INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO
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INDUSTRY 4.0 - INFORMATION SYSTEMS IMPLEMENTATION FOR INDUSTRIAL PROCESSES SUPPORT AND OPTIMIZATION

ANDRÉ FILIPE MORAIS DA SILVA
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André Filipe Morais da Silva

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ISEP – School of Engineering

Mechanical Engineering Department

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Dissertation presented to the Institute of Engineering of Porto – ISEP to fulfil the requirements necessary to obtain the Master's degree in Mechanical Engineering, specialization in Industrial Management, carried out under the guidance of the PhD Professor Maria Teresa Ribeiro Pereira.

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PhD Luís Carlos Ramos Nunes Pinto Ferreira

Associate Professor at Instituto Superior de Engenharia do Porto, ISEP

Supervisor

PhD Maria Teresa Ribeiro Pereira

Associate Professor at Instituto Superior de Engenharia do Porto, ISEP

Examiner

PhD José António Rodrigues Pereira de Faria

Associate Professor at Faculdade de Engenharia da Universidade do Porto, FEUP

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To my parents for the education, the knowledge, the values and the life guidelines that made me follow this path.

“No problem can be solved from the same level of consciousness that created it. “

by Albert Einstein

KEYWORDS

Industry 4.0; Information Systems; Document Management Systems; Decision Support Systems; Business Process Management.

ABSTRACT

The fourth Industrial revolution is the digital transformation of manufacturing, which incorporates the association of Industrial and Operational Technology, Big Data analysis and organization, coordination between Sensors plus Actuators with Robotics, leading to the Artificial Intelligence. This revolution will also decentralize manufacturing in a smart way, with self-optimization systems and the digital supply chain.

One of the fields associated with the new trend of digitization is the Document Management Systems (DMS). The main goal of DMS is to achieve different types of systems which will optimize the operator's self-decision, increasing productivity and subsequently decreasing cost. One of the biggest problems in all industry is the excess amount of paper produced, which lead to a tremendous decentralized cost.

The present work fits in the company's strategy for a more sustainable environment being an initial positive driver of Industry 4.0 implementation.

This thesis was supported by the development of two Information Systems (IS), during an internship at Toyota Caetano Portugal, S.A. The systems were developed to reduce waste and increase productivity, through better decision-making. Reducing the action time and provide a faster maintenance were also intended. Two projects were made, one to optimize the material's order and return processes and another for database maintenance and organization.

The first project's main goal was time optimization of the entire materials requirement process from the warehouse, to satisfy the line production needs and reduce paper. Therefore, a DMS was created, providing a better organized way for all process workflow. As a result of this IS implementation, a reduction of 4538 paper sheet consumption per year and time execution process optimization from the stakeholders, 0,10€ and 2,09€ per unit produced respectively, were gained.

The maintenance of the logistic database from the Land Cruiser 70 (LC70) produced in the factory was the second project's main goal. Then a DMS for decision support was developed, which allowed the user to add, edit, duplicate, delete and search every data needed in a faster and more flexible way. The user had also access to the respective image of each selected item for an accurate identification and better decision making. The IS implemented had positive results, by reducing the time decision making, from 65 to 38 minutes, which meant a cost reduction of 1,61€ per unit built, and an efficiency of 42% by providing a faster access to information due to organized structure.

PALAVRAS CHAVE

Indústria 4.0; Sistemas de Informação; Sistemas de Gestão Documental; Sistema de Suporte de Decisão; Gestão do Processo de Negócio.

RESUMO

A quarta revolução industrial é a transformação digital da manufatura, que incorpora a tecnologia industrial e operacional, análise de dados e organização, coordenação entre sensores e atuadores associados à robótica, levando à inteligência artificial. Esta revolução também descentralizará o processo de produção de forma inteligente, com sistemas de automatização de cadeias de abastecimentos. Um dos campos associados à nova tendência da digitalização são os Sistemas de Gestão Documental. O principal objetivo destes sistemas, passa pela otimização do suporte de decisão e melhor organização da informação. Um dos maiores problemas no ramo industrial é o elevado custo descentralizado, causado pelo excesso de produção de papel.

O presente trabalho enquadra-se na estratégia da empresa para um ambiente mais sustentável sendo um impulsionador inicial para a Indústria 4.0.

Esta tese teve como base, o desenvolvimento de dois Sistemas de Informação, durante um estágio curricular na Toyota Caetano Portugal, S.A. Os sistemas foram desenvolvidos para otimizar a tomada de decisão, levando ao aumento de produtividade, bem como a gestão documental associada. Otimizações foram feitas em todo o processo de requisição e devolução de material ao armazém geral. Por outro lado, a monitorização, manutenção e a rápida tomada de decisão foram os principais pilares do segundo sistema desenvolvido. As otimizações realizadas, transformaram de forma simples e ágil, todo o processo do ponto de vista documental. Permitiu ainda um melhor rastreamento de toda a informação, bem como a sua mais rápida acessibilidade.

O principal objetivo da criação do primeiro sistema esteve assente na otimização do tempo do processo de todo o fluxo, para mais rapidamente satisfazer as necessidades da linha da produção e consequentemente eliminar todo o desperdício associado. Como resultado, o consumo de papel e do tempo de execução do processo foi reduzido, tendo existido um ganho de 0, 10 € e 2, 09 € por unidade produzida, respetivamente. Assim, 4538 folhas gastas anualmente foram eliminadas do processo. A manutenção da base de dados dos componentes pertencentes ao Land Cruiser 70 Series (LC70), produzido na fábrica, foi o principal objetivo do segundo sistema implementado. À semelhança do anterior, a gestão documental para suporte à tomada de decisão foi o principal conceito adjacente no seu desenvolvimento. Após implementação, foi permitido ao utilizador adicionar, editar, duplicar, excluir e pesquisar todos os dados necessários de forma rápida e flexível. A redução do tempo de tomado decisão, bem como a manutenção da base de dados, permitiu uma otimização de 27 minutos, ou seja 42% de eficiência, levando a uma redução de custos de 1, 61 € por a unidade produzida.

LIST OF ABBREVIATIONS

BPM	*Business Process Management*
BPMN	*Business Process Model and Notation*
BPR	*Business Process Reengineering*
CPPS	*Cyber Physical Production System*
DB	*Data Base*
DMAIC	*Define, Measure, Analyse, Improve, Control*
ERP	*Enterprise Resource Planning*
FO	*Fabrication Order*
IDE	*Interface Development Environment*
IIOT	*Industrial Internet of Things*
IOT	*Internet of Things*
IPO	*Input, Process, Output*
IS	*Information Systems*
ISO	*International Organization for Standardization*
IT	*Information Technologies*
JIT	*Just in Time*
KPI	*Key Performance Indicator*
LT	*Lead Time*
ME	*Microsoft Excel*
MES	*Manufacturing Execution Systems*
MIS	*Management Information System*
MSO	*Microsoft Office*
PDCA	*Plan, Do, Check, Act*
SAP	*Systems, Applications and Products in Data Processing*
SIPOC	*Supplier, Input, Process, Output, Customers*
TCAP	*Toyota Caetano Portugal S.A.*
TPS	*Toyota Production System*
UF	*User Form*
UI	*User Interface*
UML	*Unified Modeling Language*
UX	*User Experience Design*
VBA	*Visual Basic for Applications*

LIST OF UNITS

h	Hour
min	Minute
m^2	Meter square

LIST OF SYMBOLS

€	Euro
%	Percentage

GLOSSARY OF TERMS

Industry 4.0	It is the fourth industrial revolution based on cyber physical system and cloud data assist.
User Interface	Everything designed into an information system with which a person may interact.
Lean	Methodology which aims to reduce all the waste produced.
Scrum	Software development methodology.
Gemba	Location where activities add value to the product.
Kaizen	Practice of continuous improvement.
Flowchart	Formalized graphic representation of a logic sequence, work or manufacturing process, organization or similar formalized structure.
Stakeholder	The term corresponds to people or groups that are directly affected by the company's activity.
Stock	Quantity of products stored at a given time to respond to an order from a customer.

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INTRODUCTION

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1 Introduction

1.1 Contextualization

This project was developed in Toyota Caetano Portugal S.A - Ovar Industry Division (TCAP - Ovar), during the academic year of 2017/2018. One of the goals from this internship was the development of this master's degree thesis while stablishing the connection with the enterprise world.

The internship was essential for experience and comprehension acquisition, regarding the processes and systems inside the automotive industry world and to implement problem-solving mechanisms to improve continuously the several existing problems.

In TCAP-Ovar, the LC70 is the model being produced to the South African market, which started being built in 2015 and the investment was around ten million euros. This investment was spread through different sectors, like new equipment acquisition, work tools, workers formation, logistic processes change and the creation of a new 4000 m^2 warehouse for previous storage.

Since the fourth industrial revolution, the industrial level is in constant change. Therefore, the optimization of various systems and processes in the factory are needed to promote the gradual monitoring of this global change. With the excessive use of physical documentation, as one of the negative points present in the factory, several projects can be done to combat this way to proceed, by optimizing different flows inherent to its use, reducing overall physical documentation and associated costs.

The mission of Toyota Caetano Portugal S.A. transmits the basic philosophy of operation, providing indications for its future, that guides all its employees towards a common purpose: "Improve our corporate DNA, doing more and better, supported by curiosity, creativity and passion. The complete satisfaction of our client and the consistent profitability of our operations are our goals. Day by day, we will be working hand in hand with our consumers.", quoted by Salvador Caetano.

1.2 Objectives

This project focus on the optimization of decision-making in processes already stablished and in the reduction of the overall physical documentation in the factory.

The main idea of this project was the analysis, design and implementation of an Information System (IS), like Documental Management System (DMS), to better organize documentation and support the decision making.

Based on the analysis of the found situation and using the resources available by the company, it was possible to develop and implement several solutions (named projects) able to improve the process' performance. The development of workflow solutions had four distinctive phases, seen in Figure 1.

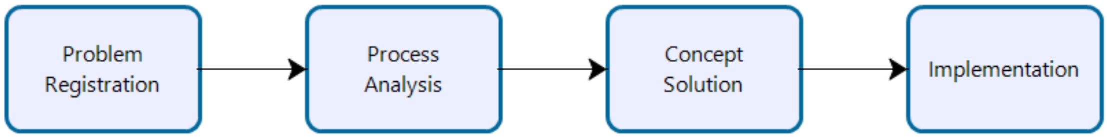


Figure 1 – Project Flow Phases

The registration of the problem followed by the analysis of the process, the design of the solution that would eliminate the causes of the problems identified and the specific implementation are the phases of each project.

The implementation of an IS allows the analysis of unstructured information flows and the creation of routines and working methods in the day-by-day of the organizations, streamlining business processes and improving business performance.

The first project aimed the creation of a solution that allowed the management of a more efficient way of the information flow (orders and returns) to the main warehouse allowing the management of information in more efficient way.

On the other hand, the second project aimed the optimization of decision-making, organization and traceability of the Land Cruiser 70 series logistic components database.

1.3 Research Methodologies

This thesis was supported by a workflow research method, listed in Figure 2.

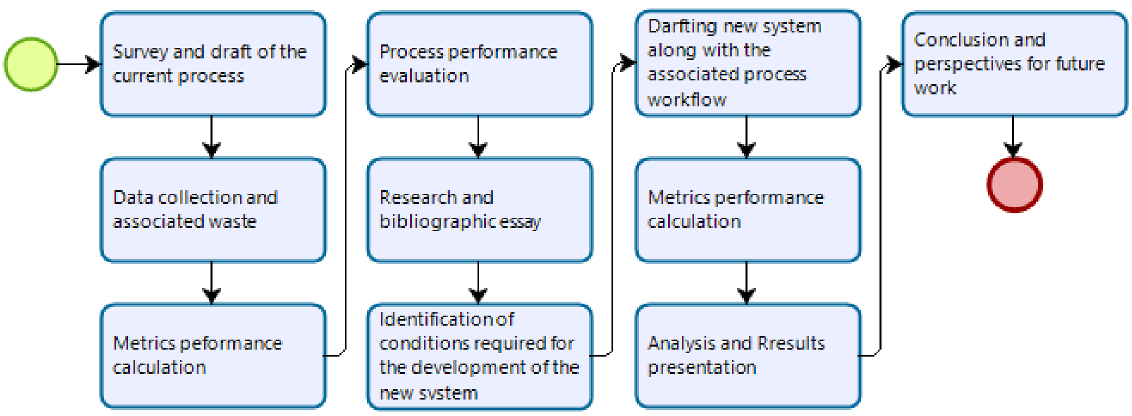


Figure 2 – Thesis workflow method

1.4 Scheduling

In this section, the chronological plan regarding the project's development are shown in Figure 3.

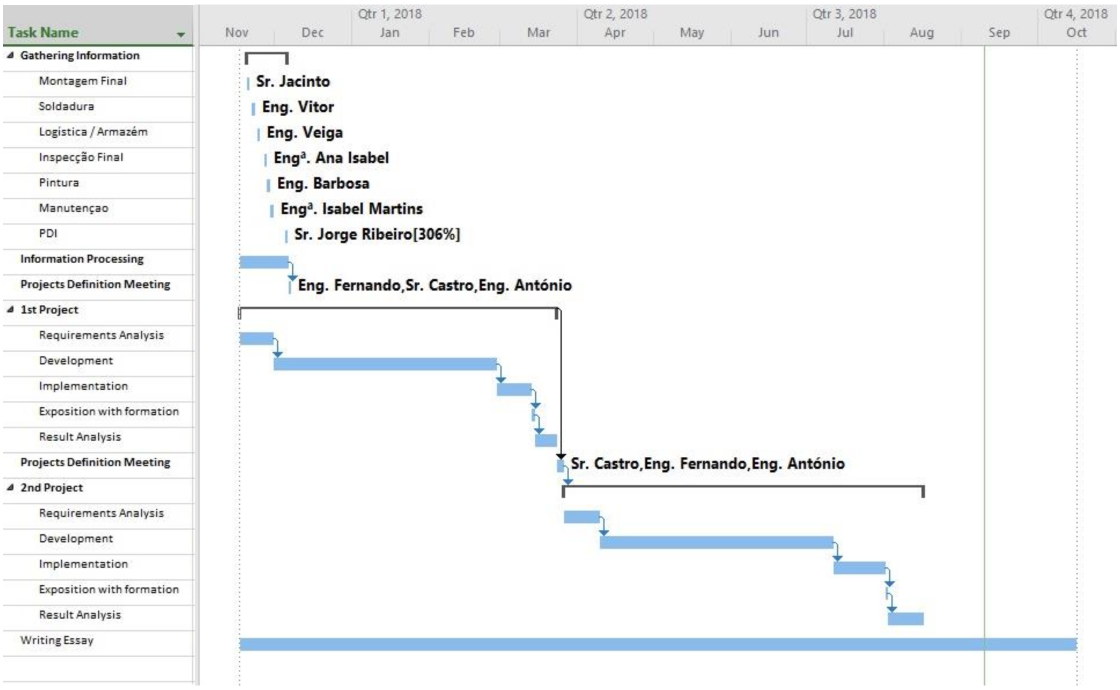


Figure 3 – Chronological Plan in Microsoft Project

1.5 Thesis Structure

This thesis is organized in seven chapters, supported by the respective annexes. It was intended to divide the different stages associated with the development of the project, respecting a chronological sequence.

This chapter introduces the company and the project, as well as the scope in which it is inserted and the objectives proposed. The chapter two regards the theoretical framework, which has served as the basis for the realization of the project. In chapter three, the methodologies and tools applied throughout the project and the respective theoretical reasons are listed. The found situation in the company is described and analysed. The causes of problems and opportunities for improvement are identified in the fourth chapter. The chapter five describes the developed product and the main characteristics with different types of models, giving a better knowledge about the system structure. In chapter six, the solution development that aims to respond to the problems previously identified and its implementation is described.

After the solution implementation, it was possible to observe the improvements obtained, a topic that falls in chapter seven, where the results are presented. In the same chapter, the conclusions concerning the development, design, analysis and implementation of the project are also described, followed by possible future optimization.

BIBLIOGRAPHIC WORK

2 Literature Review

In this chapter, several contents will be exposed, to support all the information related to the project's development.

At an early stage, an entire approach to the fourth industrial revolution is made to better frame, temporally, all the development done.

After this, an introduction to Information Systems is performed by specifying the various existing systems to be applied in an organization. All structures associated with business process are then presented, to connect both the concepts of Information System (IS), with the Business Process Management (BPM).

