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GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

BUSINESS PROCESS REENGINEERING FOR THE CENTRAL STERILIZATION UNIT AND ITS APPLICATION

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BUSINESS PROCESS REENGINEERING FOR THE CENTRAL STERILIZATION UNIT AND ITS APPLICATION

(MERKEZİ STERİLİZASYON ÜNİTESİ İŞ SÜREÇLERİNİN YENİDEN YAPILANDIRILMASI VE BİR UYGULAMA)

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The purpose of the project is the optimization of the current processes and the improvement of the quality of the service provided in the central sterilization unit. Thanks to the subject of my project, I had the opportunity to practice the business process reengineering project, its applications in the real life and understand its efficiency and importance.

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LIST OF SYMBOLS

ARIS :	Architecture of Information Systems
BPM :	Business Process Management
BPMS :	Business Process Management Software
BPR :	Business Process Reengineering
BPS :	Business Process Simulation
CMPR :	Construction Management Process Reengineering
CPI :	Continuous Process Improvement
CSSD :	Central Sterile Services Department
EPC :	Event-Driven Process Chain
ERP :	Enterprise Resource Planning
IT :	Information Technology
KPI :	Key Performance Indices
MCDM :	Multi Criteria Decision Making
MD :	Medical Device
PDCA :	Plan Do Check Act
PM :	Performance Measurement
PPMF :	Process-based Performance Measurement Framework
TQM :	Total Quality Management

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ABSTRACT

Many healthcare systems are forced to survive in a rapidly changing environment with rising costs and the need for proper resource utilization. It is inevitable that the healthcare systems will seek for business process reengineering (BPR) to address the growing requirements for effective strategic planning in order to exist. Business process reengineering (BPR) concerns the fundamental rethinking and radical redesign of business processes to obtain dramatic and sustaining improvements in quality, cost, service, lead time, outcomes, flexibility and innovation. Recently, BPR has become an important function in a healthcare system.

This paper presents a BPR method for modelling the system in healthcare sector- specifically the central sterilization unit-, As-Is and To-Be processes are modeled and compared by ARIS tools (an engineering tool based on a modeling language, using a process view and it gives methods for analyzing and evaluating the ongoing system regarding the key performance indices) and then the performance of the study is examined. The plan of the study is first investigation of the existing literature about the business process reengineering methods especially in healthcare sector, second expression of the proposed methodology, and third application of the methodology in a public hospital and finally analyzation of the results and the conclusion of the study.

ÖZET

Yüksek maliyetler ve düzgün kaynak kullanımı ihtiyacı nedeniyle birçok sağlık hizmeti sistemi hızla değişen çevrede hayatta kalmak zorundadır. Sağlık hizmeti sistemlerinin hayatta kalmak ve verimli stratejik planlama gerektiren talepleri karşılayabilmek için iş süreçlerinin yeniden yapılandırılması (business process reengineering -BPR) arayışında olması kaçınılmazdır. İş süreçlerinin yeniden yapılandırılması kalite, maliyet, servis veya inovasyon gibi alanlarda dramatik ve sürdürülebilir iyileşmeler elde etmek için temel düşünceyi ve iş süreçlerinin radikal tasarımını temel alır. Yakın zamanda iş süreçlerinin yeniden yapılandırılması sağlık hizmeti sisteminde önemli role sahip olmuştur.

Bu yazıda sağlık hizmeti sektöründeki -özellikle de merkezi sterilizasyon ünitesindeki- sistemin modellenmesi için iş süreçlerinin yeniden yapılandırılması metodu tanıtılmakta, As-Is ve To-Be süreçler modellenmekte, tasarımlar ARİS (sistemin analizi ve iyileştirilmesini sağlayan mühendislik aracı) üzerinde kıyaslanmakta ve çalışmanın performansı incelenmektedir. Çalışmanın planı öncelikle iş süreçlerinin yeniden yapılandırılması metodlarının literatürde araştırılması, ardından önerilen metodolijinin sunumu ve metodun bir devlet hastanesinde uygulanması ve son olarak sonuçların analizi ve çalışmanın sonlandırılmasıdır.

1. INTRODUCTION

The companies should regularly upgrade their operations to stay competing in the business. To do so, it is indispensable to transform its daily basis business processes. The major causes for business transformation are the worldwide integration of business operations, the fast formation of new technologies and the constantly altering customer needs. Today, the organisations should reconsider their core strategies focusing at reducing costs as well as increasing customer and job satisfaction so that these challenging facts will be confronted well.

The important components for a successful reengineering project are the suitable preference of the method and the computer supported tool (such as ERP as a software product) that will maintain the design, analysis and remodel of the business processes. During process redesign, a process model is applied as a tool of understanding and an information flow between co-workers of the team. Therefore, a process model can be used to study ongoing processes, to highlight weaknesses and difficulties and to express reengineering challenges for the “to-be” business process. There is an expanding interest for business process management in many sector. Despite the fact that there are many business process management approaches in the literature, it is essential to choose the suitable methodology for successful implementation.

On the other hand, it should not be underestimated the role of a computer-supported tool for a successful reengineering project. There are many software tools accessible in the market that all the aspects should be taken into consideration such as the relevance of the tool, the cost and the flexibility.

Because of the rising costs, the urgency for proper resources, and the global transformations, the healthcare systems will eventually look up for reengineering projects in order to survive. Business process reengineering concerns significant improvements in many aspects in an organization. That is why business process reengineering has recently turned into an important role in a healthcare system. In the following subsections, we will give brief definitions and essential concepts that are necessary for this study.

1.1 Business Process Management

A business process is a logical series of linked actions that use one or more resources (employee time, energy, machines, money etc.) in every stage in order to achieve results. The organizations use all their resources in a coherent, honest and repeatable way to achieve its goals (Zairi, 1997). Basically, in every process there are four main properties. A process has to be triggered by a definite and foreseen input; it has a linear and consistent flow; with a set of clearly certain activities; completed with a wished and reliable outcome (Bulletpoint, 1996).

Business Process Management (BPM) is an organized procedure to analyze and consistently ameliorate main activities and other major components of a company's operation. The units and operational activities are reorganized by well-organized approach in order to obtain quality improvements in operations (Davenport, 1990; Gunasekaran, 2002). BPM applications are essential for the industries to provide competitive markets by the aid of improved processes (Zairi, 1997). Essentially, the major aspects of business operations are concerned with BPM where there is high potential and a big expectation of benefit. BPM is consisting of six main components, which are strategic adjustment, governance, procedures, information technology (IT), people and culture (Rosemann and vom Brocke, 2015). Concerning these components, the following rules must be followed for successful BPM (Zairi, 1997; Rosemann and Brocke, 2015):

- Main tasks must be accurately mapped and documented.
- The horizontal linkages between principal activities are for focusing on customers.
- It is necessary that the business processes within a company are modeled, implemented, controlled, and evaluated according to the strategic priorities of the company.
- In order to meet corporate objectives, measurement actions are for defining the performance of each single process, for setting goals and for giving output levels.
- The systems and documented methods are fundamental to guarantee uniformity and repeatability of performance in quality.
- A consistent approach of optimization must be searched for getting extra benefits and problem solving.
- Best practices must encourage businesses to provide higher competitiveness.
- BPM is not only for having the right structure and systems in a particular way, but it is an action plan for culture change.

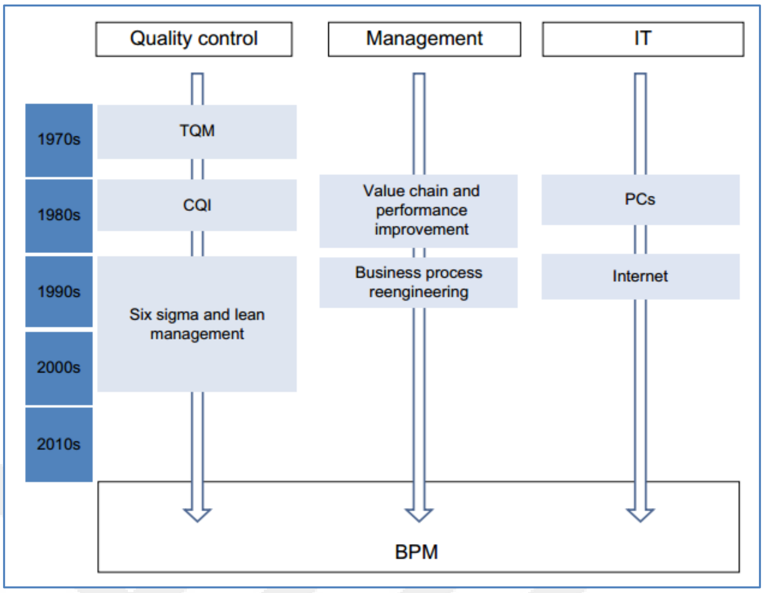

Figure 1.1: Historical development of BPM

As it is displayed in Figure 1.1, the historical supports of BPM go as long back as the 1970s with a targeting on quality management and quality improvement (Rosemann and vom Brocke, 2015). The business process management is a state of order that brings together know-how from information technology and know-how from management sciences domain and puts into practice to operational business processes. In addition, a variety of tools, techniques, and methods have been improved to maintain the analysis, redesign and management of business processes in operational level (Van der Aalst 2004, 2013; Weske 2007). BPM makes a more holistic concept possible for the organization because it gathers standard procedures from numerous different domains, such as IT, engineering, management, and sociology as well (Fowler, 2003).

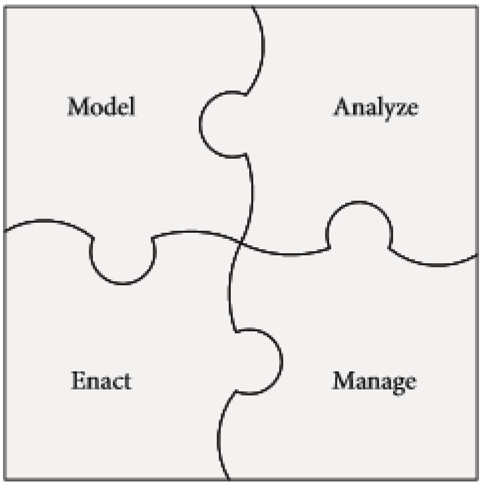

Figure 1.2: Four key activities of a general view on Business Process Management

The four essential activities on BPM are model, enact, analyze and manage. The Model is for building a process model for analysis, the Enact is for adoption of a process model as a tool to force cases, the Analyze is for examining a process with a process model or event logs (for example what-if analysis using simulation) and the Manage is for all other activities (for example process adjustion, resources reallocation). The processes should be monitored and managed to ensure that the operations go on. The business process design or the system implementation never ends in BPM because the changing circumstances can create new needs and this may trigger process adaptations (Van der Aalst, 2013). Hence, the processes must be periodically monitored and its feedbacks should be collected. That is why the four key activities of a general view of BPM shown in the Figure 1.2 are ongoing.

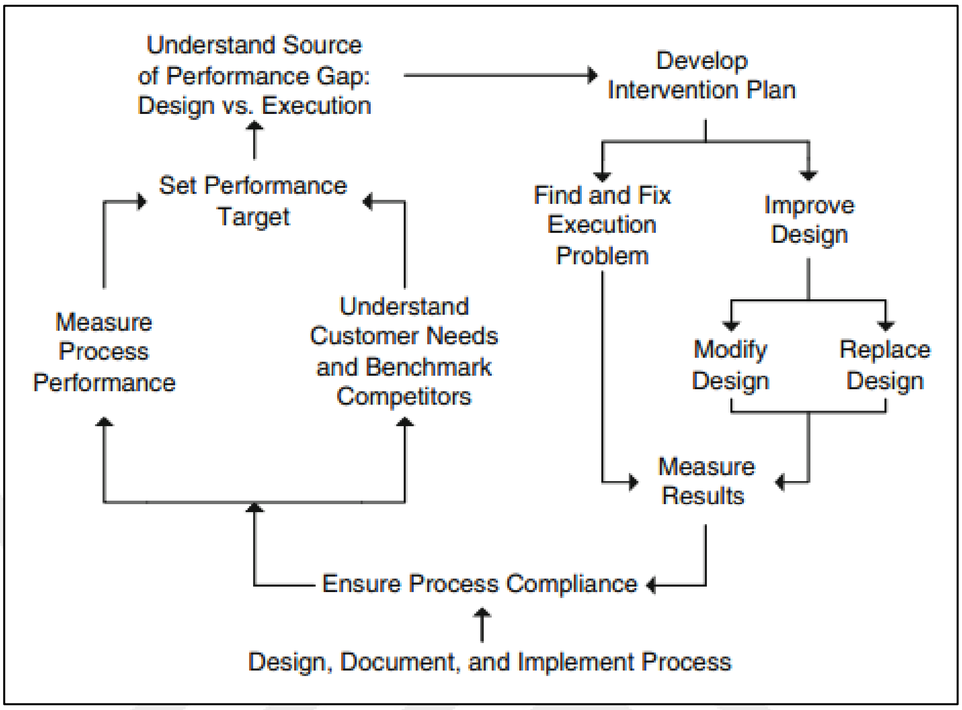

Figure 1.3: The main process management loop

The BPM's general goal is to revise business processes in improving customer satisfaction (Rummler and Brache 1995; Hassan et al. 2012). Figure 1.3 illustrates the main process management loop which is borrowed from Deming's PDCA cycle (Plan Do Check Act) (Deming, 1986). It starts with the formation of a business process along with its documentation and implementation. After the process compliance, current process performance and benchmarking are held in order to set performance target. The operational structure is improved by modifying or replacing the business processes and the obtained outcome is measured again to figure out the performance gap. This cycle needs to be handled regularly to make it operate better and to adapt the rapid changing circumstances that the company faces. The organizations are using process management to track the process performance and to identify and fix the performance issues (Rosemann and Brocke, 2015).

One of the BPM tool among many others is Business Process Reengineering (BPR). Business process reengineering is a useful technique for analysing the existing enterprise processes with a process-oriented approach, defining relations between activities and processes, redesigning processes within and between enterprises, estimating time, cost and resources of the changed processes and then improving and optimizing the processes. One of the principal strategies to initiate change over process performance developments is BPR (Huq and Martin 2006). Most of the firms have massive growth in their critical business performances with radical process redesign. According to the study of Ranganathan and Dhaliwal (2001), about 87% of companies were employed in BPR projects, or they intent to adopt BPR projects in the next few years. The aim of BPR is to accomplish the best performance possible in regard of operational and organizational solutions (Scheer and Nüttgens, 2000).

1.2 The Architecture of Information Systems

The Architecture of Integrated Information Systems (ARIS), developed by IDS Scheer AG in the early 1990s at the University of Saarland, is an architecture tailored for business processes and has been adapted ever since in many industrial practices. ARIS is suitable for many joined information systems, such as SAP R/3. It includes a business strategy that maintains an organized methodology for core processes and its sub-processes improvement. ARIS is likely benefited as a principle support for Business Process Management and Business Process Reengineering (Scheer, 1992 and 1998). ARIS, along with ARIS toolset, is an engineering tool based on a modeling language, using a process view and it gives methods for analyzing and evaluating the ongoing system regarding the key performance indices (KPI).

