the new stock, thus there are bins which point to each of the stocks, then it is possible to calculate the quantity of each stock whenever the financial reporting is finalized. When the quantity of the harvested and new stock is clearly visible and reported, the finance department can make monthly or quarterly adjustments to the valuation of these stocks. A simplified example is presented in Table 6. There are 100 materials located in stock "new" and 50 materials located in stock "harvested". Both these stocks are registered in SAP at the same price: 100% of new value price. If the value of the "harvested" stock at the end of the period is reported to be 1500 euros, the finance department can make adjustments to 70% of the value.

Stock type	Quantity	Evaluation in SAP (as % of new price)	Value before adjustment	Adjustment	Value after financial adjustment
New	100	100%	3000 euro	100%	3000 euro
Harvested	50	100%	1500 euro	70%	1050 euro

Table 6. Example of Financial Adjustment of the harvested stock

The solution of financial adjustments does not require any changes in the current SAP system in terms of evaluation of materials. All materials, also those of different stock type, would be evaluated at the same way they are currently being evaluated: as new materials. Because the volume of materials in the harvested stock is not expected to be very big in the first years, the financial adjustment of the stock at the end of the period is considered to be an easy and fast solution.

5.3 Purchasing

As explained in Chapter 4. Conceptual Design, purchasing is another important component for the design of the harvesting process. Purchasing is responsible for assuring that Initial Production and SP&R have enough available materials for producing new machines or repairing the FRU, respectively. As visualized in the organigram of the business (Appendix B), SP&R is part of the two Business Innovation Units (BIU): MR and IGT. SP&R itself does not own any materials or devices. All the repair materials which are used at SP&R for repairing the FRUs are officially owned by the BIU.

On the other hand, the parts which will be harvested at SP&R are brought and owned by the customer, SPS. When the device cannot be repaired and a scrap order is issued, SP&R will harvest materials of interest and dispose of the rest of the device. The harvested materials will then be placed in stocks and evaluated financially. Even though the official owner of the product is SPS, the harvested material is recorded in the SAP RMA system as stock value of SP&R and will be used as repair material. This signifies that instead of discarding the entire FRU and having no value left, a positive financial value will now be recorded for the BIU. On the other hand, SPS will have a decrease in the inventory for the entire value of the device which was intended to be scrapped as a whole. For an accurate accounting, it is important to have a recorded balance between the increased value of BIU and the decreased value of SPS. Therefore, the main issue originating from Purchasing is *to find a feasible scheme for regulating the interaction among the BIU and SPS with regard to harvesting.* Before investigating the possibilities of alignment between the two parties, it is important to understand the current repair pricing model.

The repair process starts when SPS issues a purchase order (PO) through their SAP MP1 interface. The order is received by SP&R in the SAP MBP interface, and then a service work order (SWO) is issued. This document includes a list of all the materials required in the repair process and the working hours for the repair. Based on the accumulated costs of materials booked and the repair hours, the business (BIU) decides yearly on a fixed repair price for all the components. Currently, the repair price for the MR components is 30% of the new buy price of the component and the repair price for IGT is 35% of the new buy price [56]. The invoice for such payments is send from SP&R to the BIU. This last periodically collects payments from SPS.

For addressing the purchasing issue, several options were investigated. Each option was analysed and discussed with representatives of all parties: SPS, BIU and SP&R. The goal was to get a thorough overview about all the possibilities that can be considered for making the financial transaction between these parties. Also, we aimed at analysing the possibilities in order to identify which one could be considered a more feasible solution and fit well into the current organizational structure. From the investigation of the organizational model and discussion with experts, three possible options have been identified. All possibilities are highly affected by the current organization structure and SAP system. Below we present and analyse these options.

5.3.1 Correction per individual PO

The first option to be researched is performing the payment of the harvested materials at the PO (Purchase Order) level. For every order (PO) that is arriving at the repair shop, if the part is scrapped there is no invoice issued to SPS. Currently, scrapping is a free service at SP&R. When some of the materials are harvested from that part, then a payment note would be issued from SP&R to SPS with the value of those materials. In this way, the harvested materials are purchased from SPS. The positive value of the harvested materials put on the SP&R stock is balanced by the payment send to the customer. Additionally, by purchasing the parts the ownership is transferred to the BIU. The parts would be officially owned by the BIU and SP&R could use them as repair parts by acting on behalf of the BIU. Ideally, for every PO in SAP is registered the costs of booked materials and the working hours spent on this PO. Additionally, the value expected to be harvested from this PO would be added as profit. Directly paying for the parts which are harvested from each PO offers an immediate and financially accurate way of balancing the value. However, there are several limitations to this scenario which are imposed by the current SAP structure.

Firstly, in order to register the right value of the harvested materials in the PO, it is necessary to know the exact materials which will be harvested during that PO. An even more accurate evaluation would be one which reflected the value of the reused parts in the coming repair orders, and not simply the harvested parts. In this way, the business would be paying for the actual benefit that is obtained through harvesting. However, it is not possible to immediately know the exact value of the materials which will be harvested and reused in the next repair order while processing the first PO.

Secondly, another obstacle for realizing the correction on the PO level derives from a disparity between the two SAP interfaces used by the SP&R and SPS, which are SAP RMA and SAP MP1, respectively. The harvested materials can be low level components of one part, and even though they are registered in SAP RMA, the system of the customer does not recognize such low level components. SPS deals with the logistics of high level components, and their SAP MP1 interface does not recognize the BOM of those components. This means that whenever SPS would receive an electronic invoice for the harvested materials, it would not be possible to match this value to any materials. Therefore, the accuracy of the value received would not be transparent.

Finally, considering the current system it is observed that the electronic invoice between SAP RMA and SAP MP1 can’t be executed. There are two reasons for this limitation. Firstly, the current electronic invoice created via SAP RMA system does not enable the usage of credit notes [38]. Secondly, even if the electronic invoice is adapted, SPS cannot process the invoice because it will not match the repair PO that they have originally registered in the system.

For the above limitations to be addressed, several changes need to be applied to the SAP systems. These IT changes would span two different systems: SAP RMA for SP&R and SAP MP1 for SPS. Since exploring in detail the requirements for each IT change request is out of the scope of this project, we focus on providing an overall analysis about the possible scenarios, their benefits and limitations.

5.3.2 Overall reduction of the repair price

By harvesting materials from the FRU components, SP&R has an increase in the repair materials stock. Most of the repair materials used at SP&R are purchased from third party vendors. Through harvesting, it is expected that the business has lower demand for parts from vendors. This means that the business has a reduction in purchased materials costs.

One way to pay SPS for the materials harvested from their FRUs and reused, is to offer a discount in the repair prices. Since the reduction in costs is accumulated from all the harvested materials and can't be linked to individual materials, the BIU could offer a general reduction in the repair price for the materials brought by SPS. If SP&R harvests and reuses materials valued 5,000 euros in one year then the total cost of buying materials from external suppliers is reduced by the same amount. This benefit received by the BIU could be transmitted to SPS by reducing the total yearly repair invoice. The discount in the repair price could be offered as a percentage of the benefited value over the total invoices. For instance, if SP&R repairs a total worth of 50,000 euros in one year, and harvests 5,000 euro, then the overall repair price might be reduced to 10% (5,000 /50, 000 euros). In this way, the following equation would hold:

(Old repair price – New repair Price) x Quantity = Harvested & Used value

However, this would not be entirely accurate because from the benefit of 5,000 euro received by the BIU should be reduced by the expenses and costs of the harvesting process. A trade-off analysis between the profits and costs of the harvesting process is offered in detail in the business case (Chapter 7). In order to offer an accurate discount of the repair price to SPS, the business needs to know exactly the amount benefited from harvesting. An accurate estimation of the value reused from harvesting requires the process to be operating for some time, i.e. 1-2 years, in order to make a correct estimation of the benefited value, and thereafter apply this value to a discounted repair price.

5.3.3 Periodic reconciliations

The two previous options enable the payment of the harvested parts through changes in the price of PO. Since these possibilities involve changes in the SAP system, other options were explored for solving the issue without affecting the system. The faster and easier way to transmit the value benefited to the customer is by sending periodic credit notes. A credit note is a document issued by the buyer to the seller stating that a certain amount has been credited to the buyer's account [60]. There are various situations when a credit note can be issued such as when invoice amount is overstated or correct discount rate is not applied. In our case, the credit note makes a correction to a not applied discount rate for the materials harvested during a PO. The period for the issuance of the credit notes can be either quarterly or annually. For example, if SP&R harvests and reuses materials with a value of 5,000 euros during a quarter, the assets of the BIU are increased by that value. Therefore, the BIU can reconcile the benefited value by sending credit note of the same value to SPS by the end of the quarter. By collaboration of the departments, the purchasing issue is solved outside of the SAP system.

Above we have presented three options for settling the financial transaction of the harvested materials. The first two options treat the payment on the PO level. The first option discusses paying immediately the amount harvested on the same order that it is scrapped from. Ideally this option is the most accurate settlement.

However, current limitations of the system require IT changes to two SAP systems in order to support this transactions. These IT changes are costly and take a long time to be implemented. The second option discusses the reduction of the repair prices of all the parts. Changing the overall repair price of the price is a minor IT change. However this requires a correct estimation of the value which will be harvested. For this option to be implemented, the harvesting process needs to be running for a few years before correct estimation on the benefited value can be made. The third option involves managing the payment through the collaboration of the departments, and not through the SAP systems. Since it does not require any IT changes or precise forecast on the value, this option is feasible if an immediate solution is required.

5.4 Concluding Remarks

In the detailed design phase, an analysis of the main requirements for three components of the framework was discussed. The outcomes of this design phase are proposed solutions to each of the three requirements. Qualitative analysis and a decision making matrix were used as tools to define the most feasible solution for segregating new and harvested stock in SAP. It is determined that locating the harvested stock in a new storage location would segregate the stocks and prevent other departments from using the second hand materials, while allowing SP&R to have access to this stock. Additionally, options for resolving the Finance and

Purchasing requirements were investigated. Evaluating the harvested stock with a different price from that of the new stock requires the activation of the "Split Evaluation" functionality of SAP R/3. This activation brings major implications for the system by affecting all the materials within the plant. Additionally, as a requirement for Split Evaluation is the implementation of "Batch Management" on the plant level. Implementing these two functionalities does not only have a great impact on the kernel and current way of working in SAP, but it also requires a considerably high investment. For these reasons, alternative ways for satisfying the Finance requirement outside the SAP system were investigated. An approach which involves the alignment between the departments was identified. Making monthly adjustments to the value of harvested stock in SAP is considered a practical and feasible solution which can be quickly adapted to the environment. Therefore, the favourite approach for addressing the harvested stock evaluation is through periodic financial adjustments.

Finally, options for aligning with the customer for the appropriation of the harvested materials were analysed. The first two identified options argue the transmission of the harvested value back to the customer through the repair orders. The first option considers making a correction on the PO level by reducing the value of the harvested material from the invoice sent to the customer for the repair. This way of alignment with the customer for the exact value which is being harvested offers an immediate and accurate payback of the value. However, this scenario requires an activity based costing, in which the price of the repair is based on the cost of materials used for repair and employee hours booked. The current pricing model is based on yearly fixed prices. Therefore, the first option is not considered to be feasible as an immediate solution for the alignment with the customer. The second option considers determining the overall value benefited from the harvested materials, and reducing the repair price for the customer. This scenario however, requires a precise estimation of the harvested value. For an accurate estimation, it is required to run the harvesting process for a considerable time, in order to evaluate the benefited value. Even though this solution can be considered appropriate for the future, it is not a feasible solution for the beginning of the process. Therefore, the third option which addressed the requirement through interdepartmental transactions is proposed as a feasible solutions for the near future. If in the future the department changes the pricing model from fixed price to activity based costing, the recommendations is to opt for the first scenario which settles the financial transaction on the same PO from where the material is being harvested.

Since we are investigating solutions for implementing harvesting in the near future, the most feasible solutions are considered the ones which are the most practical and convenient for the environment.

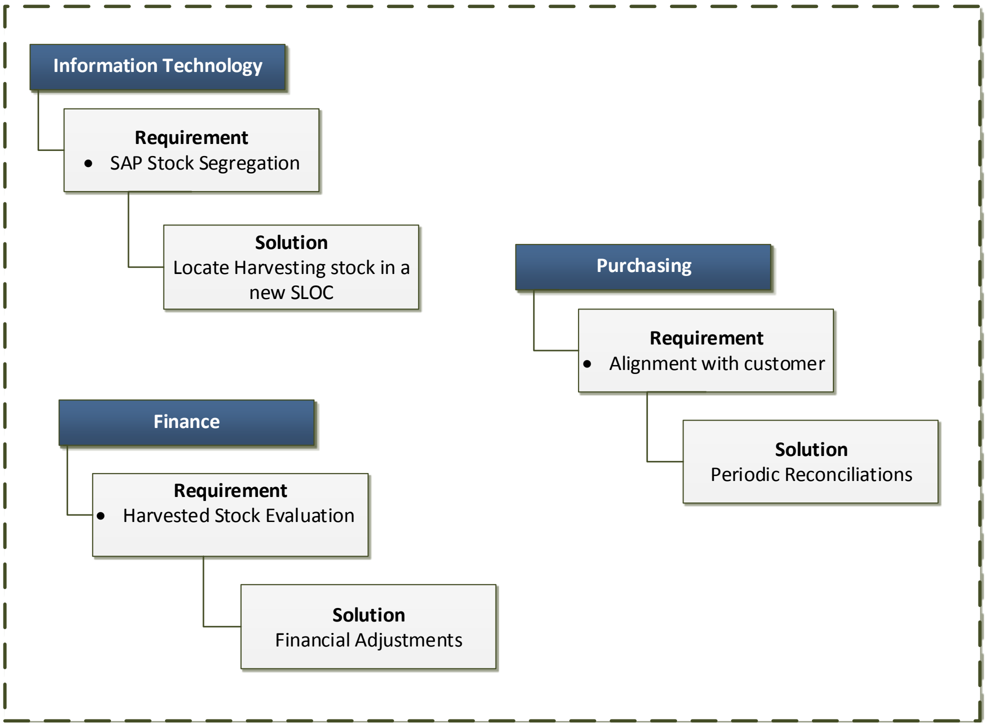


Figure 17. Proposed solutions to the requirements

Chapter 6 Integration

You can't do today's job with yesterday's methods
and be in business tomorrow.

-George W Bush

Chapter 4 identified the main components to be addressed while implementing a harvesting process and it presented these components in a comprehensive framework. Requirements for three main components were identified. Chapter 5 analysed these requirements and offered several options which address them. At the end of each component the most feasible approach to the current environment and context was presented. This chapter integrates the solutions proposed in Chapter 5 in a complete process flow. We describe how a step by step harvesting process could be applied in the real environment by adopting the proposed solutions.

6.1 Repair Process Workflow

The integration phase brings together all the components of the detailed design and enables their translation into a realizable process workflow. A workflow is a sequence of steps or tasks that comprise a work process and produce a desired outcome [61]. The desired outcome of the harvesting process is to have harvested materials stored on stock and ready to be reused in the next repair process. Therefore, the harvesting process finalizes when these materials are tested, located in the physical stock, and properly recorded in SAP. So far, we have proposed solutions for storing and accessing the harvested stock in SAP, and aligning with the supporting departments. Now, we integrate the proposed approach into the physical process which is executed at the department. It is important to start at the origin of the process and explain the workflow which brings to the harvested materials.

The defective parts which arrive at the department can go through two types of services: repair or rework. Repair service brings a defective part "A" to a functional condition of the same version of part "A". Rework, which is also referred to as upgrade, brings a defective part "A" to a functional upgraded version of the part, to "A1". Both of these flows are similar with the exceptions that more extra materials are used for the rework services. If the parts which arrive for repair or rework are considered to be beyond economical repair, the part are proposed to be disposed. Since both these process flows (repair and rework) bring to potential materials for harvesting, a general repair process flow is used to describe the initiation of the harvesting process. There are five participants in a repair process: SP&R, warehouse, supplier, customer and purchasing. The general process starts with the arrival of the defective parts at the department. After they are being unpacked, the parts are checked for the integrity of their identification data, such as labelling, 12NC etc. Once the parts are identified, the defective parts are segregated. A visual inspections is performed in order to establish if the part can be reused. If the part is not reusable, a decision to scrap is taken by the customer. If the part can be reused, a decision is taken whether the repair can be conducted in the shop floor or the part needs to be send to an external repair supplier. The repair of some complex parts is performed through external repair instead of in the department. If the part needs external repair, it is sent to the supplier and then received back as a repaired part. Otherwise, the part is repaired internally. In both cases, after being repaired the part is tested in order to assure that it is compliant with the required quality standards. The quality assurance is done through checking the design quality specifications in the DMR (Device Master Record). When manufactured, each part is associated to a DMR which specifies the quality standards that the part should meet in order to be acceptable to the market. If the part is not compliant to DMR, the part as a whole is considered to be not reusable and proposed for scrap. At this phase of the process, the part is evaluated for potential harvesting; thus, if there are any components of the part that can be reused. To take this decision, a pre-determined list with materials which are harvested will be used. The list is the outcome of a business case study which outlines the materials that are both financially profitable and technically feasible for reuse. The approach taken to determine the list of potential interesting harvesting parts is explained in detail in the Business Case provided in this study (Section 7.2).

If the part is considered as a potential for harvesting, the next step in the process is the initialization of the harvesting process which can be considered to be a subprocess of the entire repair process. The repair process is presented in Figure 18.