The concept of Lean Manufacturing and all associated tools are also described as being part of the planning and analysis of the different projects.

The exponential increase in global competitiveness, diversification of customer requirements, dynamic and unpredictable market trends challenge the manufacturing market. An integrate design for product support system processes will shorten the product development time and deal with constantly increasing complexity in products and manufacturing enterprises without compromising quality.

In this century, the skill of having a quick response to the business opportunity is considered as one of the most important factors for competitiveness. Intelligent Manufacturing Systems (IMS), such as digital, virtual and e-manufacturing, serve as a new paradigm in the manufacturing environment to refine the manufacturing business, as technology capabilities expand and business conditions change (Mourtzis, 2016).

This new era brings the digital transformation which has so many gaps regarding the digitization (automation) of existing processes and the digitization of data. Digitization is needed to optimize a digital transformation context, but this does not equal digital transformation.

2.1 Industry 4.0

The German Federal Government has been presenting Industry 4.0 as an emerging structure in which the manufacturing and logistics systems form a Cybernetic Physical Production System (CPPS). The term Industry 4.0 stands for the fourth industrial revolution, which is defined as a new level of organization and control over the entire value chain of the life cycle product and it's geared towards the increment of individualized customer requirements (Vaidya, Ambad, & Bhosle, 2018).

Inside all this movement and revolution, nine different fields are considered, Figure 4, which will transform the production of isolated and optimized cells into a fully integrated, automated and optimized production flow (Vaidya et al., 2018).

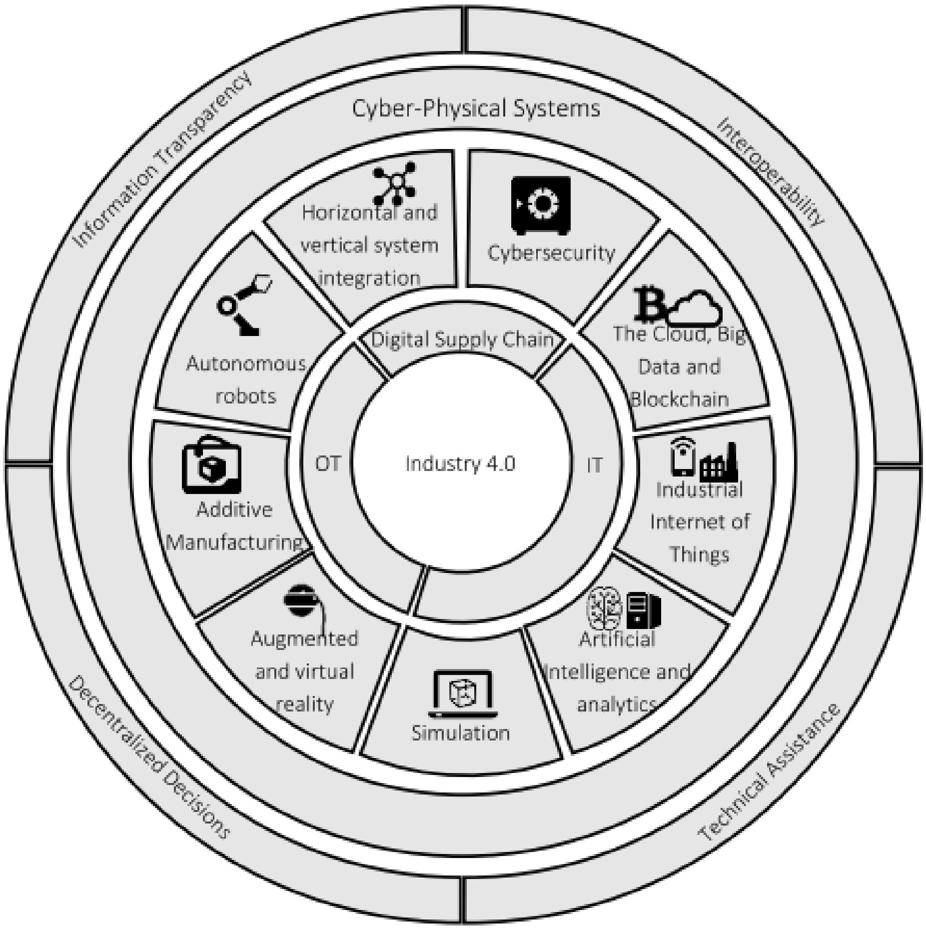


Figure 4 – Industry 4.0 nine pillars concept from (Montanus, 2016)

These new systems will use the global information and communication network for an extensively autonomous information exchange, being able to combine the production and business processes. This integration of the different fields leads to greater efficiency and change in traditional production relationships between suppliers, producers and customers, as well as between human-machine behavior (Vaidya et al., 2018).

The Internet of Things (IoT), Industrial Internet of Things (IIoT), Cloud-Based Production (CBP) and Intelligent Fabrication (IF) are the principal drivers that helps the manufacturing process transformation into fully digitized and intelligent systems (C. Santos, Mehrsai, Barros, Araújo, & Ares, 2017).

Several advantages and disadvantages are implicit in this fourth industrial revolution, seen in Table 1 and Table 2, respectively.

Table 1 – Advantages from the IoT, adapt from (Agrawal & Vieira, 2013)

Advantages	Context
Improve Customer Engagement	Current analytics suffer from blind-spots and significant flaws in accuracy, leading to a passive engagement. IoT completely transforms this to achieve richer and more effective engagement with audiences.
Technology Optimization	The same technologies and data which improve the customer experience, also improve device use and aid improvements to technology. IoT unlocks a world of critical functional and field data.
Reduce Waste	Current analytics give us superficial insight, but IoT provides real-world information, leading to more effective management of resources.
Enhance Data Collection	Modern data collection suffers from its limitations and it is designed for passive use. IoT breaks those spaces out and places them exactly where humans really want to go to analyse our world. It allows an accurate picture of everything.

Table 2 – Disadvantages from the IoT, adapt from (Agrawal & Vieira, 2013)

Disadvantages	Context
Security	IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite security measures. This leaves users exposed to various kinds of attackers.
Privacy	The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.
Complexity	Some IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.

Flexibility	Many are concerned about the flexibility of an IoT system. They worry about finding themselves with several conflicting or locked systems.
Compliance	IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

Big Data and Analytics

Nowadays, data is generated at highly rate, mainly due to emerging and advancement of the cloud computing, internet, mobile devices and embedded systems, sensors and actuators. The data produced by daily organizations activities and the rate at which the transactions occur may create unprecedented challenges in data collection, storage, processing and analysis. The collection and comprehensive evaluation of data from many different sources, like production equipment and systems, as well as enterprise and customer-management systems will become standard to support real-time decision making (Caro, Guevara, & Aguayo, 2003; Courtney, 2001). The analysis of previous recorded data is used to find out the threats occurred in different production processes earlier in the industry and forecast the new issues occurring (Vaidya et al., 2018).

Autonomous Robots

Autonomous machines, noun as Robots, are becoming each day more and more flexible, cooperative and autonomous, leading to a safe interaction between each machine and work safely side by side with humans. They can complete tasks more accurately, precisely and intelligently within the limited time, focus on safety, flexibility, versatility and collaboratively (Vaidya et al., 2018).

Simulation

The use of simulations' methods in plant operations are increasing rapidly, leveraging real-time data to mirror the physical world in a virtual model. By using simulators, the cost associated can be reduced, allowing the non-waste of materials and avoiding the error on a large scale, but never eliminating it, since there are different existing variables from the physical world which cannot be always contemplated in the virtual one (Vaidya et al., 2018).

The two- and three-dimensions simulations, 2D and 3D respectively, can be created for virtual commissioning and for simulation of cycle times, energy consumption or production facility ergonomic aspects and decision making quality (Artiba, Debrauwer, Iassinovski, Legros, & Pichel, 2000).

System Integration

Integration and self-optimization are the two major mechanisms used in industrial organization. The Industry 4.0 is composed essentially by three types of integration:

1) Horizontal integration across the entire network value creation;
2) Vertical integration and network manufacturing systems;
3) End-to-end engineering across the entire product life cycle;

All this digital and manufacturing processes integration in the vertical and horizontal scope imply an automation of communication and cooperation, especially along standardized processes (Vaidya et al., 2018).

The Industrial Internet of Things

The Internet of Things (IoT) means a worldwide network of interconnected and uniform addresses that communicate via standard protocols. This consists of networking physical objects, environments, vehicles and machines by means of embedded electronic devices, allowing the collection and exchanging of data (M. Y. Santos et al., 2017).

IoT provides the possibility of advanced object interaction with an existing environment and physical conditions of any existing object. The value chain should be intelligent, agile and networked by integrating physical objects, human factors, intelligent machines, smart sensors, production process and production lines together across the boundaries of organization. Software and data are key elements for intelligent planning and control of machines and factories of the future (Vaidya et al., 2018).

Security into Cyber Physical Systems

With the increased connectivity and use of standard communications protocols that came with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cyber security threats increases dramatically. As a result, secure, reliable communications, as well as sophisticated identification and access management of machines are essential. The strong connection of the physical service and digital world can improve the quality of information required for planning, optimization and operation of manufacturing systems (Vaidya et al., 2018).

The Cyber Physical Systems (CPS) has been defined as a tight integration between natural and human made systems (physical space) with computation, communication and control systems (cyber space). Two of the main characteristics of CPS are the decentralization and the autonomous behavior of the production process (Vaidya et al., 2018).

The Cloud

Cloud-based Manufacturing can be described as a networked model with reconfigurable cyber-physical production lines, enhancing efficiency, reducing production costs and allowing optimal resource allocation in response to a customer. With Industry 4.0, organization needs increased data sharing across the sites and company's servers, optimizing the reaction times to problem-solving or decision making from any worker in a matter of seconds or even faster. The digitalization concept is related to the different devices connections from the cloud for information share, that can be extended to set-up machines from a shop floor, as well as the entire plant (Vaidya et al., 2018).

Additive Manufacturing

Additive Manufacturing (AM) methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex and lightweight designs (Vaidya et al., 2018).

Technologies like 3D printing are going to be more localized, distributed and reconfigurable, which will completely change the supply chain (M. Y. Santos et al., 2017).

The production should be faster and cheaper with the use of additive manufacturing technologies. As customer needs are changing continuously, many companies are being challenged to increase individualization of products and reduce market sending time. Same model cars are offered with many variations in engine, bodywork and equipment, and this is an example of the increasingly inform and demand customers, nowadays (Vaidya et al., 2018).

Augmented Reality

Industry can use augmented reality to provide workers real-time information, improving decision making and work procedures. Workers may receive repair instructions on how to replace a part, as they are looking at the actual system needing repair. The use of a google glass is a perfect example of a device with augmented reality, which try to give the user all the real-time information from the object detected into the device vision field (Vaidya et al., 2018).

2.2 Information System

An Information System (IS) is constituted by people, procedures, data and information technologies (IT) components (like hardware, software and communication), which collect, process, store, analyse and distribute information with specific functionalities. It gathers and disseminate information in order to provide to its users. According to Davis and Olson, information is, and going on to quote, "A data that has been processed into a form that is meaningful to recipient and is of real or perceived value in the current or the prospective action or decision of recipient." (OBrien, 2004).

It is understood that a system is an organized and dynamic process with input functions, which are processed in order to organize, structure and disseminate raw data into information, see Figure 5 (M. T. R. Pereira, 2003).

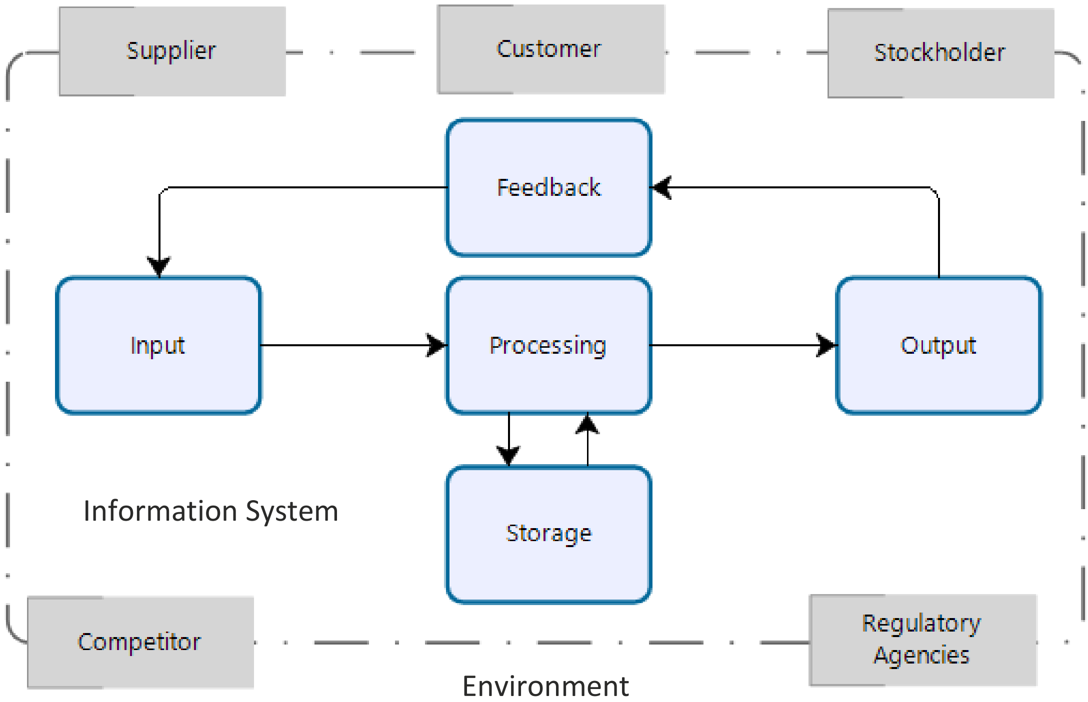


Figure 5 – Information System Structure

The input captures and collects raw data from within the organization or from the external environment. After this, it is processed, which involves converting the raw data into meaningful information. The process stage can involve calculations, comparisons, taking alternative actions and storing data. Finished the processing phase, an information output is received, normally in form of documents and/or reports (M. T. R. Pereira, 2003). The feedback process verifies, analyses and evaluates the IS outputs, being able to connect, if necessary, the input functions (Baker, 1995; Gräßler & Yang, 2016).

The IS development workflow, seen in Figure 6, show the five different stages of analysis and data compilation structure and cooperative methodology.

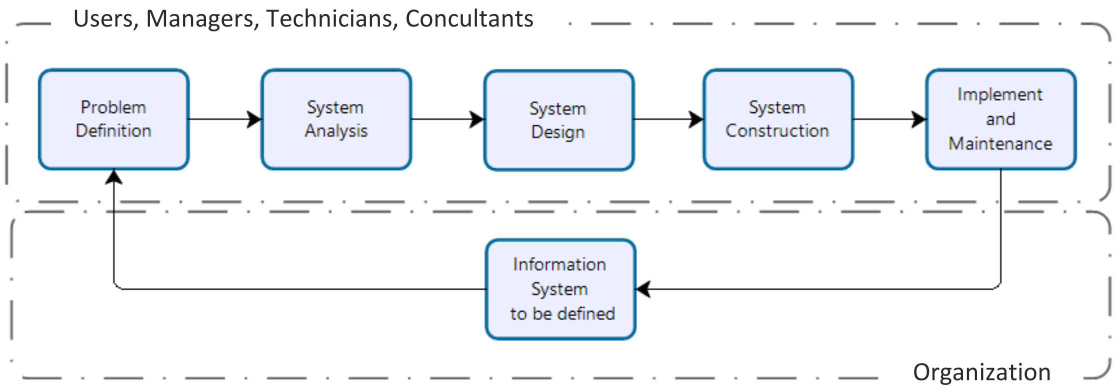


Figure 6 – Information System Development Workflow (Caro et al., 2003)

The system flow of information always begins with data collection, followed by setting tasks that allow the incorporation of new data without having drastic changes in the present situation of the company. The third step is the organization and data storage, so it can be easily and quickly located, when necessary. The fourth step is processing, by transforming raw data into quantified results, for future analysis, followed by the information's distribution. The last step is the use of information for decision making or management improvement (Gilman, 1977). A general overview of how an IS planning is made, according to, needed business project and consequent process, is described in Figure 7 (Baker, 1995).