The ARIS tool set offers an overall computer maintenance for business process designing. It ensures representing the different views of an enterprise (functional, informational, organizational and control) based on different levels (conceptual, technical and implementation). The user guidance is maintained for the modeling process. As a process management tool, ARIS is often used to do reengineering of information systems. (Di Martinelly, 2009).

ARIS not only presents a common and well detailed methodological structure but also a effective business process-designing tool. This tool assists the whole process re-designing project throughout the all project phases. ARlS benefits from several notations to design business processes such as event-driven Process Chains (EPCs). In this study, the basic ARIS framework with EPC notation is applied to optimize the processes of a central sterilization unit while taking into account of the essentials of the healthcare organization.

1.3 Enterprise Resource Planning

ERP applications are known as one of the most preferred Business Process Management Software (BPMS) product among others. ERP is a business process management software that permits a company to adopt an integrated operation system to control the organization and automate various business operations. It is an operating system tailored to be benefited from many organizations. ERP software represents and links a plenty of business processes and allows the data stream between them.

Many companies are pushed to transform their businesses due to the considerable progress in information technologies (IT) and the growing open trade. For making such a transformation possible, most popular process adaptation tool among others is Enterprise Resource Planning (ERP) (Al Mashari, 2001). The organizations achieve a strategic competitive position by implementing ERP systems into their companies. The latest progresses in client, server computing and the expanding application areas of BPM tools such as BPR has escalated the improvement of ERP systems (Earl, 1997). The fact that ERP applications can resolve endless process difficulties, by new improvement supports in IT field such as image processing and multimedia, it is now possible to diminish the number of non-value added tasks in a company.

BPM has a vital role on successful ERP implementation. To avoid the standardized ERP system dissatisfaction of companies, BPR and customized works are engaged in the business software implementations (Scheer et al, 2000). A business structure must be reorganized around processes in favor of a successful ERP implementation (Schneider, 1999). Therefore, concerning to eliminate traditional cross-functional barriers, such as performance measures or conflicting objectives, it is necessary to have a detailed change management program (Donovan, 1999).

Like many organizational transformations, a deliberate implementation is needed to achieve a success in BPM and different organizational aspects affect that (Sidorova and Isik, 2010). In the same manner, information technology is necessary in business process redesign. One of the common process change approach generally used in practicing ERP implementation is business process reengineering. ERP systems are normally considered as ‘the missing link to reengineering’. The information technology is the essential facilitator for a fundamental change in companies’ current business processes. Today, the information technologies have an important role and should be included to the business reengineering projects from the beginning. Otherwise, without its existence, the business process reengineering methods can’t work well and the outcome will be much less than expected (Wu, 2002). The existing processes should not be just replaced with information technologies; instead, alongside the use of information technologies, it is indispensable to change and develop processes (Al Mashari, 2001).

ERP software have become to be known as process software systems, considering that the cross-functional structure allows giving effort on an end-to-end scope. ERP systems are software tools that allow businesses to (Samaranayake, 2009):

- Merge the business objectives throughout the enterprise.
- Share collective information throughout the whole enterprise.
- Automate crucial sections of the business processes.
- Obtain real time information with a singular database.

1.4 The Central Sterilization Unit

Healthcare services have always been an important area for applications of Business Process Reengineering. The central sterilization unit is basically where the hospital items such as surgical and medical items, both nonsterile and sterile, are cleaned, packed, sterilized, stored, and issued when needed. The departments are generally separated into four primary fields to fulfill respectively the activities of decontamination, assembly and cleaning sterilization, sterile storage and distribution. These units work in coordination with other units of a hospital, and they are a central place in fighting and destroying pathogens and microorganisms, which is important to maintain the unit's safety. Sterilization is a highly effective process that removes all microorganisms from medical devices. This process includes basic steps such as washing, packaging and cleaning, sterilization, quality control, sterile storage and distribution. The used instruments are freed of microorganisms by sterilization. After this process, these instruments are reused for the patients; therefore, all activities should be certainly conducted in this unit because of its importance to all patients and hospital staff (Dağsuyu et al., 2016).

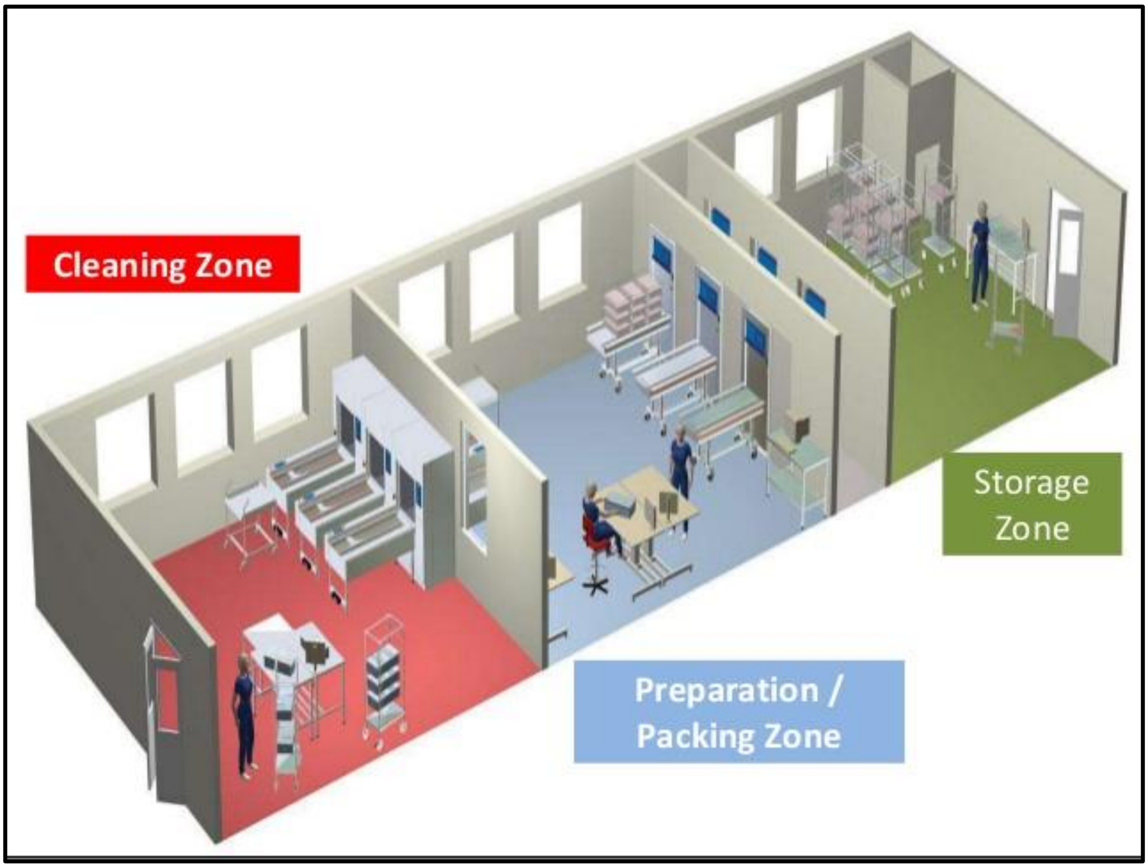

Figure 1.4: Central Sterile Services Departments

The three principal zones of the Central Sterile Services Departments (CSSD) in a hospital are shown in Figure 1.4, which are the cleaning zone, the preparation/ packing zone and the storage zone. The aim of CSSD is to centralize the activities of receipt, assembly, cleaning, sterilizing, storage and distribution of sterilized items from a central sterilization unit where secure sterilization is made under controlled circumstances. CSSD provides a practical supply of sterilized items to numerous sections of the hospital to bring quality and contamination free healthcare.

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Figure 1.5: Example of a room layout

Figure 1.5 shows a basic example of a room layout in a central sterilization unit. Dirty instruments first come to the dirty area where the first check test is held for cleaning and assembly, then the instruments go to the Autoclave area for the second screen test and sterilization. After the sterilization process, the instruments are dated and stored in the clean and storage area which is temperature controlled room. The clean instruments pass to the dispensing area when they are needed in the hospital departments.

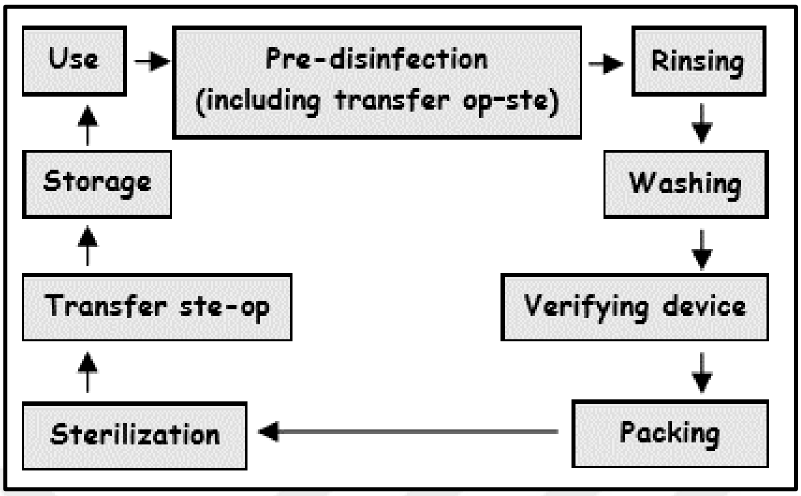


Figure 1.6: Loop of sterilization

In a process of sterilization, most of the medical equipment are reentered in the sterilization process after the usage in the operating room (See Fig. 1.6). The purpose of the Pre-disinfection step is to diminish the population of microorganisms on the equipment and to facilitate the future washing. The Rinsing does not always exist in the central sterilization units. The Washing aims of eliminating any kind of stains to receive a functional and clean Medical devices (MDs). On Verifying device state, the cleanliness of the medical device should be examined to guarantee that there is not any deterioration that might affect its functioning or its security. The Packing is made as fast as possible after the washing. The Sterilization is made by Autoclave machines. The Transfer ste-op resembles to the delivery of sterile MDs from the sterilization area to the storage area where it will be close to the operating rooms (Mascolo at al., 2016).

The healthcare sector is one of the major field of the business process reengineering study. Because of the importance of the sterilization processes in hospital institutions and the intention of preventing the healthcare related infections, the application part will be done in this area. As the amount and diversity of surgical procedures expanded and the variety of equipment, MDs and supplies multiplied, it becomes more and more important that a centralized sterilization process is necessary for finance, efficiency and patient care. A framework is required to describe the current working system and also to lead the needed changes. In the literature there are different methods and they have the same approach: initially, the actual working system is analyzed and modeled to illustrate the current on-going processes (in other words AS-IS situation); secondly, the targeted system is developed to form the suitable planning and control system (in other words TO-BE situation). Finally, the expected performance is evaluated after the implementation of the proposed solutions. In this case, the proposed solution will be an information technology to enable the improvements.

In the AS-IS process analysis step, the current way of working in the central sterilization unit will be summarized and documented. Data collection such as observation records, interviews and its analysis will be applied during this phase. In the TO-BE process-modeling phase, the future workflows will be remodeled and the workflows of each phases will be modeled and compared by using ARIS tool. In this process-modeling step, the data collection will be collected automatically by the information system. After the implementation, the results will be compared and the areas that will be automated by the proposed solution - using an Enterprise Resource Planning - will be observed.

In this thesis, central sterilization unit's business processes will be reengineered in order to obtain performance improvement and efficiency. ERP-driven BPR will be used to reengineer the current processes and the future processes will be operated through this ERP system. With the obtained new process design, it is expected to get standardization in all level of the central sterilization unit. In this context, the sterilization processes of Bahçelievler Public Hospital (Bahçelievler Devlet Hastanesi) will be observed, the current inefficiency causes of the sterilization operations will be determined and new process design will be modeled. An ERP solution will be developed after the new process design and will be implemented on Bahçelievler Public Hospital.

The rest of the study is organized as follows. After the introduction phase, Section 2 introduces the literature review related to business process reengineering field. Section 3 presents the materials and methods including the subtitles; business process reengineering, IT's role in process redesign efforts, expected advantages of BPR and the related methodology. The proposed methodology is then implemented with an application and the results are presented in Section 4. The problem, the results and limitations are discussed in Section 5. Finally, Section 6 provides some final conclusions and directions for future work.

2. LITERATURE REVIEW

The existing literature is searched for the investigation of various methodological tools in the field. According to the literature survey, the studies in the field can be grouped under a few categories and most of the studies are solved by using business process reengineering method. That is why in this study business process reengineering will be used as a methodology in healthcare sector.

Main studies that use literature review as a tool are as follows. Al Mashari (2001) provided an overall research study in the ERP field related to process management, organizational change and knowledge management. Ranganathan and Dhaliwal (2001) presented the results of the business process reengineering practices survey accompanied by firms in Singapore. Gunasekaran and Kobu (2002) studied a survey for searching the analysis, modelling and tools/techniques used for modelling of BPR. Silvestro and Westley (2002) stated the outcomes of case-study research that was handled for investigating the functional developments appearing from organizations' process re-engineering. Vanwersch et al. (2016) investigated the research procedures of the studies that were used to create the framework. Leijen-Zeelenberg et al (2016) evaluated the present knowledge about the influence of process redesign on the healthcare quality.

Studies that use Business Process Redesign approach are as follows. Jansen-Vullers and Reijers (2005) defined a redesign method established on a set of current redesign heuristics and applied this method in a mental healthcare case. Noumeir (2006) involved in modeling the process of radiology interpretation that outcomes in generating a diagnostic radiology report. Mansar and Reijers (2005) presented a structure for helping the process designer in selection of the convenient best practice(s). Mansar et al. (2009) proposed a strategy for the implementation of business process redesign. Pourshahid et al. (2009) proposed a methodology that will examine the effect of business processes changes with what-if scenarios based on the most convenient process remodeling motifs among many possibilities.

Studies that use Business Process Reengineering approach are as follows. Crowe et al. (2002) addressed a developed tool to guess the potential risk level of a BPR effort before an organization allocates its resources. Wu (2002) proposed a unifying approach established on a strategic vision and examined the plan by an empirical study. Cheng and Tsai (2003) precised the process reengineering definition and description and developed Construction Management Process Reengineering Method to improve the efficiency of construction management. Attaran (2004) examined a series of connection between business process reengineering and information technology. Attaran addressed possible obstacles to successful reengineering implementations and described important factors for its achievement. Rahmati and Cao (2005) examined the impact of different organizational and national factors on the reengineering of the business processes to adopt ERP. Huq and Martin (2006) made a comparison between the concepts towards BPR implementation and prepared some proof to state which concept proposes bigger success. Vergidis et al. (2008) discussed business workflows by proposing a new categorization pattern for business process models and by displaying the present analyzing trends and optimization methods. Samaranayake (2009) proposed an integrated method to process implementation, automation, and optimization through upgraded business process models. Lesselroth et al. (2011) described a self-service patient kiosk implementation engaged patients for a clinic appointment check in and gathered a medication attachment history that is accessible from the electronic health record. They showed how business process design and simulation modeling were used for infrastructure impact estimation, and proposed strategies for kiosk deployment in an ambulatory care clinic. Leu and

Huang (2011) applied the main ARIS approach for optimizing an emergency department's clinical processes in a mid-size hospital with 300 clinical beds and studied the essence of a healthcare organization at the same time. Bahramnejad et al. (2015) presented BPR method that adopts Enterprise Ontology for modelling the on-going system and its purpose was to enhance current system analyze and to reduce the failure rate of BPR, the process performing time and the cost. Rasheed and Khan (2015) showed how workflow can be optimized through re-engineering methodology in Tele Cardiac system. Leggat et al. (2016) explored the perceptions of hospital staff on the effect of a process remodel initiative on healthcare quality. Hakim et al. (2016) presented a methodology to assist enterprise decision makers (DMs) to select from a number of processes during Business Process Reengineering according to organizational objectives.