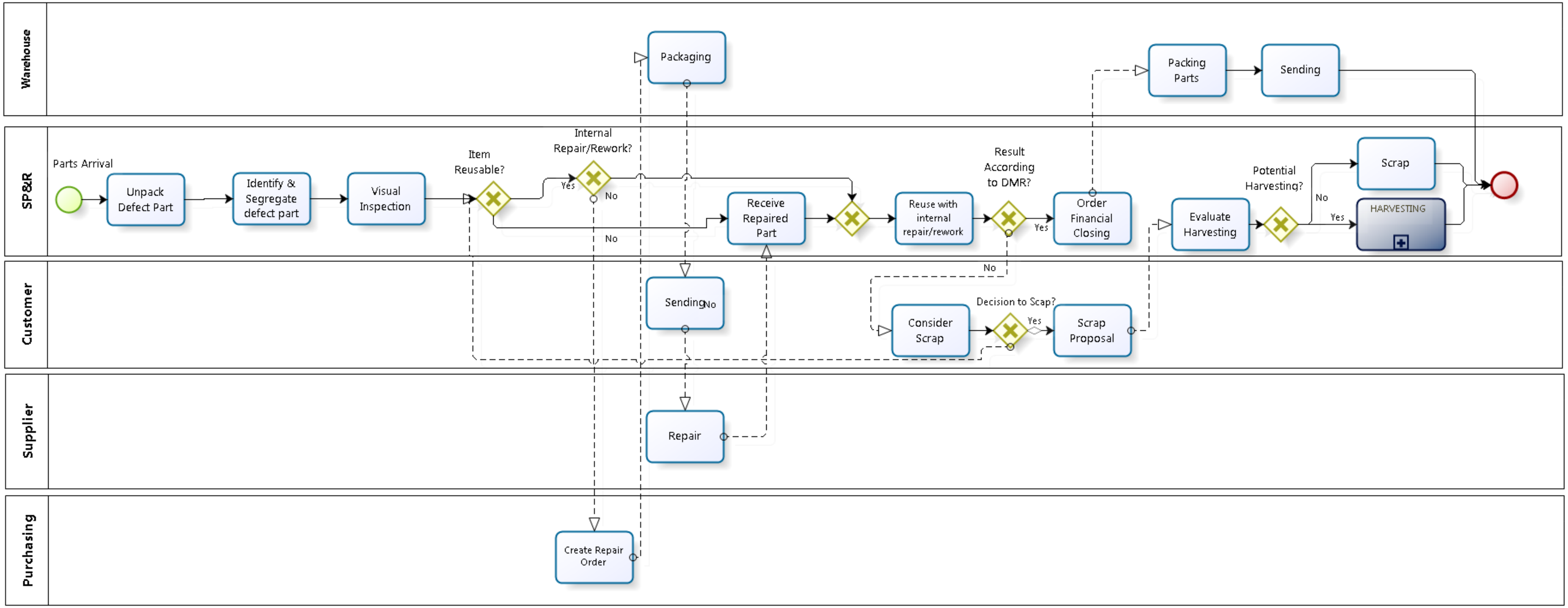


Figure 18. Entire Repair Process

6.2 Harvesting Process Workflow

The harvesting process is triggered when a part is considered beyond economical repair and it is about to be disposed. This process starts with an evaluation of the technical possibility of extracting the materials from the part. Even though the technical feasibility is a criteria considered in the pre-determined list of materials to be harvested, the conditions of materials in the defective devices can vary. Therefore, this evaluation is performed again at the beginning of the harvesting process. If harvesting is defined technically possible, the part is disassembled and the materials which could be reused are removed. While the rest of the device is scrapped, the harvested materials are visually inspected to determine if they are reusable. Afterwards they are evaluated if there is any work that needs to be done in order to bring the quality to the specified requirements. If work is required, the materials are then repaired, cleaned, repaired or polished and then tested if it is compliant with DMR. If the material is not compliant, some additional work (repair, cleaning, polishing) is done on the part in order to attempt bringing it to a good quality. To prevent an infinite loop between testing and repair, it is considered reasonable that after maximum of three revisions the material is considered not reusable anymore and it is been scrapped. If the material is compliant to DMR then it is considered to be in good condition for reuse. After storing the material in the physical stock, the SAP transactions need to reflect the status of the material.

While the part is being serviced in the shop floor, first a repairable and then as a harvested part, the order is processed in SAP as a regular repair order. The SAP transaction flow of a repair order is presented in *Appendix F.* After the physical harvesting has finalized, the next step is updating the i-Base (Installed Base) of the part which is being processed on the repair order. The i-Base provides information about the condition and components of the part under processing. After the harvested materials are removed from the i-Base of the part, the repair order of the part is closed as scrapped. The harvested materials are then evaluated for their serial number (SN). Most of the parts being used in the repair shop have a SN, which is important for tracing the materials through the supply chain. Through their SN it can be determined where the materials has been used before and what is their quality history. Traceability of the harvested materials is very important because it must be assured that the materials are not being used more times than allowed by their design specifications. However, since harvesting can also take place at a very low material level, some materials might not already have a SN. If the materials don't have a SN, after being harvested a new SN is assigned to them, in compliancy with quality regulations [6].

Afterwards, the harvested materials are booked in the harvested stock which is located in the new created SLOC, as proposed by the stock segregation solution in the detailed design. The value of the materials in the harvested stock is visible in SAP and transparent to the financial department. In accordance with the proposed approach in the detailed design, at the end of a period (i.e. quarterly), the finance department adjusts the financial value of the harvested stock to reflect a reduced price for second hand materials. After the value of the harvested materials has been calculated, a credit note is sent to the customer (SPS). The credit is a reconciliation for the value harvested from the materials owned by the customer. After the customer receives the credit note, the last step of the harvesting process is finalized. The flow of the harvesting process both in the physical shop and through the SAP transactions is presented in Figure 19.

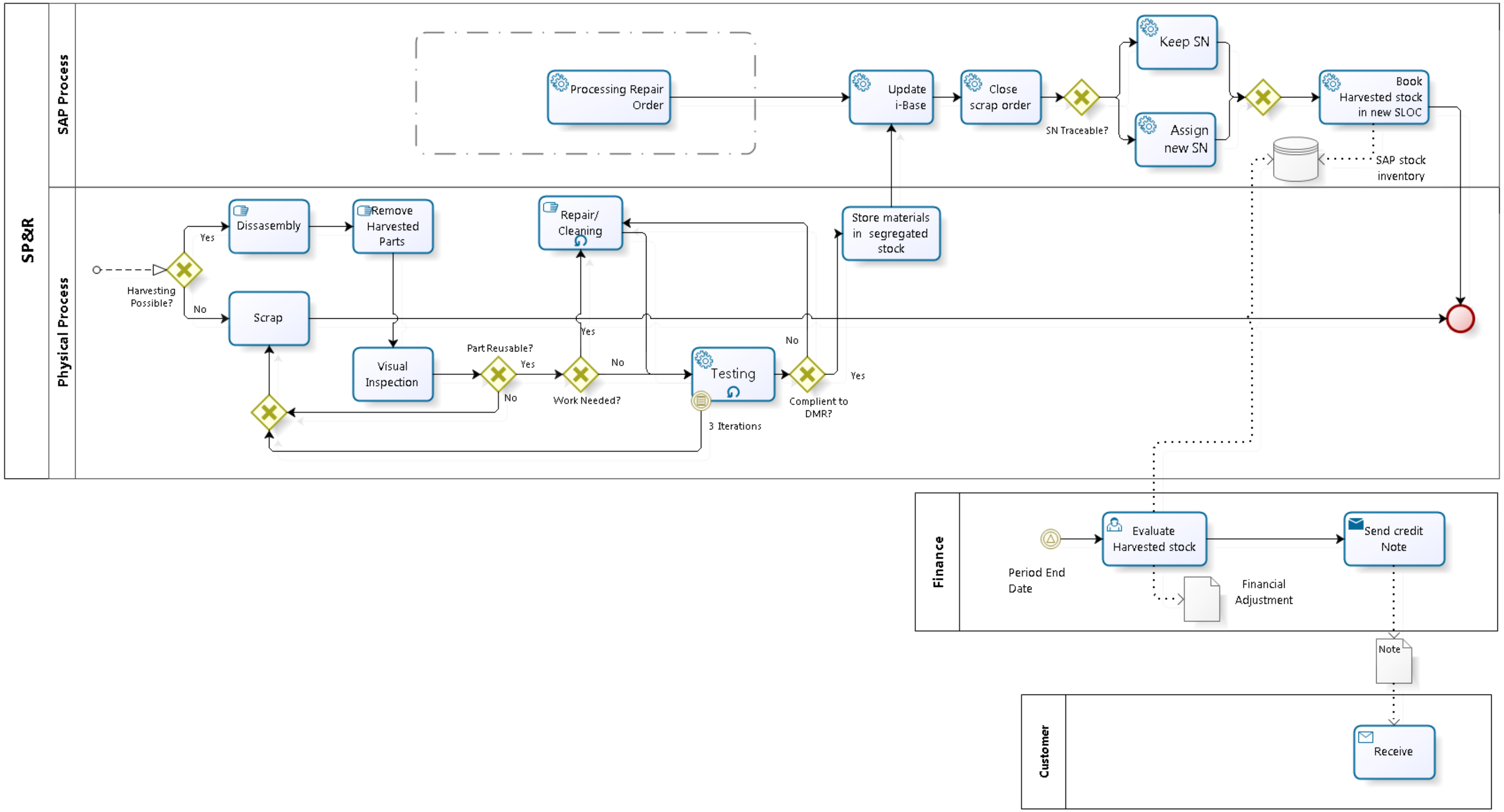


Figure 19. Harvesting Process

Chapter 7 Validation

The man of science has learned to believe in justification,
not by faith, but by verification.
-Thomas Henry Huxley

This chapter describes the validation part of this project. Validation is the process of checking whether or not a certain design is appropriate for its purpose, meets all constraints and will perform as expected. Our validation contains two parts.

In the first part we validate our SAP design solution of enabling a harvesting process through a new storage location. According to the research methodology followed in this project [9], there are different ways to justify and evaluate our design. The approach chosen to validate our SAP solution is experimental through testing scenarios.

In the second part of this chapter we conduct a business case analysis to validate the economic rationale behind implementing a harvesting process. We explain the approach followed to determine the financial profitability of the project. For reasons of confidentiality, the value worth of this project is omitted from the report. However, the approach taken to determine the business value can be used by the management as a guiding tool for business decisions.

7.1 SAP Testing

This validation starts by explaining the testing approach and the testing environment. Then it continues by presenting the testing scenarios and their executions. Finally, section 7.1.3 offers the results of the testing scenarios and conditions for execution.

7.1.1 Testing Approach and Environment

For the validation of the design solution presented in this project we conduct tests which simulate the entire repair process workflow with harvesting (Figure 18, Figure 19) executed in SAP. Our approach involves testing two scenarios. For each scenario we initially outline the expected results of the tests. Then we identify the conditions needed for the executions of the tests and the steps involved in it. Finally, we present the results of the tests and compare against the desired outcomes. The results of the tests are considered satisfactory if they match the desired outcomes of the scenarios.

The environment used for testing the scenarios is SAP MBQ, a testing application for SAP. This application is an instance of the SAP MBP system and it contains all the functionalities of the real system. All the actions and transaction executed in the SAP MBQ are used merely for testing purposes and have no impact on the real SAP system. Testing environments enable businesses to manage and run the SAP testing activities for project rollouts, functional releases, version upgrades, support packages etc. In this project, we use SAP MBQ in order to simulate the repair process at SP&R with the harvesting design that we propose. In our design the process spans two storage locations: the current storage location in use (OXB1) and a new storage location which is used for locating the harvested stock. For the role of the new storage location in our tests we make use of an empty instance of a storage location (called XNL1). Similar to the proposed solution, SP&R is the only organization which has access to this SLOC and authorization for material movements.

7.1.2 Testing Scenarios

Scenarios are hypothetical stories to help the tester work through a problem or test a system. In order to test the SAP design solution presented in this project we conduct two scenarios. The first scenario concerns the usage of the harvested bin from a new storage location (XNL1). The operations to date of the department have all been executed within one storage location. Therefore, it is important to test if the material movement from one storage location to another one is easy and convenient to perform. In the first scenario we create a new bin in the new storage location (XNL1) and simulate the booking of different materials from the current storage location (OXB1) to the new one.

In the second scenario an integration testing is performed. Integration Testing is accomplished through the execution of predefined business flows, or scenarios, that emulate how the entire process will run in the business [57]. Therefore, the second scenario simulates the repair process of one part by using materials which have been previously harvested from another part. This test integrates the first test scenario into the SAP RMA transaction flow of the current repair process. The goal of the second test scenario is to provide an overall overview about the possibility and convenience of performing repairing processes by using a new SLOC as home to harvested materials. Therefore, this test validates our SAP design solution and builds confidence that this solution can be performed in a business environment.

Scenario 1. New SLOC and bin for Harvested stock

The first testing involves booking materials from SLOC OXB1 to the SLOC XNL1 and the reverse. The desired outcome of this test is the proof that all transactions for enabling these material movements are possible and fast to execute. This test requires a few setup actions before being conducted because the new storage location XNL1 is an empty test location. As conditions for the test, we create a material which will be harvested, a storage type, a new bin and a new MRP view in the SAP master data. After creating the above element, the MIGO transaction is used for material movement. All the test steps are listed and explained below.

Test Steps

1. Create the material which will be harvested (here called material A) in the new storage location XNL1
2. Create storage type RR2 in the new SLOC XNL1. Storage types are explained in Figure 9. We create type RR2 which is the storage type for repair parts, but any other storage type could also be created.
3. Within the storage type RR2, create a new bin called "Harvested" bin. The materials which are harvested will be located in this bin.
4. Fill the SAP master data of the new material. We specify that the material is located in the "Harvested" bin of type RR2 in SLOC XNL1.
5. Create a new MRP view for the material in SLOC XNL1. This step is required because the previous MRP views are linked to the storage location OXB1. For the new SLOC it is needed a new MRP view.
6. Move one part of Material A from a bin in SLOC OXB1 into SLOC XNL1. In SLOC OXB1 we use storage type 111 and bin called 92ASS10. Therefore the movement is made from storage type 111 and bin 92ASS10 into "Harvested" bin, storage type RR2, SLOC XNL1. The transaction for this step is the SAP MIGO transaction.
7. While transferring in step 6 via MIGO transaction we enter Serial Number for the part.
8. Create transfer order in MIGO, and enter. After saving the MIGO transaction, a TO (transfer order) is created and confirmed.

Before the confirmation of the TO, the total stock of materials on storage bin "92AS10", type 111, SLOC OXB1 shows 11 elements. The number of materials on SLOC XNL1 is 1 (Figure 20). After the transfer order confirmation we see that one element is removed from the stock in SLOC OXB1 and added to "Harvested" bin in SLOC XNL1. The stock of material before the TO and after the TO are presented in Figure 20 and Figure 21. As it is shown in the screenshots, the number of stock per material in SLOC OXB1 is decreased by one while the stock in the "Harvested" bin is increase by one. Therefore, the material movement from SLOC OXB1 to SLOC XNL1 is successfully performed.

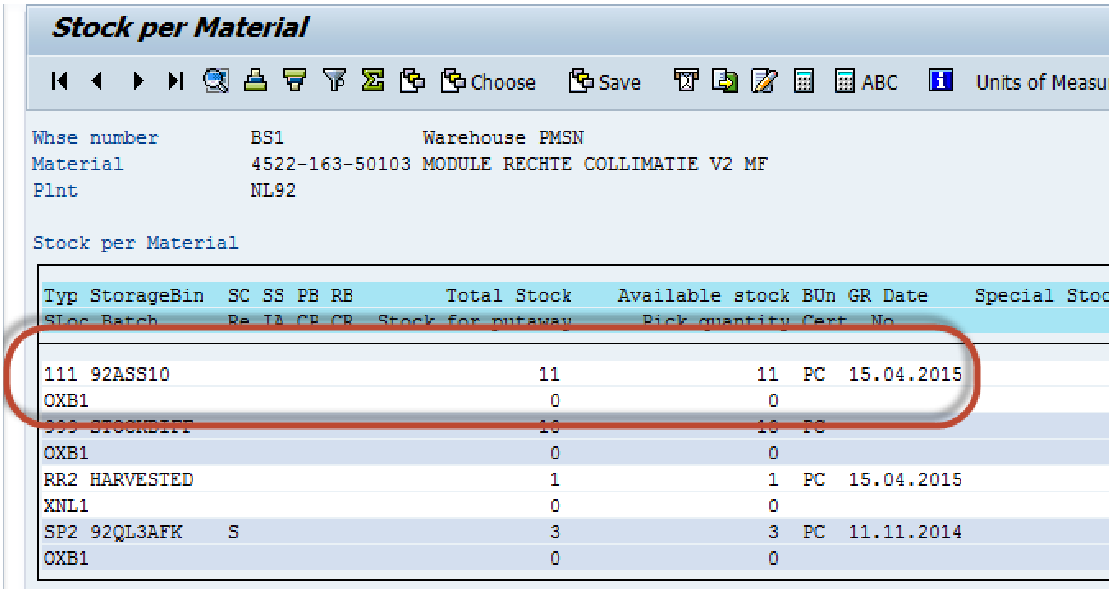


Figure 20. Stock per material before Transfer Order

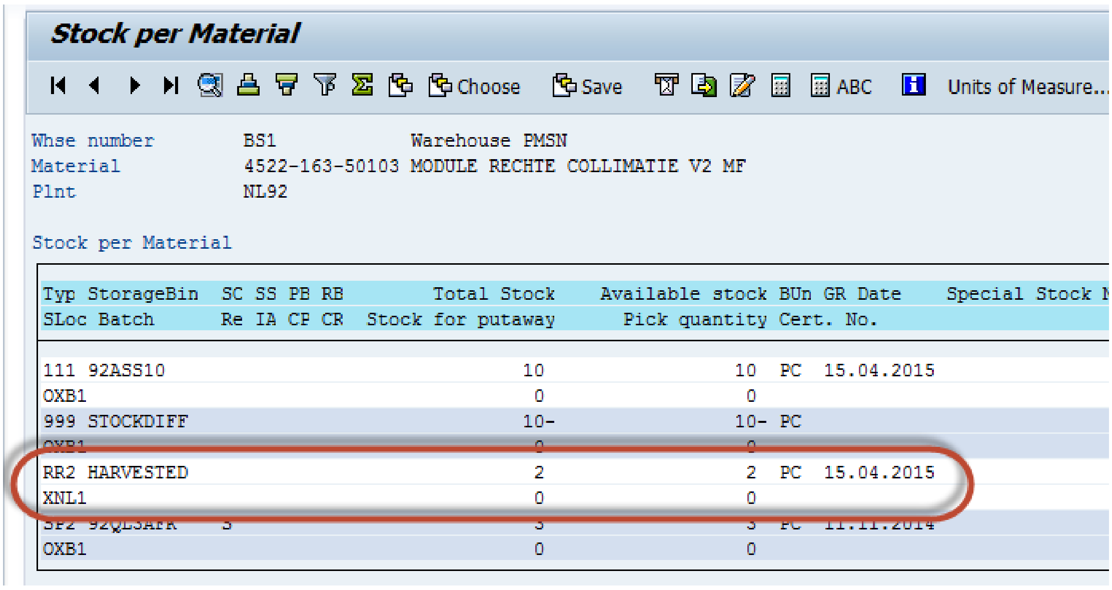


Figure 21. Stock per material after Transfer Order

The next step of the first test scenario is reversing the above operations. In this part we test booking materials from SLOC XNL1 "Harvested" bin into SLOC OXB1 to storage type 111 and bin "92ASS10".