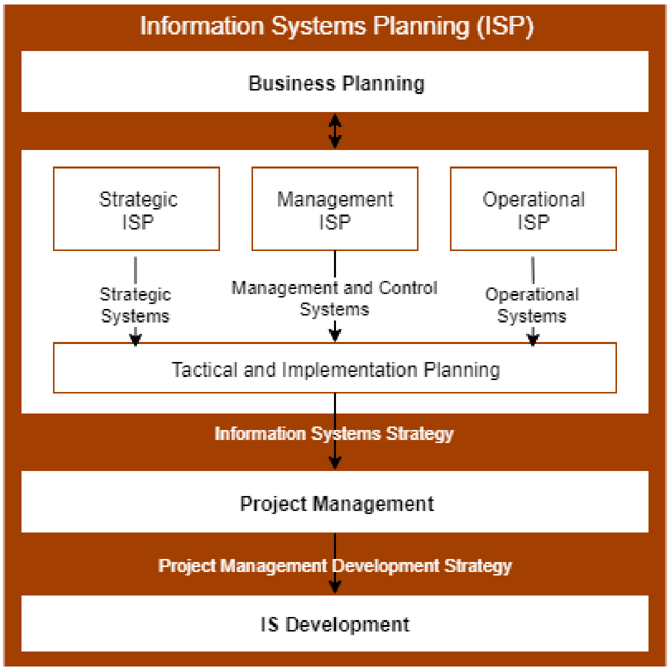


Figure 7 – Information System Planning (ISP) for Business Project Management (BPM), adapted from (Baker, 1995)

A set of components related to each other, which act in an environment with the purpose of achieving common goals with the ability to self-control, is designated as a system. All the systems are incorporated into other systems (meta-systems) and can always be divided into smaller systems (sub-systems) (Baker, 1995).

Types of Information Systems

Within an organization, an IS can be divided and classified into three structures (Baker, 1995). This hierarchical levels of an IS are directly related to the decision-making level, see Table 3, (OBrien, 2004).

Table 3 – Difference between MIS, DSS and EIS, adapt from (OBrien, 2004)

Information Systems	Description
Management Information System (MIS)	All type of information system that serves to support management.
Decision Support System (DSS)	Provide interactive information support to the decision-making process.
Executive Information System (EIS)	They combine many characteristics of the MIS and DSS

The growth of the demand for information, the increase in the amount of data generated and the greatest need for availability and control of this information for quicker decision-making lead organizations to a need of an interconnected set of IS.

In Figure 8, it is shown the structure from a standard system, where the outputs are the results of processed inputs, plus external Controls and Enablers (David D. Walden et al., 2015).

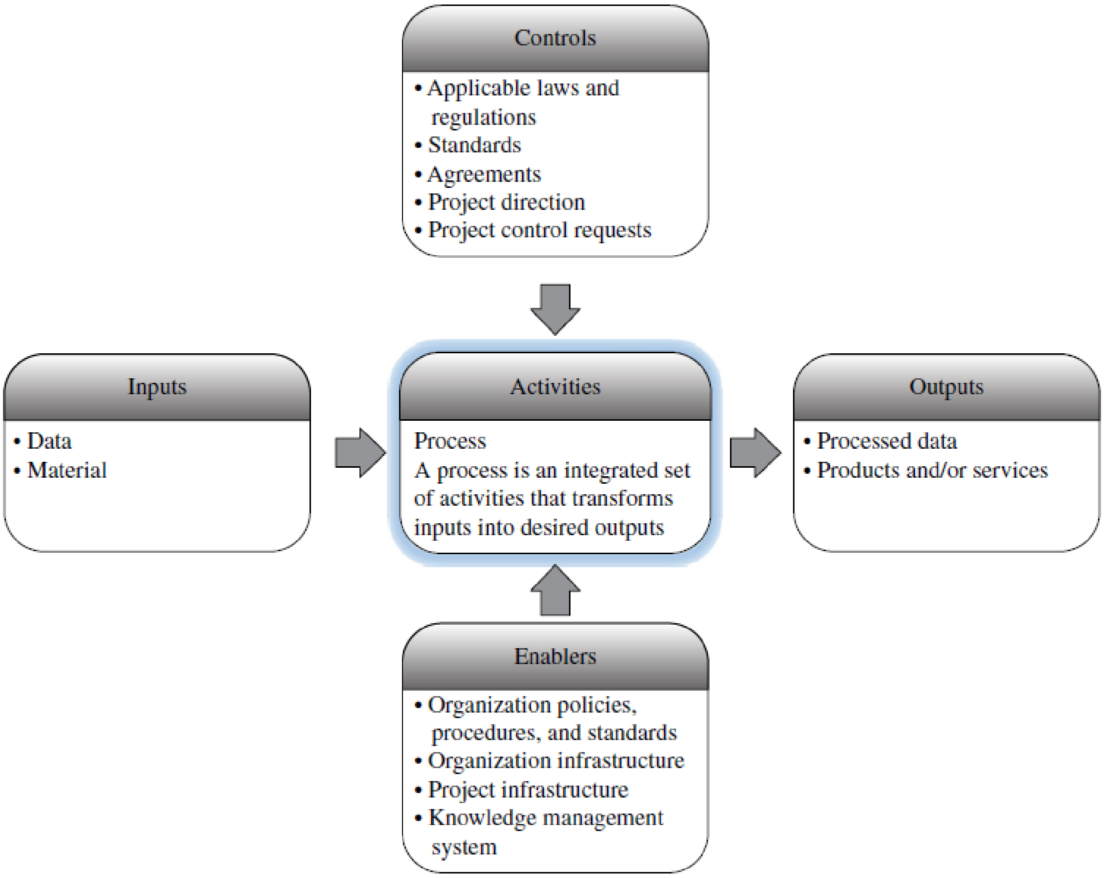


Figure 8 – Information Systems scope, adapted from (David D. Walden et al., 2015)

According to systems theory, a complex system is made of three fundamental sub-systems, see Table 4.

Table 4 – Sub-Systems from Management Information System, adapt from (Romero & Vernadat, 2016)

Systems	Context
Physical	The operative part made of physical components, including human and technical agents as well as material and physical flow.
Decision	The control part where organization, planning, decision and monitoring actions are made.
Information	Data processing part dealing with the flow of information as well as process, storage and retrieval actions on data, information and even knowledge.

The waste associated with the flow of information

The Information flow has always some kind of waste due to different causes. These are normally associated with (Gilman, 1977):

- Outdated documents or data;
- Lack of information;
- Divergent information;
- Incorrect data;
- Repetition of information.

The Information Systems goals

The main goals adjacent to the implementation of an information system normally are the ones described (OBrien, 2004; M. T. R. Pereira, 2003):

- All information technology supports and assists the Organization's strategies and objectives;
- Ensure greater control;
- Expand security and productive processes;
- Minimize associated risks such as loss of information;
- Broaden overall performance;
- Improve resource applications;
- Reduce costs associated with processes;
- Support in decision making.

2.3 Document Management Systems

A Document Management System (DMS) is an Information System (IS) which provides the management of the entire document information lifecycle, regardless the format in which it was originally created: paper, .pdf, .docx, .xlsx, .jpeg, .html, among others. More than that, DMS allows the analysis of unstructured information flows and the creation of routines and working methods in the organizations, improving their performance. It is noticeable, due to all changes occurring with the Industry 4.0, that the market for DMS is evolving, both on the supply and demand side (Ferreira, 2010).

Initially, DMS was associated with the process of paper dematerialization. However, today the concept has evolved and it is much more than just capturing, scanning, archiving and later querying documents (Manuel, Hernad, & González, 2013).

In this context, the time consuming involved in tasks of creating, searching, retrieving, updating and archiving documents are concerns, mainly in companies historically oriented to documentary production. The uncontrolled management of these contents, both internal and external, increases the time attributed to the documentary tasks, which is more valuable in the process's execution. With this massive physical documentation, organization can be hard to keep due to physical space necessity, having associated costs (Elói, 2010; Manuel et al., 2013).

The requirement to manage process documentation has been one of the driving forces behind the creation of the DMS, see Table 5.

Table 5 – Document Management System (DMS) Functions, adapt from (Elói, 2010)

A DMS stores, tracks document and supports the following aspects	
Versions and Timestamps.	The DMS will keep multiple versions of documents. The most recent version of a document is easy to identify and will be served up by default.
Approvals and Workflows.	When a process needs to be changed, the system will manage the access to the documents for editing and routing the document for approvals.
Communication.	When a process changes, those who implement the process need to be warned about the changes. A DMS will notify the appropriate people, when a change in a document is approved.

A DMS enables companies to manage all unstructured information, which is a deciding factor for their business. Then, a well stablished DMS should follow the next six concepts (Ferreira, 2010).

Dematerialization

This concept means digitization of documents, usually received in paper format. As a result, dematerialization produces electronic documents that are a photograph of the paper.

Standardization

The document management standardization allows the normalization of all types of documents of the company, internal and external entities and process uniformity, using always the same procedures.

Indexing

Index, catalog and categorize electronic document are equivalent to the physical file process, adding the benefits of applying an organized methodology into the IS.

Workflow

Control of the various states by which a document flow, including publication, approval, distribution and circulation of the file. This concept evolved in the industrial and business world referring to the taking place processes in the office or during manufacturing floor, "*Gemba*" (Caro et al., 2003).

Research

Implementation of a search engine capable of performing optical character recognition (OCR) on the scanned documents, allowing the immediate location of a document.

Cost Reduction

With the use of a document management solution comes the copies' cost reduction, increased productivity in search and rerouting of documents and the reduction of the physical file space.

ISO 30301 – Information and Documentation

The International Standards Organization (ISO) published the ISO30300:2011 and ISO30301:2011 as part of a series of standards, which aim to provide guidelines for improving the management of recording information. The first one is related with a standards' introduction, objectives outlines and principles of management system for records. The second one specifies the requirements to be accomplished by a management system of records (MSR) and the methods how an organization can be certified (Nurse, 2015).

Based on the analysis of the document requirements stated on "ISO 9001:2008 Quality management systems" and in the study of "ISO 30301:2011 Information and documentation - Management systems for records", document processes associated with Quality Management Systems (QMS) have been identified as an advantage taken of the current existing tools in any organization (Nurse, 2015).

The necessary steps to implement a proper ISO supporting DMS are the following ones (Bustelo Ruesta, 2012; Manuel et al., 2013):

1) Definition of document requirements;
2) Evaluation of existing systems;
3) Identification of Document Management strategies in the organization;
4) Design the DMS;
5) Implementation of the DMS;
6) Maintenance and Continuous Improvement of the DMS;

Once a Document Management workflow system is implemented the following advantages will come right away (Ferreira, 2010):

- Documents and associated process dematerialization;
- Management of the company's file in a centralized way;
- Standardization of documents, processes and procedures;
- Standardization of work processes;
- Speed in the availability, access and treatment of documents;
- Control of information flows (documents and processes);
- Gains in administrative efficiency and consequently reduced operational costs;
- Reduction of the need for physical space for files and cost with photocopies;
- Ability to measure resource efficiency;

2.4 Decision Support Systems

It must be said that all IS supports decision making, even if indirectly. These systems facilitate dialogue with users when they consider alternative problem solutions and the system provides database access and models constructed to present information (Prasad & Ratna, 2018).

A Decision Support System (DSS) is considered as a computer-based system which can help the decision makers to use models and data, to solve unstructured problems identified previously (Qaiser, Ahmed, Sykora, Choudhary, & Simpson, 2017). These systems provide automation to a variety of tasks, facilitating optimal decision-making within a given supply chain (Courtney, 2001).

They collect and analyse information from multiple sources to support decision-making at various hierarchical levels, supporting all data warehouse that contains historical and current data (unaggregated and aggregated) and external sources.

DSS are gaining popularity in various domains, including business, engineering, military and medicine. It can add human cognitive efficiencies by integrating various sources of information, providing intelligent access to relevant knowledge and by structuring process decisions (Prasad & Ratna, 2018).

A DSS, see Figure 9, performs the manufacturing process analysis, improvement and adaptation to projected changes in market conditions and production scheduling (Artiba et al., 2000).

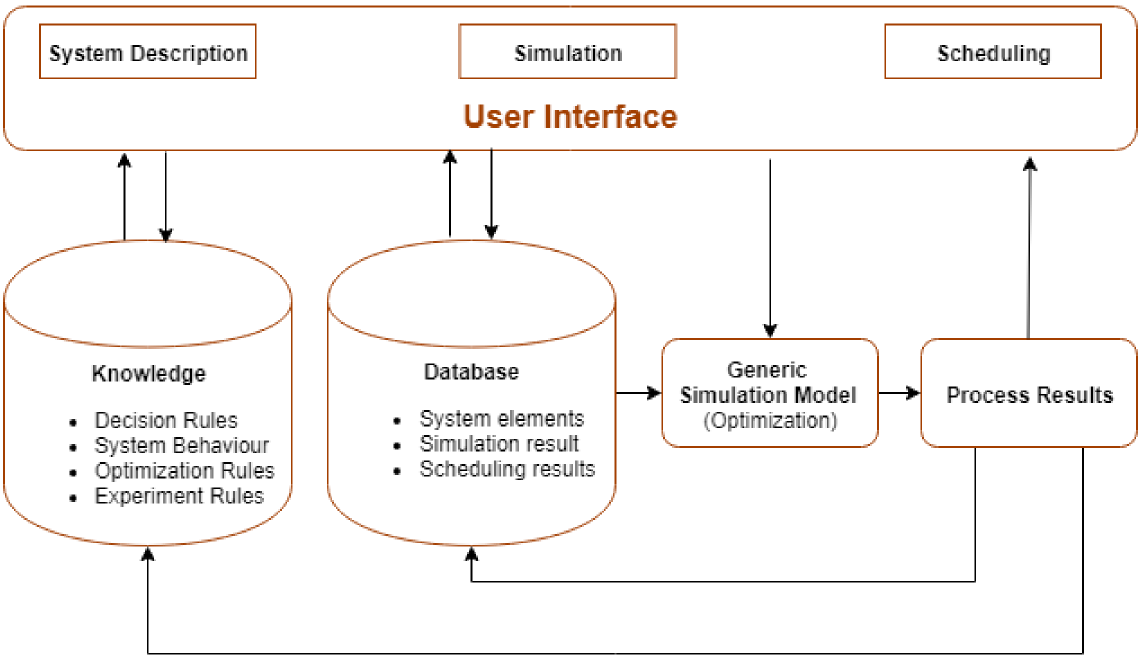


Figure 9 – The functional architecture of the DSS adapted from (Artiba et al., 2000)

2.5 Customer Relationship Management

In Industry 4.0, it is the customer who dictates how a product is designed, manufactured and delivered. Customer Relationship Management (CRM) systems help manufacturers understand the purchasing habits of their customers. In order to provide production flexibility for mass customization, manufacturers need firstly to know what their customers require. A good customer relationship provides a better understanding of his needs, leading the company to new strategies. There are three different types of CRM: the Operational, which focus on customer solutions, the Analytical, where data is collected for posterior analysis and the Collaborative, which integrates all points between company and customer (Fróis, Teresa Pereira, & Ferreira, 2019).

The principal difference between a DSS and a CRM is that the first one is a data focused system and it is oriented by a user, while the other is business and marketing driven, being responsive to the customer actions, in this case, stakeholders. These two types of systems are technically independent, but in practice they are related one to another, being, in most of the cases, implemented at the same time. They also complement different types of analysis of the company's knowledge (Misdolea, 2010).

The characteristics of this combination of systems are:

- Knowledge access;
- Knowledge communication;
- Use of knowledge;
- Representation of knowledge on all the organizational levels.

Many decisions concerning the improvement of future company's activity are based on the customer's behavior, which is evaluated by CRM functionalities. Then, all analysis are based on historical data and on the forecast for good production, purchasing and selling DSS information. While a CRM system is essential for business, a DMS is an essential office solution for information management, providing an effectively use of it and easier access to it. The posterior use of a DSS typically consolidate customer information from a variety of systems into massive data warehouses and use various analytical tools to organize it into different segments. They can guide about pricing, customer retention, market share and new revenues. (Fróis et al., 2019; Misdolea, 2010; Park & Kim, 2003).

2.6 Business Process Management

Business Process Management (BPM) became the framework that describes all the continuous improvement approaches to process management. Total Quality Management, Workflow Management, Lean Methodology and Six Sigma are now viewed as narrow areas of the larger BPM (Karout, Awasthi, & Mandal, 2017). Optimizing the performance and efficiency of organizations through process management is the main objective of this methodology. This methodology allows to reduce costs, operate expenses and cycle time of processes, increase the operational efficiency of companies and make them more competitive, see Table 6.