Studies that use Business Process Simulation approach are as follows. Greasley (2003) introduced a business process simulation case study based on a BPR framework for change. Mascolo et al. (2006) proposed a simulation model of a real sterilization service. Kolker (2008) matured a simulation process model of Emergency Department patient flow considering a time of stay difference between allocations of patients dismissed home and patients allowed into the hospital. Han et al. (2009) proposed a two-stage process analysis for redesigning a process that integrates BPS (business process simulation) and PPMF (process-based performance measurement framework). Smits (2010) developed a system design to maintain the intake and treatment process management in a mental healthcare. Lesselroth et al. (2011) described a self-service patient kiosk implementation engaged patients for a clinic appointment check in and gathered a medication attachment history that is accessible from the electronic health record. Bisogno at al. (2016) provided a method for analyzing and improving the operational performance of business processes (BPs).

Besides, there are many other studies in the field, such as, Scheer and Nüttgens (2000) presented a common business process structure which is founded on ARIS and which is collected of the four levels of process engineering, process planning and control, workflow control and application systems. Kwak and Lee (2002) presented a MCMP application (multicriteria mathematical programming) for supporting strategic planning for an organization's business process infrastructure advancement. Aguilar-Saven (2004) inspected business process-modelling literature, explained the principal process modelling methods, and suggested a framework for categorizing business process-modelling methods. Tan et al. (2008) displayed a vision and methodology set throught a business process intelligence using an evaluation of the dynamic process performance, along with the measurement models established on ABM (Activity Based Management) and a dynamic enterprise process performance evaluation methodology. Martinelly (2009) developed a modeling framework that permits decision makers to reengineer and evaluate their hospital supply chain. Combi et al. (2014) proposed a new process modeling language (TNest), that permits to deliberate the time constraints and the data dependencies with ease throughout the process design. Buttigieg (2016) investigated how BPM standards can aid to obtain better healthcare management and considered the BPM principle application in healthcare sector.

3. MATERIALS AND METHODS

3.1 Business Process Reengineering

According to Davenport (2013), a process is a structure for actions beyond time and place, including a beginning and an end. A business process is expressed as a system suitable for adding value to a company. Business process reengineering is an essential approach that was proposed in 1990 by Hammer. BPR has been treated as a crucial way to remodel business organizations for succeeding important progress in performance. To obtain a successful BPR performance, a business process should be studied by definite characteristics from an advanced aspect.

BPR is the analysis and remodel of processes for the sake of optimizing end-to-end processes and automating non-value-added actions within and between organizations. BPR intends to accomplish the best efficiency possible concerning for the business and organizational solutions by investigating main activities in line with companies' strategies. Business processes are defined by three components: the inputs, the processing or the transformation of the data and the output. BPR principally reengineers in the processing part in favor of becoming more efficient. More particularly, BPR is represented as the use of mathematical tools, models and methods in order to get the fundamental rearrangement of an organization that outcome meaningful performance gains (Zigiaris, 2000).

Today, the companies are facing with complex operational issues. Putting into practice a business processes reengineering project and/or a continuous improvement is inevitable in order to exist in a competing and constantly growing environment. BPR, which is a component of BPM, is accepted for the organizational transformation in various business. A business process reengineering project transforms almost everything in the organization: processes, jobs, managers and values, because of the fact that these features are related, they are called the four points of the business system diamond by Hammer and Champy, which is demonstrated in Figure 3.1.

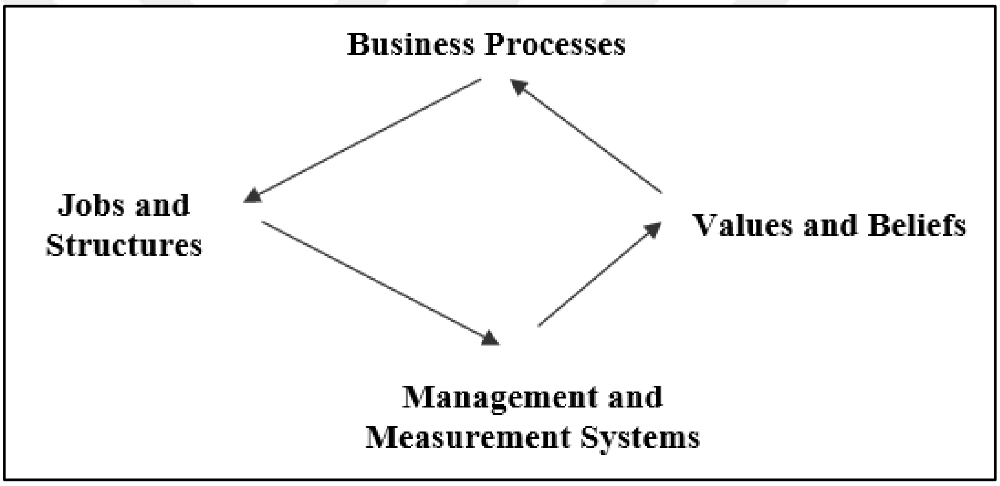


Figure 3.1: The business system diamond

Hammer and Champy (1993) recommended seven radical reengineering standards to simplify the business process and obtain major improvements in time management, cost, speed and quality:

1. Organize the results instead of the activities.

2. Analyze all the processes in an enterprise and prioritize them by the impact to the organization.

3. Merge the information processing work into the actual work that generates the information.

4. Evaluate geographically distributed resources as if they were centralized.

5. Connect parallel tasks in the workflow instead of just merging their results.

6. Place the decision point where the task is executed, and establish control into the process.

7. Take information once and at the source.

3.2 IT's Role In Process Redesign Efforts

Information technology relates to the hardware, software and knowledge systems that allow and assist the business processes. IT elements concentrate on the particular requirement of each process level and are measured from aspects such as suitability of automation, customization, accessibility and integration with other IT solutions (Rosemann and Brocke, 2015).

IT enables BPR implementation projects possible and valuable. Without the engagement of IT support in BPR projects, it is not likely to get profitable results and the performance will not be as hoped (Wu, 2002). Engaging together, business process reengineering and information technologies have the power to develop more adaptable, team-focused, harmonized and communication-based work potential (Whitman, 1996). That is why IT is a significant enabler of business process reengineering and its efforts should be taken into consideration in the BPR project implementations. IT abilities and their impact to the organizations are shown in Table 3.1.

Table 3.1: IT abilities and their organisational impact

Capability	Organizational Impact/Benefit
Transactional	IT can transform unstructured processes into routinized transactions
Geographical	IT can transfer information with rapidity and ease across large distances, making processes independent of geography
Automational	IT can replace or reduce human labor in a process
Analytical	IT can bring complex analytical methods to bear on a process
Informational	IT can bring vast amounts or detailed information into a process
Sequential	IT can enable changes in the sequence of tasks in a process, often allowing multiple tasks to be worked on simultaneously
Knowledge management	IT allows the capture and dissemination of knowledge and expertise to improve the process
Tracking	IT allows the detailed tracking of task status, inputs, and outputs
Disintermediation	IT can be used to connect two parties within a process that would otherwise communicate through an intermediary (internal or external)

In the past, the computers were considered as instruments for automating in-house business processes but today they are treated as a communication tool that assist completely new business standards. In other words, IT is not just a business process assistant that control information, instead it is a new approach of reconstructing the business processes, as well as, an indispensable element of all the business processes. It should not be forgotten that IT is valuable if only it guides workers to do their job better and inordenary. During a BPR project, information technologies' abilities are as follows (Attaran, 2004):

- Collect a massive information for the business process
- Deliver the complicated analytical methods and different approaches to use on the business process
- Make it possible for better decision analysis with fewer dependence on current information flows
- Determine the operators for the new process modeling for defeating geographic boundaries
- Understand the know-how and the nature of the change and develop the process by matching with the IT strategy
- Inform the current outcomes of the BPR project
- Convert unorganized business processes into automatized actions
- Cut down the work force in a business process
- Evaluate the performance of the ongoing processes
- Specify definite performance goals and objectives to initiate the BPR effort
- Specify the borders and the range of the business process

IT has the powerful effect on standardization or removal of process variations (Figure 3.2). IT abilities can bring good awareness into the existing process structure. An ERP software can organize the company concerning the data distribution, the reporting, the uniformity and more adequate business processes. Information technologies' power is so effective that it can actually develop new process design alternatives, instead of just maintaining it. For that reason, Michael Hammer advises firms to first reconsider their processes for improvement and then automate them. In addition, this kind of organization can simply be managed by a team consisting of the process owners and IT personnel to carry out the process analysis. (Huq and Martin 2006)

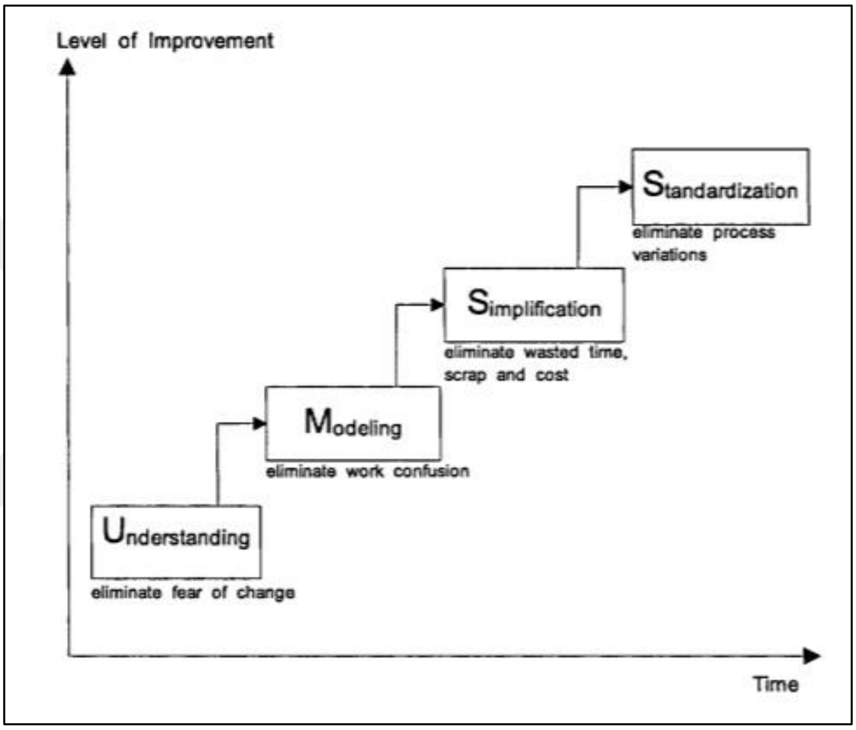


Figure 3.2: Process improvement sequence

As reported by Dorgan and Dowdy (2004), the amount of IT deployment versus the amount of process management study's outcomes are as follows. Businesses that adopt a technology without controlling their processes can gain almost 2 % from their investments. On the other hand, businesses that strongly control their business processes with a reasonable use of technology for assistance can realize almost 8 % profit from their investment. These results clearly show that controlling business processes increases the return on investment compared to using technology. Moreover, businesses that both strongly control their business processes and have a full technology support too can have nearly 20 % return from their investment. Hence, the highest profit grows from well-designed business processes accompanied by well-chosen technology implementation to assist the business processes.

In addition, reengineering projects usually demands many kinds of resources, which can only be enabled by a support of a top-level management. That is why, it should be taken into account that, without the executive supports, most of the IT efforts will be useless and the chances will be decreased to promote a business process remodel and a related organizational change (Attaran, 2004).

3.3 Expected Advantages of BPR

BPR has been universally accepted as a necessary prior step and a strategic profitable element too for the ERP implementation. The profits of a BPR implementation will bring considerable cost reductions, effectiveness in operations, quickness and quality. The expected benefits for an organization that puts into action BPR are as follows:

- Redistribution of tasks and processes in order to be connected into fewer, to be performed in its own order, at the same time and by the minimal amount of employees.
- Rearrangement of the firm's organizational design (downsizing) and employee empowerment.

- Tasks and processes get responsive in order to be performed in line with the each case requirements, firm's needs and customer's demand’s (hybrid centralized/decentralized operations).
- Steps in the actions are executed in everyday order, and multiple tasks accomplished at the same time.
- Processes with numerous versions allow the economies of scale that will happen from mass manufacturing and provide service and product customization.
- A single point of contact is maintained to clients (Zigiaris, 2000).

In order to achieve the expected results, the application of BPR is supported by main elements that consists of redesign, retool, and orchestrate. Resources and operations that objectifies each element are shown in the Table 3.2 as following.

Table 3.2: The three Rs of Re-engineering

REDESIGN	RETOOL	REORCHESTRATE
▪ *Simplify* ▪ *Standardize* ▪ *Empowering* ▪ *Employeeship* ▪ *Groupware* ▪ *Measurements*	▪ *Networks* ▪ *intranets* ▪ *extranets* ▪ *WorkFlow*	*synchronize* ▪ *processes* ▪ *IT* ▪ *human resources*

When employing the business process reengineering management method to a company the implementation unit concentrates on these goals: Productivity, Innovation, Speed, Adaptability, Quality, Compression and Customer focus. In order to achieve these objectives a business process reengineering methodology is necessary.

3.4 Methodology

Most of the BPR methodologies have general aspects and phases. All the business process-reengineering projects should have general phases (See Fig. 3.3):

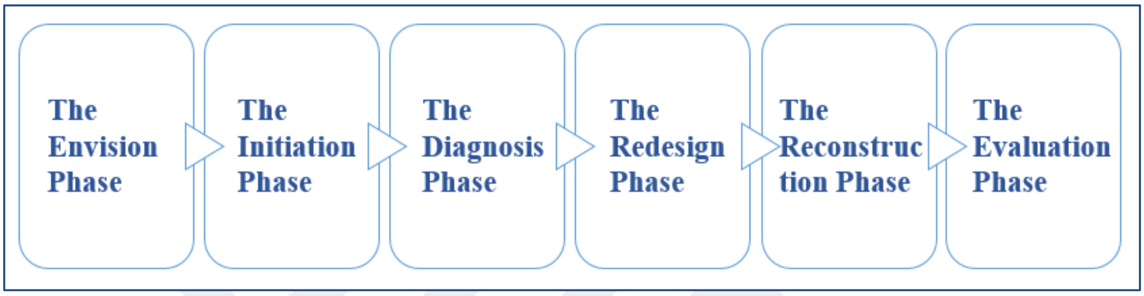


Figure 3.3: General phases of BPR

- **The Envision Phase:** In this learning phase, the firm analyzes the current plan of actions and processes. Business processes, companies' current conditions and problems are focused for revision and technology benefits are determined.