The materials put in the "Harvested" bin will be used as repair materials in the repair process. Therefore, it is important to demonstrate that these materials, which are located in SLOC XNL1, can be used into the repair process occurring in SLOC OXB1. The steps performed in this part of the test are listed below:

9. Transfer with MIGO transaction from SLOC XNL1 to SLOX OXB1.
10. Fill quantity and serial number of the material check and post document
11. Create TO and enter. Set the "Confirm" and change storage type in 111 and the bin into 92ASS10.
12. After saving the MIGO transaction a transfer order is created. Once the transfer order is confirmed the material movement is completed.

After executing the above steps, the number of stock per material in the "Harvested" bin is decreased by one while the stock located in SLOC OXB1 is increased by one (Figure 22).

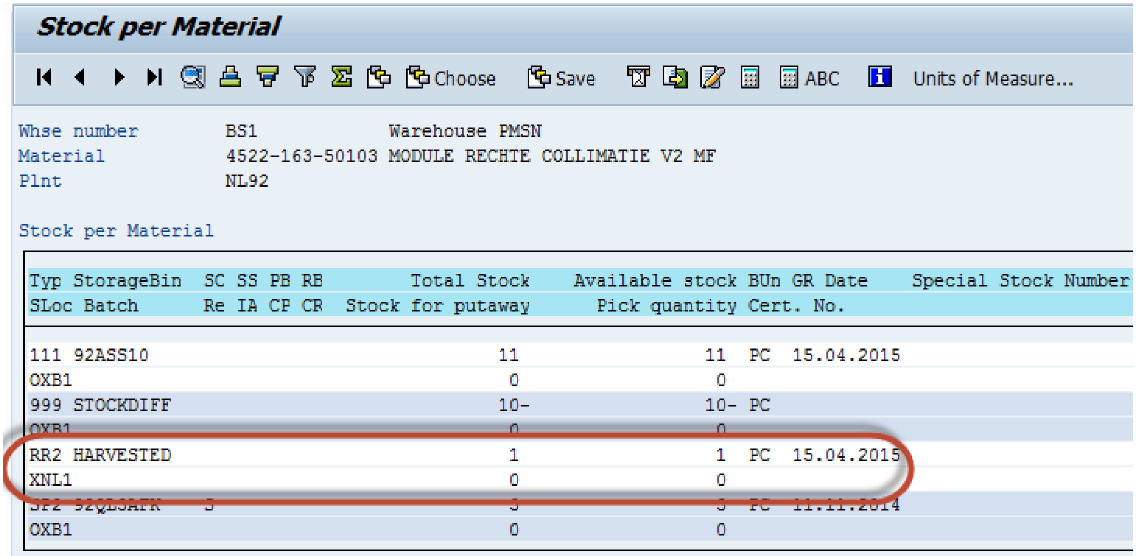


Figure 22. Stock per material after reverse material movement

The results of the tests show that it is possible to book materials from the current storage location to a newly created bin in another storage location. These operation was executed through test steps 1-8. The reverse operation is also possible with just a few transactions, as demonstrated in steps 9-12. Therefore, the results of the first testing scenario are satisfactory.

Scenario 2. RMA rework process with new SLOC and harvested bin

The second testing scenario emulates the entire repair process in SAP RMA with the integration of the transactions for using harvested materials from the new storage location. As explained in the previous chapters, the services that are offered in the SP&R department are Repair and Rework. Repair is repairing the same defective part to a functioning condition of that part. Reworking involves not only repairing the part but also upgrading it to the latest version. Reworking is a more complex process than simple repair, therefore it is the chosen scenario for our second test. By testing the rework scenario with harvesting, the simpler repair scenario is also tested. If the test results are proven satisfactory this is a strong proof of the validity of our solution.

In this scenario a part “A” is received for repair and rework from SPS. Part “A” is composed by materials: B, C and D. For a newer version of part “A”, material C needs to be substituted with the newer material C1. By doing so, part “A” is also upgraded to part A1. In this test it is assumed that material C1 is located in the “Harvested” bin of SLOC XNL1. Also, it is assumed that part C is considered useful to be used later and therefore it is booked from SLOC OXB1 to the “Harvested” bin in SLOC XNL1. In our test, component C is booked out from the SWO (service work order) and booked into the “Harvested” bin of SLOC XNL1. Following, component C1 is taken from the “Harvested” bin of SLOC XNL1 into a stock in SLOC OXB1. The component is now available to be used as repair material for part A. The material is booked in the service work order for the repair of part “A” which is now converted to part “A1”, the upgraded version. The procedure of reworking through the usage of the harvested stock is visualized Figure 23.

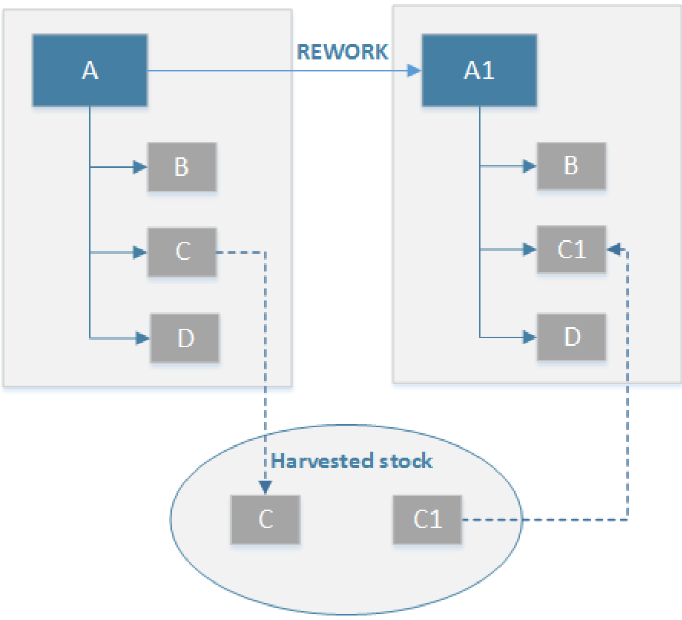


Figure 23. Reworking through harvesting bin

The above reworking process is translated in a sequence of SAP transactions which enable all the actions required for material movement and repair. The main SAP transactions flow of this testing scenario are presented in Figure 24.

Each box presents the steps taken in the process. The SAP transactions required for every step are highlighted in red. The flow is triggered by the creation of a RPO (Repair purchase order) which is done by SPS through their SAP MP1 interface. The order is received as a SO (Sales Order) by SP&R in the SAP RMA interface and it is confirmed by issuing a CDD (Confirm delivery date). After this confirmation, the reworking process starts being performed in SP&R and the steps are presented below.

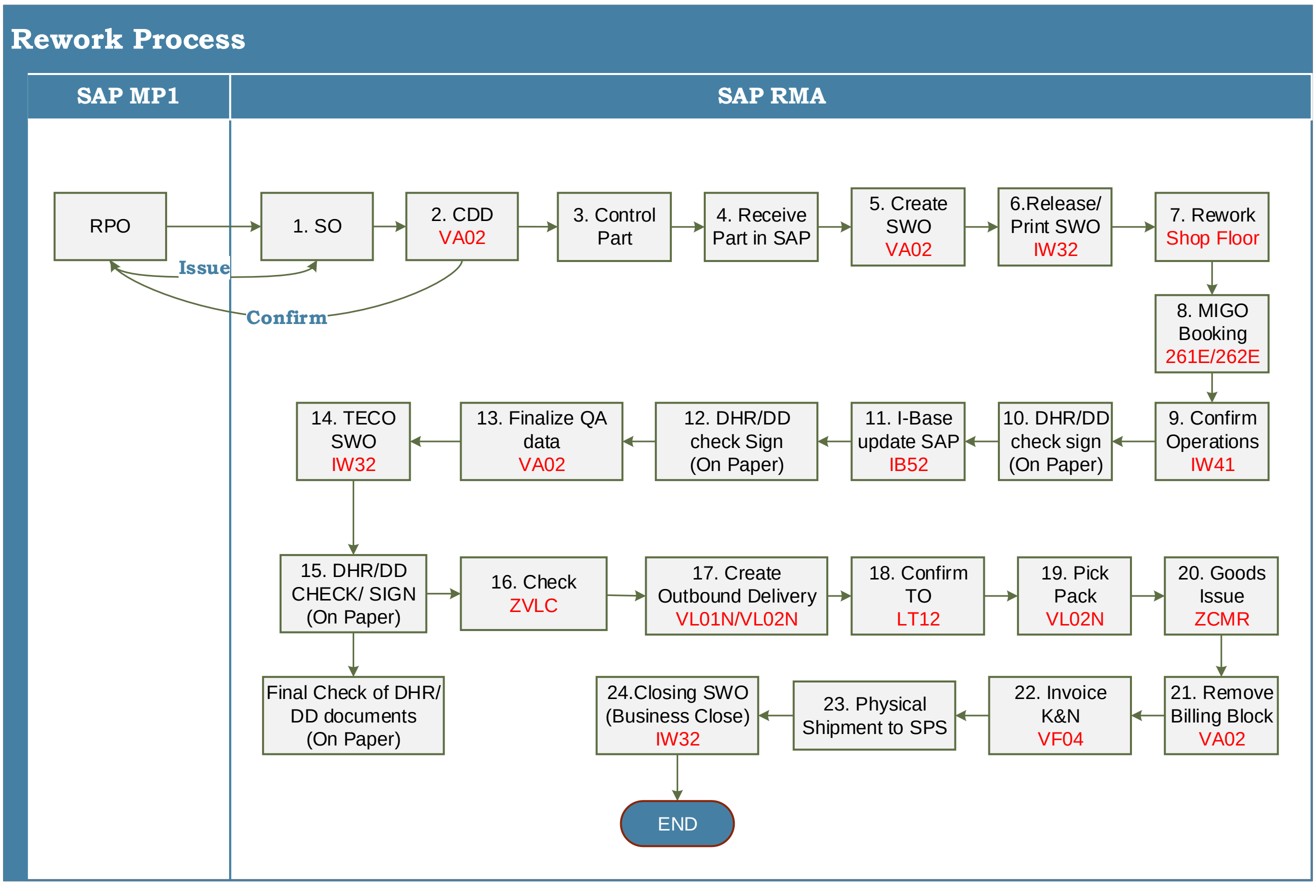


Figure 24. Rework SAP transaction flow

The above figure offers an aggregated visualization of the actions taken for testing the scenario of reworking through the harvested bin. Within each step there are more detailed actions which for a reason of space or omitted from this part of the report. A more detailed description of the steps performed and the screenshots of the testing are provided in *Appendix H*. For reasons of space, the complete testing script (98 pages) for this scenario is omitted from this report, and is found on Philips HealthTech reports, as "Test Script: RMA process with Harvesting".

7.1.3 Test Results

The results of both testing scenarios were positive. The desired outcome of the first testing scenario was to validate the possibility of having material movement from one storage location to another one, therefore enabling the use of the harvested stock. The results of our tests proved that the booking of materials can be performed with a few SAP transactions. The outcome of second testing scenario is the successful rework of part A into part A1 version by using harvested materials from another storage location. Booking material C from OXB1 to XNL1 was easy and convenient. The average time taken for this step is 2 minutes. Booking material C1 from the harvested stock in XNL1 into OXB1 and using it for the rework of part A into A1 is also possible. However, this step requires the execution of many SAP transactions and it takes a longer time to be processed (8-10 minutes). Considering that reworking is more complex than simple repair, the time required for executing the repair process is estimated to be around 5-6 minutes. Therefore, the proposed solution is not only realizable but also quick to operate.

There are several conditions that need to be in place for these operations to be possible. Firstly, the organization must have authorization to access and use the new storage location. Secondly, materials should be created in the new storage location and linked to a new storage bin and storage type. Finally, MRP views should be created in SAP master data for the new storage location. This is necessary to view material availability in the new storage location. If these conditions are satisfied, the SAP design of implementing harvesting through a new storage location is an effective solution. Our testing scenarios which emulated the everyday work of operating a repair process with harvesting validate that the design proposed in this report is a feasible solution.

7.2 Business Case

Whenever an organization plans to commit finance or resources to a project, it should be in support of a demonstrable business need. The business case is what captures the business justification for initiating a project. A thorough business case includes written arguments which help the management to decide whether they should initiate or not a project. Usually, the strongest motivation for starting a project is based on financial profitability. To this purpose, the business case should clearly display the return on investment (ROI) that will be received in the short or long term by conducting the project. Other reasons for initiating projects are related to social responsibility and environmental initiatives. The motivation for initiating a harvesting process in the SP&R department of Philips HealthTech has both economic and environmental grounds (Section 1.1 Context and Motivation). In this chapter we focus on the economic motivation and try to provide an analysis of the financial profitability of this project. We explain in detail the approach taken to assess the economic attractiveness of harvesting spare parts given the current business model and environment of working.

For a project to be financially attractive to a business it should show that by implementing this project either the general revenues will increase, or the operating costs will decrease. In the repair process, SP&R uses new parts as substitute for defective parts in order to fix the entire component. These repair parts are mostly ordered from third party vendors which deliver to SP&R within the specified lead times. By harvesting spare parts which otherwise would be disposed, and reusing them as repair parts in the repair process, a considerable part of the demand for repair parts can be provided internally. Therefore, the general volume of parts which are being ordered by third vendors is expected to decrease. This signifies a clear reduction in supply costs and increase in profit. In order to quantify the profit and build a solid business case, it is necessary to look at the volume and price of the parts which are being reused. The approach that we follow for our analysis is that of identifying a list with potential interesting parts to be harvested and assess the financial impact of reusing these parts. SP&R is using a vast list of parts in their operations which accounts for more than 805 registered parts [63]. Naturally, several criteria have to be applied to the list in order to filter only the most interesting parts to be harvested. In our approach for selecting components of interest for harvesting we apply two main criteria: financial attractiveness and technical feasibility.

Financial attractiveness aims at selecting parts which have solid financial reasons for being reused, for example being expensive. Other filters applied within the financial criteria regard the volume of usage for the parts, the scrap rate, and the predicted rate of reusing those parts in repairing process. Specifically, the questions asked for each component during the selection process of the potential components for harvesting are the following:

1. *Price of the part.* Is the part financially interesting to be reused? – This questions aims at narrowing the list of components down to only the parts which have a considerable price and are therefore worth it to be reused. Parts whose price is considered too low, are defined not interesting for harvesting and left out of the list.
2. *Volume.* How often has the part been used in the Service Work Orders of repair orders? - This question filters the list of components to the most frequently used ones. If high quantities of the components have been used in the repair process then this is indicator that a considerable amount of those parts can be harvested and reused.
3. *Scrap Rate.* How often is that part being disposed? – When a component is about to be scrapped, all the parts within that component are scrapped as well. If a component has been scrapped frequently that gives a good possibility to save a good amount of those parts.
4. *Reuse Rate.* How often can the parts which have been scrapped be reused? – This question aims at assessing the amount of parts which have been scrapped but could have still been reused. For this information many technical features of the parts were taken in consideration. The information was collected by interviews and discussions with engineers who operate with the parts in every day basis.

The data for the price of the part, and the volume are retrieved from the EveryAngle software, which represents the SAP data into simple information. The scrap rate for single parts in not presented in SAP. For this rate we made the assumption that a part has been scrapped as many times as the component in which this part is located is scrapped. For example, if component A is built by parts B, C, and D, then part B is scrapped as many times as its higher level component A is scrapped. Similarly, for the reuse rate assumptions are made for each part by assessing the technical characteristics of the part. This rate is derived by the many filters applied to the products as part of the technical feasibility criteria which is explained below.

A combination of the above mentioned factors defines the financial attractiveness of harvesting a part. For example, if a part which costs 150 euro has a volume of 60 parts during one year, the yearly cost for that price is 9000 € (150€ x 60parts). If the scrap rate of that part is 30%, then the entire scrapped value of that part is 2700 € (30% x 9000€). With *reuse rate* we can calculate how much of the lost value in scrapping could have been saved. For example, a reuse rate of 50% signifies that half of the times that a part has been scrapped it could have been saved and reused, therefore 1350€ per year (50% x 2700€) is the saved value of reusing that part, therefore the gross profit.

Part Name	Price	Volume	Scrap Rate	Reuse Rate	Gross Profit (per part)
A	150 €	60 parts/year	30%	50%	1350 €

The total Gross Profit of harvested parts is calculated as a sum of the gross profit of each part.

$$Total\ Gross\ profit = \sum_{k=1}^{n} (\text{Price x Volume})\text{x Scrap Rate x Reuse Rate}$$

Where, n is the total number of harvested parts, while the other variables are explained above.

By looking at the yearly gross profit of one part, it can be estimated if the part is financially attractive to harvest or not. Parts which are financially attractive, by having a considerable gross profit per year, are included in the potential harvesting parts list. The list is then narrowed down by the other criteria, technical feasibility.

Technical feasibility is another criteria applied to the list of components in order to come to a shortlisted list with the interesting parts to be harvested. This criteria aims at assessing the technical possibility and effort required to harvest and reuse repair parts. The motivation behind this criteria is that looking at the financial benefit of reusing parts is not sufficient without assessing the practical feasibility of the actual reuse. In addition to coming to a shortlist, this selection criteria is also used to gather inputs on the steps required for harvesting certain parts, such as type of testing required to make sure it is functional. We went through a set of questions which help determining the possibility and effort of harvesting and reusing the parts:

1. Can the part be reused?
   a. Is it allowed by the R&D design specification?
   b. Is this part being used in the current products or is it obsolete?
   c. Does the part require any significant rework (i.e. cleaning, polishing)
2. Is it possible to harvest the part without damaging it?
3. Is visual inspection possible and sufficient?
4. Is any testing needed to assure the part's quality?
   a. If yes, what test is needed?
   b. Does SP&R currently have the required test in place?
      i. If not, what is the amount of effort required to set up and validate this testing?