Business processes orientation to IS implies the convergence of organizational business and software models, providing a framework that allows a model design of technological implementation and organizational interdependence architecture. To this supported method, the scientific research call Business Process Model and Notation (BPMN) (Kalpič & Bernus, 2006).

Table 6 – BPM workflow, adapt from (A. Q. Pereira, Santana, & Frederico, 2016)

BPM workflow	Description
Initial needs analysis	Identify the process to be mapped, in addition to the duration, cost and its goal.
Documentation, design and analysis of the current process	Document, draw and analyse the existing process to improve the conditions of its execution and operation.
New process design and model	Model the new developed process to provide a better structure analysis and identification.
New process implementation	After modeling and simulation, the new process is implemented through several validations that ensure the success of its execution.
Process Management	The process is kept under control and monitoring to seek further improvements and initiating new needs analysis to keep the BMP lifecycle continuous.

Regarding the BPMN, the main purpose of modeling is that features of the business processes must be represented, giving a broad range of knowledge and better interpretation of whole system (Kalpič & Bernus, 2006; Montanus, 2016).

Understanding the goals of a process and then dramatically redesigning it from the ground up to achieve dramatic improvements in productivity and quality is called Business Process Reengineering (BPR) (Murray & Lynn, 1997).

2.7 Data Modeling

Modeling is an essential phase in software projects. The use of models ensures the complete and correct definition of functionalities, satisfaction of customer needs, robustness, security and other types of requirements before code development and implementation. This leads to a cost reduction that may arise from future changes which are difficult to carry out in unstructured architectures (Kalpič & Bernus, 2006; Scott, Wesley, Longman, & Harlow, 1999).

Unified Modeling Language (UML) is a standard modeling language applied in software and systems engineering (Scott et al., 1999). Then it can be divided in two different types of diagrams, see Figure 10.

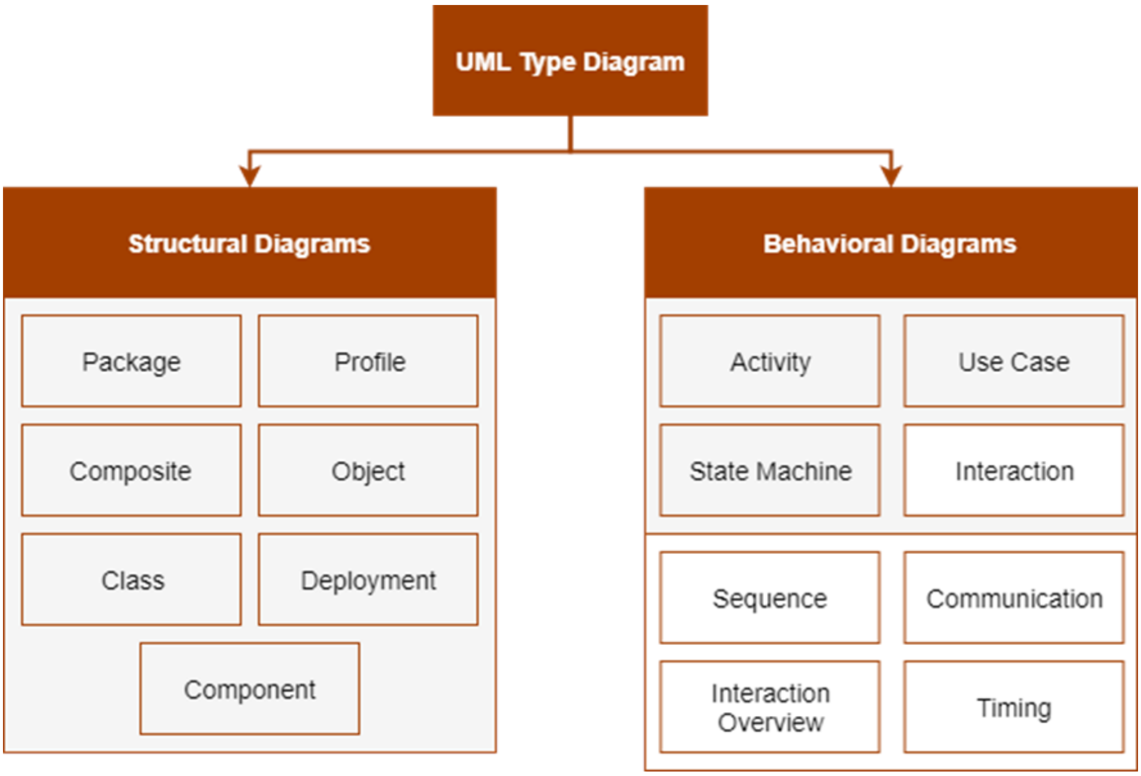


Figure 10 – UML Diagram Types, adapted (Scott et al., 1999)

On the left side, it is represented the static structural diagram, composed by objects, attributes, relationships and operations, including class diagrams. On the right side, it is represented the dynamic behavior diagram, which shows the collaboration among objects and changes in objects' internal state, including the sequence, activity and state diagrams (Lin, Yang, & Pai, 2002).

Structure diagrams are used to document the architecture of software systems and are involved in modeling of the system. Table 7 presents the different structure diagrams (Lin et al., 2002).

Table 7 – UML Structure Diagrams Functions, adapt from (Scott et al., 1999)

UML Structure Diagrams	Context
Class Diagram	Represents system class, attributes and relationships among the classes.
Component Diagram	Represents how components are split in a software system and dependencies among the components.
Deployment Diagram	Describes the hardware used in system implementations.
Composite Structure Diagram	Describes the internal structure of classes.
Object Diagram	Represents a complete or partial view of the structure of a modeled system.
Package Diagram	Represents the splitting of a system into logical groupings and its dependencies.

Behavior diagrams, as already mentioned, represent the functionality of processes, the software system and it emphasize what must happen in the system when being modeled. In Table 8, all the behavior diagrams functionalities are described.

Table 8 – UML Behavioral Diagrams Functions, adapt from (Scott et al., 1999)

UML Behavior Diagrams	Context
Activity Diagram	Represents step by step the workflow of business and operational components.
Use Case Diagram	Describes functionality of a system in terms of actors' goals.
UML State Machine Diagram	Represents states and state transition.
Communication Diagram	Represents interaction between objects in terms of sequenced messages.
Timing Diagrams	Focuses on timing constraints.
Interaction Overview Diagram	Provides a nodes overview, for communication diagrams representation.
Sequence Diagram	Represents communication between objects in terms of a sequence of messages.

2.8 Systems Engineering Methodology

The Industrial Engineer (IE) has a well-established reputation for effective computer utilization in areas of scheduling, simulation, inventory control, forecasting and operations research. The IE role to develop and maintain computerized administrative IS are less visible (Gräßler & Yang, 2016; Muller, 2013).

The system engineering through the vision of an IE has the following workflow, see Figure 11.

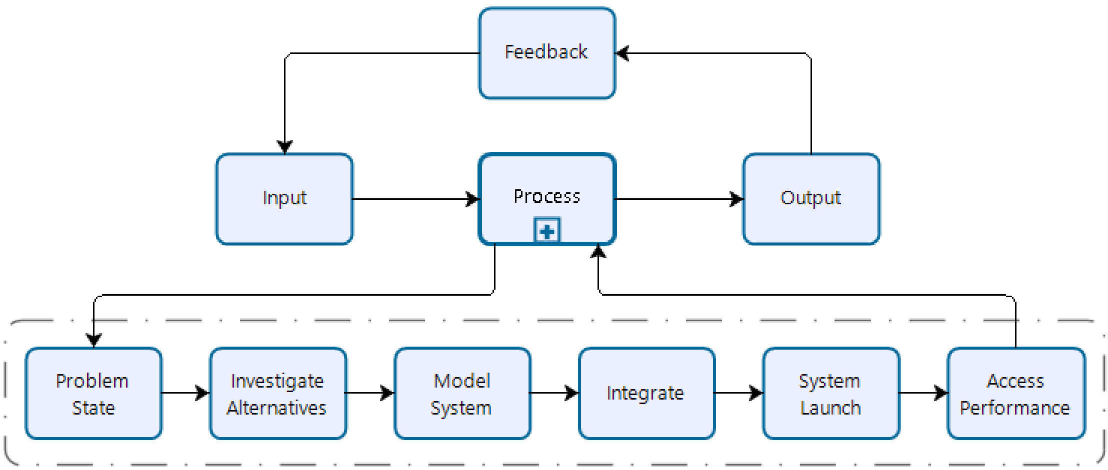


Figure 11 – Industrial Systems Analysis workflow, adapt from (David D. Walden et al., 2015)

The additional skills and techniques required to fully complement the systems development process are, for the most part, traditional industrial engineering functions (Muller, 2013).

Systems Engineering (SE) is used interchangeably with Industrial Engineering (IE), aiming the creation of a new system or improve an existing one. The word "system" is meant to remind the IE of three key points (Gräßler & Yang, 2016; Martin-Vega & Maynard, 2004):

1) Components, including machines and people, interact with each other to create the overall behavior of the system;
2) The system being studied is always a subsystem of a larger system and these interactions must also be considered;
3) Systems are a caution against sub-optimization of the meta-system through optimization of a subsystem.

2.9 Engineering Requirements

Currently, the use of IT is an integral part of the reality of daily work in organizations, reinforcing its structure and processes and allowing the control and coordination of the various activities associated with its business.

Requirements Engineering, Table 9, aims to develop methodological tools to guide the definition of IT application requirements that can serve human capital in organizations and make more efficient processes. It is a method that encompasses a structured set of activities to produce document requirements and an integral part of the *Software* engineering (Muller, 2013; Murray & Lynn, 1997).

Table 9 – Requirements Engineering categories, adapt from (Murray & Lynn, 1997)

Requirements	Context
Functional	Describe what the system is expected to do, being related to functionality that the system should run or with information it should maintain. They cover the description of inputs and outputs of information that result from the interaction between users and systems.
Non-Functional	Qualitative system properties, describing attributes and overall qualities that the system should provide to functional requirements, such as performance measurements or security considerations.
Development	They describe constraints to the system development process and are not noticeable by the users.
Ease-of-use	They aim to ensure that the developed system, its users and tasks to perform interact easily.

All the definitions of requirements must be preceded of a technical framework and human possibilities with the strategy of the Organization. Only the satisfaction of all interested elements (Stakeholders) can result in a viable project (Gräßler & Yang, 2016; Muller, 2013).

Identify and analyse the problems in the perspective of direct users of the system, obtaining the requirements for it. Once identified the functional and non-functional requirements, it is important to classify them, providing a more global view and the resolution of possible conflicts. At this stage, it is also made a requirement prioritization, followed by a final confirmation to validate them (Gräßler & Yang, 2016).

The production phase of the document requirements usually comprises three types of specifications (Muller, 2013):

- User requirements – it is intended for the various hierarchical levels of the organization and should describe what the system should and must do in a simple language.
- System requirements – it has more technical character and the language used is more complex and structured.
- Design of the application – describes the system architecture and the details about its implementation.

At this stage, consistency, compliance with norms and other parameters of the system requirements are set. Validation is done through various techniques such as revision of the requirements, the prototyping and testing (Gräßler & Yang, 2016).

2.10 Lean Manufacturing

Nowadays, in order to have a competitive industry, lean implementation is a current process in automotive industry. This cannot be achieved without experimentation and innovation, being a fundamental step the lean and agile methodologies implementation, where rethinking with redesign and continuously improvement actions must be done.

Reducing waste, reaching the market on time and managing manufacturing stocks that are highly responsive to customer demand, while producing quality products in the most efficient and economical manner, are the main goals of the lean manufacturing (Rahman, Sharif, & Esa, 2013).

Toyota Production System (TPS) philosophy has two main goals, both described by Liker and Morgan, 2006, as "Cost reduction through the elimination of waste" and "Full utilization of worker's capabilities". This represents the basis for the creation of lean thinking (Lander, Liker, Arbor, & Arbor, n.d.). However, Liker argues that TPS is a production system in which all parts involved aim to increase quality and safety in one way and reduce costs and lead times in another. The TPS principles, values and culture are described, in Figure 12, by the TPS house.

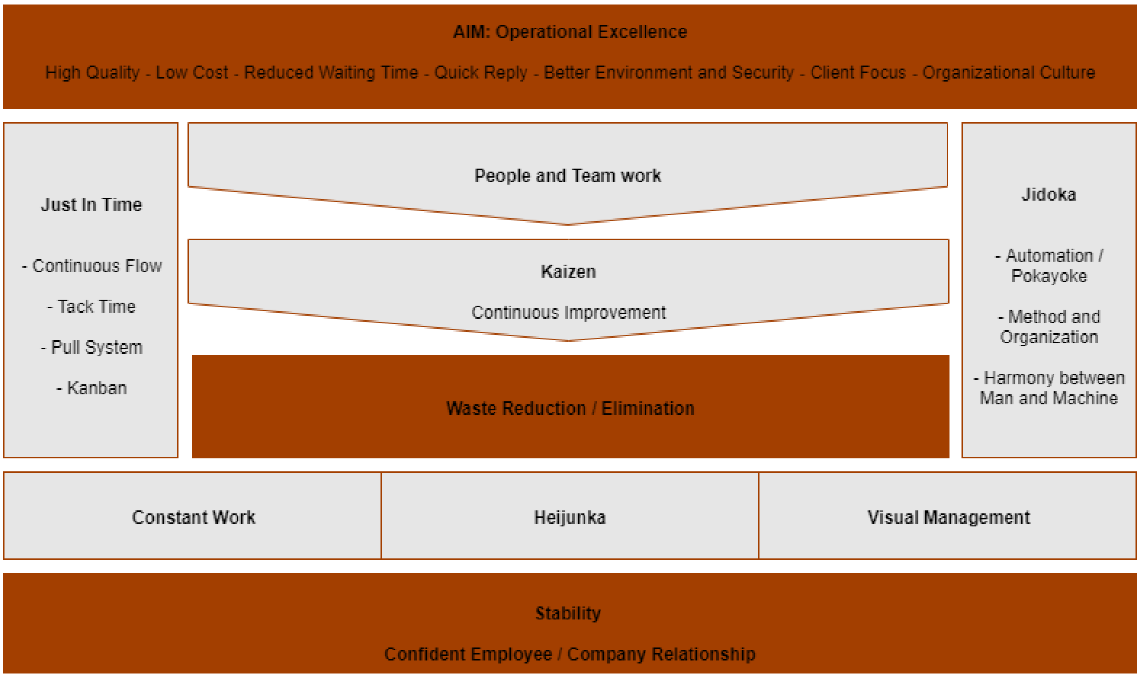


Figure 12 – Toyota Production System House (TPS) adapt from TCAP-Ovar

Kaizen

According to Daily, Kaizen refers to the philosophy of continuous improvement, which involves all employees, aiming the continuous evaluation and improvement of all processes, such as time, resources, quality and other aspects that contribute for the stakeholder's satisfaction (Imai, 2012). The continuous improvement is generated according to principles, as seen in Table 10 (Coimbra, 2013).

Table 10 – Kaizen Goals, adapt from (Coimbra, 2013)

Kaizen Goals	Context
Focus on Quality	To put the quality first, given the fulfilment of the customer's needs, which allows the creation of upstream improvements.
Go to the Gemba	The systematic presence in the place where the actions value the product, what provides the detection of problems that allows the continuous improvement of the processes.
Waste elimination	Identify and eliminate three types of waste: "*Muda*" means waste; "*Mura*" means features variation, fluctuation and irregularities; "*Muri*" represents excesses and overloads.
Employees Involvement	For each type of improvement there is, a routine change that must be adopted by a group of collaborators.
Visual Management	Based on the importance that the steps of the process have all structured in clear and visible way.
Process and Results	The goal set and the method to achieve results are important, given that for the whole process to be focused on achieving the same goals should be analysed in detail.
Pull approach	The demand of the client is what initiates the flow of material, and for the order to be satisfied, the supply chain is organized with the aim of optimizing the flow of material and information.

Each step given in the direction of process continuous improvement is sustained by a cycle called PDCA, described later on this chapter.

Muda

The word "Lean" in manufacturing means zero waste produced. "Muda", the Japanese word for waste, has seven different types of sectors where it must act (Rahman et al., 2013). In the following table, the seven wastes and contributions to the occurrence of them are presented, see Table 11.