- **The Initiation Phase:** In this preparation phase, the employees are selected for the tasks. The project plan, the performance objectives and the employee announcements are decided.

- **The Diagnosis Phase:** The critical business processes are diagnosed and detailed from a global aspect using a set of process maps. Process maps allow a workflow picture of the company, which demonstrate core processes that can be broke down to sub-processes. The process and sub-process documentations are prepared by concerning process attributes. Current processes (as-is processes) are modeled and analyzed at this phase to find change opportunities that will increase the overall performance.

- **The Redesign Phase:** Since it is impossible to reengineer all the business processes of a firm, the processes that will be redesigned should be determined. The selection can be made by the impact to the organization as well as to the customers, by the adaptability to change or by the accordance with the companies' strategies. The reengineering team members create an improved and superior process model to have the required vision. The simulation analysis can be helpful to compare the possible alternatives. To-be processes are modeled and analyzed by brainstorming at this phase.

- **The Reconstruction Phase:** The change management takes place to assure easy shift to the future process responsibilities and personnel roles and to obtain the expected benefits from the transformation.

- **The Evaluation Phase:** In this calculation stage, the to-be processes are implemented and observed to decide if objectives are satisfied and to analyze the performance. This is a stage for a transition to a continuous process improvement (CPI) effort.

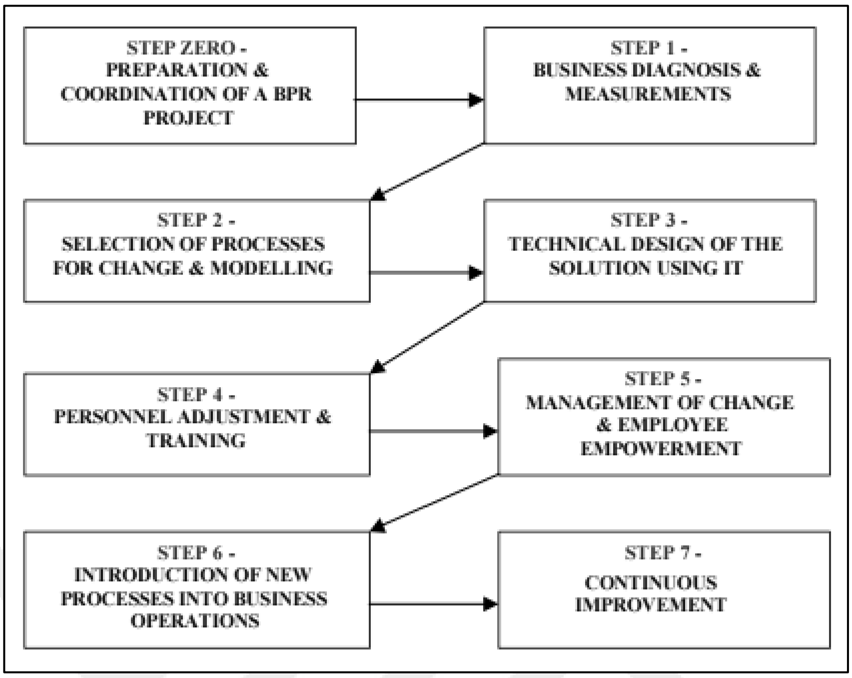


Figure 3.4: Business process reengineering methodology steps

In every business process-reengineering project, these fundemental steps must be followed as they presented in Figure 3.4:

Step 0 - Preparation and Coordination of the Project

Goals:

· To build a powerful management support

· To describe the project and job details to the team members

Actions:

· Express the urgency to perform the project to the executive management and get their support

· Assign the best suitable employees to the project team and give their roles

· Lead a workshop with the team members

. Identify the problems and the challenges

Step 1 - Business Diagnosis and Measurements

Goals:

. To understand the mechanism of the system

· To analyze and pinpoint troubled sections in the ongoing processes

. To calculate the ongoing process performance metrics

Actions:

· Design each process with the help of a process design tool

· Report the performance measurements for each step of a current process such as number of customer complaints, average cycle time, average resource usage, rate of delays or number of errors

· Load all the performance measurements in to the selected process design tool for future study and evaluation

· Diagnose benefit actions that have a considerable effect on the system.

Step 2 - Selection of Processes for Change and Modeling

Goals:

· To select the crucial processes that are beneficial to tranform

· To remodel and analyze the targeted processes

Actions:

· Define the process nature, which are valuable to the company

. Select the processes according to the benefits and flexibility for change

· Remodel the processes regarding to the beneficial characteristics

· Simulate and analyze the processes in real time conditions utilizing the process design tool

· Design the future processes utilizing the process design tool

Step 3 - Technical Design of the Solution

Goals:

· To automate modeled processes in the selection of processes for change and modeling step using IT and process tools

· To remodel and analyze the new processes

Actions:

· Organize network relations between co-workers

· Organize intranet platform for transferring files between co-workers

· Arrange an automatic workflow application as a scheduled task to operate in each step in the new process model

Step 4 - Personnel Adaption and Training

Goals:

· To instruct employees for the new jobs with the usage of IT in the new process model

· To remodel and analyze the new processes

Actions:

· Adapt each position based on the required talent in the selected process

. Define new job and role descriptions

· Instruct employees about the new process operations to prevent them from feeling threatened by the changes

<u>Step 5 - Management of Change and Employee Empowerment</u>

Goals:

· To create a constructive approach between employees towards the change

· To reduce the refusal to change by empowering the positions according to the performance assessment and reward systems

Actions:

· Build top-level management assurance for change and take precautions for any efforts of resistance to change

· Promote the change management process by showing the benefits of change

<u>Step 6 - Introduction of New Processes into Business Operations</u>

Goals:

· To appoint the operating time under the future business processes, indicating that the current processes do not work well

Actions:

· Adjust and check all background resources (such as supplies, documents or technology)

· Schedule time and date for running under the redesigned processes

· Implement the new business processes

Step 7 - Continuous Improvement

Goals:

· To take advantage of the business process reengineering project and to promote internal specialists for other projects

Actions:

· Regularly assess the business processes performance

· Set the resources and the date for the next business process reengineering project

4. APPLICATION

For the application phase, we benefited from a large hospital in Turkey for the case study to get the challenges of a central sterilization unit in a healthcare organization. The study uses BPR implementation methodology with an ERP software. The data used as an input to implement the proposed methodology were collected by means of interviews with the central sterilization unit personnel. The content of the process documentation is obtained through the questionnaires and surveys.

There are many bottlenecks and inefficiencies (such as delays on the reception and delivery of equipment, human resources, unnecessary paper usage and schedule problems etc.) in the current sterilization cycle of surgical equipment that needs to be optimized and automated. Therefore, some radical changes are required with a BPR application. In this study the primary motivation to apply BPR to the healthcare sector, specifically into a central sterilization unit, is to improve the productivity of the sterilization process of surgical equipment.

4.1 Problem

The hospital wants to check and track in which dates, where, and by whom the items are processed and wants to ensure that the sets are used efficiently according to the last sterile dates of the items. In the central sterilization unit of the hospital, the surgical instruments are mostly lost or damaged and they cause serious financial loss for hospitals. Overall, a centralized processing is needed in the sterilization unit for efficiency, economy, and patient safety.

Figure 4.1: Example of central sterilization unit

To solve the problem of the sterilization process (see Figure 4.2); the hospital management wants to set up an automated sterilization system for tracking their sterilization process. The needed system could give a solution to hospital's problem: an automated system that could bring more control in the system; an appropriate inventory management with the control of an information system, potential savings and minimization of the human related errors. At the beginning of the study, the ERP was not implemented yet in the central sterilization unit. This project is still undergoing today because of the lack of resources, human and financial. This study seeks for the potential gains of the project about the implementation of ERP in hospitals.

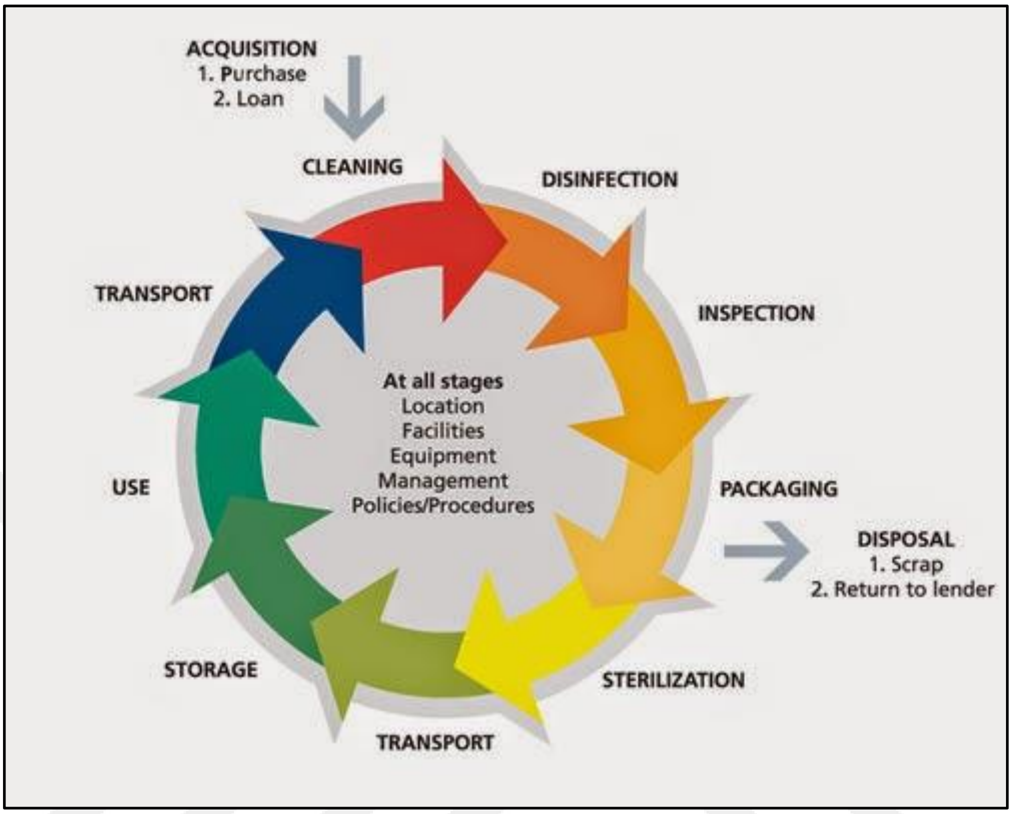


Figure 4.2: The sterilization process

In this case, with BPR in healthcare where improper business process redesign efforts may have harmful effects not only on the efficiency of organization but on patients' well-being as well.

4.2 Solution Method

With the leading progress in medical imaging technology, the healthcare information science has developed over the years, establishing itself as one of the backbone in the service of quality healthcare. In this context, BPM combines healthcare processes with the information technologies to obtain efficiency by automatizing and unifying its paper-based disorganized business processes.

In this study, a process redesign with ERP is proposed for the operation of the sterilization to automate the work processes. In the technical design of the solution phase, an ERP will be selected as an IT solution and reengineered in order to meet the requirements for better information flow and for reduced inventory costs. The future processes will be operated through the ERP system. With that, the business efficiency will be enhanced and the overall ability will be improved to fit the needs of the central sterilization unit. Problems will be diagnosed earlier and the error rate will be reduced. Also, with the well resource allocation and effective use of resources, the waiting times of the hospital departments will be reduced.

As a solution method, ERP-driven BPR will be used to reengineer its processes. Within this framework, the requirements of the current system will be analyzed, AS-IS and TO-BE processes will be modeled by using EPC notation in ARIS software tool and then the performance of the reengineering processes will be held after the implementation of the proposed solution in order to compare the results and the automated areas. All the processes will be standardized and documented throughout the central sterilization unit.

4.2.1 Business Diagnosis and Measurements

In this step, to understand the mechanism of the system, the actual system is analyzed and modeled for describing the current way of working (AS-IS situation). The existing activities are identified as value-adding and non-value-adding activities. The actual system will give the opportunity to investigate and spot troubled sections in the ongoing processes. The crucial on-going processes in the central sterilization unit will be summarized and documented in this step. The current core and sub-processes of the central sterilization unit are shown in Figure 4.3.

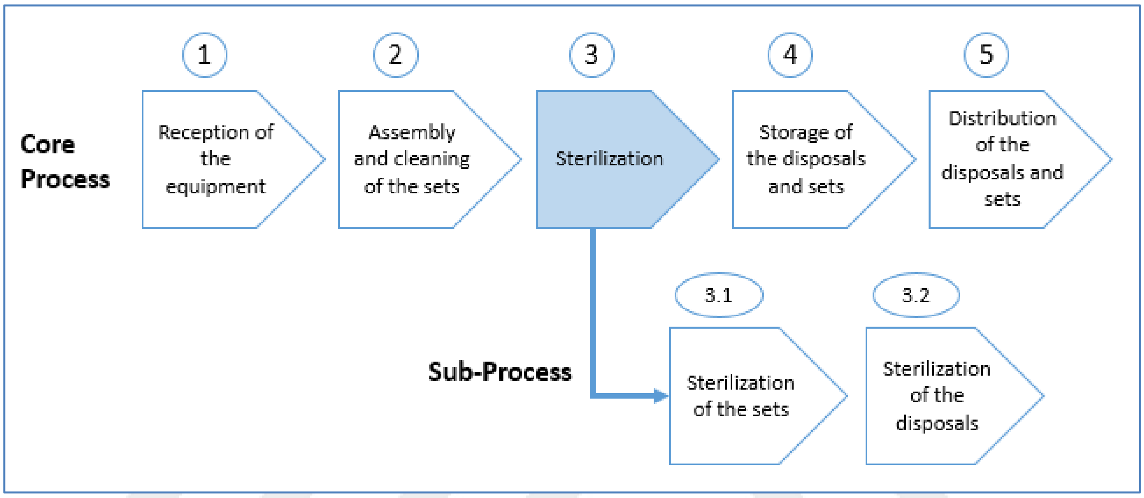


Figure 4.3: Current core and sub-processes of the sterilization process

1) In Reception of the Equipment step is consists of the transportation of the both used and newly bought non-sterile items to the dirty area in closed trolleys and the inspection of the items. During the reception of the equipment, the Material Delivery Form must be filled and signed by the authorized personnel and as well as the nurse in order to track the responsible for missing or damaged items (See Appendix A).