The above questions aim at addressing the technical possibility of harvesting and reusing the parts. After this criteria is applied to the potential harvesting list, a shortlist with all the parts which are both financially attractive and technical possible to be harvested is outlined. The sum of all the saved values of these parts per year, represent the economic gain brought to the business by the harvesting project.

Naturally, the above gain is only the profit received by harvesting materials instead of discarding them. In order to evaluate the real value of any project the costs required to set up the process must be considered. Performing a return on investment ratio (ROI) is a commonly used approach by businesses for determining the real profitability of a project. Therefore, a breakdown and estimation of total costs is necessary to determine the investment required for the project. The cost for this project is compound by one time investments and regular operating costs for the harvesting process. By analysing the costing activities and researching previous similar investments it is concluded that the main elements which constitute the one time investment for the process are the following:

- IT change request (CR)
- Buying Testing equipment
- Purchasing additional storage space
- Employee training

In addition, the regular costs of the working hours that employees would spend on the harvesting process are also considered.

For a realistic and ready to use list of harvesting materials, only the materials for which testing is already possible in SP&R are included in the harvesting list. Therefore, the extra costs of testing equipment do not apply to this project. Similarly, the current space in the shop floor is sufficient for setting up extra bins of harvested parts and there is no need for additional storage space. Finally, the employee training for harvesting process is estimated to last only 1-2 days.

The hours the employees spend on the training are counted as daily working hours; therefore, the training does not represent extra costs. Consequently, the only significant cost as a one-time investment for the harvesting project is the IT change request (IT CR) for creating a new storage location in SAP. By looking into similar previous investments and consulting SAP experts, the CR cost is estimated to be between 5,000 to 8,000 euros[3].

To calculate the cost of regular working hours during harvesting the following approach was taken. For each material to be harvested, an estimation of time required to disassembly, test, and book transaction in SAP was provided by the technicians in the shop control. The time required for harvesting highly depends from the material and its condition. Therefore, the average amount of time required to harvest one material was taken into assumption (10 minutes). Following, in order to obtain the yearly working hours the average time to harvest one material is multiplied by the number of materials expected to be harvested within one year. The total cost incurred by the employees is calculated as the product of the yearly hours spent on harvesting and the hourly pay rate.

As a conclusion, the IT change request and the employee costs are the main significant elements which are considered as the required investment for implement the harvesting process in SP&R. The return on investment ratio is calculated as follows:

$$ROI = \frac{(Total\ Gross\ Profit - Investment\ Cost)}{Investment\ Cost}$$

Where

Total Gross profit = the sum gross profit per part of all the harvested materials in one year

Investment Cost = IT CR cost + employee costs

The results of the ROI are interpreted as rates of return of the money invested on the project. Therefore, it is used as a good indicator of the profitability of the project.

The business case is highly dependent on the flow of products which come at SP&R for service. The production of medical devices is part of a dynamic and evolving industry. The business structure and the flow of products might change in the future, and similarly the business case might evolve.

[3] The cost of the investment varies from the IT customization

Chapter 8 Conclusion

Change is the end result of all true learning.

-Leo Buscaglia

This chapter presents the research conclusions derived from the analysis of the empirical findings and the design of the framework. First, the answers to the research questions are provided. Second, the limitations of the research are pointed out. Finally, recommendations for future work in continuation of this project are provided.

8.1 Research Conclusions

Within this master thesis we addressed the problem of setting up a harvesting process in a servicing organization of Philips HealthTech. In order to investigate this topic, both technical and business aspects of the organization were considered. The technical aspect of the problem involved finding a feasible solution for supporting the physical harvesting process through SAP RMA, the system for processing service materials. For addressing this issue, an analysis of the different options for implementation was made and the most favourite approach to the environment was proposed. The business aspect of the problem involved aligning between the different participants of the process for an efficient and convenient flow of information. To address this aspect, an analysis of the current organizational structure was performed and approaches for aligning between the participants were identified. Specifically, the purpose of the current study was to answer three main research question.

RQ1. *What are the main components to be considered for setting up a harvesting process?*

The first research question was answered in Chapter 4. The first contribution of this project was designing a conceptual framework which serves as a comprehensive guide for setting up a harvesting process. The framework was designed after identifying the requirements from the environment, analysing the current structure of the business, and by using an existing operational model as a base reference. The framework presents the main actors of the process and their dependencies. The identified components of the framework are Organization, Quality & Regulatory, IT, Purchasing, Finance, Process and Implementation. Each of these components plays an important role for setting up the process. However, it was identified that the most important components which pose challenges and limitations to our project are IT, Finance and Purchasing. The main requirements for implementing the harvesting process originate from these three components of the framework. Therefore, addressing and offering solutions to these requirements becomes a priority for designing the process.

***RQ2**. What are the options for supporting the harvesting process through SAP?*

This research question was addressed in Chapter 5. Detailed Design, and it also represents the main contribution of this research work. A thorough analysis of SAP options for supporting the harvesting process was conducted in three areas of the framework: IT, Finance and Purchasing. The detailed design phase addressed three main requirements: *SAP segregation between harvested and new stock*, f*inancial evaluation of the harvested stock*, and *alignment with the customer*. For addressing the stock segregation requirement, various options which involve different SAP functionalities were explored. These options included features of the blocked stock status, batch management and the usage of a new storage location. A qualitative analysis and decision making matrix were used as tools for evaluating the different scenarios and for comparing against each other. The qualitative analysis followed a benefit-drawback approach where the main features of each scenario were outlined. In order to try and quantify the analysis and have a clear comparison between the options, desired attributes of the system were used as criteria for the decision making matrix. By assigning weights to each criteria and allocating scores to the options, the most feasible solution was determined. The proposed approach for segregating in SAP between harvested and new stock is to locate the harvested stock in a new storage location. This measure ensures that the other departments within the same SAP storage location as SP&R do not accidentally access this stock, while allowing SP&R an easy and convenient usage of the stock. This option was tested and validated through the SAP test environment, where a harvesting process with the use of the extra storage location was simulated. The testing scenario depicted the process flow with real materials in order to test the feasibility of the solution in the real environment. The testing proved that the solution is not only realizable but also convenient to execute, as it requires few SAP transaction.

The other requirements which were addressed in the detailed design concerned the finance and purchasing areas of the conceptual framework. For the evaluation of the harvested stock in the system, the SAP functionality of "Split Evaluation" was investigated. The activation of this functionality was determined to have a very big impact on all the company operations located within the same SAP plant level. Alternatively, this requirement was addressed through a business scenario in which the collaboration with the finance department allows for periodic adjustments to the value of harvested stock. This scenario ensures an accurate inventory value of the harvested stock on the financial statements and it is a convenient approach which does not affect the SAP system. Similarly, for addressing the purchasing requirement three options for alignment with the customer were considered. The proposed course of action is to align through departmental collaboration and by periodic reconciliations.

The approaches proposed in this report are determined by aiming at a convenient and feasible solution for the current environment. After investigating several solutions for each requirement, the preferred approach was considered the one which was the most practical to execute and had the lowest impact on the other supporting departments. However, the analysis on the various SAP functionalities for the support of this process, gives a good overview on the options and possibilities for enabling the process through SAP. This source of information can be used in case the context or the business structure change in the future.

RQ3. *How can the harvesting process flow be integrated to the current operations?*

This question was addressed in Chapter 6. Integration. By adapting the solutions proposed in the detailed design, a general process overview showed the repair process with harvesting as a subprocess. Harvesting will initialize after the whole part is determined beyond economical repair, but it contains components which are considered interesting for harvesting. This decision is based on the financial attractiveness and technical feasibility for harvesting and reusing those parts. An approach to the decision making process is shown in the business case in the validation chapter. The integrated process flow of repair and harvesting (Figure 19) showed a parallel executions of the harvesting process both in the physical flow and in the SAP system. The process flow serves both as an illustration of the main tasks to be performed in the harvesting process and as a work instruction for the employees. The complete process flow of reworking a component with the use of harvested materials from a new SAP storage location was tested as the second scenario of our validation phase. The testing depicted the everyday operation of reworking a defective device until it is up to a compliant quality and the order is finalized. The testing results showed that the proposed SAP solution allows for an accurate execution of the tasks and it can be conveniently integrated into the current operations of the department.

8.2 Limitations

The current research project has several possible limitations.

- The scope of this project was limited to the servicing organizations, and specifically conducted to accommodate the current organizational structure of Philips HealthTech.
- This research work does not cover detailed material traceability. In order to track the materials which are previously used, it is necessarily to have a mechanism which keeps track of usage history of the materials. In this way, it is avoided the reuse of the same materials more times than its design specification. In our project we take in consideration that the usage history is recorded in the material DHR (Device History Record). However, this data can be visible only for materials which have a Serial Number that is traceable. The traceability of the other materials should be researched and thoroughly analysed.
- The scenarios for solving the "Finance" and "Purchasing" components are based on thorough analysis of the environment and discussion with field experts. However, these scenarios were not tested or evaluated in case studies. Applying the theoretical scenarios in real life by conducting case studies would add confidence on the efficiency of the solutions, or point out potential bottlenecks.

8.3 Future Work

The research conclusions and potential limitations of this thesis outline several recommendations for future research.

- Consistent with the major limitation of this research having a restricted scope, the future research could expand the model with considerations to changes in the organizational structure of Philips HealthTech. Future research could analyse how the proposed framework should be adapted to accommodate any likely future developments in the reverse supply chain.
- Another option for further research is performing a detailed analysis of the material traceability. For a proper management of the material flow along the supply chain, it is necessary that the materials are easily traceable. Items which do not have a traceable serial number can't be traced through SAP; therefore, it exists the risk of being overused. Future work should research alternative traceability approaches and control mechanisms which prevent the over utilization of the materials.
- The value of the overall framework would be improved if more validation is conducted on the Finance and Purchasing blocks. Conducting case studies for the proposed scenarios

would increase the credibility on the success of implementing the framework in the real life environment.

- Further research could focus on the harvesting decision making process. In this research we discuss the approach taken to identify interested parts for harvesting based on two criteria: financial attractiveness and technical feasibility. Within the financial attractiveness criteria, we analyse the business need for the parts based on historic data about the usage of those parts during the last years. Based on the recent year's data, forecasts were made regarding the need for those parts in the future. The research could be expanded by allowing a more dynamic decision making approach based on inventory planning. Deciding on whether to harvest or not certain parts based on the inventory levels, would assure that the process meets the business needs more closely.

Bibliography

[1] C. MacKechnie, “Information Technology & Its Role in the Modern Organization,” *Houston Chronicle,* 2015.

[2] S. K. Srivastava, “Network design for reverse logistics,” *Omega,* vol. 36, no. 4, pp. 535-548, 2008.

[3] J.-C. Zheng and X. Qing, “Production servicing business and the division of labour.” *Science & Technology Progress and Policy,* pp. 13-15, 2005.

[4] M. Fleischmann, “The impact of product recovery on logistics network design,” *Production and Operations Management,* pp. 156-173, 2001.

[5] G. Ferrer and R. U. Ayres, “The impact of remanufacturing in the economy,” *Ecological Economics,* pp. 413-429, 2000.

[6] Philips Medical Systems, “Quality Management System,” 2015.

[7] “Top 5 ERP Client/Server software applications,” 2015. [Online]. Available: http://www.erpsoftware360.com/erp-software.htm.

[8] V. B. Gargeya and C. Brady, “Success and failure factors of adopting SAP in ERP system implementation.” *Business Process Management Journal,* pp. 501-516, 2005.

[9] v. A. R. Hevner, S. March, J. Park and S. Ram, "Design science in Information Systems Research," *MIS Quarterly,* pp. 75-105, 2004.

[10] S. T. &. S. G. F. March, “Design and natural science research on information technology,” *Design Support Systems,* pp. 251-266, 1995.

[11] Philips, “Good Manufacturing Practice,” Philips, Eindhoven, The Netherlands, 2012.

[12] E. H. Schein, Organizational culture and leadership, John Wiley & Sons, 2010.

[13] Y. Leyy and T. J. Ellis, “A systems approach to conduct an effective literature review in support of information systems research,” *Informing Science: International Journal of an Emerging Transdiscipline,* pp. 181-212, 2006.

[14] R. Vanwersch, K. Shahzad, K. Vanhaecht, P. W. P. J. M. J. Grefen, v. M. G.G and R. H. A, “Methodological support for business process redesign in health care: a literature review protocol,” *International Journal of Care Pathways,* vol. 15, no. 4, pp. 119-126, 2011.

[15] A. Bryman and E. Bell, “Business Research Methods,” *Oxford: NY: Oxford University Press Inc.,* 2007.

[16] J. W. M. Bertrand, J. C. Wortmann and J. Wijngaard, Production control: a structural ad design oriented approach, Elsevier Science Inc., 1990.

[17] P. Cronin, R. Frances and C. Michael, “Undertaking a literature review: a step-by-step approach,” *British journal of nursing (Mark Allen Publishing),* no. 17, pp. 38-43, 2008.

[18] R. B. Newell, Research for Evidence-Based Practice, 2006.

[19] Webster, J., & Watson, R.T., “Analysing the Past to Prepare for the Future : Writing a Literature Review,” *Management Information Systems Quarterly, 26(2),* pp. 13-23, 2002.

[20] V. Guide, R. Daniel and L. N. Van Wassenhove, Full cycle supply chains, Carnegie Mellon Press, USA, 2003.

[21] G. Ferrer and R. U. Ayres, “The impact of remanufacturing in the economy,” *Ecological Economics,* no. 32, pp. 413-429, 2000.

[22] M. Thierry, M. Salomon, J. Van Nunen and L. Van Wassenhove, “Strategic Issues in Product Recovery Management,” *California Management Review,* no. 37, pp. 114-135, 1995.

[23] J. R. Duflou, G. Seliger, S. Kara, Y. Umeda, A. Ommetto and B. Willems, “Efficiency and feasibility of product disassembly: A case-based study,” pp. 583-600, 2008.

[24] J. V. Guide, R. Daniel, R. Srivastava and M. E. Kraus, “Product complexity structuring and scheduling of operations in recoverable manufacturing,” *International Journal of Product Research,* no. 11, pp. 3179-3200, 1997.

[25] J. Guide, V, R. Daniel, V. Jayaraman, R. Srivastava and W. C. Benton, “Supply-chain management for recoverable manufacturing systems,” *Interfaces,* vol. 30, no. 3, pp. 125-142, 2000.

[26] W. Kennedy, W. J. Patterson and L. D. Fredendall, "An overview of recent literature on spare parts inventories," *International Journal of Production Economics,* vol. 30, no. 3, pp. 201-215, 2002.

[27] A. Sleptchenko, M. Van der Heijden and A. Van Harten, "Trade-off between inventory and repair capacity in spare part networks," *Journal of the Operational Research Society,* vol. 54, no. 3, pp. 263-272, 2003.

[28] A. Diaz and M. C. Fu, "Models for multi-echelon repairable item inventory with limited repair capacity," *European Journal of Operational Research,* vol. 97, no. 3, pp. 480-492, 1997.

[29] P. Murphy and R. Poist, "Managing of logistics retro movements: an empirical analysis of literature suggestions," *Transportation Research Forum,* vol. 29, no. 1, pp. 177-184, 1989.

[30] C. Carter and L. Ellram, "Reverse Logistics: a review of the literature and framework for future investigations," *Journal of Business Logistics,* vol. 19, no. 1, pp. 85-102, 1998.

[31] D. Rogers and R. Tibben-Lembke, "Going backwards: reverse logistics trends and practices," *Reverse Logistics Executive Council,* 1999.

[32] M. P. De Brito and R. Dekker, A framework for reverse logistics, Springer Berlin Heidelberg: Reverse Logistics, 2004.

[33] PWC, "Reverse Logistics," Integrated Supply Chain Solutions, 2008.

[34] N. Ferguson and J. Browne, "Issues in end-of-life product recovery and reverse logistics," *Production planning & Control: The Management of Operations,* vol. 12, no. 5, pp. 534-547, 2001.

[35] B. Janes, P. Schuur and M. De Brito, "A reverse logistics diagnostic tool; the case of the consumer electronics industry," *International Journal of Advanced Manufacturing Technology,* vol. 47, no. 5-8, pp. 495-513, 2010.

[36] J. R. Stock and D. M. Lambert, Strategic Logistics Management, 4 ed., Boston: McGraw-Hill/Irwin, 2001.

[37] WERC Sheet, "In Through the Out Door," *WERC Sheet,* no. 26, pp. 1-3, 2003.

[38] Philips Medical Systems, "SAP RMA service return - Work Manual," 2013.

[39] S. Shang and P. B. Seddon, "A comprehensive framework for classifying the benefits of ERP systems," *AMCIS 2000 proceedings,* no. 39, 2000.

[40] R. F. Boykin, "Enterprise resource planning software: a solution to the return material authorization problem," *Computers in Industry,* vol. 45, pp. 99-109, 2001.

[41] W. H. DeLone and E. R. McLean, The DeLone and McLean model of information systems success: a ten-year update, Journal of management information systems, 2003.

[42] K. E. Wiegers, "Software Requirements," *Microsoft press,* 2009.

[43] D. Zowghi and C. Coulin, "Requirements elicitation: A survey of techniques, approaches, and tools.," *Engineering and managing software requirements.,* pp. 19-46, 2005.

[44] M. Muqeem and R. R. Beg, "Requirement elicitation technique.," *International Journal of Software Engineering & Applications (IJSEA),* vol. 3, no. 5, September 2012.

[45] Regulations F. D. A, Code of federal regulations 21 CFR part 820., Food and Drug Administration, 1997.

[46] P. McAllister and J. Jeswiet, "Medical device regulation for manufacturers.," *Journal of Engineering in Medicine,* pp. 459-467, 2003.

[47] A. R. Hamimi and Izatul, "ISO 13485: 2003: Implementation reference model from the Malaysian SMEs medical device industry," *The TQM Journal,* 2009.

[48] L. M. Walther, Financial Accounting 2015 Edition, 2015.

[49] R. D. Snee, "Digging the Holistic Approach," *Quality Progress,* 2009.