Table 11 – Seven wastes descriptions, adapt from (Protzman, 2016)

Muda	Definition
Over-Production	Produce more than the customer needs; for stock based on sales forecast providing, high product in stock; Process large batches to generate more output; Transport in large quantities to reduce transport costs.
Transport	Product movement that does not add value; Unnecessary expense of capital, time, energy and movements between warehouses.
Movement	Product movement that does not add value; Disorganization of workplaces; Incorrect layouts.
Waiting times	Free time because the materials, people, equipment or information are not ready; Results in irregular streams, as well as in long lead times.
Over-Processing	Effort that does not add value from the customer's point of view; Incorrect use of equipment, tools and resources.
Inventory	Many storage locations. Results in excessive costs, low performance and poor customer service; Have higher product and material quantities than needed, resulting in planning errors.
Defects	Process and Product quality problems; Rework; Mistakes or lack of something needed.

According to Taiichi Ohno, the seven wastes are the process activities which do not add any value to the customer, just to the product cost. The identification of waste is not an easy task, being sometimes perceived as part of the process. Therefore, it is important to know how to identify and act in the reduction of "*Muda*" (Protzman, 2016; Rahman et al., 2013).

2.11 Lean Methodology and Tools

For elimination of existing problems throughout the value chain, there are several lean tools that can be implemented. Along this section, it will be presented, in a simplified way, several existing lean methodologies and tools (Sokovi, Jovanovi, & Vujovi, 2009).

The choice of the right tools is critical for the best problem solution achievement, so it should be mentioned that more emphasis will be given to the crucial tools for the development of this dissertation.

PDCA cycle

The following cycle consists in four stages: Plan, Do, Check and Act. It is a problem-solving methodology with clear goals established and creates a repetitive process of continuous improvement are points that make the current methodology (Sokovic, Pavletic, & Pipan, 2010).

In Table 12, the main objectives from the different stages are described.

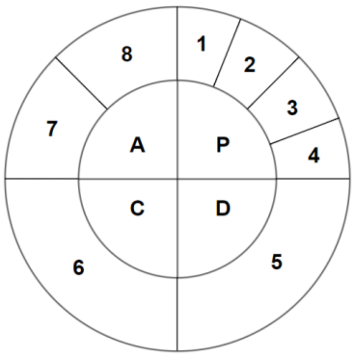
Table 12 – PDCA Cycle, adapt from (Sokovi et al., 2009)

PDCA	Context
Plan	Define the action plan to achieve the objective.
Do	Implement the action plan.
Check	Check whether the implementation continues in the right path and whether it causes the intended improvement.
Act	Define and standardize new procedures, to prevent repetition of the original problem.

The PDCA methodology has a continuous improvement cycle that aims to improve the system with the cyclical process realization. Although the resolution of critical problems in the system is established as a priority in a PDCA cycle, it also must be applied to any process optimization. The fact that the cycle is application-capable in different environments makes it universal and thus useful to use (Sokovi et al., 2009).

Below, on Table 13, shows which are the leanest used tools for each phase of the project development.

Table 13 – PDCA Tools, adapt from (Sokovi et al., 2009)



	Identification and description of the problem	Observation of the problem and Process Analysis	Cause identification/analysis	Realization of the plan of actions	Do	Check Results	Act
Brainstorming	X		X	X	X		
Pareto diagram	X	X			X		
5W1H	X			X			X
Stratification		X				X	
Flowchart				X		X	X
Histogram / Bar Chart		X	X			X	
Ishikawa diagram			X				
PERT diagram				X			

Ishikawa Diagram

This tool allows to group and visualize the various causes that are at the root of problems or situations that are intended to improve. After grouping the causes, it is possible to identify mutual relations between the factors involved.

Developed in 1943 by Kooru Ishikawa, it is also known as a fish spine diagram or a cause-effect diagram, see Figure 13. Generally, its elaboration is done by working groups involving all the agents of the process under review (Gwiazda, 2006).

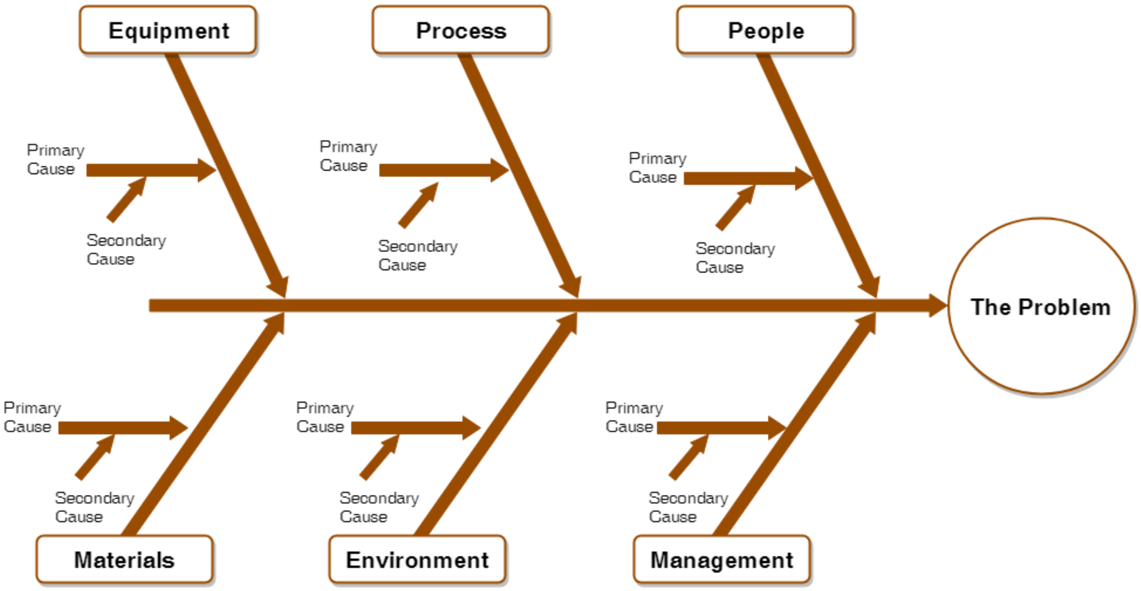


Figure 13 – Ishikawa diagram

After identifying the problem, the possible causes are enumerated. The problem is displayed at the end of the horizontal arrow. The causes are actively and synergistically thought to represent the group's knowledge of the problem and are represented by arrows extending to the main arrow and may still contain causes.

5 Why's

The Five Why's, are a question-answer technique that aim to deepen the brainstorming with the Ishikawa diagram, exploring the identified causes-effect relationships.

It is a lean tool that aims to discover the origin of the causes that are associated with the problem in analysis. The iterations must be made until the root cause is identified, without necessarily being asked the five questions. Then, when the root of the problem is found the solution starts being built. (Sokovi et al., 2009).

Flowchart's

The process-mapping method involves flow diagrams systems. It is a particularly useful method for the system definition, as inputs and outputs are identified during the mapping process (OBrien, 2004; Sokovi et al., 2009)

The term *Flowchart* designates a graphical representation of process or workflow. They are used to describe various situations, actions and processes in a sequential order that represents an algorithm or a workflow. Through this graphical representation, it is possible to easily understand the transition of information or documents between the elements participating in the sequence concerned. In Figure 14, it can be seen an example of the DMAIC methodology flow.

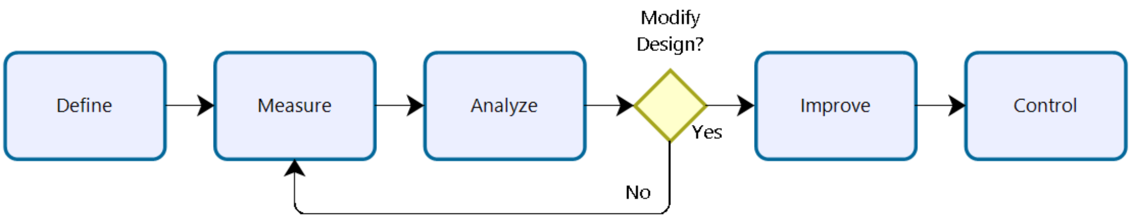


Figure 14 – DMAIC Flowchart, adapted from asq.org website

This tool is fundamental for the continuous optimization and improvement of the processes developed in each department of the organization. The layout simplification allows better understanding of the process, the consequent detection of incoherent routines and opportunities for improvement (OBrien, 2004; M. T. R. Pereira, 2003).

2.12 Lean Methodology in IT processes

This methodology supports process improvement by providing the right information, at the right time, in the right format, to the right audience. The usefulness of information is determined by the nature of work being performed (Martin, 2009).

In a lean IT team, an example of overproduction would include producing software code in anticipation of customer needs or known requirements, see Table 14.

Table 14 – Seven major forms of waste in Software development, adapt from (Martin, 2009)

Muda	Definition
Over-Production	Producing software code or other functionality in advance of requirements.
Waiting	Team members have no work due to many causes.
Transportation	Information or materials are moved through several intermediaries.
Inventory	Software code or other functionalities built in advance of customer or business needs.
Over-Processing	Adding non-essential design, service features or functions to a product.
Over-Movement	Unnecessary work activities at an individual level, including looking for tools and information.
Defects	Work that does not meet requirements and must be redone, waste of time and money and, in some situations, the reduce of customer satisfaction.

Relatively to the process standardization, which creates efficiency, an IS should be designed to reinforce explicitly defined procedures. Efficient processes are fortified when an IS automate routine tasks, such as mistake-proofing data entry and providing feedback for ongoing improvement (Grieves., 2006).

Agile Methodology

Agile is a development software methodology which main goal is to build a software, incrementally using short iterations, so that the development process is aligned with the changing business needs (Beck et al., 2001).

Instead of a single development from 6 to 18 months, where all the requirements and risks were predicted upfront, Figure 15, this methodology adopts a process of frequent feedback where a workable product is delivered after 1 to 4 weeks iteration, Figure 16.

Figure 15 – Traditional methodology of software development

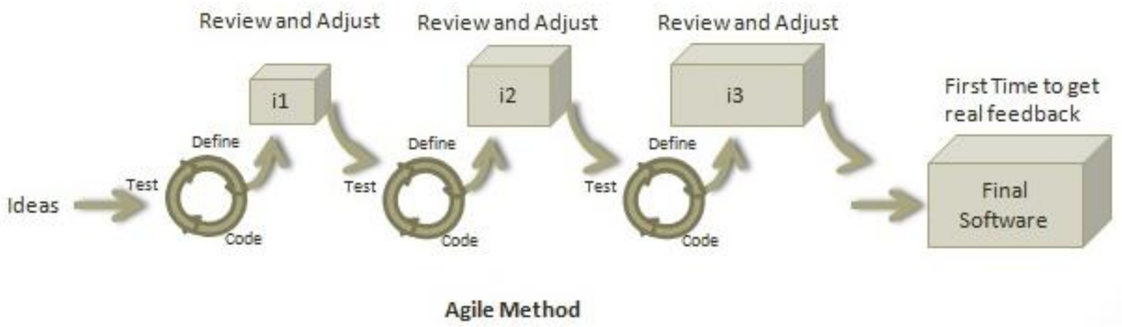


Figure 16 – Agile methodology of software development

The goal of the agile methodologies is to provide the flexibility of an iterative approach, while ensuring a quality product. This recent method has twelve essential principles, all mention in the Table 15 (Beck et al., 2001).

Table 15 – Agile Methodology Principal, adapt from (Beck et al., 2001)

Principles	Context
Customer satisfaction	Highest priority is given to satisfy the requirements of customers through early and continuous delivery of valuable software.

Embrace change	Changes are inevitable during software development. Ever-changing requirements should be welcome, even late in the development phase.
Deliver working software	Deliver a working software, ranging from a few weeks to a few months, considering shorter time-scale.
Collaboration	Business people and developers must work together during the entire life of a project.
Motivation	Projects should be built around motivated individuals. Provide an environment to support individual team members and trust them to make them feel responsible to do their job.
Conversation	Face to face conversation is the most efficient and effective method of conveying information to and within a development team.
Measure the process	Software must be working and it should be the primary measure of process.
Maintain constant pace	Agile processes aim towards sustainable development. The business, the developers and the users should be able to maintain a constant pace through the project.
Monitoring	Pay regular attention to technical excellence and good design to enhance agility.
Simplicity	Keep things simple and use simple terms to measure the work that is not completed.
Self-organized teams	An agile team should be self-organized and should not depend heavily on other teams, because the best architectures, requirements and designs emerge from self-organized teams.
Review the work	Review the work done at regular intervals so that the team can reflect on how to become more effective and adjust its behavior accordingly.

Daily Kaizen Meeting vs Daily Scrum

One of the practices used in the IT sectors is the application of the Scrum methodology, based on daily scrum meetings, transported every day by a sprint, which are usually in the same place, at the same time. The main purpose of these meetings is to frame the entire team about the work to be done on that day, so that's the reason for taking place in the morning, before work starts. These meetings are short, approximately fifteen minutes, in order to keep a lively and relevant discussion (Beck et al., 2001; Monteiro, 2014).

The same concept is set in TCAP-Ovar, where short-term daily meetings are stablished, designed by daily Kaizen meeting. The projects under development following the PDCA methodology are exposed into the room white board, as seen in Figure 17.

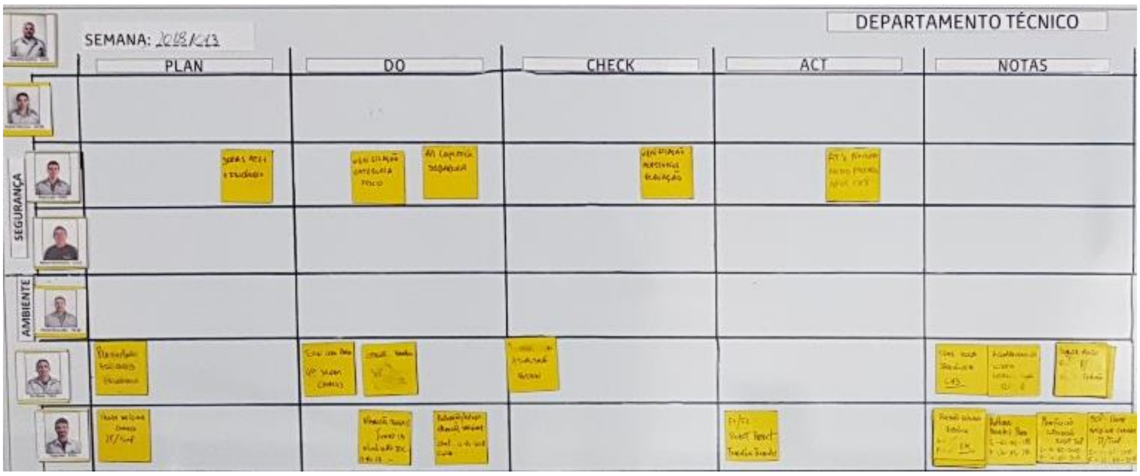


Figure 17 – TCAP Engineering department PDCA board

Therefore, both methodologies have the advantage time reduction during information transmission between team elements, avoiding errors.

Despite the similarities, the scopes of the two meetings are different. The Daily Scrum meetings are focused on projects, where participants discuss only project's issues and the meetings only exist if the project sprint lasts. On the other hand, the daily Kaizen meetings are made every day, regardless the projects in which they are involved (Monteiro, 2014).

2.13 Articles analysis

In the literature review, it's possible to find several articles about analysis, design and implementation of different IS.

By adopting the business process strategies, capable of significantly increase its decision-making capability along with the optimization of all document management, the following articles, Table 16, were studied with more emphasis.

Table 16 – Articles analysis for the literature review

Work References	Article Description
(Artiba et al., 2000)	A Decision Support System (DSS) is presented in this paper. This DSS analyses the performance of manufacturing systems in a Business Process Reengineering (BPR) phase. The created DSS is used to control the reorganized manufacturing system. The operational architecture of the DSS is also illustrated with a demonstrative example derived from a real industrial application.
(Courtney, 2001)	Decision Support Systems (DSS) must embrace procedures that can deal with this complexity and go beyond the technical aspect. Organizational decisions of the future may include social, environmental and economic concerns. This paper discusses the DSS designed to deal with wicked decision situations and knowledge management in organizations.
(Gräßler & Yang, 2016)	In this article, Systems Engineering (SE) methodology is discussed. This type of engineering is used in product development to support interdisciplinary collaboration and to manage rising complexities at a given time and cost. Based on a comparison between current production system development procedures and Systems Engineering (SE) methodologies. Potential improvements are identified and a tailored production system development approach is presented.
(Kalpič & Bernus, 2006)	The article discusses the role and contribution of Business Process Modeling (BPM) and its basic concepts. It also presents definitions and concepts of major knowledge categories, processes and resources.