2) In Assembly and Cleaning of the Sets step; The basic steps are rinsing and washing of items (with washer/decontaminator, ultrasonic washer, tunnel

washers or cart washers) and inspection of the items to make sure they are intact. If any problem is observed throughout the inspection of the items, they must be sent to technical service for repair based on the problem observed (See Fig. 4.4). The non-sterile items are received in the assembly and cleaning area and are then assembled into sets or trays according to recipe cards and prepared arranged for issue, storage or further processing (like sterilization).

Figure 4.4: Example of an inspection of the items

With rinsing and washing steps, the items are cleaned and decontaminated in the decontamination area by means of manual or mechanical cleaning processes and chemical disinfection to eliminate all detectable remains from an item and to scale down the amount of pathogens (See Figure 4.5) (See Appendix B).

Figure 4.5: Example of rinsing the nonsterile items

3) In Sterilization step, prepared for sterilization items must be packaged so that their sterility can be preserved to the point of usage. The appropriate packaging materials should be selected for items to be sterilized (See Figure 4.6 and Figure 4.7).

Figure 4.6: Example of a preparation and packaging

Figure 4.7: Example of packaged items to be sterilized

The time between sterilization and usage may differ from a few minutes to several weeks or to several months depending on the package type (such as rigid container systems, nonwovens, textiles or pouch packaging) and the characteristics of the packaged items as shown in Figure 4.8.

Figure 4.8: Picture of nonwovens, pouch packaging and rigid container systems

The items (both the sets and the disposals) are freed of microorganisms by sterilization in the autoclave machines (See Figure 4.9).

Figure 4.9: Example of a clean area with autoclave machines

Controlling of the sterilization process is important to guarantee that all the sets and disposals are sterile when needed. The affirmation that sterilization settings have been obtained can be realized through several ways depending on the item to be sterilized. The mechanical, chemical or biologic indicators are used for diagnosing process or human related errors in packaging or loading and to warn employees if the process has been insufficient. If the items are not sterilized at the end of the cycle, the sterilization process must be repeated until it is done successfully. When the items are sterilized, they are ready to be transferred to sterile storage area.

A safe sterilization relies on contact of the sterilizing agent with all surfaces of the item to be sterilized. Preference of the agent to obtain sterility depends mainly upon the characteristic of the item to be sterilized. The applied sterilization process methods are steam, ethylene oxide, dry heat, microwaves, formaldehyde gas, hydrogen peroxide gas plasma, ozone gas, liquid chemical solutions or ionizing radiation depending on the items to be sterilized. Only qualified healthcare professionals should operate the decontaminating agents. In addition, all employees who are in charge of the sterilization process must exactly pursue the written protocols and policies of the healthcare system (See Appendix C and D).

4) In The Storage of the Disposals and Sets step; the sterile items are transferred to the sterile storage area and they are stored until the time to be issued. The storage area is a safe and secure field allocated to stock all sterile items where the unique physical circumstances are measured to provide the sterile items care and to prevent contamination and damage to the package integrity (See Figure 4.10) (See Appendix E).

Figure 4.10: Example of a sterile storage area

5) In The Distribution of the Disposals and Sets step; the items are prepared and delivered from the distribution area when they are needed in the hospital departments, as well as the external entities. Before the distribution of the sterile disposals and sets, the Material Delivery Form must be filled and signed

by the authorized personnel and as well as the nurse in order to track the responsible for missing or damaged items in the departments of the hospital. In order to prevent contamination, internal elevators and sealed carriages are utilized for the distribution of sterile items to the departments (See Figure 4.11). After the usage of sets, non-sterile items are transferred to the dirty area for decontamination (See Appendix F).

Figure 4.11: Example of sealed carriages

4.2.2 Selection of Processes for Modeling and Technical Design of The Solution

In this phase, the crucial business processes that are beneficial to change will be identified and the targeted system (TO-BE situation) with selected processes will be re-designed and the workflows of each phases will be remodeled by using ARIS tool. ERP-driven BPR will be used to reengineer the current processes and the future processes will be operated through the ERP system. In this project, in order to gather all the necessary data and to recognize bottlenecks, both the employees and managers are interviewed and the benchmarks are considered. The jobs which are accomplished by personnel out of habit, the data which the managers want to monitor and also the government's health regulations are analyzed for modeling the future processes.

Within this scope, an ERP will be selected as an IT solution and will be reengineered for better information flow and for standardized healthcare service. Then, the non-value added work will be standardized and these operations will be automatized by an IT solution. A small code from the ERP program's algorithm is as follows (See Table 4.1, Table 4.2 and Table 4.3).

Table 4.1: Equipment barcode example

```
private void ProcessEquipmentBarcode(string readBarcode)
        {
            using (var context = new AlfionCatsEntities())
            {
                if (GlobalSession.SI.CurrentAppUser.IsAdmin.Value || GlobalSession.SI.CurrentAppUser.IsSuperAdmin.Value)
                    GlobalSession.SI.SimpleEquipmentBarcodeRead(readBarcode);
                else
                {
                    Item readedItem = SetOperations.FindItemByBarcode(readBarcode);

                    //if equipment is a solo item, we need to open set tracking page of that equipment
                    if (readedItem != null && readedItem.IsSolo.Value)
                    {
                        if (readedItem.Set != null)
                        {
                            if (GlobalSession.SI.CurrentReadingMode == ReadingModeEnum.BulkOperationStartBarcode)
                                GlobalSession.SI.AddSetInBulkOperationBarcodeRead(readedItem.Set.UniqueKey);
                            else if (GlobalSession.SI.CurrentReadingMode == ReadingModeEnum.LoadAutoClaveBarcode)
                                GlobalSession.SI.SetLoadForAutoClaveBarcodeRead(readedItem.Set.UniqueKey);
                            else if (GlobalSession.SI.CurrentReadingMode == ReadingModeEnum.DeliveryStartBarcode)
                                GlobalSession.SI.DeliveryAddSetBarcodeRead(readedItem.Set.UniqueKey);
                            else
                            {
                                GlobalSession.SI.TitleChanged(string.Format("{0}", Properties.Resources.SoloItem));
                                GlobalSession.SI.LoadUserControl(new SetDetailForEquipmentTracking(readedItem.Set.UniqueKey));
                            }
                        }
                    }
                    else
                    {
                        if (readedItem != null && readedItem.Set != null)
                            GlobalSession.SI.ShowNotification(NotificationTypeEnum.Info, "Alet :" + readedItem.Name, "Ait olduğu 
set : " + readedItem.Set.Name);

                        GlobalSession.SI.EquipmentReadBarcodeRead(readBarcode);
                    }
                }
            }
        }
```

Table 4.2: Handle barcode example 1

```
private void HandleBarcode(string barcode)
        {
            if (string.IsNullOrEmpty(barcode))
                return;

            string barcodePrefix = StringHelper.GetStringPrefix(barcode);

            using (var context = new AlfionCatsEntities())
            {
                BarcodeHistory barcodeHistory = null;
                BarcodeType barcodeType = null;

                var barcodeTypes = (from a in context.BarcodeType select a).ToList();

                if (barcodePrefix.Equals(string.Empty))
                {
                    //if barcode has no prefix but a 13 digit number, it must be a stock no of an equipment
                    if (barcode.Length == 13)
                        barcodeType = barcodeTypes.Where(bt => bt.Id == BarcodeTypeEnum.Equipment).FirstOrDefault();
                    //else it might be a personal id
                    else if (barcode.Length == 11 && PersonalIdHelper.IsPersonalId(barcode))
                        barcodeType = barcodeTypes.Where(bt => bt.Id == BarcodeTypeEnum.User).FirstOrDefault();
                }
                else
                    barcodeType = barcodeTypes.Where(bt => bt.Prefix.Split(',').Contains(barcodePrefix)).FirstOrDefault();

                if (barcodeType == null)
                {
                    barcodeHistory = new BarcodeHistory() { Date = DateTime.Now, IsConstant = false, UniqueKey = barcode,
Description = "UNKNOWN" };
                    EntityHelper.SetBaseEntityValues(barcodeHistory, SetBaseEntityModeEnum.Insert);
                    context.BarcodeHistory.Add(barcodeHistory);
                    context.SaveChanges();

                    return;
                }
```

Table 4.3: Handle barcode example 2

```
                if (GlobalSession.SI.CurrentAppUser == null && barcodeType.Id == BarcodeTypeEnum.User)
                    ProcessLoginBarcode(barcode);
                else if (GlobalSession.SI.CurrentAppUser == null)
                    return;

                switch (barcodeType.Id)
                {
                    case BarcodeTypeEnum.User:
                        if (GlobalSession.SI.CurrentReadingMode == ReadingModeEnum.DeliveryStartBarcode)
                            ProcessDeliveryUserBarcode(barcode);
                        else
                            ProcessLoginBarcode(barcode);
                        break;

                    case BarcodeTypeEnum.Set:
                        Stage stageToOpen = context.Stage.Where(s => s.IsSetLoadable == false && s.IsBulkOperationLoadable == false
&& s.StageTypeId == Properties.Settings.Default.CurrentStageTypeId && s.IsEnabled == true).FirstOrDefault();
                        if (stageToOpen != null)
                        {
                            GlobalSession.SI.CurrentStage = stageToOpen;
                            ProcessSetBarcode(barcode);
                        }
                        break;

                    case BarcodeTypeEnum.Equipment:
                        ProcessEquipmentBarcode(barcode);
                        break;

                    case BarcodeTypeEnum.BulkOperation:
                        ProcessBulkOperationBarcode(barcode);
                        break;
                    default:
                        ConstantBarcode constantBarcode = context.ConstantBarcode.Include("BarcodeType").Include("Stage").Where(cb
=> string.Compare(cb.Barcode, barcode, false) == 0 && cb.Stage.IsEnabled == true).FirstOrDefault();

                        if (constantBarcode == null)
                            return;

                        GlobalSession.SI.CurrentStage = constantBarcode.Stage;

                        ProcessConstantBarcode(barcode, constantBarcode);
                        break;
                }

                barcodeHistory = new BarcodeHistory() { Date = DateTime.Now, IsConstant = true, UniqueKey = barcode, Description =
barcodeType.Description };
                EntityHelper.SetBaseEntityValues(barcodeHistory, SetBaseEntityModeEnum.Insert);
                context.BarcodeHistory.Add(barcodeHistory);
                context.SaveChanges();
            }
        }
```

The TO-BE processes in the central sterilization unit will be summarized and documented in this phase; the data collection will be collected automatically by the ERP system. The core and sub-processes of the new central sterilization unit process are shown in Figure 4.12.

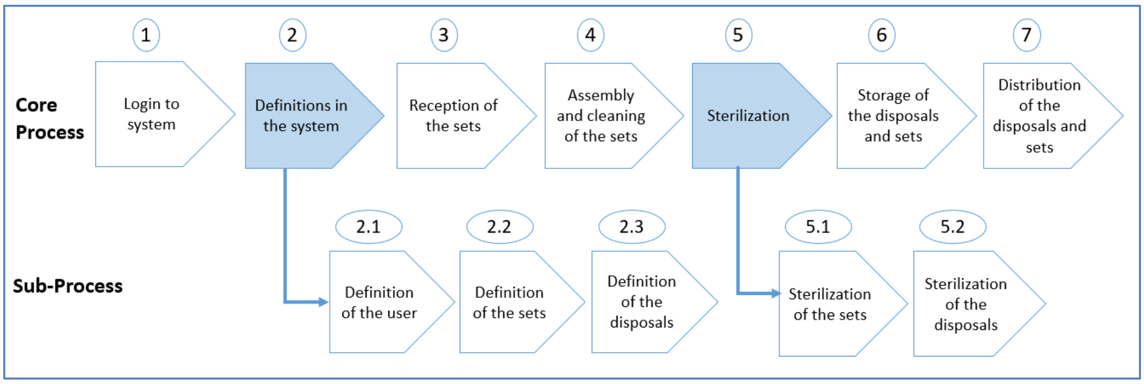


Figure 4.12: Core and sub-processes of the sterilization process

1) In Login to System step; there are two ways to login to the system, manually or with using the Personal ID Card. With this step, it is possible to track the personnel who do the action in the related process (See Appendix G).

2) In Definitions in the System step; the users, the sets and as well as the disposals are defined and saved with specific information in the system. The editing is possible at any time after saving the information in the system (See Table 4.4). In addition, it is possible to print out from the ERP system like Personal ID Card of the users or needed barcodes of the related sets and the disposals (See Appendix H, I and J).

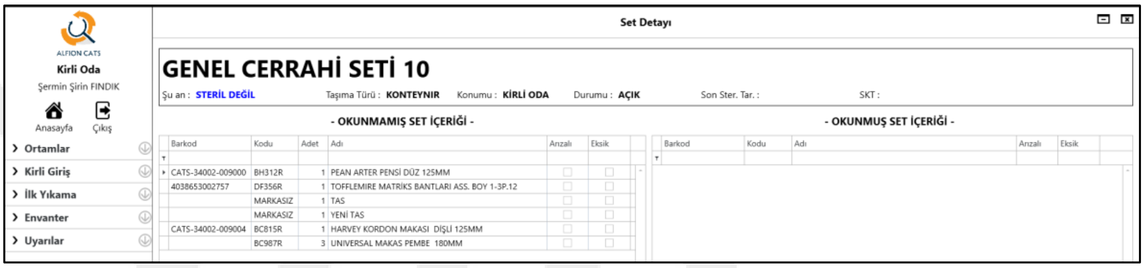
Table 4.4: Screen shot of the ‘new user’ page

3) Reception of the Sets step; non-sterile items come to the dirty area for the first check. After the inspection of the items, The Material Delivery Form is filled and the related personnel receive the dirty equipment through the ERP system (See Appendix K).

4) In Assembly and Cleaning of the Sets step; after the reception of the non-sterile equipment, the equipment is checked, rinsed and assembled into sets. The inspection of the content of the set is made thought the ERP system (See Table 4.5). If any problem is observed throughout the inspection of the items, they must be sent to technical service for repair based on the problem observed. All broken and/or lost items are marked through the ERP system in order to track them. Sets are loaded and unloaded from the washing machine and

checked for the cleanness while related barcodes are read by the personnel. In this way, it is possible to track down the used washing machines and the items which are cleaned. After the washing step, the non-sterile items are transferred to the clean area for sterilization (See Appendix L).

Table 4.5: Screen shot of the 'set detail' page



5) In Sterilization step; after the assembly and cleaning of the sets and disposals, the items are checked. The inspection of the content of the set is made thought the ERP system. All broken and/or lost items are marked through the ERP system in order to track them. Depending on the items to be sterilized, the suitable packaging materials should be chosen. Disposals are packed in the packing area and the related label is printed out from the system and the package is labeled for tracking the information such as the related item, the expiration date and the sterilization period. The department and the amount info are entered through the ERP system. The sets and the disposals are then loaded into the related AutoClave machine with reading the barcodes respectively; the "AutoClave Load" barcode, the related item's barcode, the "AutoClave Run" barcode. After the sterilization process, all items are checked, if the action is successful, the items are transferred to the sterile storage area, if not, the "AutoClave Cancel" barcode is read and the process repeats until the sterilization is successful. Once

the sterilization is successful, the items are transferred to sterile storage area. (See Appendix M and N)

6) In The Storage of the Disposals and Sets step, the items are transferred to the sterile storage area until it is time for them to be issued. The sets and the disposals are placed on shelves (See Appendix O).