[50] M. Wolf-Pany, "The Operational Framework," Vancouver Community College, 2008.

[51] M. Murray, SAP MM-functionality and technical configuration, SAP Pr America, 2008.

[52] T. Volman, W. Berry and D. Whybark, Manufacturing Planning and Control Systems, IL: IRWIN, (1992) .

[53] J. A. Hernandez, SAP R/3 Administrator's Handbook, McGraw-Hill, 1999.

[54] SAP, "Split Evaluation," 2015. [Online]. Available: https://help.sap.com/saphelp_46c/helpdata/en/47/61017149f011d1894c0000e829fbbd/frameset.htm.

[55] A. Korkmaz, Financial Reporting with SAP, Galileoi Press, 2008.

[56] Philips, "Invoicing and Repair costs settlement at SP&R," 2013.

[57] E. Dustin, Effective Software Testing: 50 Ways to Improve Your Software Testing, Addison-Wesley Longman Publishing Co., Inc., 2002.

[58] T. Ramanathan, "The Role of Organisational Change Management in Offshore Outsourcing of Information Technology Services: Qualitative Case Studies from a Multinational Pharmaceutical Company," 2009.

[59] Ekstedt, M., Jonsson, N., Plazaola, L., Silva Molina, E. J., & Vargas, N., "An organization-wide approach for assessing strategic business and IT alignment," in *Portland International Conference on Management of Engineering and Technology*, 2005.

[60] J. Creswell, Research design: qualitative, quantitative, and mixed methods approaches, Sage Publications, Thousand Oaks, 2009.

[61] I. Holloway, Basic Concepts for Qualitative Research, Blackwell Science Ltd, 1997.

[62] G. Winter, "A comparative discussion of the notion of validity in qualitative and quantitative research," *The qualitative report, 4(3),* pp. 4-10, 2000.

[63] M. K. Lee, "IT outsourcing contracts: practical issues for management," *Industrial Management & Data Systems, 96(1),* pp. 15-20, 1996.

[64] J. N. Lee, "The impact of knowledge sharing, organizational capability and partnership quality on IS outsourcing success," *Information & Management, 38(5),* pp. 323-335, 2001.

[65] K. J. Davis, "IT outsourcing relationships: an exploratory study of interorganisational control mechanisms," Harvard University, 1996.

[66] J. Peppard and J. Ward, "Beyond strategic information systems: towards an IS capability," *Journal of Strategic Information Systems,* pp. 167-194, 2004.

[67] J. W. R. Webster, "Analysing the Past to Prepare for the Future : Writing a Literature Review," *Management Information Systems Quarterly,* pp. 13-23, 2002.

[68] Revlogs, "What is Reverse Logistics?," 2005. [Online]. Available: http://www.revlogs.co.za/what-is-reverse-logistics/.

Appendix A. Detailed Project Planning

Project Phase	Tasks	Origin	Destination	Method	Deliverable
1. Orientation	a. Initial department document review	Knowledge base	Research	Document study	Research Proposal
	b. Problem Definition	Environment	Research	Document study	
2. Analysis	a. Analysis of current process	Environment	Research	Interviews/Document Study	Requirements Gathering
	b. Identification of possible issues	Environment	Research	Interviews	
	c. Analysis of impact on other functions	Environment	Develop/ Build	Interviews/ Document study	
3. Design	a. Identification of main components	Environment/ Knowledge Base	Develop/ Build	Interview/ Documents	Conceptual Framework
	b. Identification of options for the requirement	Develop/Build	Evaluate	Analytical	Detailed Design
	c. Integration of the favourite approach in a workflow	Environment/ Knowledge base	Develop/ Build	Theories/ Artifacts	Process Flow, BPMN diagram
4. Validation	a. Design Set up test scenarios	Develop/Build	Evaluate	Analytical	Scenario conditions
	b. Conduct tests	Knowledge	Evaluate	Testing	Test Results
	c. Identify profits and costs of the project	Develop/Build	Justify/ Evaluate	Data Analysis	Business Case
5. Implementation	a. Future work recommendations	Develop/build	Environment	Analytical	Recommendations
	b. Write work instruction	Develop/build	Environment	Analytical	Work Instructions

Figure 25. Detailed Project Planning

Appendix B. Organigram

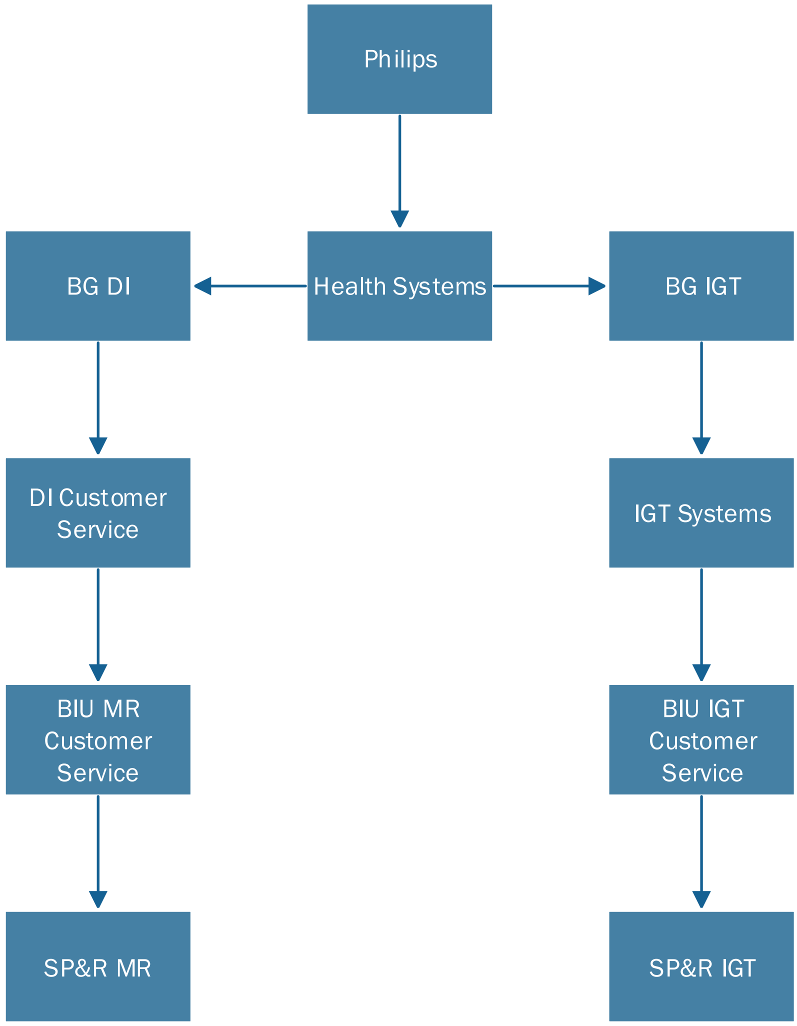


Figure 26. Organigram of Philips HealthTech

Appendix C. Interview questions

Process Interview	
Position:	**Date:**
Interviewee:	**Time:**
Question	
1. How is the current process of repair/rework for IGT/MR products?	
2. What type of tests do you conduct to make sure that the product's quality is up to the quality standards?	
3. Are all products evaluated according to their DRM (Device master record)[4]?	
4. If a harvesting process would be implemented, what types of testing or validation would be needed before the harvested spare parts were considered good to reuse?	
5. What types of stocks are you currently using during your processes?	
6. How do you differentiate between these types of stock?	
7. What products of IGT/MR are currently most frequently being repaired?	
8. Do these parts have components that could be reused after the rest of the device is scrapped?	
9. What benefits do you think will be derived if some service parts could be harvested?	
10. In which cases would these benefits be bigger?	
11. What do you think would be the most difficult tasks for implementing a harvesting service parts process in SP&R?	

SAP Interview	
Position:	**Date:**
Interviewee:	**Time:**
Question	
1. What would be the biggest impact that harvesting at SP&R would have to other functions?	
2. What other functions would be affected by Service parts harvesting in SAP finance?	
3. What is missing in the current SAP RMA that SP&R is using in order to implement harvesting there?	
4. What do you think would be the biggest challenge in harvesting process in SAP?	
5. What are some options for evaluating the harvested parts in SAP as used stock?	
6. How can the cost of the order be affected by re-using harvested materials for repair?	
7. Can two price levels be assigned to the same product?	
8. How is the stock managed in SAP for SP&R?	

[4] When initially produced, all products are assigned a record which explains the functional specifications and the quality standards to which the product should be compliant

Quality and Regulatory Interview	
Position:	**Date:**
Interviewee:	**Time:**
Questions	
1. To which standards is SP&R compliant to?	
2. What would be quality requirements to select parts to be harvested?	
3. What are the quality requirements to reuse harvested parts?	
4. Is there a difference in quality between harvested parts & new-buy parts?	
5. What should be the final acceptance criteria?	
6. Could initial production be allowed to use reused parts in their new products?	
7. If yes, what are the requirements that these parts have to fulfill in order to be used in IP?	
8. If yes, Up to what % of the new product can reused materials be?	

Finance Interview	
Position:	**Date:**
Interviewee:	**Time:**
Questions	
1. Is it a financial requirement to have harvested material and a new material with different evaluations?	
2. If a harvested part is purchased form the customer and put on stock, who is the owner of these parts?	
3. Will SP&R be able to act with those part, for i.e. use them again in the repair process?	
4. Will there need to be a change on the price of selling the harvested parts back to the customer?	
5. How is the selling price of a part defined?	
6. What will be the issues to be solved during the purchase of harvested parts?	
7. Is a requirement for the transaction between SP&R and SPS to be done in the PO level?	
8. What other options are there to balance the transfer of harvested service parts?	
1. To which standards is SP&R compliant to?	
2. What would be quality requirements to select parts to be harvested?	
3. What are the quality requirements to reuse harvested parts?	
4. Is there a difference in quality between harvested parts & new-buy parts?	
5. What should be the final acceptance criteria?	
6. Could initial production be allowed to use reused parts in their new products?	
7. If yes, what are the requirements that these parts have to fulfil in order to be used in IP?	
8. If yes, Up to what % of the new product can reused materials be?	

Interview Questions Motivation

Process Interview	
Question	**Motivation**
1. How is the current process of repair/rework for IGT/MR products?	In order to know the overall process workflow
2. What type of tests do you conduct to make sure that the product's quality is up to the quality standards?	To gather information on the tests and acceptance criteria currently used and what would be the gap of testing process after harvesting
3. Are all products evaluated according to their DRM (Device master record)[5]?	
4. If a harvesting process would be implemented, what types of testing or validation would be needed before the harvested spare parts were considered good to reuse?	
5. What types of stocks are you currently using during your processes?	To gather information on the usage of stocks in the current process.
6. How do you differentiate between these two types of stock?	
7. What products of IGT/MR are currently most frequently being repaired?	To detect products of Interest for harvesting
8. Do these parts have components that could be reused after the rest of the device is scrapped?	
9. What benefits do you think will be derived if some service parts could be harvested?	To gather information about the challenges and benefits of implementing harvesting within the department.
10. In which cases would these benefits be bigger?	
11. What do you think would be the most difficult tasks for implementing a harvesting service parts process in SP&R?	

[5] When initially produced, all products are assigned a record which explains the functional specifications and the quality standards to which the product should be compliant

SAP Interview	
Question	**Motivation**
1. What would be the biggest impact that harvesting at SP&R would have to other functions?	To assess the organizational impact
2. What other functions would be affected by Service parts harvesting in SAP finance?	
3. What is missing in the current SAP RMA that SP&R is using in order to implement harvesting there?	To investigate the gap and challenge of realizing the harvesting process in SAP
4. What do you think would be the biggest challenge in harvesting process in SAP?	
5. What are some options for evaluating the harvested parts in SAP as used stock?	Evaluation of the harvested stock and new stock
6. How can the cost of the order be affected by re-using harvested materials for repair?	
7. Can two price levels be assigned to the same product?	
8. How is the stock managed in SAP for SP&R?	To gather insight on the inventory hierarchy in SAP

Quality and Regulatory Interview	
Questions	**Motivation**
1. To which standards is SP&R compliant to?	To gather information about the regulatory standards (FDA, ISO etc.) that regulate the business.
2. What would be quality requirements to select parts to be harvested?	Selection Criteria Requirements
3. What are the quality requirements to reuse harvested parts?	Reuse Criteria Requirements
4. Is there a difference in quality between harvested parts & new-buy parts?	
5. What should be the final acceptance criteria?	Acceptance Criteria Requirements
6. Could initial production be allowed to use reused parts in their new products?	Interdependency with other functions of the company
7. If yes, what are the requirements that these parts have to fulfil in order to be used in IP?	Investigating requirements for the cooperation with the other department.
8. If yes, Up to what % of the new product can reused materials be?	

Finance Interview	
Questions	**Motivation**
1. Is it a financial requirement to have harvested material and a new material with different evaluations?	Parts Evaluation Requirements
2. If a harvested part is purchased form the customer and put on stock, who is the owner of these parts?	Ownership of the product
3. Will SP&R be able to act with those part, for i.e. use them again in the repair process	
4. Will there need to be a change on the price of selling the harvested parts back to the customer?	Pricing of the harvested parts
5. How is the selling price of a part defined?	
6. How is it possible to reflect the change in value of the inventory between the harvested stock and the new stock if they are registered under the same price in SAP?	Stock evaluation
7. What will be the issues to be solved during the purchase of harvested parts?	Interaction with the supplier and customer (SPS)
8. Is a requirement for the transaction between SP&R and SPS to be done in the PO level?	
9. What other options are there to balance the transfer of harvested service parts?	

Appendix D. Interviewee Panel

Interviewee	Gender	Nationality	Role	Organization	Expertise
1	Male	Dutch	Unit Manager IGT	SP&R	Process/Products
2	Male	Dutch	Unit Manager MR	SP&R	Process/Products
3	Male	Dutch	Project Manager	SP&R	Process/Finance
4	Male	Dutch	Quality Assurance Engineer	SP&R	Q&R
5	Male	Turkish	Process Engineer	SP&R	IT /Process
6	Male	Dutch	Manufacturing Engineer IGT	SP&R	Process/Products
7	Female	Dutch	IT business specialist	CG O2C	IT /Process
8	Female	Dutch	Business Analyst	CG O2C	IT/Process
9	Male	Dutch	Process Improvement Manager	Refurbished Systems	IT/Process
10	Male	Dutch	Team lead IGT	SP&R	Products/Process
11	Male	Dutch	Trouble-shooter	SP&R	Products
12	Male	Dutch	Supply Manager	SPS	Process/ Purchasing
13	Male	Dutch	Senior Quality Engineer	SP&R	Q&R
14	Male	Dutch	Quality Assurance Engineering Manager	IS Q&R MRI	Q&R/Process
15	Male	Dutch	Senior Manager Regulatory	MR	Q&R/Process
16	Male	Dutch	Engineering Manager IGT Operations	IGT Global Operations	Q&R/Process
17	Male	Dutch	Project Manager	RS	Process
18	Male	Dutch	Finance Controller	IGT Systems	Finance/Purchasing
19	Male	Dutch	Finance Analyst	Refurbished Systems	Finance
20	Male	Dutch	Supply Management	SPS	Purchasing
21	Male	Dutch	Finance	SPS	Finance

22	Female	Dutch	Supply Management	SPS	Purchasing
23	Male	Dutch	Technician	SP&R	Products
24	Male	Dutch	Technician	SP&R	Products
25	Female	Dutch	Technician	SP&R	Products
26	Male	Dutch	Manufacturing Engineer MR	SP&R	Process/Products

Table 7. List and profile of interviewees

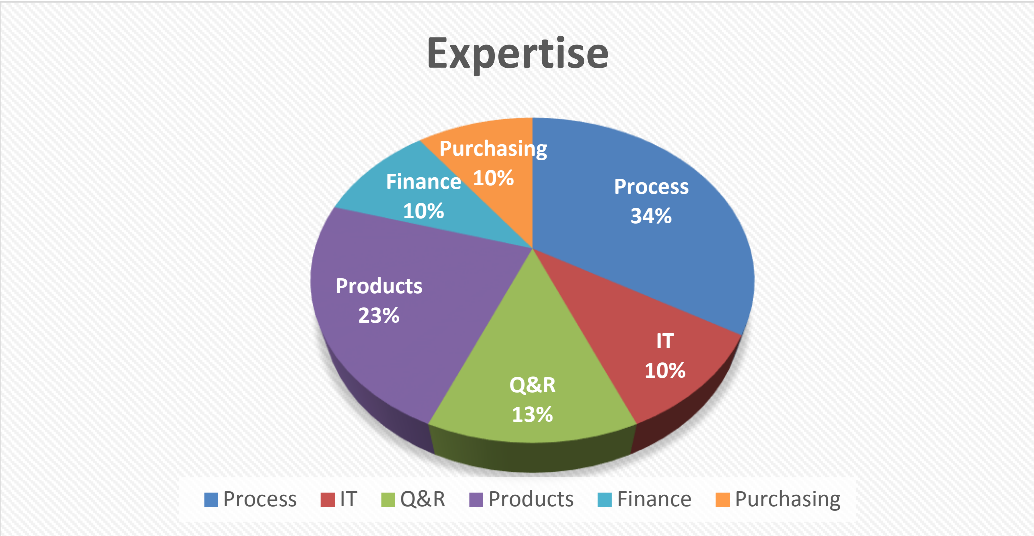


Figure 27. Demographics of the panel of experts

Appendix E. Requirement Elicitations

In this appendix we present all the requirements gathered for the harvesting process. The requirements are elicited from different areas, however some requirements can belong to more than only one category, for example both to Q&R and operational requirements. For our presentation we group the requirements in Q&R, Financial and Operational. The operational requirements are those related