(Karout et al., 2017)	This paper shows how companies can use a systematic approach, such as DMAIC, to eliminate errors and improve efficiency. It helps them to identify and implement improvements that leads to an increased confidence in the quality of the product produced at all levels.
(Lin et al., 2002)	This paper proposes a generic structure for modeling business processes to capture essential concepts of business process and represent them structurally. The generic structure possesses two main features suitable for business process modeling: one represents a business process in various concerns and multiple layers of abstraction and the other lowers the barriers between process representation and model analysis by embedding verification and validation with the model. Also, in this paper, a generic modeling method is illustrated by an order fulfillment process in a supply chain network.
(Murray & Lynn, 1997)	The inflexibility of older IS/IT constrained growth and competitiveness, leading to a substitute processes development. Newer IS/IT provides better flexibility, however to leverage this for competitive advantage, business processes and IS/IT must be brought together. Therefore, organizations must turn to Business Process Reengineering (BPR) and successfully deal with the resulting change management issues.
(OBrien, 2004)	Information Technology provides a powerful managerial resource that can help in the management of business operations, make better decisions and gain competitive advantages. Its goal is to help students become managerial end users who can propose and participate in developing information systems solutions to business problems. This text is distinguished from the competition by its extensive use of up-to-date case material.

THESIS DEVELOPMENT

Data Flow Diagram

Use Case Diagram

Flowchart

Activity Diagram

Sequence Diagram

Entity Relationship Diagram

Class Diagram

Package System Diagram

5.2 Business Process Modeling and Notation for the 2nd System

Data Flow Diagram

Use Case Diagram

Flowchart

Activity Diagram

Sequence Diagram

Entity Relationship Diagram

Class Diagram

Package System Diagram

6.1 1st System concept solution

6.2 2nd System concept solution

6.3 Process Management

Implemented kaizen for the 1st system developed

Implemented kaizen for the 2nd system developed

3 Problem Registration

Along this chapter, both projects' initial situation will be described, followed by the identification of problem causes with the respective measurements to be done. The goals for the solution implementation will be also described.

3.1 Description of the initial situation

1st Problem

The first project being developed was the optimization of the entire process of ordering and returning material to the main warehouse. All type of material, including the raw material, specifically used to build the car, had to be required from the Team Leader (TL) by filling a small paper and delivered to the main warehouse. Per year, an average of 7800 sheets of papers are produced through all factory sectors, giving a cost of 240€. This excessive production of paper is a big problem for every company, because it is a process with a considerable amount of waste and cost associated, due to all physical dossier produced to keep all the historic information traceability from the required material.

Regarding the first problem mentioned, its initial situation is shown on Table 17, followed by its initial state workflow in Figure 18.

Table 17 – 1st Project Initial State Problems

Process initial state problems (Current state)
Sheets with defined layout for detailed filling of the material to be ordered and returned;
In some cases, after filling, the user would have to move to the warehouse to associate the SAP number of the respective materials;
Displacement for delivery of the document;
After delivery, there is a wait for the warehouse to prepare all the intended material;
Errors in filling the sheets lead to a high correction by the warehouse.

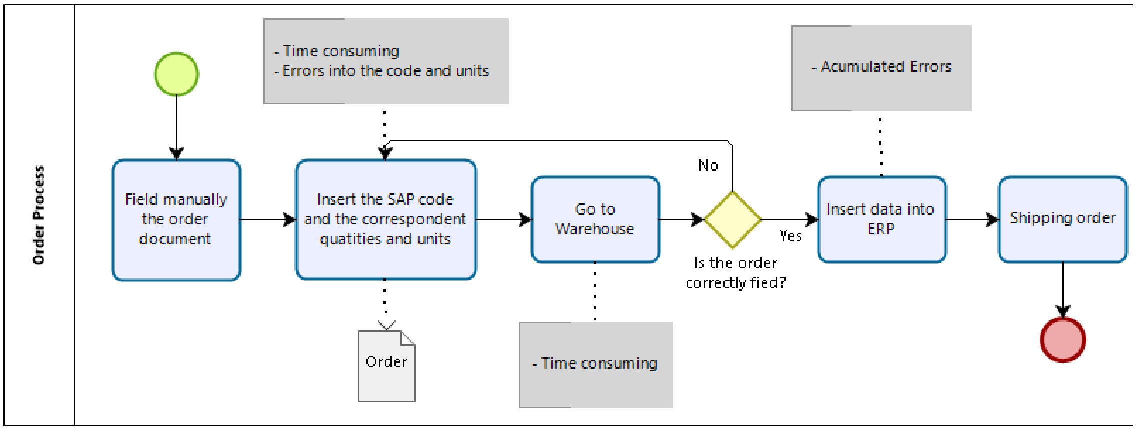


Figure 18 – 1st process initial state workflow

2nd Problem

A logistic database optimization was the second project to be developed. The main goal from this database was to register any change of material occurred into the assembly of the product built, the Land Cruiser 70 series (LC70), during the process. With this, it was also intended to provide a more productive way to their maintenance, support the reduction of time decision making and increase the speed of providing all materials to the different plant sectors. When any change occurred into database, an email from Japan was sent, with an attached document with the required needs. The engineering team had to proceed to the change registrations. These changes were done into an Excel datasheet composed by 120.000 data cells.

The initial situation of the second problem's process is listed on Table 18, following by the initial workflow process in Figure 19.

Table 18 – 2nd Project Initial State Problems

Process initial state problems (Current state)
The database maintenance of the LC70 components were made into an Excel sheet;
Database composition of 3000 lines and 40 columns of data;
This amount of data led to a non-flexible way to search or edit the needed data;
There was not any historic data from the changes made into the database.

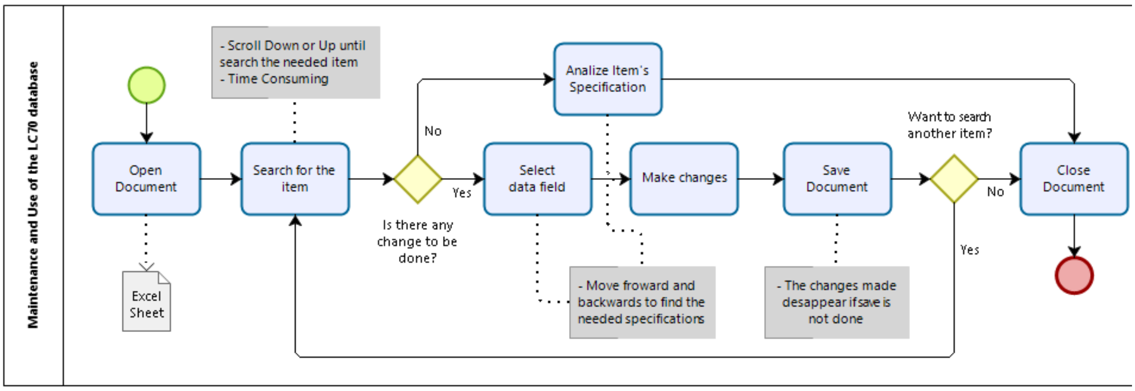


Figure 19 – 2nd process initial state workflow

3.2 Causes of the problem

In general, the several problems detected before the IS implementation in both projects were the following ones:

- Difficulties in searching information;
- Register information errors;
- Lack of rigor in the contents of the documents;
- Lack of adequacy of process information;
- Delays in the execution of whole process;
- Inappropriate visual management;
- Excessive number of actors in the process.

1st Problem

The whole process of the material order and return was done on paper, which means there was an excessive amount of paper waste for a simple request process with an inherent standard volume of information. It is clear that every time a transition from the physical to an electronic process occurs, almost all paper that used to be used is eliminated, leading to a cost reduction.

The flow from all the ordered procedure was studied and analysed, from the data inputs to the defined outputs. For a comprehensive analysis of the evidence mentioned above, several brainstorming meetings were done, where the Ishikawa diagram lean tool, Figure 20, was used.

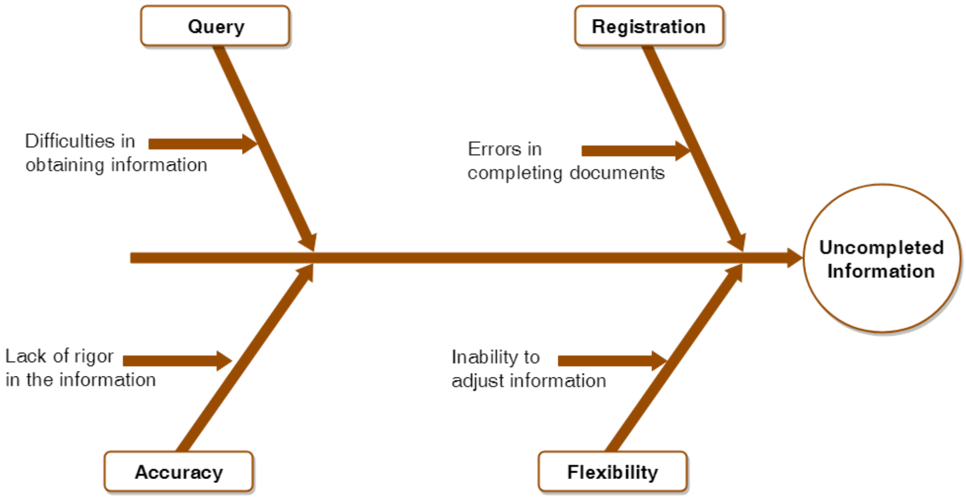


Figure 20 – 1st Project Ishikawa Diagram for problem causes detection

In a first approach, it was concluded that inside the information registration occurs most of the problems verified. On the other hand, rigor and flexibility were identified as two fundamental factors for managing the flow of information associated with the process. It is critical that information is error-free and similarly that relevant information cannot be omitted.

After detecting the main causes of the problem, it is necessary to identify the roots of it. For that analysis, it was applied the 5Whys lean tool, as seen in Table 19.

Table 19 – 5Whys tool applied for the 1st system problem detection

Problem	**Difficulties in obtaining information**
Why?	Unfilled Information fields.
Why?	Dispersed Information.
Why?	Inappropriate Information.
Problem	**Errors in completing documents**
Why?	Human error.
Why?	Lack of concentration.
Why?	High time-consuming for the document to be filled.

Problem	Lack of rigor in the information
Why?	Omission of information.
Why?	Unreadable calligraphy.
Problem	**Inability to adjust information**
Why?	Unnecessary Information.
Why?	Omission of relevant Information.

The roots of the causes that generated the main problems were detect after two or three iterations. It was then concluded that the difficulties in obtaining information were due to inappropriate information given. The constant errors in completing the document for proceed the order was related to high time consuming. The unreadable calligraphy was the main cause of the lack of rigor of the information given to the warehouse. Finally, the constant omission of relevant information was the main cause of the warehouse workers inability to adjust the received information.

2nd Problem

The method used in the second problem analysis was the same used in the first one, see Figure 21. The database maintenance was not a very intuitive process, requiring a lot of time searching and data organization.

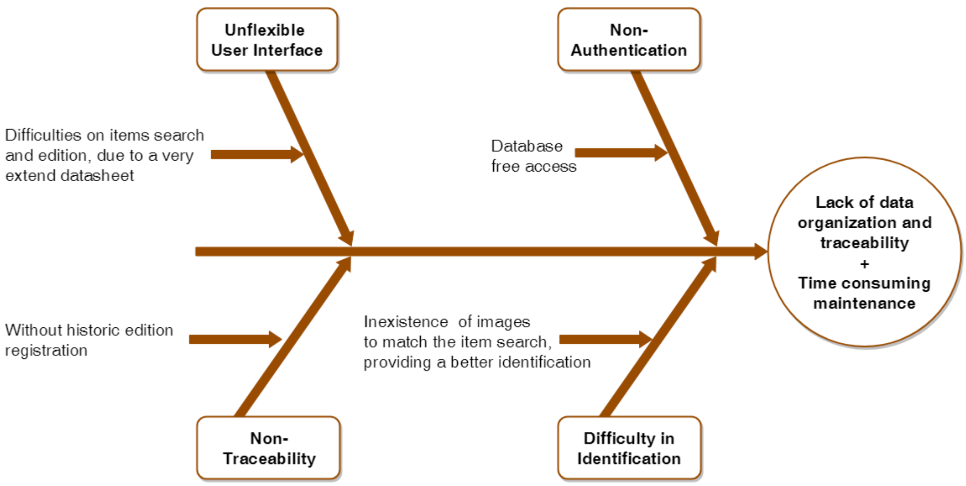


Figure 21 – 2nd Project Ishikawa Diagram for problem causes detection

It turns out that the nonflexible User Interface (UI), the absence of authentication, the traceability inexistence and the difficulty in components identification were the main causes of the lack of organization and data logging, plus the excessive maintenance time problems.

As the same way as it was applied into the causes roots identifications of the first problem, the 5 Whys lean tool was also applied to analyse this second root causes problem, as seen in Table 20

Table 20 – 5Whys tool applied for the 2nd system problem detection

Problem	**Difficulties on items search and edition**
Why?	The user needs to scroll up and down and move forward and backwards, every time he needed an item specification
Why?	Existence of a large database layout sheet
Why?	The database is composed by 3000 lines plus 40 columns
Problem	**Database free access**
Why?	To provide access and flexibility to the respective users.
Why?	Everyone should make the needed changes.
Why?	For faster database maintenance.
Problem	**Without historic edition registration**
Why?	The items' editions are not notified into the database.
Why?	Inability to create a traceable sub-system into the database.
Problem	**Inexistence of images for better identification**
Why?	Inability to integrate the *.jpeg* files into the database layout of the current system.
Why?	Code development is needed for data synchronization.

In this second problem it was not needed a deep analysis due to the obvious inherent main problems associated. The difficulty in searching and editing an item was due to an extended layout database, composed by 3000 lines and 40 columns. The user needed to constantly scroll the layout up and down, which meant a high-time consuming process.

The reason why the database had free access was to provide a faster maintenance, enabling all the users to the respective changes. On the other hand, the inability to create a traceable sub-system for the database registration was the main cause of the historic inexistence. Finally, it was also concluded that the inability to provide the items respective images into the database was due a systems incompatibility.

3.3 Measurements

After the causes analysis being made, it was concluded that automating processes, integrating dispersed information and creating a database for better information processing and traceability, were the way to go. Therefore, the main goals to be achieved in both projects were:

1) Optimize the flow of information process;
2) Delete unnecessary waste during the process;
3) Reduce paper used in the factory.

To implement these solutions, it was necessary the use of programming skills for maximizing the needed output. The diagram, shown in Figure 22, illustrates the reasoning described.

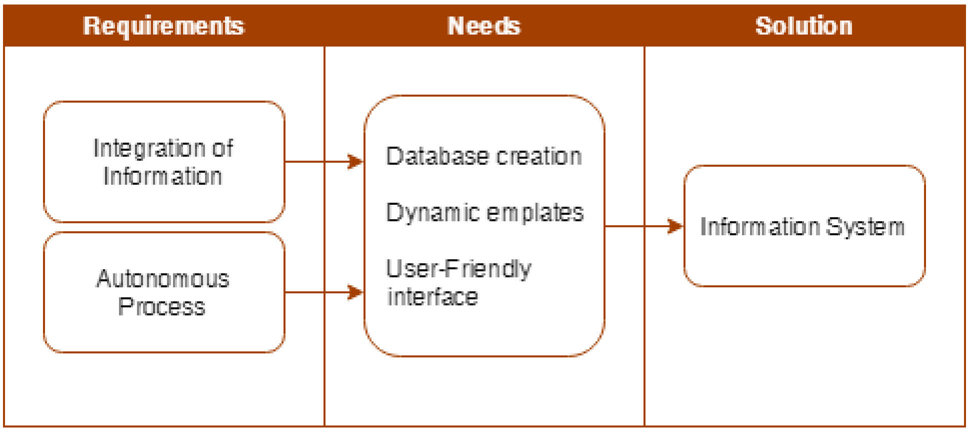


Figure 22 – Information System Requirements and Needs

For the system to become flexible and to adapt the information generated to the process specification, it is necessary to transform the static models into dynamic models, with the ability to adjust the documents to different productive products and processes. To do so, as already said before, it is inevitable the use of code development, so once the input is entered, the program adjusts the structure and the contents of the document, generating automatically the desired output.