7) In The Distribution of the Disposals and Sets step; when a set or a disposal is needed on hospital's units, the items are checked by their expiration date thought the system. When an item is needed, its barcode is read or selected from the list by the system. At the end, Material Delivery Form is printed and the items are sent to the departments of the hospital (See Appendix P).

4.2.3 Personnel Training and Management of Change

After redesigning and modeling the selected processes, the objective of this phase is to prepare the employees for the new jobs with the usage of ERP in order to minimize the resistance to change and to create a positive mindset for the change between co-workers (see Figure 4.13). All the personnel should feel a sense of being part of the process change for the sake of the project's success. The human resources of an organization are essential for a profitable process management implementation. Without the expertise of the employees, the business processes developments will not bring successful results.

Figure 4.13: Example of a personnel training for the new processes

In this step, all related items such as personal ID cards, labels, barcodes, barcode readers, label printers (see Figure 4.14) etc. will be introduced and its necessary usage trainings will be given before the implementation in order to eliminate possible errors or delays.

Figure 4.14: Example of a barcode reader and a label printer

4.2.4 Introduction of New Processes into Business Operations

In this phase, the operating time and date under the new processes are set. All the resources such as employees, documents and equipment are prepared and tested for the new system and the new processes are ready to implementation.

4.2.5 Continuous Improvement

After the implementation, the results are compared and the areas that are automated by the proposed solution are observed in this phase for measuring the central sterilization unit's excellence. With the automated areas fewer rework or fewer human related error will be taken place and eventually the total cost will be reduced and the total quality will be improved. The obtained business processes performance will be regularly assessed.

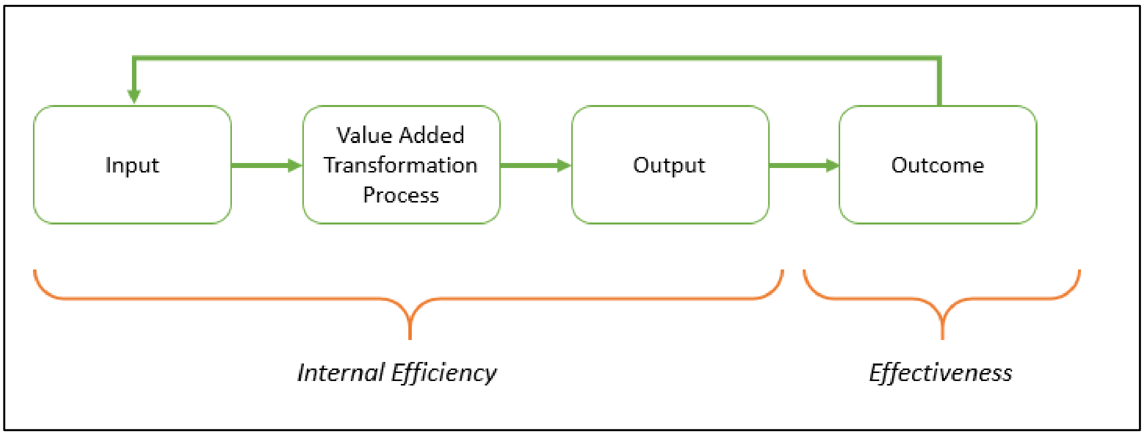


Figure 4.15: A process model

It should be assured that the data used for the process metrics is ready for use and can be reported. According to the literature research, any process can be calculated depending on three performance metrics which are cycle time, cost and quality. Crucial business processes are commonly executed through resources that often appear as bottlenecks. Solving these bottlenecks can turnout a much more efficient process with a reduced cost and time as well as customer satisfaction. The aim of using an ERP solution for a reengineering project is to automate jobs as much as possible and to reduce human related errors or delays. As the errors and delays are reduced due to process improvements, the costs will also be reduced. If we manage to reduce the cycle time in a reengineering project, all the three performance metrics can be improved sooner or later.

Cycle time is a measurement of a certain period of time between tasks to complete an action, and it shows the efficiency of the related process. A shorter cycle time provides a more efficient operation and promotes progress in overall business operations. Using cycle time as a performance metric can tell about the efficient and inefficient business processes in a reengineering project.

In this thesis, it is focused on the reduction of the cycle time as a process metric. The cycle time of the original process and the redesigned process is investigated and the results (in min.) are reported below (See Table 4.6 and Table 4.7). The observation is made for the same washing machine (Operation time= 60 min.) as well as for the same auto clave machine (Operation time= 180 min.) (N_1= N_2= 80):

Table 4.6: Observation for the original process cycle time

Original Process (min.)							
350	365	335	400	390	370	345	400
410	405	440	375	365	340	470	375
380	425	470	375	405	365	510	325
350	430	360	375	390	365	360	345
435	430	360	405	430	390	345	360
380	405	420	375	360	365	415	420
395	415	365	350	450	430	405	395
435	385	425	360	460	430	440	355
380	385	365	390	400	440	460	445
445	435	350	375	405	435	390	435

Table 4.7: Observation for the redesigned process cycle time

Redesigned Process (min.)							
320	340	320	350	355	340	325	365
355	365	375	350	335	320	385	345
355	370	400	360	365	340	440	310
330	375	335	345	350	330	325	325
365	380	345	380	360	370	320	310
350	370	405	355	335	325	365	355
365	380	340	325	380	385	370	360
380	350	370	325	390	360	380	320
335	355	335	350	350	380	395	360
370	390	340	355	380	400	365	395

Let μ_1 be the mean cycle time of the original process and μ_2 be the mean cycle time of the redesigned process. The hypotheses that we wish to test are

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 > \mu_2$$

The results of applying the pooled t-test to this observation with Minitab are as follows:

	N	**Sample Mean**	**StDev**	**SE Mean**
Original Process	80	396.1	37.7	4.2
Redesigned Process	80	356.6	25.0	2.8

Difference = μ (Original Process) − μ (Redesigned Process) = 39.56

T- Value	**DF**	**P- Value**
7.82	137	0.000

Because the P-value is so small (< 0.001), the null hypothesis would be rejected with the confidence level of 0.99. Strong evidence supports the claim that the redesigned process has shorter cycle time compared to the original process.

Confidence interval on the difference in means is as follows: $27,6 \leq \mu_1 - \mu_2 \leq 51,5$. Since this interval does not contain 0, H_0 has to be rejected. The confidence interval supports the hypothesis. We can claim that the redesigned process has shorter cycle time than the original process at the 99% level of confidence.

The central sterilization processes are analyzed for more efficient business processes and therefor a continuous improvement. Cycle time as a process metric will be checked regularly to gain a progress and to obtain strategic business objectives. The performance of the new business processes will be periodically monitored and evaluated and a new plan will be scheduled as well for the next business-reengineering projects.

4.3 Results

The process performance metrics give the data that the managers seeks for the evaluation of the business processes and for the better decision making. The advantages of using an ERP software are process automation, bottlenecks elimination, cost reduction and increase in profitability. The process automation gives companies a chance to reduce the human contact. After the implementation, the hospital management can detect any error or delay on time and can make strategic decisions correctly. Also they can analyze the performance of the sterilization process by monitoring and generating alerts, reports or indicators and with that they can take corrective measures.

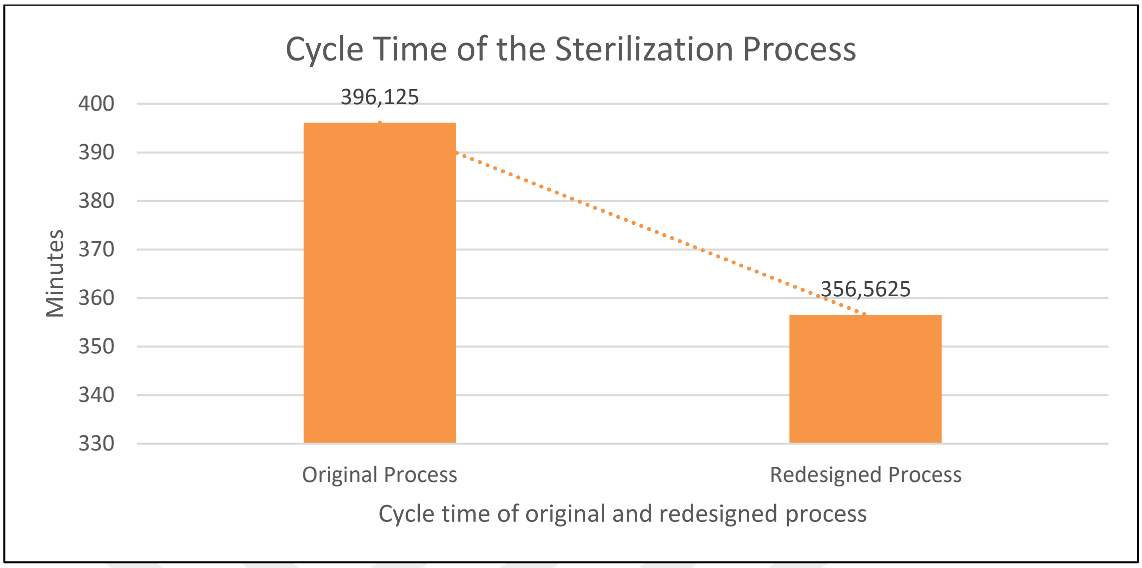
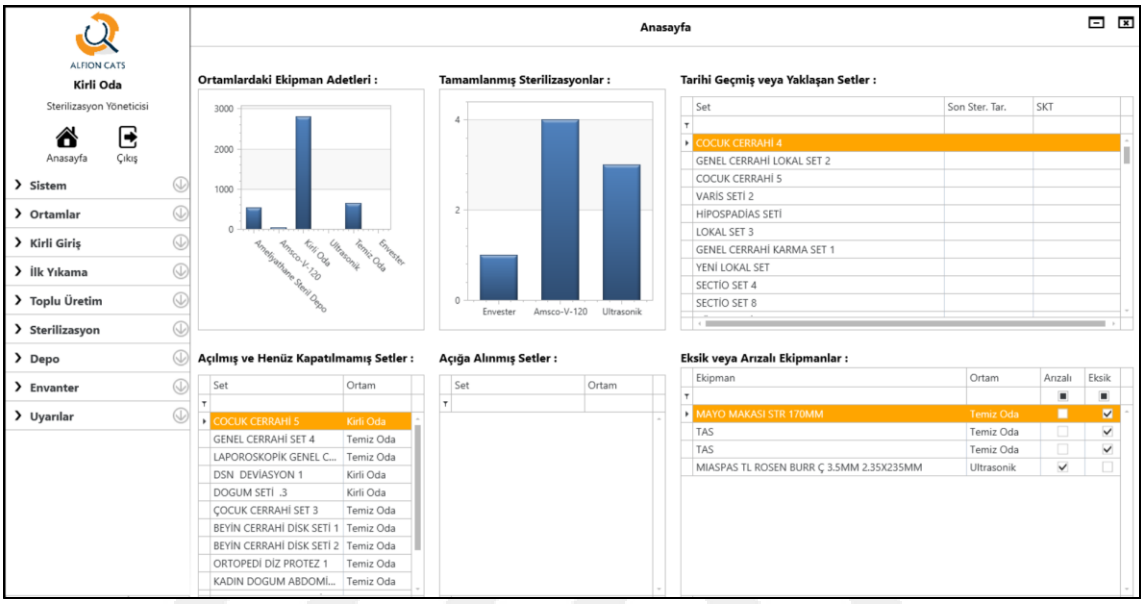


Figure 4.16: Cycle time of the sterilization process

Figure 4.16 shows that the current process requires a cycle time of 396 minutes approximatively to finish the sterilization task whereas the proposed future process requires 356 minutes approximatively (10 % reduction in cycle time - 39,5 minutes).

While implementing the new processes, we experienced workforce culture and resistance for a change. The main reason for this attitude is that the hospital management asked a new process design but they didn't support enough the change management team throughout the implementation.

Table 4.8: Screen shot of the 'home page'



5. DISCUSSION

The proposed methodology in this paper is an effective and easy tool to adopt. The purpose of modelling BPR is to understand the problems and to recognize the constraints with the information and material flows and to seek optimal solutions for improving the overall performance of the system. The achievement of BPM relies on the sustainability of the realization of the short term goals of the company.

It is noticed that in many sterilization services jobs are accomplished out of habit and the control procedures are rarely used. That is why an ERP solution is recommended and developed in order to automate some sterilization tasks and track down the information flow in the central sterilization unit. With the ERP solution it is possible to track in which dates, where, and by whom the items are processed. On the other hand, in the sterilization process the sets are used efficiently according to the last sterile dates of the items. Also with the ERP system, it is possible to reduce unnecessary paper usage and this gives the hospitals the opportunity to be more ecological and sustainable. As a result, a centralized sterilization process with an IT support provides efficiency, economy, and patient safety.

The results and measures of these processes will be reviewed periodically and the necessary adjustments will be again take place.

5.1 Limitations

The healthcare business processes are complex, often recursive, and necessarily organic to manage changes in input. Nonetheless, we intentionally simplified models to enable analysis and schematically represent key steps.

The data is collected from a single central sterilization unit, which may not reflect other healthcare contexts. Different environments, applications, staffing models, and preregistration expectations may all have an important effect on implementation. Additional observational data should be collected from different locations to validate and refine the model.

Finally, further multi-modal evaluation using careful methodology is necessary.

6. CONCLUSION

The healthcare sector is the more rapidly developing industries among others (Lockard & Wolf, 2012). That is why, the healthcare sector is increasingly confronting challenges that it is necessary to react by adapting new processes into the organization of healthcare. By supporting integrated systems for business performance management as well as current process management, BPM can give solutions to problems and treats that healthcare sector confronts today.

BPM have a valuable part in transformation projects to promote a practical healthcare management. If a company confronts with severe obstacles, then a well-guided BPR project can give the needed vital changes to defeat these problems and to obtain a competitive profit.

In a reengineering project, an automated system can bring more control in the system; an appropriate inventory management with the control of an information system and enable potential savings. For this matter, a business process management software is developed and implemented to the central sterilization unit so that the information flows more safely and the managers can track the results quickly by charts and reports.

This study seeks for the potential benefits of an ERP implementation in healthcare sector. As a result of this project, improvements in productivity, cost and quality are expected in sterilization processes since the new process design will bring automation, human related error reduction and equipment tracking system. This project is still undergoing today because of the lack of resources, human and financial support.

As for the future work, further testing and external validation of the approach are needed, including evaluation of other hospitals, testing in different healthcare settings, and validation with larger observation samples.