Quality & Regulatory Requirements

ID	Name	Description	Priority	Source
1	Storage	Harvested Products or Components on stock need be segregated from New Products or Components	High	**Philips SP&R**
2	Storage	Untested harvested parts will be segregated from the regular production during all stages of storage and processing	High	**FDA** 820.150, **Philips** XJV-051000.21
3	Selection	Justification and acceptance criteria (e.g. level of wear out, reliability) for a spare part to be selected for the harvesting process shall be defined and documented by the SP&R and BiU.	Medium	**FDA** 21CFR 820.80,820.86 **Philips QMS/BMS**
4	Selection	Selection of parts to be harvested shall be based on a risk analysis (e.g. potential risks due to age and reliability, wear out)	Medium	**FDA** 820.80, 820.100
5	Disassembly	Harvested spare parts with patient information carriers shall be processed in such way that previous patient data is permanently removed to ensure data privacy at all times	High	**FDA** 21CFR 820
6	Decontami-nation	Harvested spare parts shall bear no unreasonable risks regarding infection of any person upon receipt, during or after harvesting process.	High	Philips BMS/QMS
7	Decontami-nation	The decontamination process as described in IGT BMS and MR QMS shall be used.	High	**FDA** 21CFR 820.70
8	Labelling	Harvested spare parts shall be labelled to ensure the correct and safe handling during the storage and reuse in the repair process.	Medium	**FDA** 21 CFR 820.120, **Philips XJV-051000.21**
9	Labelling	The marking and/or labelling should contain date of release and signature or individual releasing the item.	Medium	FDA 21CFR 820.120
10	Traceability	A harvested component must contain its original identification, serial number and date of manufacture to assure the traceability of materials, processes and use of the product or component	Medium	**FDA** 21CFR 820.65

11	Repair/test	Any Repair/test of the harvested spare part shall be executed by qualified personnel	High	**FDA** 21 CFR 820.25
12	Repair/Test	The repaired/tested harvested spare part shall be tested according to a documented test specification as approved by the BU QMS	High	Philips QMS
13	Testing	Additional instructions for personnel performing the testing process shall be made available when deemed necessary, to be decided upon the SP&R.	Medium	**FDA** 21 CFR 820.3
14	Validation	The outcome of any SPH tests shall be part of DHR, including name of test person, test date and signature.	Medium	**FDA** 21 CFR 820.30
15	Validation	The quality of the harvested component must meet full DMR specifications including specified reliability, performance and safety/legal requirements	High	**Philips QMS/BMS**

Financial Requirements

ID	Name	Description	Priority	Source
1.	Selling Price	The selling price of the product should be the standard cost price plus 10%.	High	**Philips QMS/BMS**
2.	Evaluation	The cost price of the same 12NC material need not be different for the two conditions of that material: harvested and new buy.	High	Financial Controller
3.	Transaction	The transaction of buying parts form SPS has to display a correct balance of goods received (+) and charge of goods (-)	High	Financial Controller
4.	Accounting	An adjustment should be made on the journal entries to display the correct evaluation of the harvested stock	Medium	Financial Controller

Operational Requirements

ID	Name	Description	Priority	Source
1.	Stock	The untested and tested components shall be stored in clearly segregated physical locations	High	**FDA** 820.150
2.	Testing	If testing the materials is not necessary, a visual inspection shall be performed	High	Interview: Q&R Person
3.	Testing	The operations shall have procedures for testing at the lowest material level which is being harvested	High	**Philips QMS/BMS**

Appendix F. SAP Repair Process

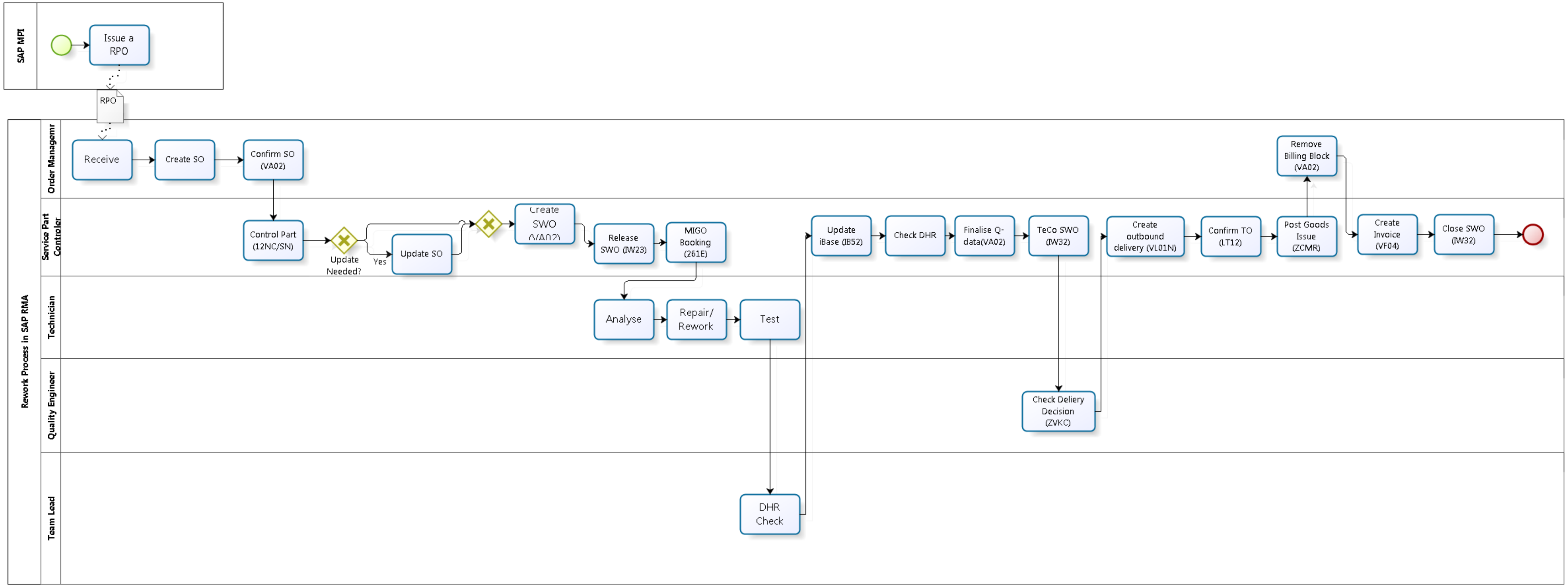
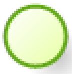
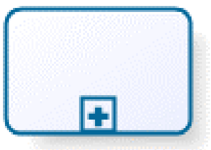
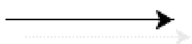
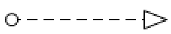


Figure 28. SAP Repair Process

Appendix G. BPMN notation

	**Start** Indicates the start of the process
	**Task** An atomic activity included within a process
	**Service Task** A service task is any task that uses an automated application or web service to complete the task.
	**User Task** Indicates that the task is being performed by a person and cannot be easily broken down into simpler tasks.
	**A manual task** Is used wherever a part of a process has to be executed manually. It can be executed without any outside help or application.
	**Sub-Process** Is an activity which contains other activities (a process)
	**Sequence Flow** A sequence flow is used to show the order that the activities will be performed in a process
	**Message Flow** Is used to show the flow of messages between two entities that are used to send and receive them. In BPMN two separate pools will communicate through message flows.

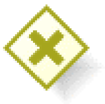
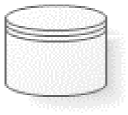
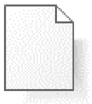
	**Exclusive Gateway** Indicates that the flow can take one or another path, not both.
	**Parallel Gateway** Indicates that two or more parallel flows of the process can occur at the same time.
	**Data Store** Provides a mechanism for the activities to store and retrieve data which will persist beyond the scope of the process.
	**Data Object** Provides information about how documents, data and other objects are used and updated during the process.
	**End** Indicates the end of the process

Table 8. BPMN Notation

Appendix H. Testing RMA process with Harvesting

In this Appendix we include the testing of the RMA rework process with harvesting. The document serves as both a testing script and working instructions for employees. The steps and screenshots demonstrate how to conduct a rework process by using harvested materials through SAP. This appendix includes only partially the SAP workflow of the process. The complete report is found on Philips HealthTech internal database.

Test in MBQ whole RMA process with new SLOC (OXB1 and XNL1) and bin for harvested stock.

Test steps:

- First receive part for repair
- Move defect component to new storage location
- Move harvested stock of the component from new storage location to existing storage location.

Conditions:

Create MRP views in SAP master data for new SLOC XNL1

Create new bin for harvested stock in SLOC XNL1.

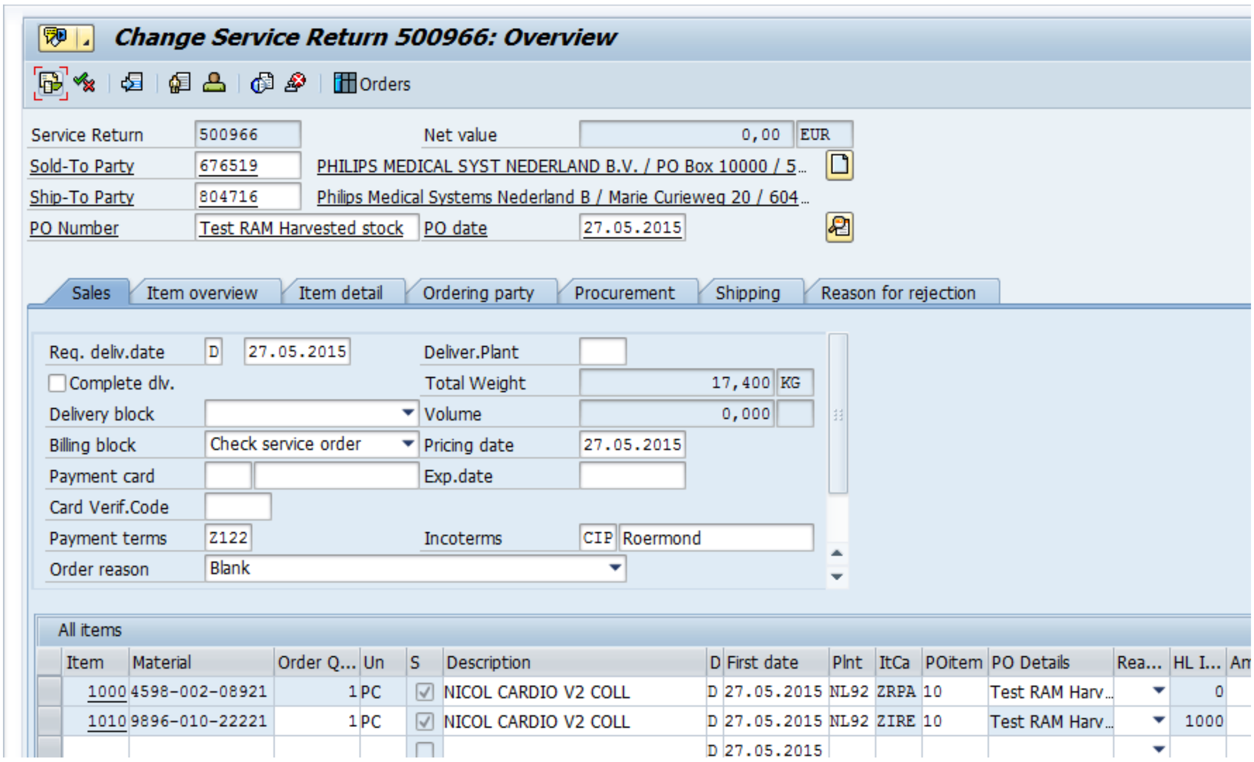
Book harvested stock materials from SLOC OXB1 to SLOC XNL1

Book harvested stock materials from SLOC XNL1 to SLOC OXB1 back.

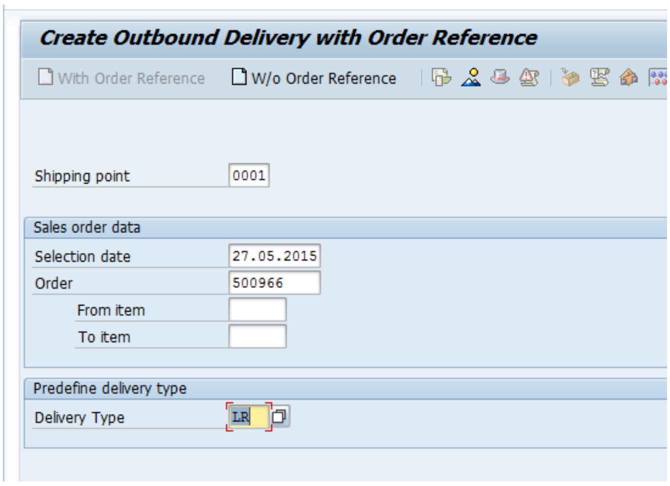
Test execution:

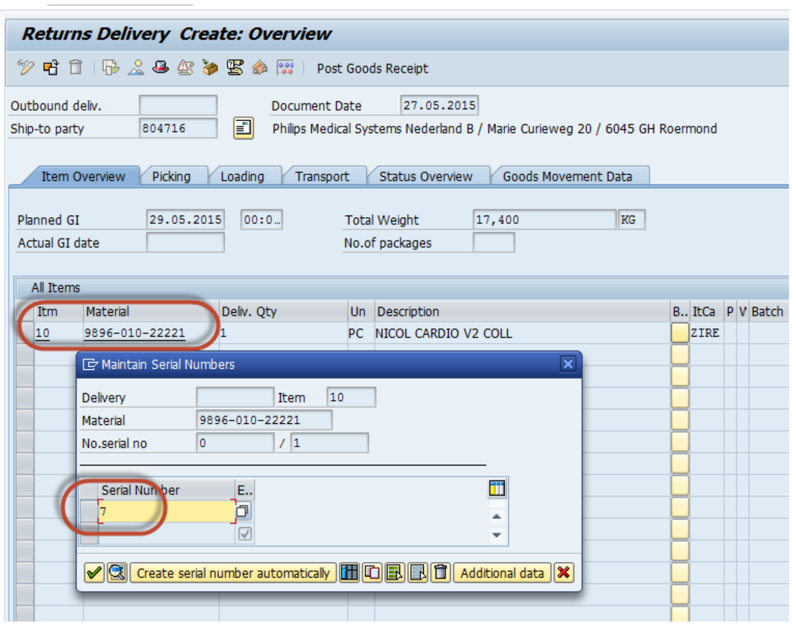
Receive part 9896-010-22221 from SPS and rework it into kit 4598-002-08921. During repair remove defect component 4522-163-50103 to new storage location and move harvested component stock from new storage location to existing storage location.

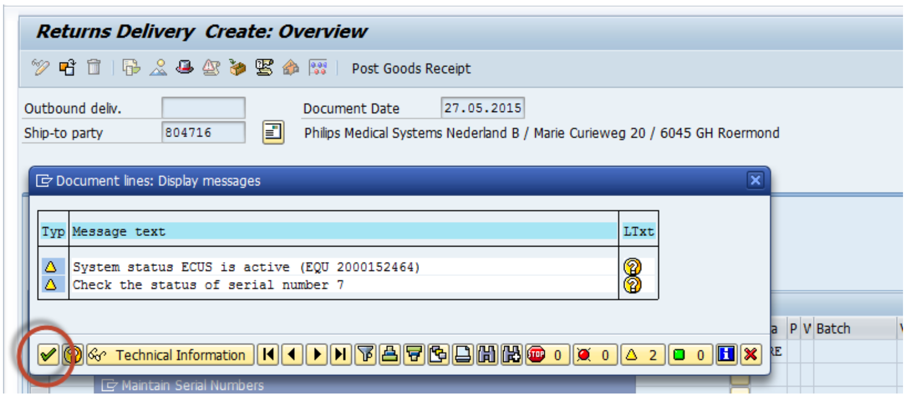
SO 500966 is created (VA01)

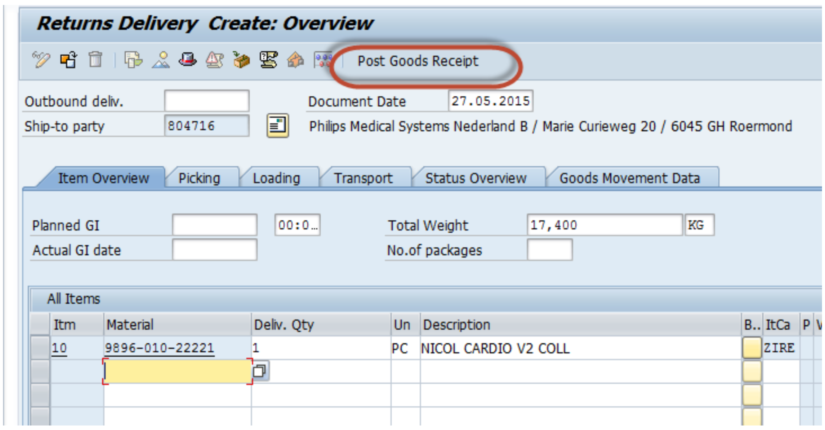


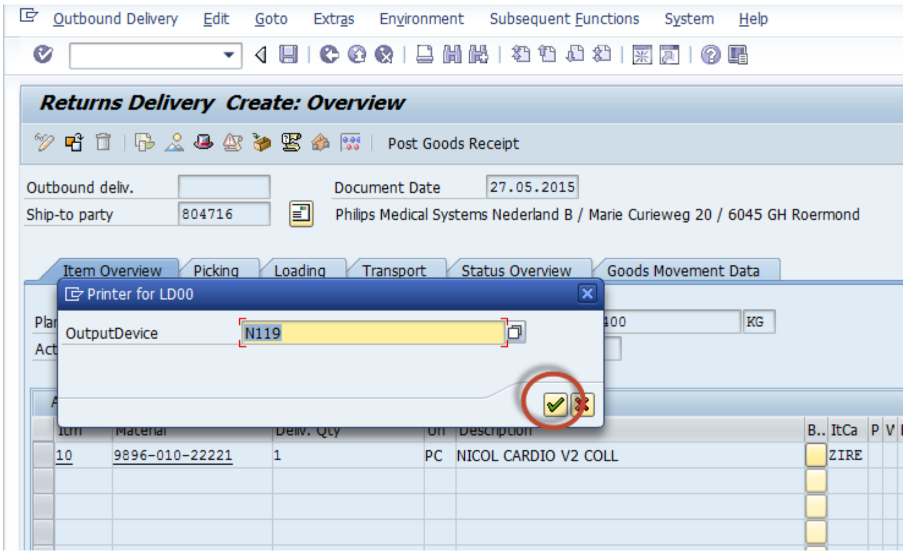
Create return delivery (VL01N)