It is intended that the implementation of the project allows the elimination of tasks that do not add value to the process and significantly reduce the execution time of the remaining ones. A flexible system is expected to be designed, which allows the adjustment of the information presented to the requirements.

It is necessary to ensure that the implemented system continues to be used in the future. Therefore, its development is indispensable.

The requirements of the implemented IS were:

- Develop a solution that is accessible to all employees;
- Simple management process, within the reach of its actors;
- To be prepared to adapt to future product changes.

3.4 Goals to be Achieved

1st Project

After this current state analysis, several ideas were debated in brainstorming meetings, on the Information Systems Division (ISD), to find the best possible solution according to the existent variables. Therefore, the best solution registered are listed in the following Table 21.

Table 21 – 1st Project Future State System

Future State
Creation of Excel templates for easier fill;
Develop a VBA code for fill automatization with interconnected database;
Send order material document via email to the warehouse, providing not only an online historic on the Outlook system, but also a *.pdf* file, if necessary.
Elimination of 7800 annual paper sheets.

Considering the solution planned, the advantages and disadvantages predicted are described on the Table 22.

Table 22 – 1st Project Advantages and Disadvantages

Advantages	Disadvantages
• Time reduction; • Considerable reduction of paper; • Optimization of user functions for who makes and receives the order requested.	• Requires adaptation to the material standard names; • Requires a small adjustment, due to the transition between a manual to an IT process.

2nd Project

After the second project current state analysis, a future state, shown in Table 23, was planned and designed.

Table 23 – 2nd Project Future State System

Future State
The developed application allows to add, edit, duplicate, delete and search in a very intuitive, flexible and fast way, leading to a productivity increase;
The administrator will keep all database intuitive and effective;
The common users are only able to search for the needed component, location, quantity and all characteristics belonging, in a very intuitive and fast way.

The advantages and disadvantages predicted for this second project solution are mentioned on Table 24.

Table 24 – 2nd Project Advantages and Disadvantages

Advantages	Disadvantages
• Monitoring on a single screen; • Faster and more flexible edition; • Access restriction; • Traceability; • Increase data security; • Maintenance not required.	• Access restriction; • It may take some time working issues due to external network sharing factors, if the use of the program is done into the company's cloud share folder.

It is intended to develop a system capable of responding to the problems and improve the performance of the processes, reduce running task times, eliminate errors and information that does not add value, among other opportunities for improvement.

For the created solution's implementation is required a very low investment. On the other side, it is crucial that the implemented solution continues to be used in the future. Consequently, it is necessary to comply with certain usability restrictions to ensure the systems could be easily used and managed by the company employees.

In this way, the following requirements were considered in the approach to both projects to safeguard the interests of the organization:

- Use of software licensed by the company;
- The developed solution must be accessible to all employees and specific know-how is not required;
- Simple management process, within the scope of the actors in it;
- There are no desirable solutions requiring qualified maintenance. Current employees must independently manage the implemented system;
- The developed program must have a simple and intuitive interface;
- The development and implementation of the project should involve a reduced monetary investment;
- The program's running time should be reduced;
- The developed solution should be formulated with the aim of adapting to future operating changes, new products, documents and procedures;
- After the systems implementation, there must exist quantitative improvements relatively to the preview's ones;
- It is expected that the project development culminates in its implementation.

4 Process Analysis

In this chapter, several topics are described in order to support the process of the new system's structure and design. Requirements' analyses of the program were done, and the engineering point of view was described.

4.1 Steps to follow

Initially, the analysis of the problems' causes was done, providing the know-how to take actions into its main roots. After, the design of a new system was built and able to manage the information flow more efficiently. As result, the developed system was ready to be implemented. The solution development workflow is enumerated below:

1) Identification and selection of documents capable of being integrated into the program to be developed;
2) Application of the lean methodology to these documents and associated tasks;
   a. Transform obsolete documents into simplified and current templates;
   b. Delete all information that does not add value;
3) Identification of the actions and tasks associated with the process, which are liable to be automated;
4) Software definition and proper programming language;
5) Database structure and content definition;
6) Computer support definition, where the database will be stored;
7) Survey of requirements for the program to be developed (Functional and Non-functional);
8) Definition of the program input (what information will be required) to generate the desired output;
9) Control and security actions definition;
10) Identification of which parameters are common;
11) Elaboration of formulas and functions that ensure autonomous processes;
12) Design of a simple and intuitive interface;
13) Training of those who will be the users of the developed system;
14) Implemented changes registration in the associated documents;
15) Collection of user reviews and possible improvement actions;
16) Monitoring and control of the new system implemented.

4.2 Documents Integration

The first step in the solution development corresponds to the identification and selection of documents that are eligible to be aggregated in the program.

It is intended that the program integrates all the documents associated with the production, whose filling can be in some way automated and/or its structure and parameters should vary according to the specifics needs. The main data source engine for both IS developed was an Excel sheet.

1st System Structure and Content definition

In order to automate the process and adapt the information for the need of each request, it is essential the existence of a database that supports all program. It is with this database that the program is able to automatically generate the desired information, as well as to adjust the structure and content of each specific document to each product and production process. The first step in the database creation was the structure definition, being identified the relevant parameters to be integrated.

All the information comes from the SAP software, which the use was not allowed due to the high investment required. The limitation of the solution found concerns the need to manually update the database. Consequently, in the future, whenever a new product is launched, a manual database update will be necessary. The inability to automatically update the designed database results in data being stored in the SAP system, uncapable of being directly shared with the other existing software, due to technical incompatibilities. However, the information extracted is effectively relevant to the purpose of the process. Therefore, it is advantageous to integrate the data from the SAP system into the created database, even if it implies a manual update.

2nd System Structure and Content definition

In the second project, a DMS for decision support was planned in order to optimize the engineering process of the logistic database maintenance.

An Excel sheet supported by 120.000 data cells was created. Due to changes of components in the LC70 assembly, internal quantities or locations, updates had to be done by the engineering department. Normally, this information is sent by Japan’s main factory. Therefore, as all the back-end development had already been initiated, a program able to optimize the surrounding database was thought and designed. The ability to adapt users to a new working environment with the changes that could benefit the most of the whole developed IS were considered in order to provide a better decision-making. Furthermore, the administrative monitoring and maintenance of the entire system was also considered.

4.3 Software and Programming Language definition

For the selection of the software and language used, it was authorized the use of a solution that would allow to resolve the problems identified and, at the same time, meet the restrictions mentioned in the project's objectives, for example:

- Use of software licensed by the company, in this specific case, the use of Microsoft Office tools and/ or the ERP system, SAP;
- Program that does not need the specific know-how, being accessible to all stakeholders in the process;
- Simple management process.

Given the mentioned assumptions and the defined objectives, it was easy to conclude that Microsoft Excel (ME) was the most appropriate solution in the context of this project.

Other enterprise-licensed software is SAP, an efficient and rich ERP solution. However, its implementation has been more complex and time consuming and would require the use of more resources, which were not justified. In addition, besides Office's licenses being cheaper compared to SAP, ME is a more familiar program, giving assurances regarding easy use and management simplicity.

This Microsoft Office tool has an integrated IDE, providing the development of several algorithms and functions, synchronized with the Excel worksheet. The code developed allowed, to acquire better and more efficient results, beyond the single capacity of advanced Excel. With the Visual Basic for Applications (VBA) programming language, macros, functions and algorithms were created, allowing the automation of the system and the performance of complex tasks.

The following Table 25 shows the different software tools used during this project's development.

Table 25 - Work Software

SOFTWARE	USE DESCRIPTION
MS Word	Survey of requirements for task development
MS Excel	Development of task scheduling Development of user form, macros and VBA code
MS Access	Database support
MS Project	Chronological management plan

Outlook	Email exchange Task Schedule
Network	Allows communication and file sharing between multiple computers. Since several divisions work with common documents, monthly each one updates an Excel sheet with its information for further treatment by another division, if necessary to have a form that allows quick and easy access to files.

4.4 Chronological Schedule of the System Development

In order to better schedule, organize and coordinate the several project activities, a chronological diagram was created. It presents the activities done and its dependencies from the start to the end of the developed system. The system development was divided in four different stages, following the PDCA methodology. The chronological schedule of the first project is presented at the PERT diagram, in Figure 23.

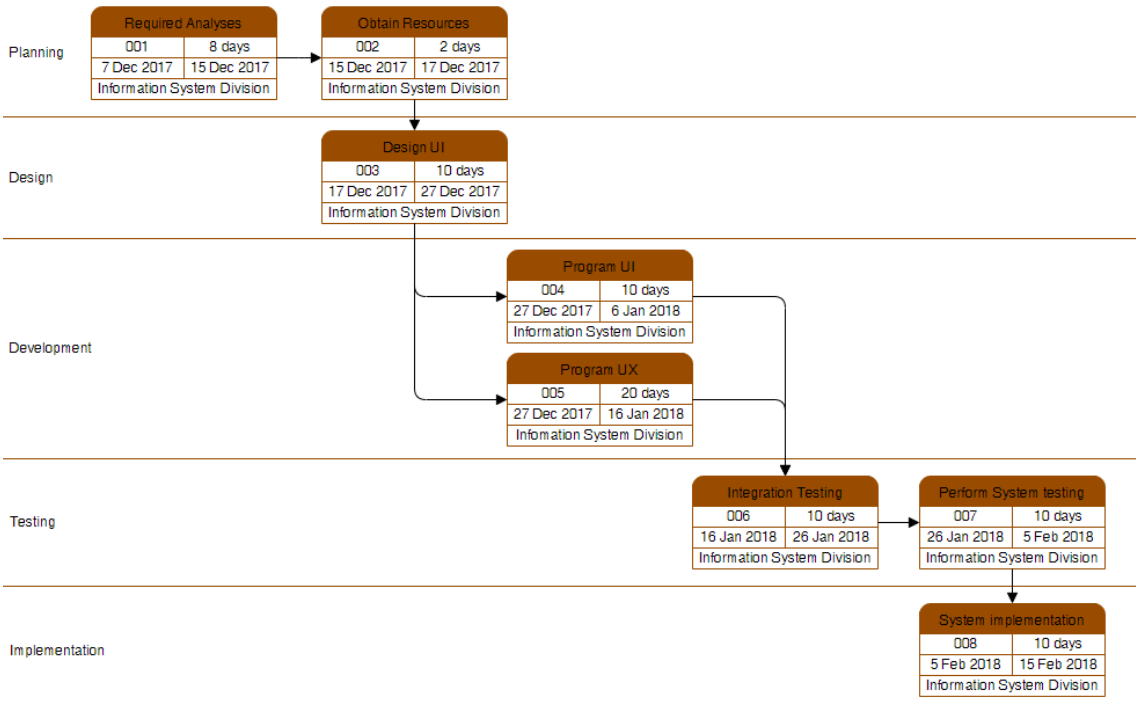


Figure 23 - 1st Project Software Development PERT Diagram

The defined plan was the first stage, in order to analyse the requirements needed for the problem solution. After this analytical research, the needed resources were obtained. Then, the new system design began to be built. This system needed to answer all the stakeholder's requirements. The UI layout was built, providing an easier transition for its code development. The UI and UX development were done in parallel for better organization, which lead to an easier correlation and integration between functions and algorithms developed. Before the system implementation, a testing performance was done, assuring all the best function of the entire program.

As the first project, a Pert diagram was also used for planning support of this second project's development, see Figure 24.

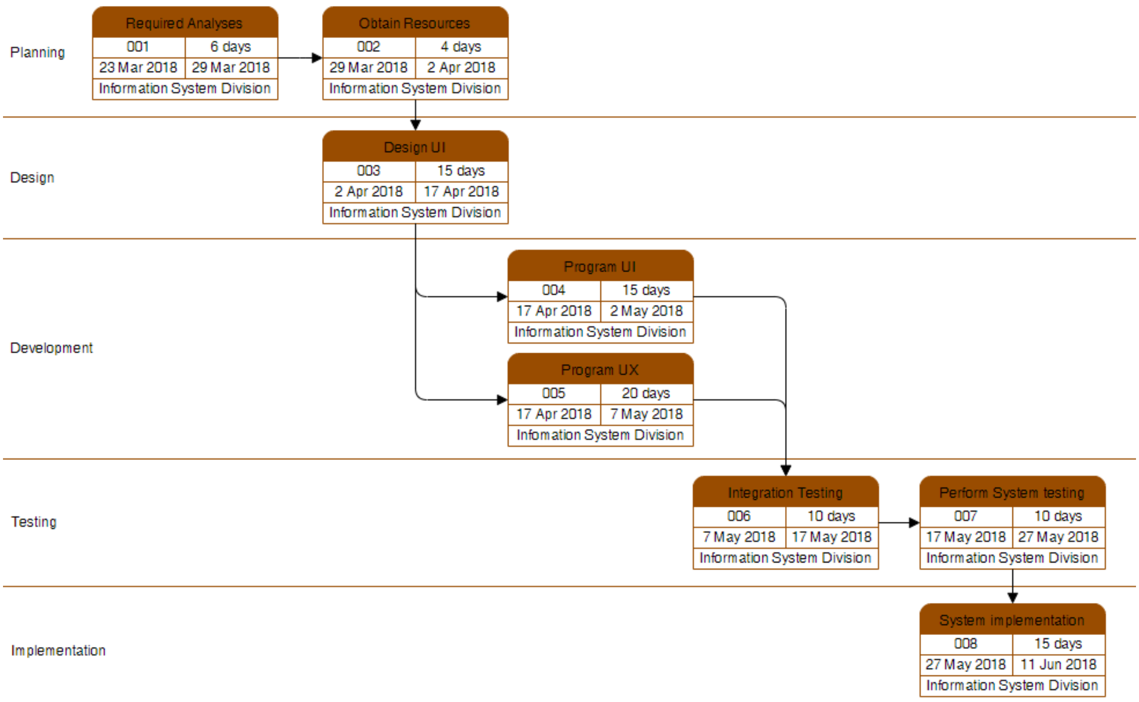


Figure 24 – 2nd Project Software Development Diagram

4.5 Engineering Requirements

Functional requirements describe what the system was expected to do. It was related to the functionality the system should perform or which information should keep. They covered the description of information inputs and outputs that resulted from the interaction between users and systems.

On the other hand, Non-functional requirements were related to qualitative system properties, describing attributes and overall qualities that the system should provide to functional requirements, such as performance measures or security considerations. Below are described the Functional and Non-Functional requirements from the first and second project, respectively.

1st System - *Functional Requirements*

- Elimination of information that does not generate value;
- Automatic application of formulas and functions that make the program smarter and the generated output more appropriated;
- Adjusting the document layout to the need of the concerned process;
- Automatic generation of observations and alerts, in accordance with the specificities required;
- Automatic mail generation with the required document attached, ready to be shipped with all the necessary specifications for the warehouse.

1st System - *Non-Functional Requirements*

- Program code access requires password input;
- Only the administrator is allowed to edit the system code and design;
- Acceptable processing speed of the program execution;
- Common language and knowledge, therefore available to all stakeholders;
- User-friendly interface for intuitively use;
- External Excel database for SAP code searching support of all the stock materials;
- Access database as the main motor of all system. This Database allows a simple and faster management, reducing drastically the time execution's maintenance by the team.

1st System - *Program Requirements*

Relatively to the program requirements, it was defined that the software to use might be licensed by the company in such a way that the implementation of the project implied the smallest investment possible. In the beginning, the SAP platform usage was questionable, however since a developer license was needed for code creation, this option was immediately rejected, due to the high costs involved.

Therefore, it was intended to identify the participants in the process and their tasks, as well as the aspects whose improvement was crucial for the optimization of the system.

Then, the following questions were done giving a better direction for the system development.

- To whom is the information system made?
  For all the employees of the organization whose activities are related to some of the stages of the process, with emphasis on those who will be responsible for issuing the materials order's.

- What is needed to develop the intended system?
  It is necessary to create a database that integrates the dispersed information, and subsequently develops a program that allows the automation of the process.

- How is the work developed?
  Starting from the findings and constraints of the initial situation, the existing problems must be identified and solutions thought and registered. Then the best possible alternative must be defined, designed and structured. Its implementation takes place after the performance tests being made.