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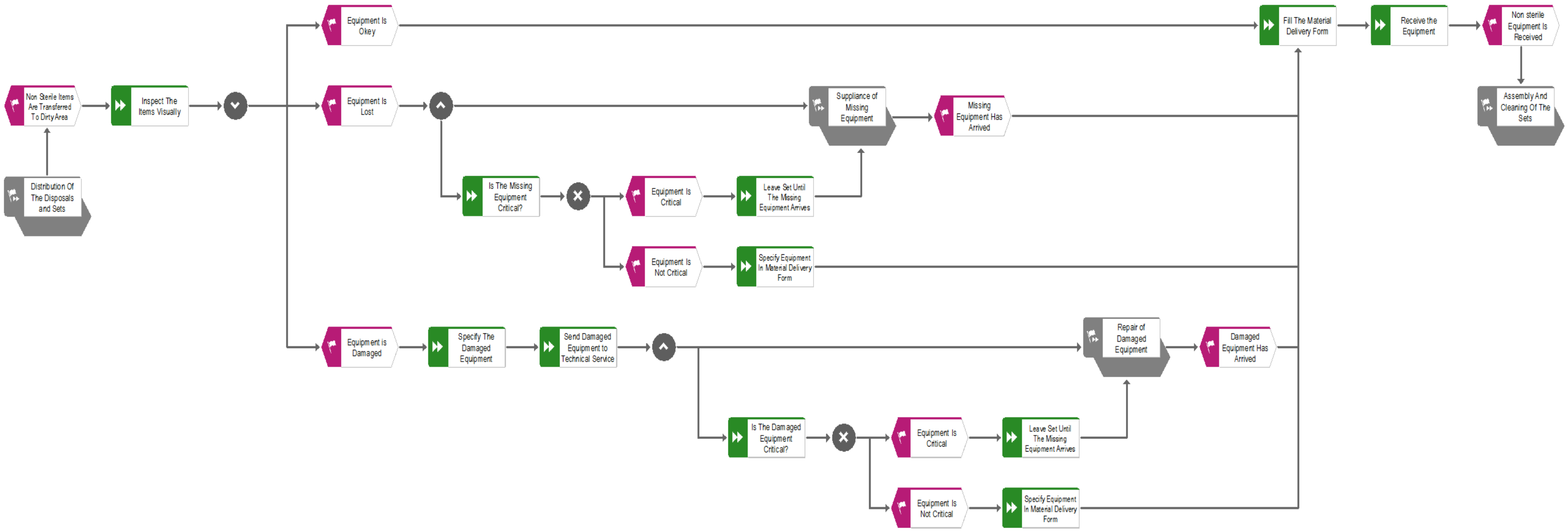
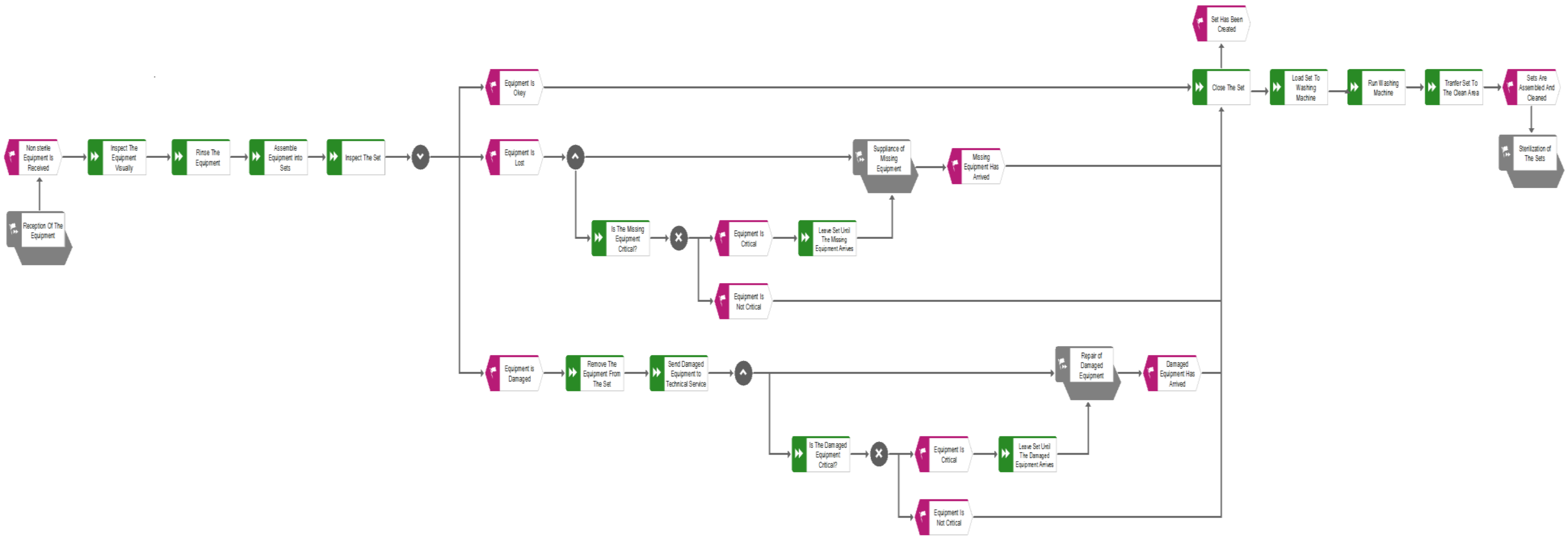
APPENDIX

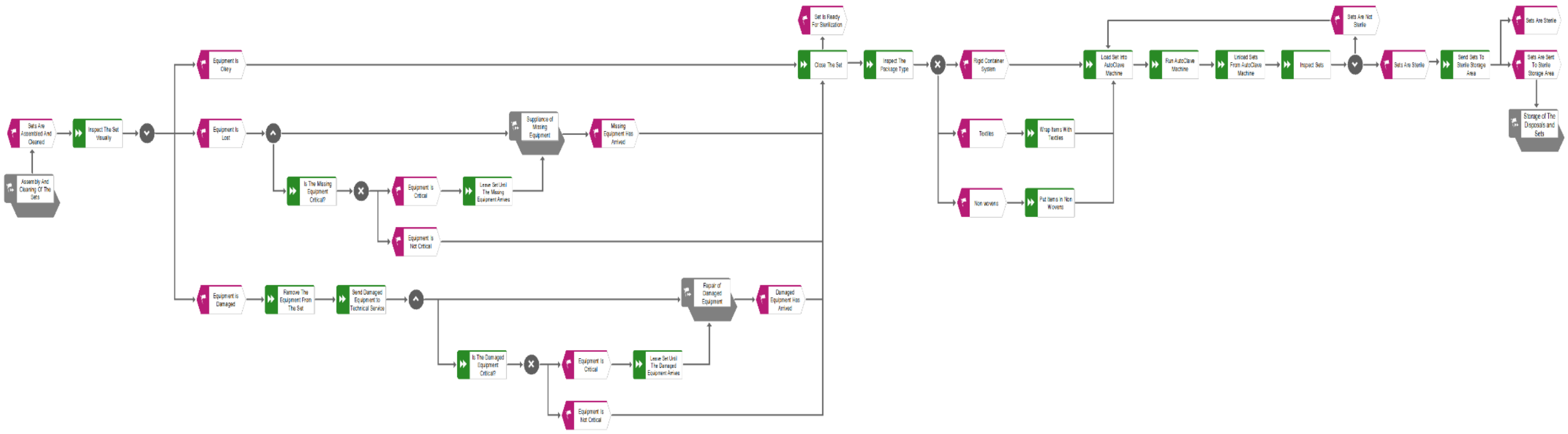
Appendix A: Reception of the Equipment



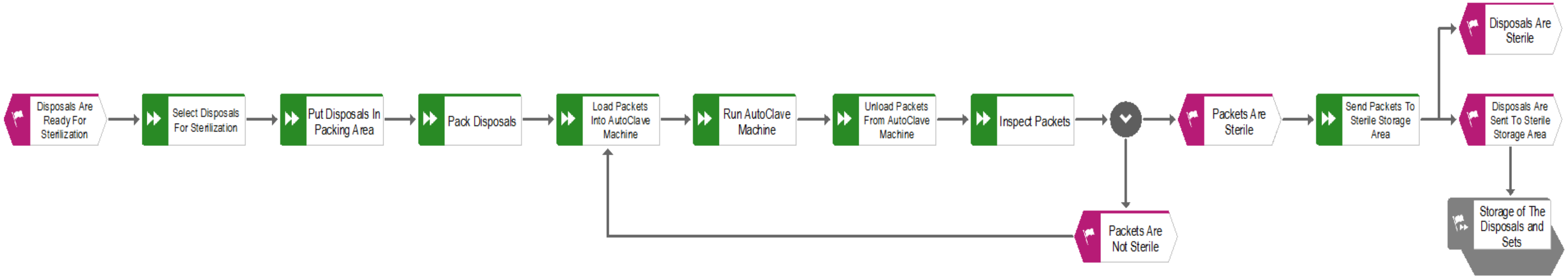
Appendix B: Assembly And Cleaning Of The Sets



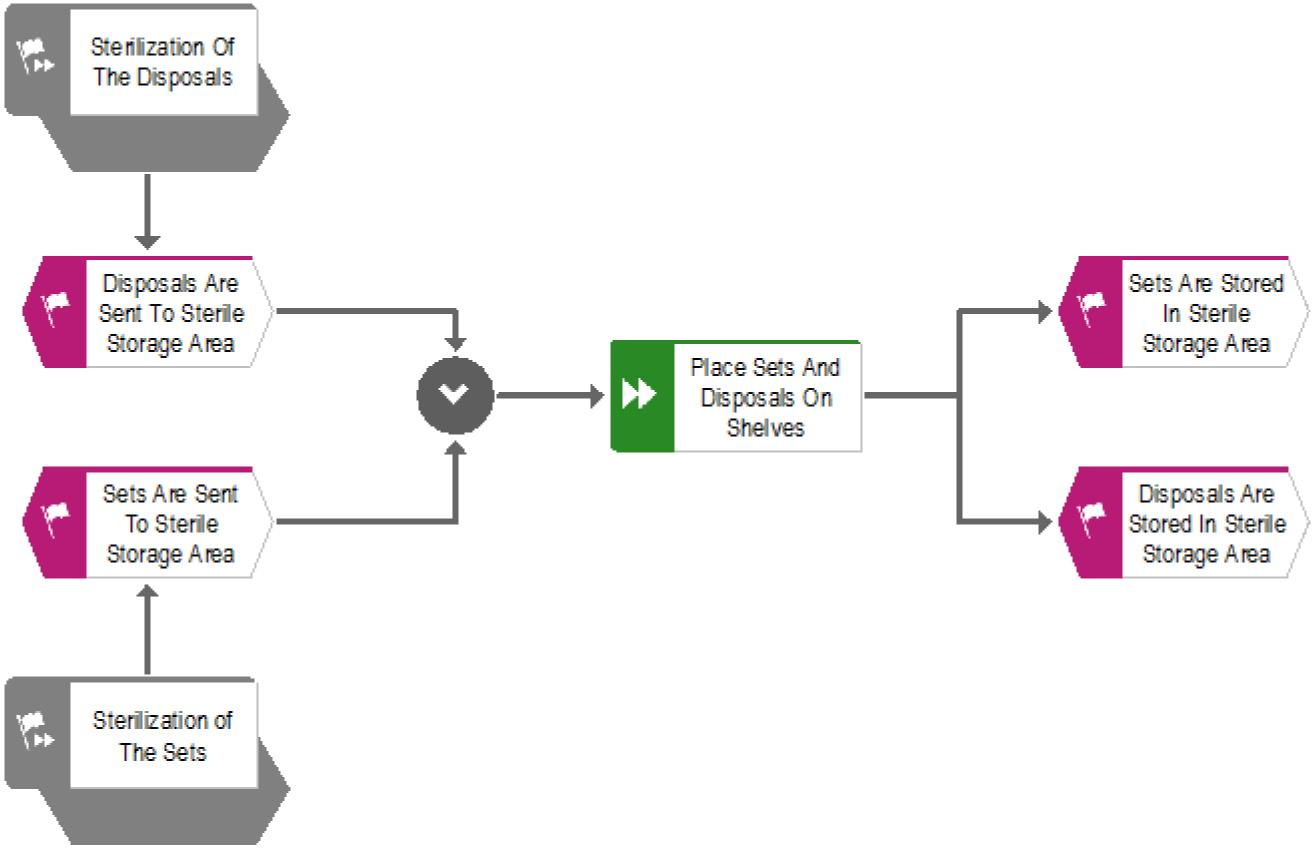
Appendix C: Sterilization of The Sets



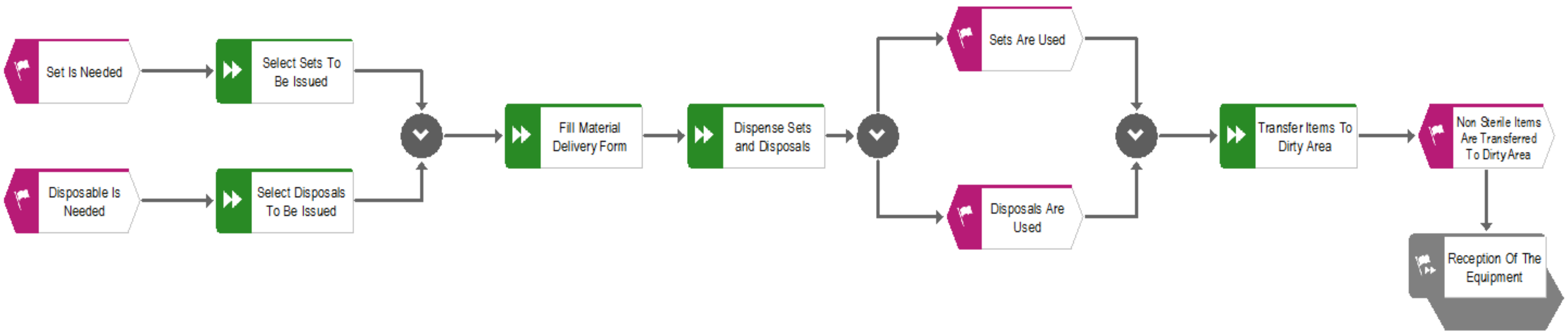
Appendix D: Sterilization of The Disposals