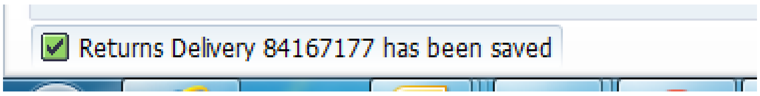



Returns Delivery Create: Overview
Post Goods Receipt
Outbound deliv.
Ship-to party 804716
Document Date 27.05.2015
Philips Medical Systems Nederland B / Marie Curieweg 20 / 6045 GH Roermond
Item Overview
Picking
Loading
Transport
Status Overview
Goods Movement Data
Planned GI 29.05.2015 00:0..
Actual GI date
Total Weight 17,400 KG
No.of packages
All Items
Itm Material Deliv. Qty Un Description B.. ItCa P V Batch
10 9896-010-22221 1 PC NICOL CARDIO V2 COLL ZIRE
Maintain Serial Numbers
Delivery
Item 10
Material 9896-010-22221
No.serial no 0 / 1
Serial Number E..
7
Create serial number automatically
Additional data

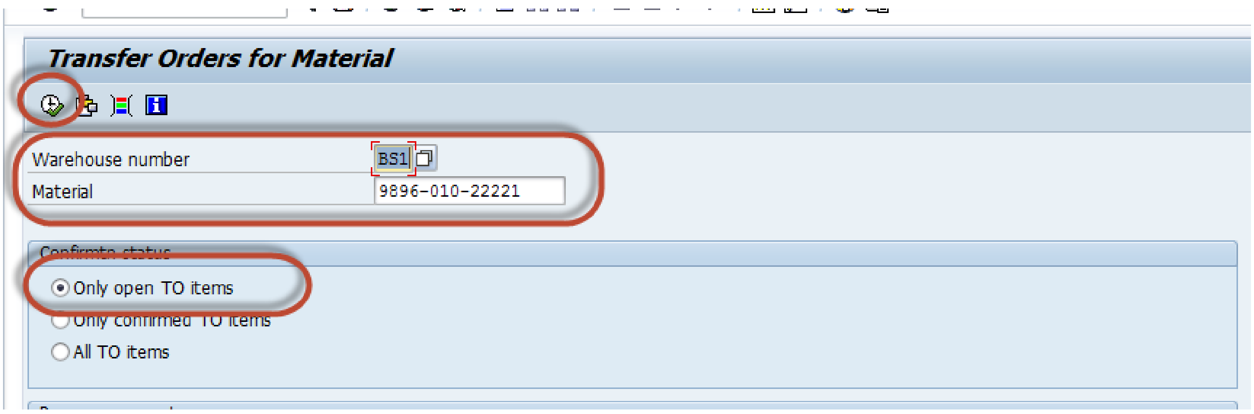

Returns Delivery Create: Overview
Post Goods Receipt
Outbound deliv.
Ship-to party 804716
Document Date 27.05.2015
Philips Medical Systems Nederland B / Marie Curieweg 20 / 6045 GH Roermond
Document lines: Display messages
Typ Message text LTxt
System status ECUS is active (EQU 2000152464)
Check the status of serial number 7
Technical Information
0 0 2 0
P V Batch
Maintain Serial Numbers

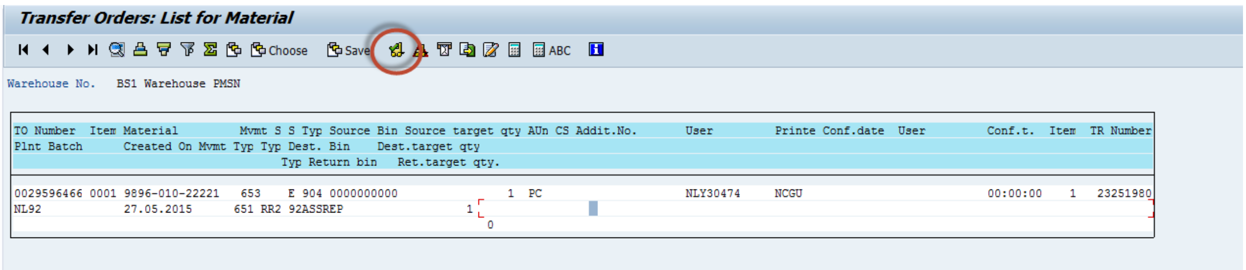

Returns Delivery Create: Overview
Post Goods Receipt
Outbound deliv.
Ship-to party 804716
Document Date 27.05.2015
Philips Medical Systems Nederland B / Marie Curieweg 20 / 6045 GH Roermond
Item Overview
Picking
Loading
Transport
Status Overview
Goods Movement Data
Planned GI 00:0..
Actual GI date
Total Weight 17,400 KG
No.of packages
All Items
Itm Material Deliv. Qty Un Description B.. ItCa P V
10 9896-010-22221 1 PC NICOL CARDIO V2 COLL ZIRE

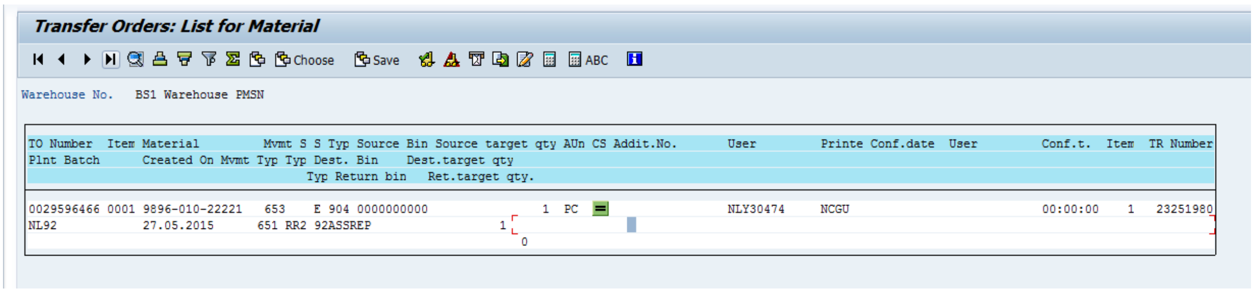


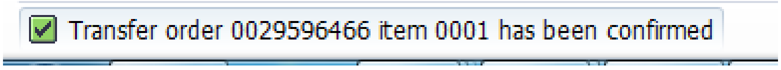


Confirm TO (LT24)

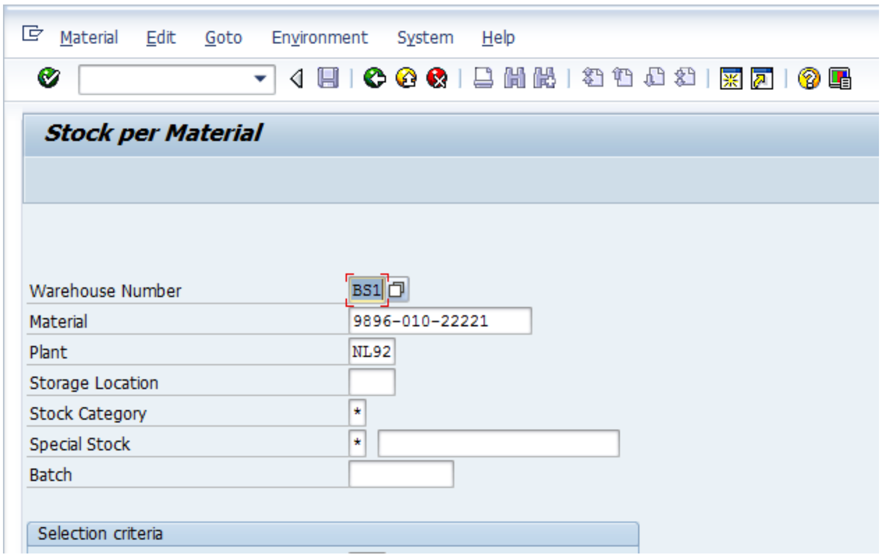




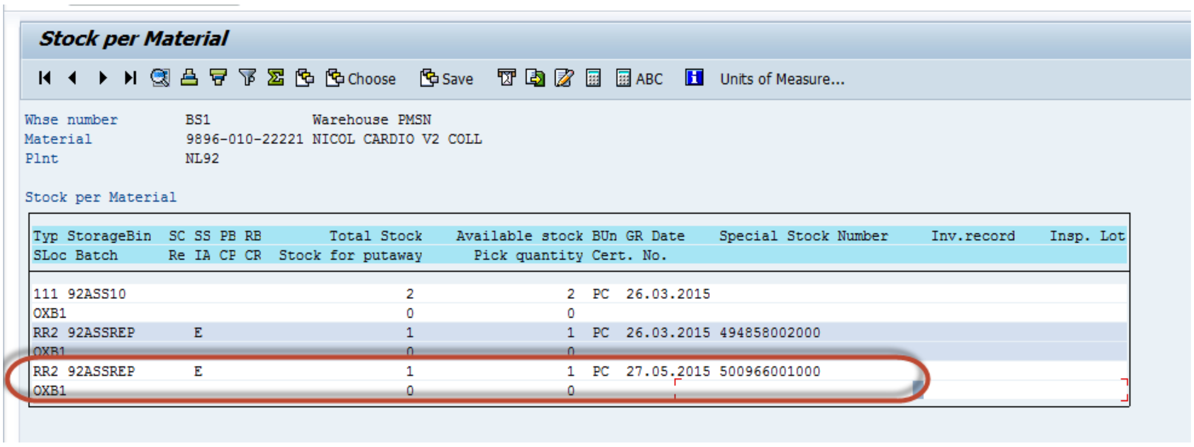




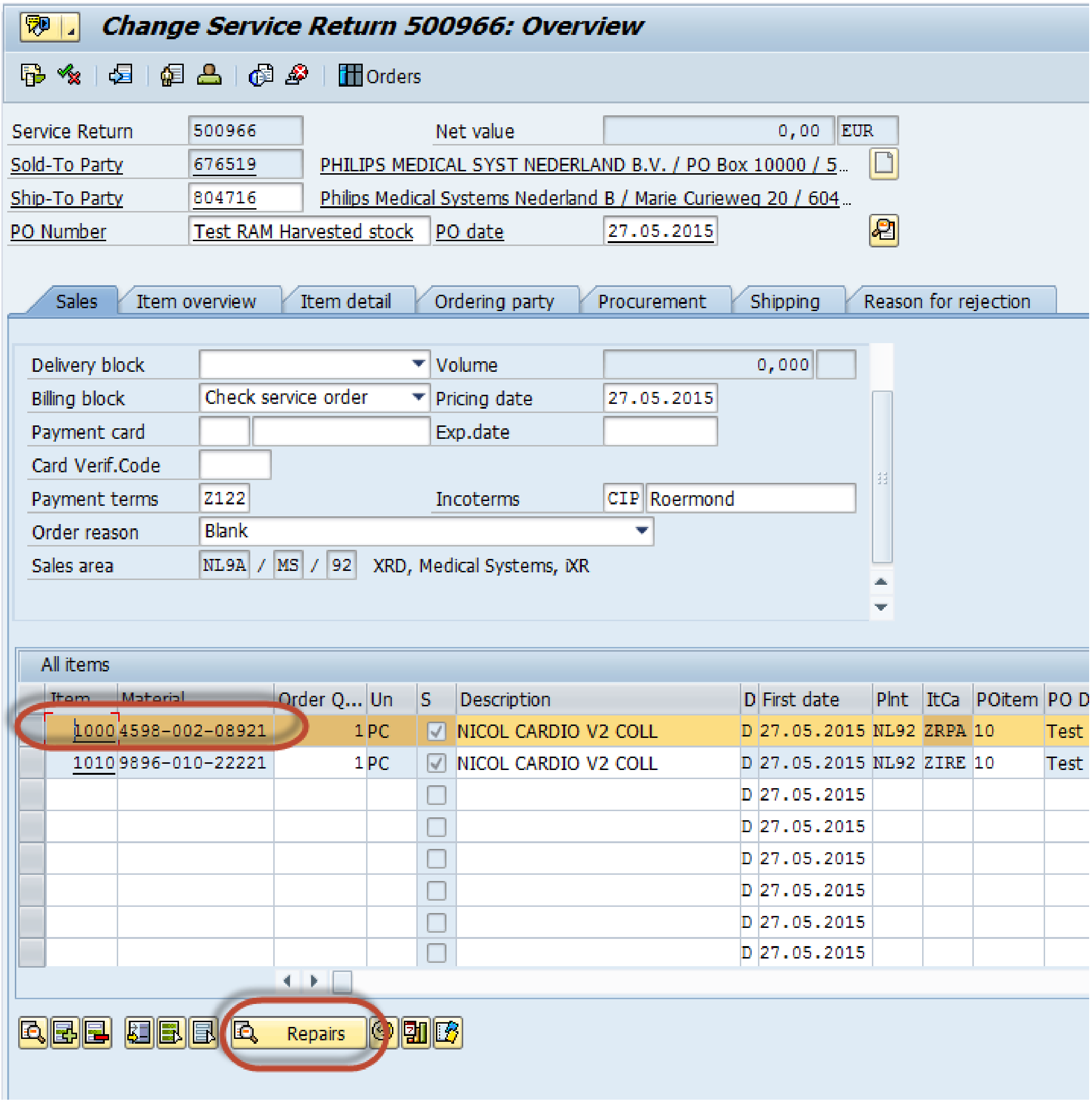
Check or material is received at sales order stock (LS24)



Material is received at sales order stock at storage type RR2 and bin 92ASSREP.

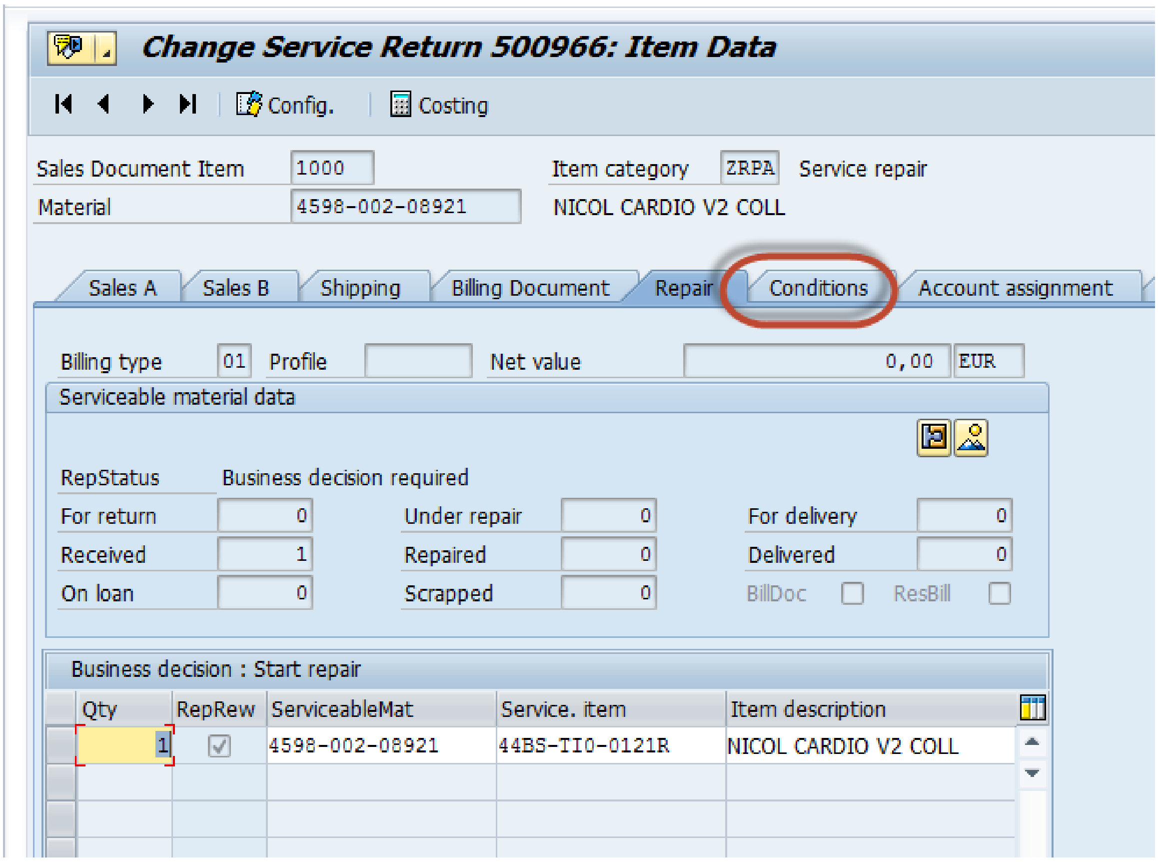


Create SWO for material 4598-002-08921. (transaction VA02).

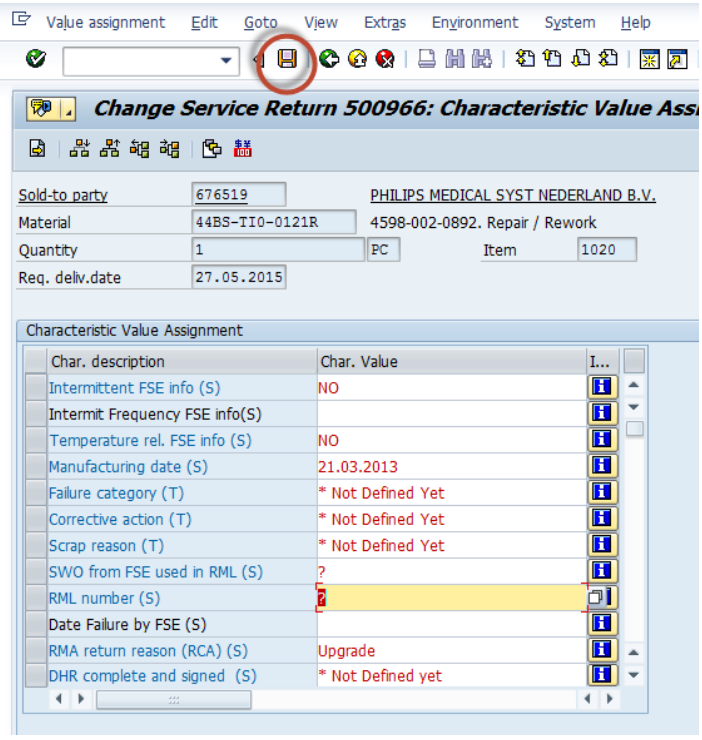


Fill in material number and service product. After that push on “Serial” button.