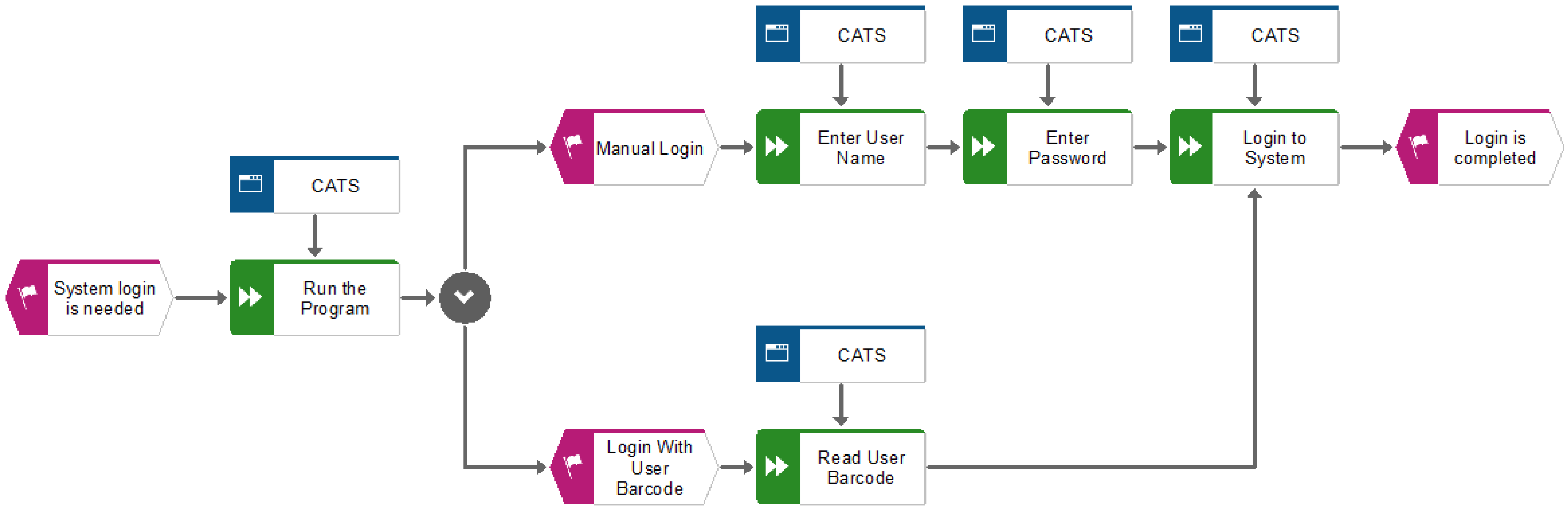
Appendix E: Storage of The Disposals and Sets



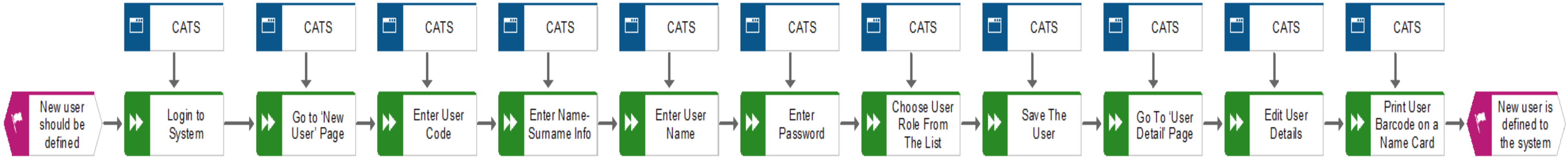
Appendix F: Distribution of The Disposals and Sets



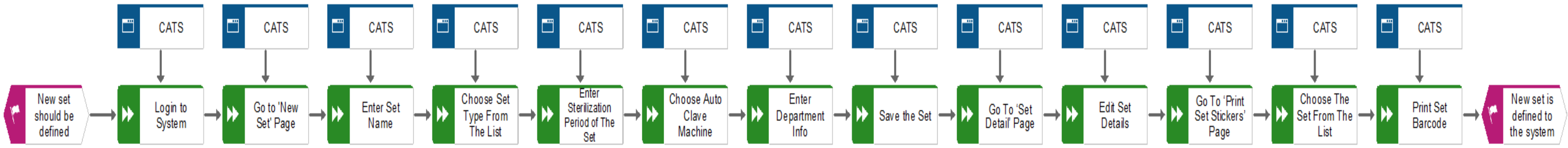
Appendix G: Login to System (to-be)



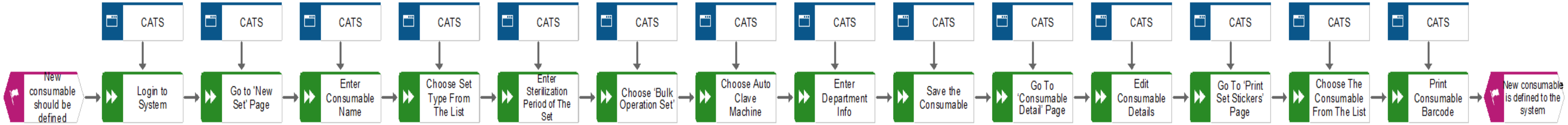
Appendix H: Definition of The User (to-be)



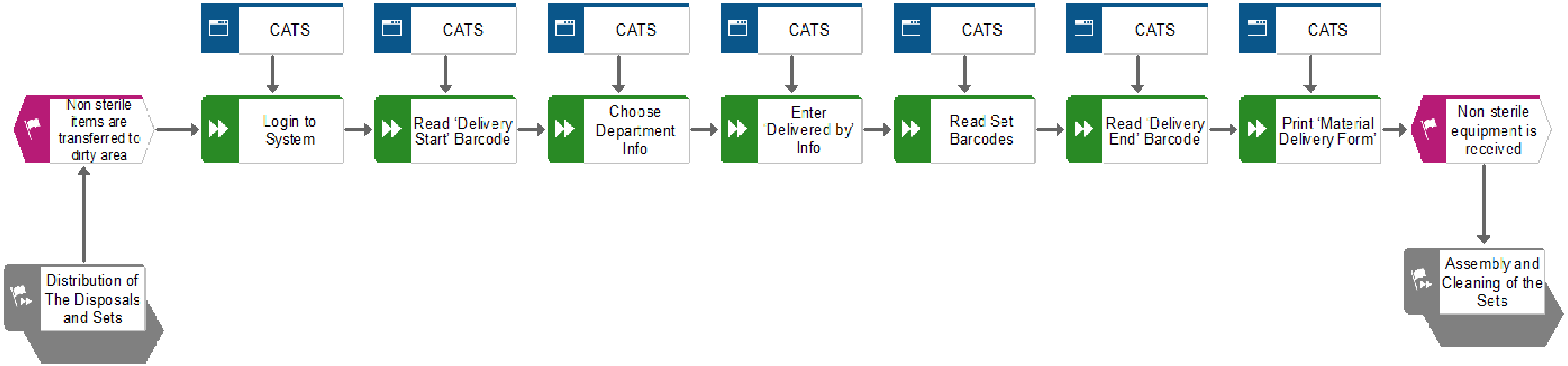
Appendix I: Definition of The Sets (to-be)



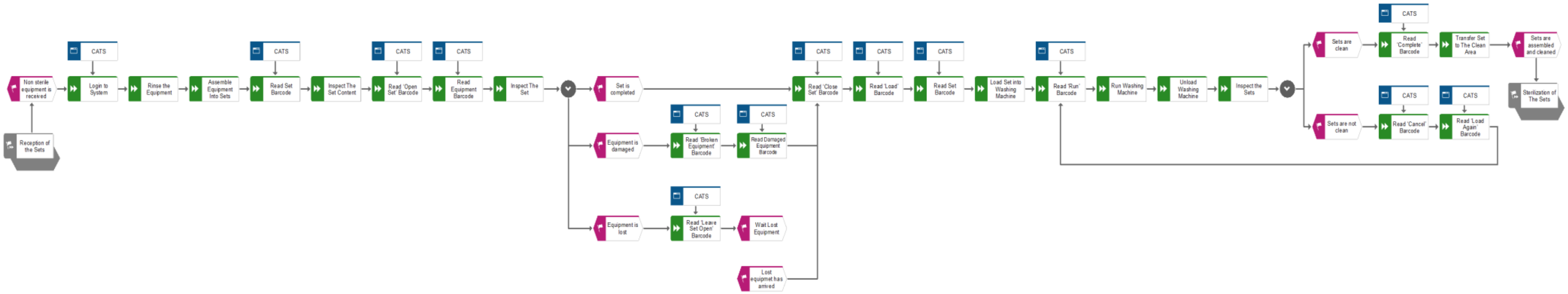
Appendix J: Definition of the Disposals (to-be)



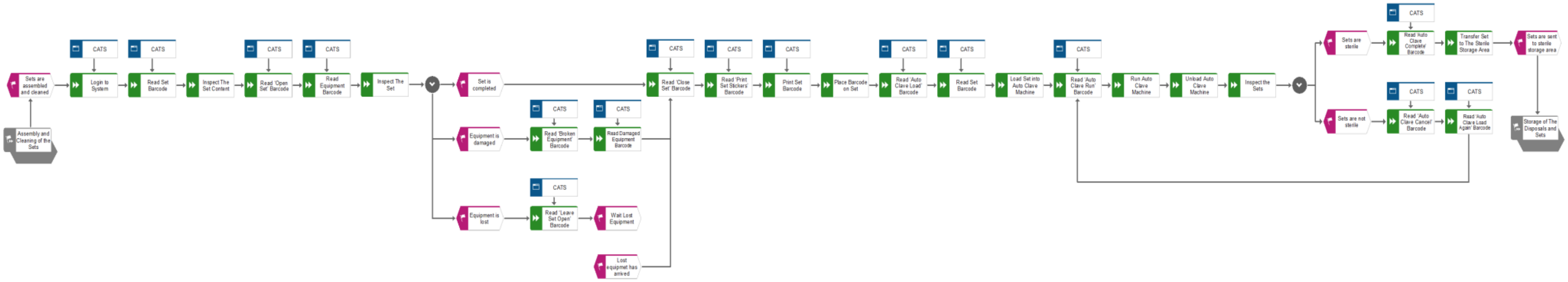
Appendix K: Reception of The Sets (to-be)



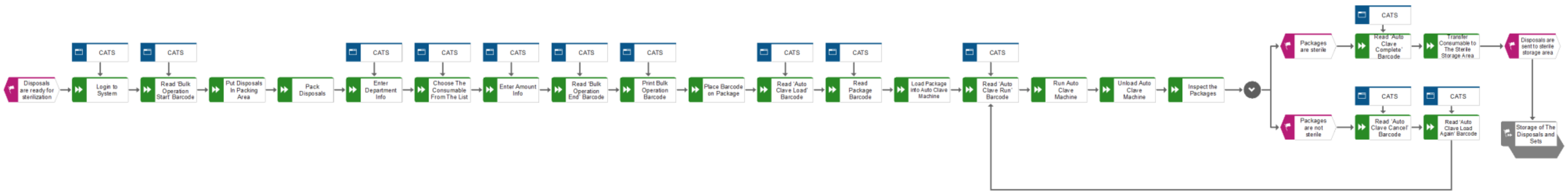
Appendix L: Assembly and Cleaning of the Sets (to-be)



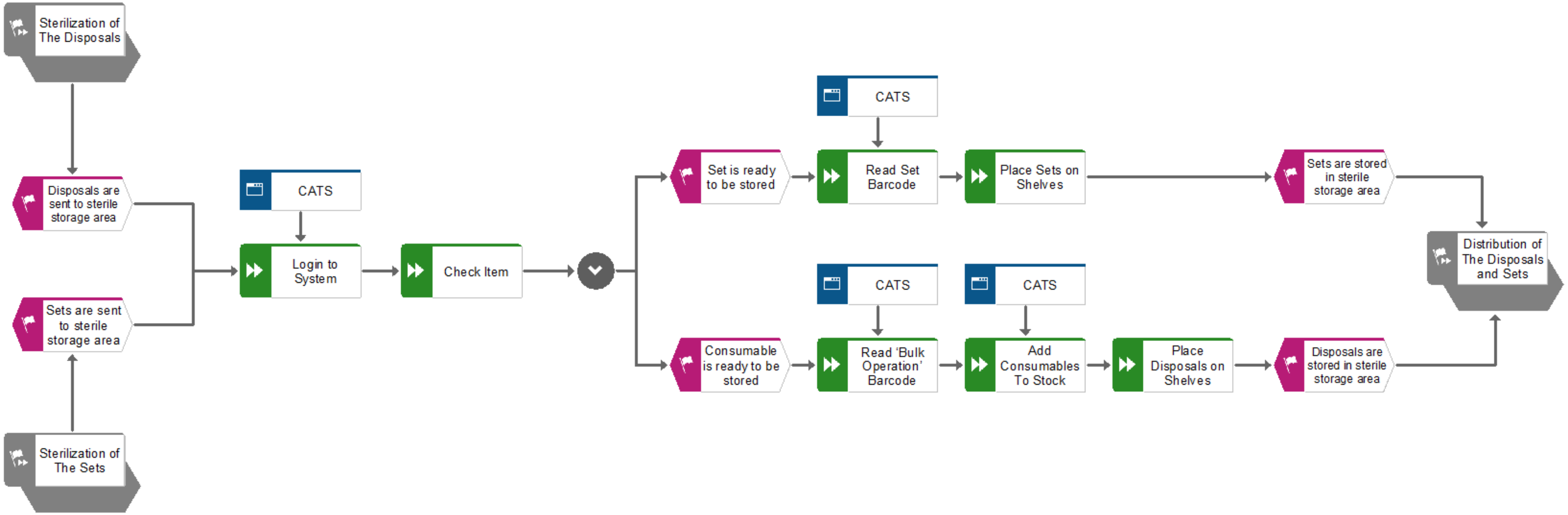
Appendix M: Sterilization Of The Sets (to-be)



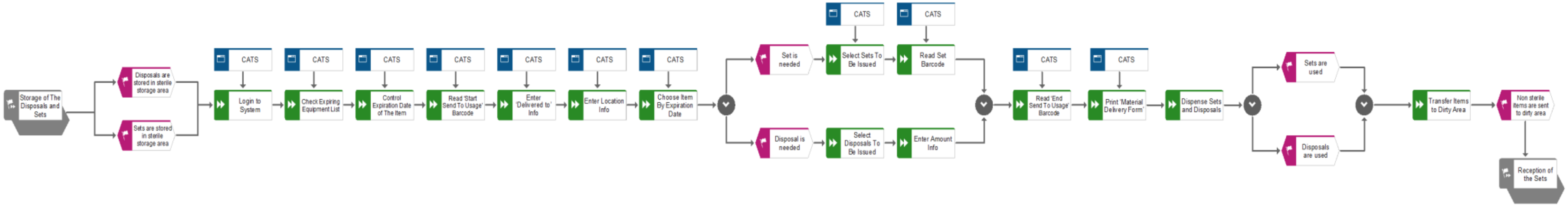
Appendix N: Sterilization of The Disposals (to-be)



Appendix O: Storage of The Disposals and Sets (to-be)



Appendix P: Distribution of The Disposals and Sets (to-be)



BIOGRAPHICAL SKETCH

Şermin Şirin FINDIK was born in İstanbul on March 26, 1987. She studied at Notre Dame de Sion French High School where she was graduated in 2006. She started her undergraduate studies in the Industrial Engineering Department of Galatasaray University in 2006. In 2010, she obtained the B.S. degree in Industrial Engineering. In 2014, she has started to study for master degree in industrial engineering under the supervision of Assist. Prof. Dr. Mehtap DURSUN at the Institute of Science and Engineering Department of Galatasaray University.

She is the co-author of the paper entitled “Business Process Reengineering For The Central Sterilization Unit” which was presented at the 15th International Logistics and Supply Chain Congress, LMSCM 2017.