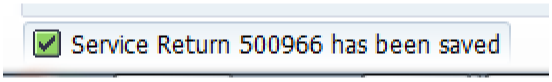
Select tab “Conditions” for filling QA questions. These are the characteristics (QA questions with answers.



After filling of QA questions push on save button.



Push on save button.

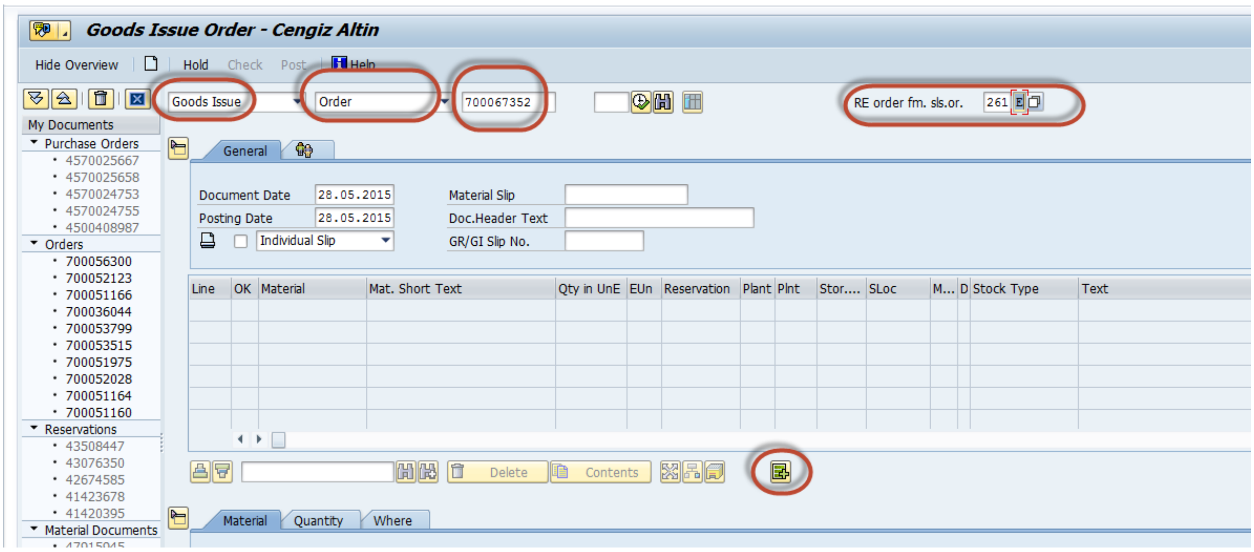


Release SWO and print SWOP (IW32).

Now we have to create a new serial number for material 4598-002-08921. This is needed because RMA order variant is "rework". We received part 9896-010-22221 and will send back 4598-002-08921.

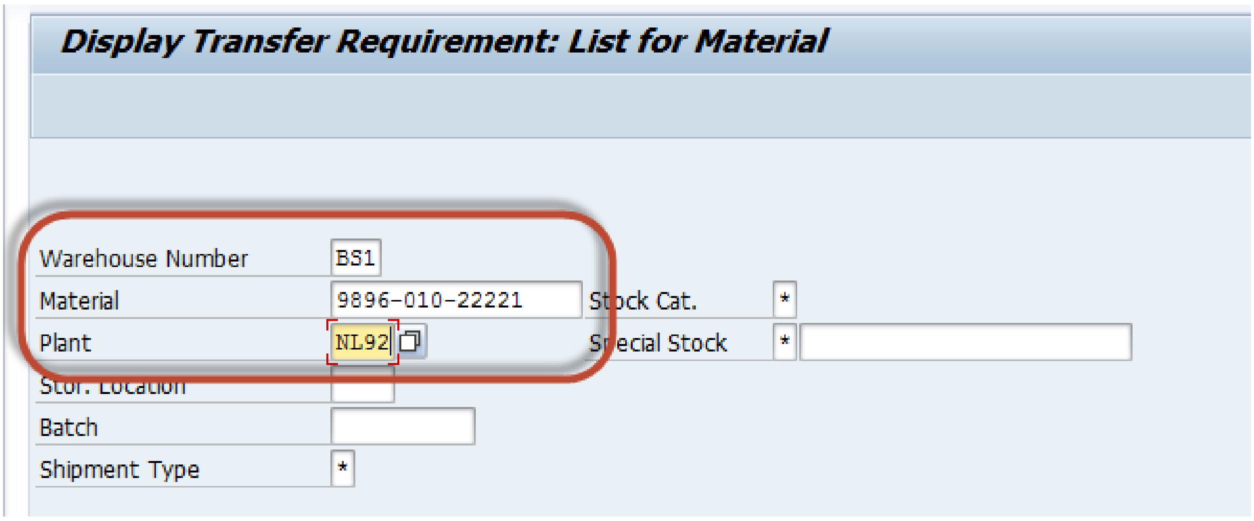
Via MIGO 261 E booking we are going to consume material 9896-010-22221 in SWO. After that we have to do 262 E booking for creating new serial number for material 4598-002-08921.

261 E booking in MIGO for material 9896-010-22221. This is needed to consume material 9896-010-22221 in SWO of material 4598-002-08921.

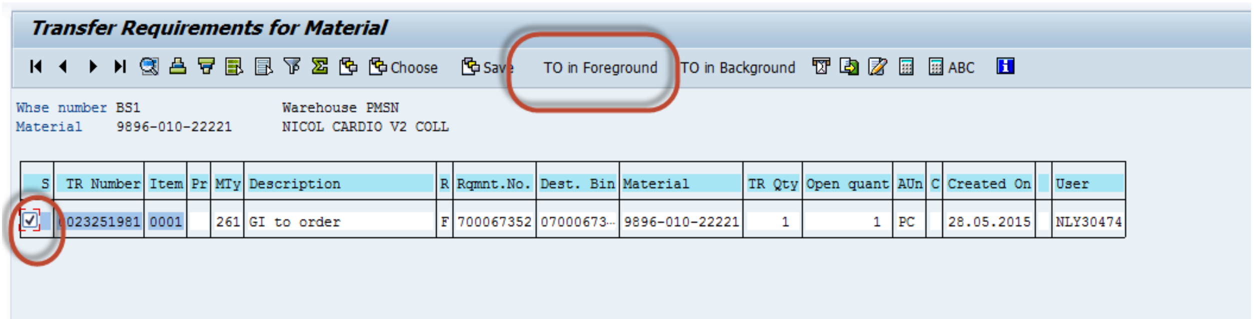


Go to transaction LB11 to set the TR (transfer requirement) into TO (transfer order). Fill in:

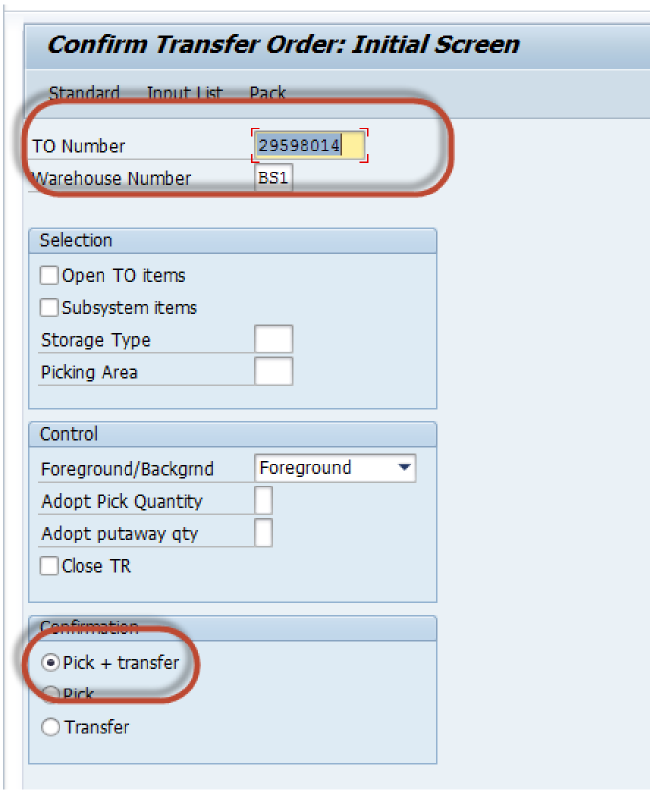
- Warehouse number
- the material number
- Plant and give enter.



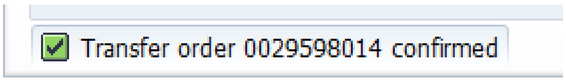
Select line of the TR and push on "TO in foreground" button.



Confirm TO (LT12). Fill in TO number and give enter.



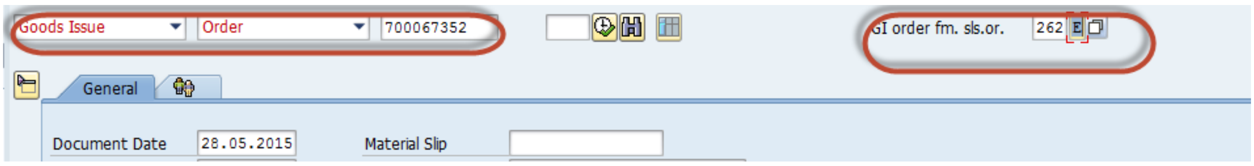
After saving TO is confirmed.



Stock of material 989601022221 before picking. Material is linked to sales order stock. (LS24)

Now 262 E booking for creating new serial number for material 4598-002-08921 via MIGO transaction. This is needed to set the material 4598-002-08921 on sales order stock and link it to sales order.

Go to MIGO transaction.



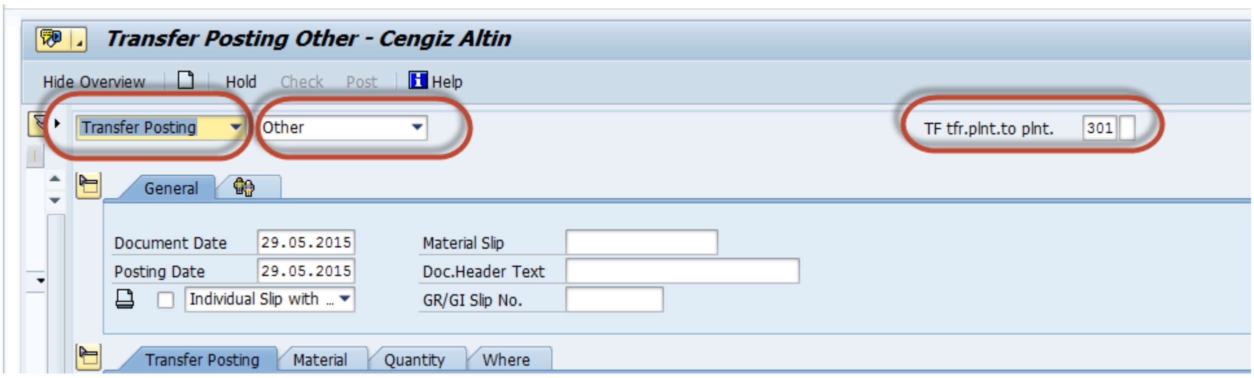
Push on plus button.

Move 1 PC of material 4522 163 50101 from storage type 111 and bin 92ASS10 to new SLOC XNL1 and storage type RR2 and bin HARVESTED. (Via MIGO transaction).

301 booking from SLOC OXB1 to SLOC XNL1.

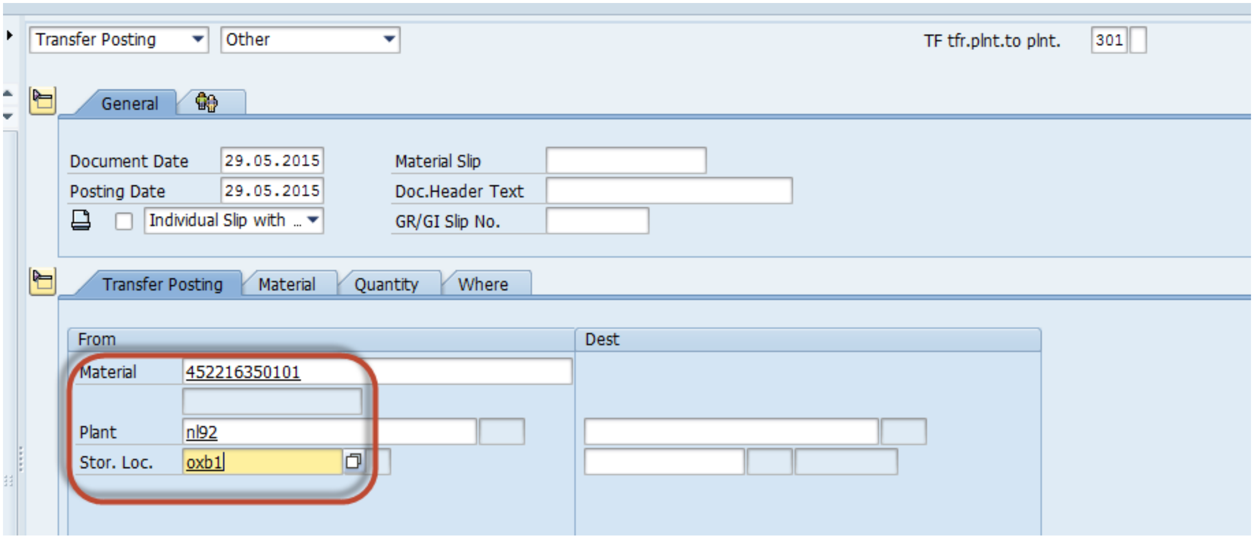
Go to transaction MIGO. Choose:

- Transfer posting
- Other
- Movement type 301.



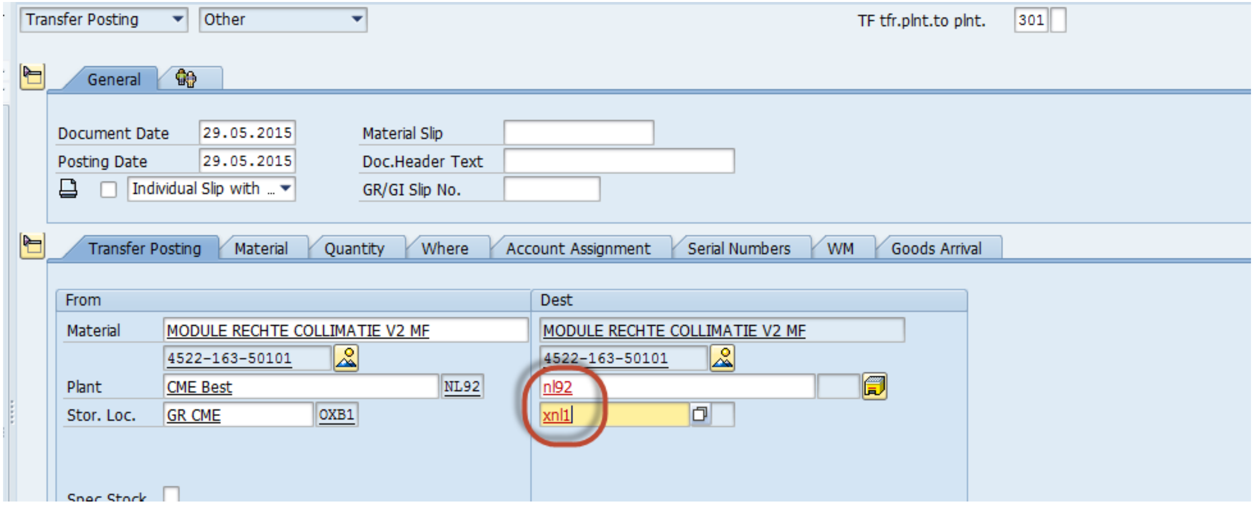
Fill in:

- Material number
- Plant NL92
- Storage location OXB1 and enter.

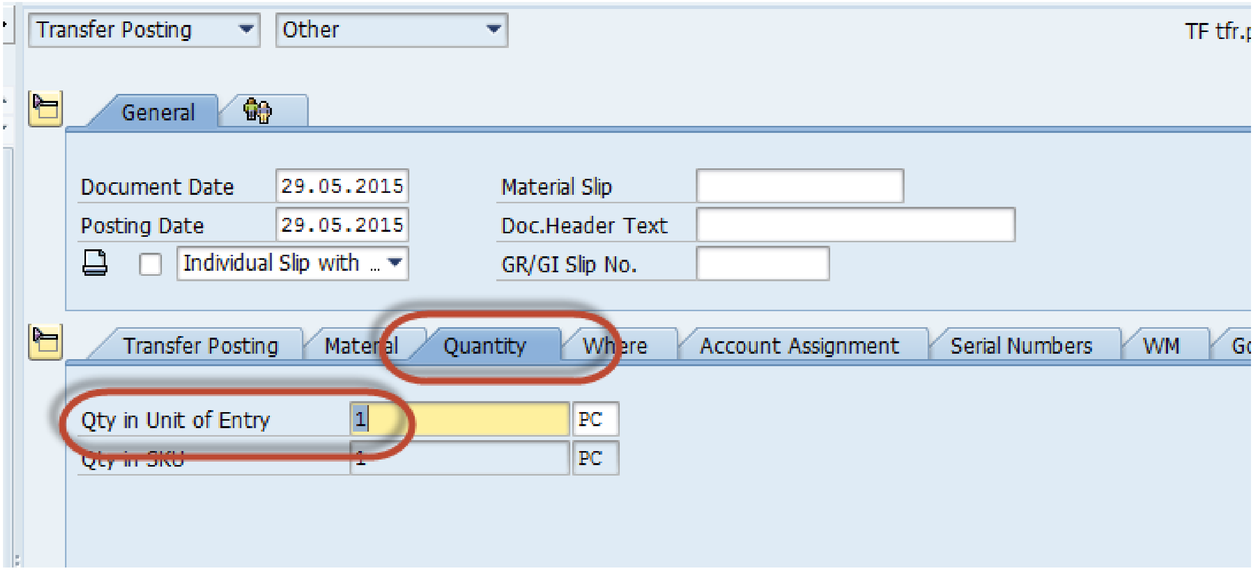


Fill in:

- Plant NL92
- Storage location XNL1 and give enter.



Go to tab "Quantity" and fill in 1 PC and give enter.



Go to tab "Serial Number" and fill in the serial number of material 4522-163-50101 which must be transferred.