- What does the program do?
  The developed program is able to select, fill, edit and send the required document of material order to the warehouse. Using a material database with advanced functions programmed, it was possible to automate processes and tailor the information to the needs of each order, by the different cost centers. Autonomous synchronization from the material ERP code and its units were also developed.

- Who enjoys the developed work?
  With the implementation of the new system, all stakeholders of the process benefit from the output generated by the program. It was intended that they stop taking tasks that can be done automatically and they could obtain indications and data that would assist in the implementation of the tasks they still had to perform.

In the same way as the first engineering requirement analysis, the second system was also analysed and study, before the developed solution was built, to prevent unnecessary entropies into the new implemented system.

2nd System - *Functional Requirements*

- Elimination of information that does not generate value;
- Reorganization of the data parameters;

- Automatic application of formulas and functions that make the program smarter and the output generated more appropriated;
- User friendly layout, providing an easier and faster maintenance;
- Data and User Traceability, providing a better control of the system;

2nd System - *Non-Functional Requirements*

- Program code access requires administration and user password input;
- Only the system developer is allowed to edit the system code and design;
- The administrator has access to an historic data traceability;
- Common language and knowledge, therefore available to all stakeholders;
- User-friendly interface that is intuitively used;
- Excel database support for the developed system.

2nd System - *Program Requirements*

- To whom is the information system made?
  These DMS was developed specifically for the Engineering department team, directly related to the logistical changes made in the LC70 assembly components used.

- What is needed to develop the intended system?
  It was debated along with the engineering team all the system functionality, as well as the actions used in the process. A lack of flexibility in monitoring and maintaining all data were registered. Completed the survey of the necessary requirements for optimization, it was noticed that a program should be built for the database support.

- How is the work developed?
  The initial process is done on a simple Excel sheet, where 120.000 data field are monitored through associated filters. Therefore, it was necessary to create a program supported by the existing database, to allow the user a greater, better and easier monitoring and maintenance of the whole system. The created program was developed in such a way that one main UF provides all needed work actions and functions and immediate access to visualize the data information. This simple layout UI allows a faster and effective maintenance of all data. Besides this main UF, several UF were designed and built in order to provide the best user experience.

- What does the program do?
  The program allows the user to visualize in a faster and more effective way all the necessary information of the components, regarding their location in the logistic warehouse. All the monitoring and maintenance of this data information was simplified, thus making all necessary actions, such add, remove, edit and search in a more user-friendly way. On the other hand, data security policy has been considered. Therefore, a program entry system was created with login data tracing, allowing the administrator to view the historic of visits and the changes that were made.

- Who enjoys the developed work?
  The Engineering department benefits from this optimization, since they are the ones who monetarize and maintain all this data, reducing the time decision making from the logistic collaborators.

5 Implementation

The next chapter presents the modeling of both IS setup. These models supported the process development structure to be implemented. It also provided the knowledge of the entire workflow, actors (users) and interesting parts (stakeholders), which led to a better knowledge of all IS developed. The BPMN aims to show the interconnectedness of the various existing subsystems. Several behavior and structure UML diagrams such as Class, Use Case, Activity, Sequence and Package diagrams could be seen to explain the different process and procedure from the implemented systems. An Entity Relationship Diagram (ERD) was also built to show the major entities within a system and their inter-relationships.

The conceptual system development model adopted, seen in Diagram 1, allowed to get a clear idea of how both DMS for decision support were developed.

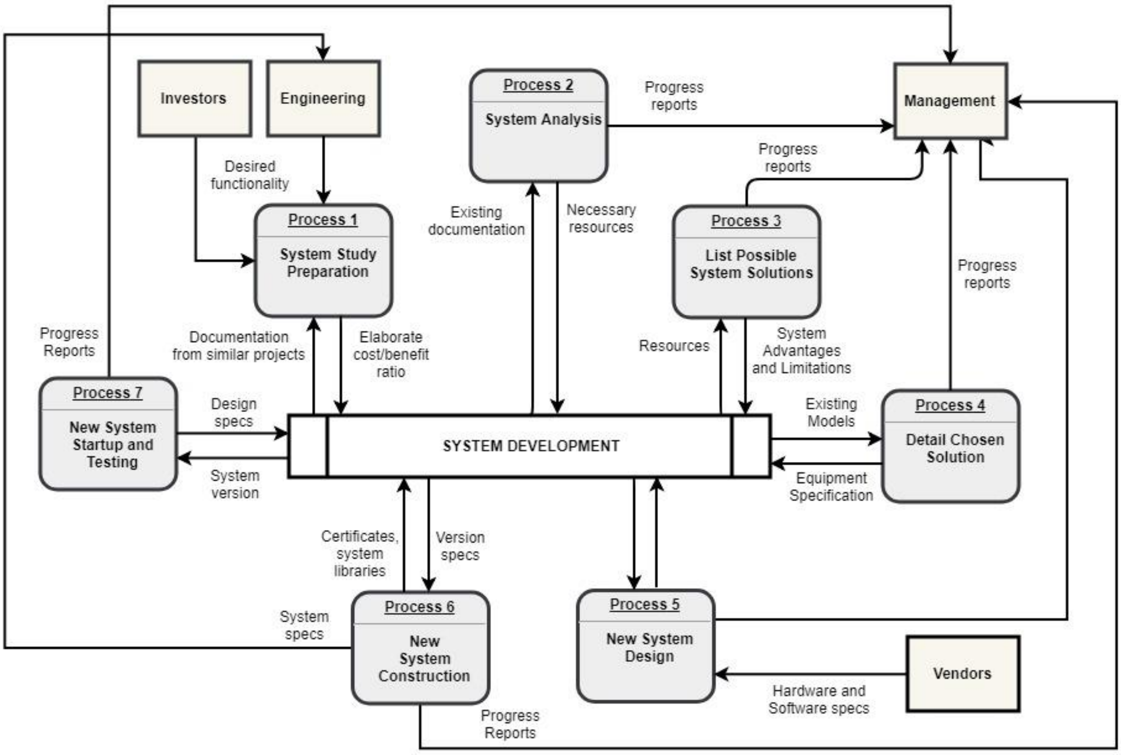


Diagram 1 - System Development model approach

5.1 Business Process Modeling and Notation for the 1st System

The following BPMN, shown in Diagram 2, presents the structure from all the material order and return process, explaining the DMS workflow.

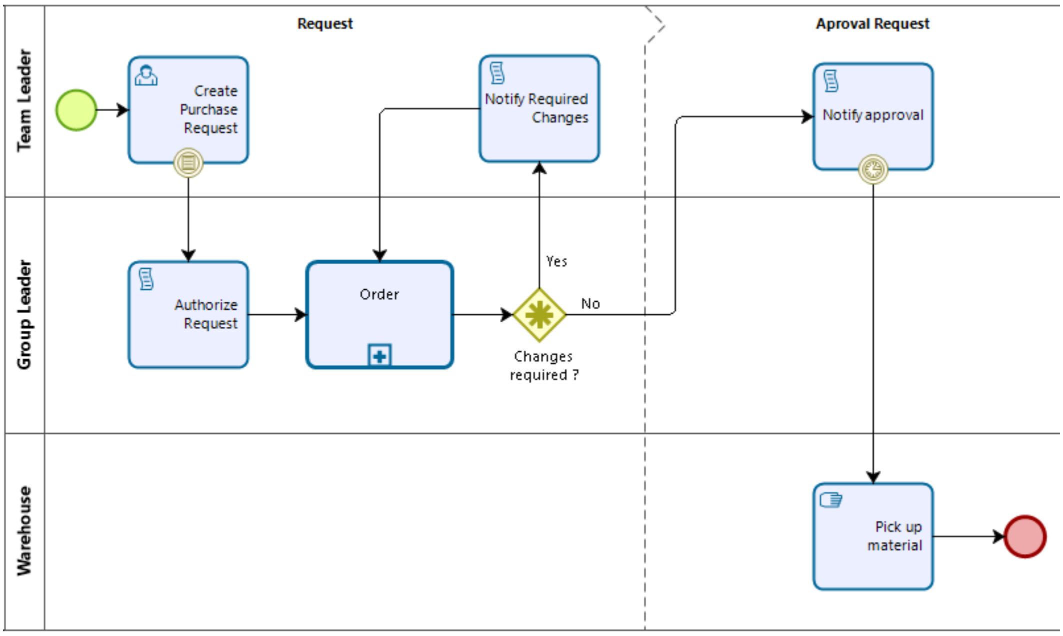


Diagram 2 - 1st Project BPM (Request Order Process workflow)

It is seen that the process began with the Team Leader (TL), being the one which did the order request to the Group Leader (GL). After the request validation, the GL could proceed the order. The process order sub-system is described at Diagram 3. If any required changes were done in the processing order, they would be notified to the TL, being then notified the approval for the material shipping. Then, the TL had to conclude the process by picking up the order into the warehouse.

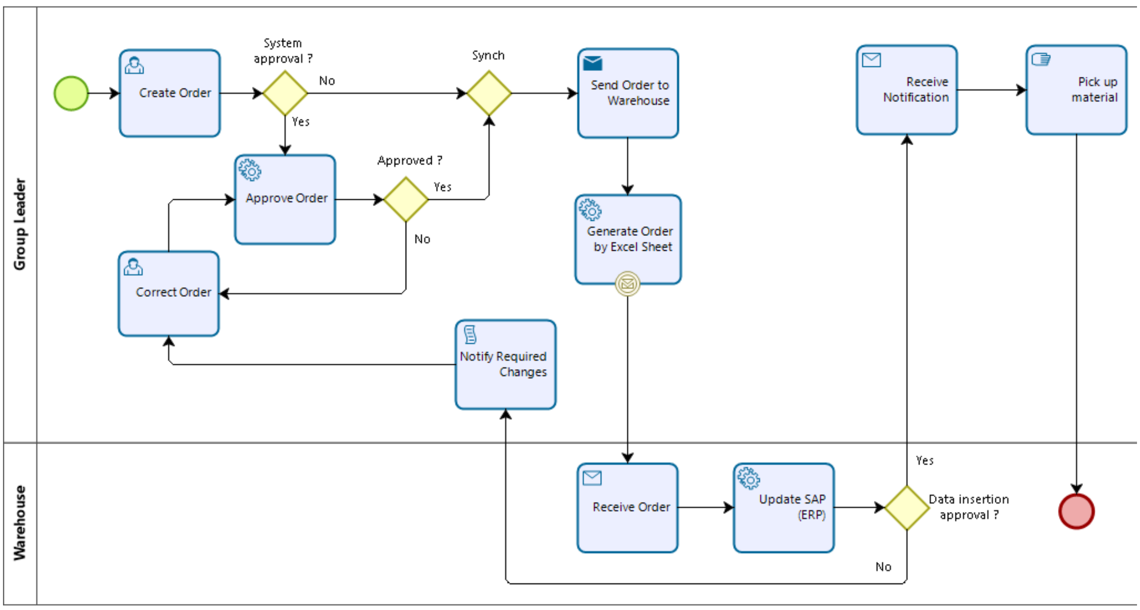


Diagram 3 - Order material processing workflow

Data Flow Diagram

It was developed, as a preliminary step, a Data Flow Diagram (DFD) to show what kind of information was inputted and outputted from the system, how the data flowed through the system and where the data was stored.

In this diagram, Diagram 4, all the system flow from the input to the output can be visualized. It began with the initial order from the Group Leader, the one who was in charge for to the order requirement process. After the sent order, the data input from all code components was inserted into the ERP system and simultaneously the physical inventory order was organized for previous dispatched.

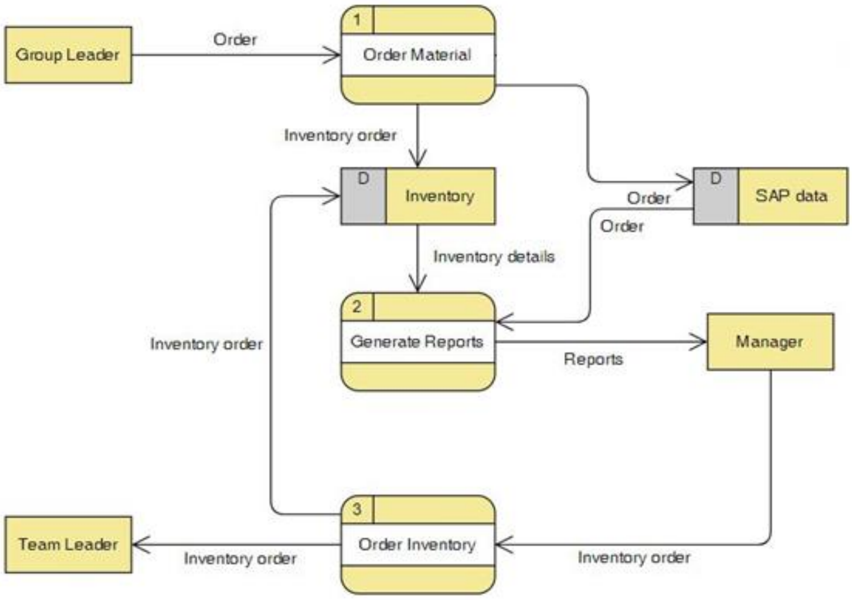


Diagram 4 - Order Materials Information System UML diagram

Unlike a traditional structured flowchart, this diagram does not show information about the process timing or whether processes will operate in sequence or in parallel. In the software developers' point of view, working with DFD, requires a clear understanding of the boundary between the existing systems and their sub-systems.

Use Case Diagram

The following Use Case Diagram (UCD) describes how the main functions of different parts, in this case, the actors in the system, were involved. It describes how the systems were used by the users to accomplish the particular goal.

The principal actions' interaction between TL and GL of each sector can be seen in Diagram 5. The GL depended mainly on the TL for the order material execution, since it was needed to request the necessary materials for the line production.

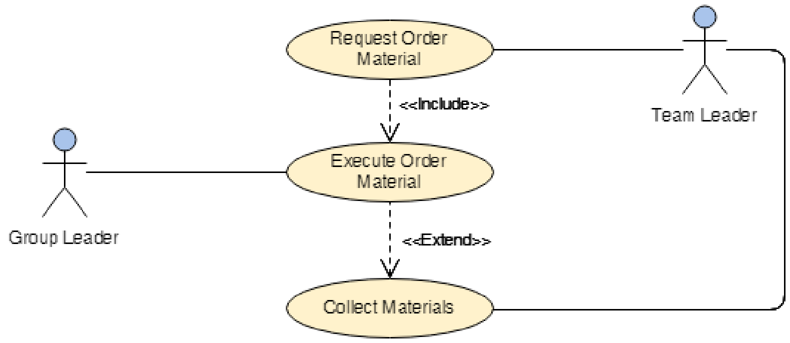


Diagram 5 - Order Material Use-Case diagram (Team and Group Leader interaction)

Normally, the TL was the one which requested the order, since he was always in the *gemba.* When the shipping process was done, normally finished until 12 am from the next day of the material order execution, the TL was responsible to pick up the needed materials from the warehouse.

After the order be processed, the warehouse data worker received all the needed information to begin the order delivery process, Diagram 6. Consequently, the ERP system used in the company, SAP, was uploaded with the referred data. At the same time, another warehouse worker started packing the ordered materials for posterior shipping, Diagram 7.

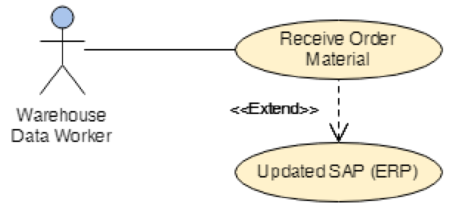


Diagram 6 - Order Material Use-Case diagram (Warehouse Data Worker)

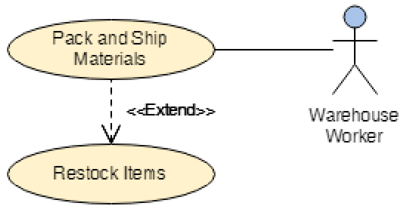


Diagram 7 - Order Material Use-Case diagram (Warehouse worker)

Flowchart

The following Diagram 8 shows the IS flow user's point of view from processing an order.

First, the user had to search the required component to field the program parameters. If he did not find the needed component after a second search, it meant there was a lack of maintenance from the database subsystem, which had to be reported to the system administrator. The system administrator was responsible for solving the occurred problem and inserting manual data. On the other hand, if the component was found, the user had to proceed according to the standard protocol from the order system requirement.

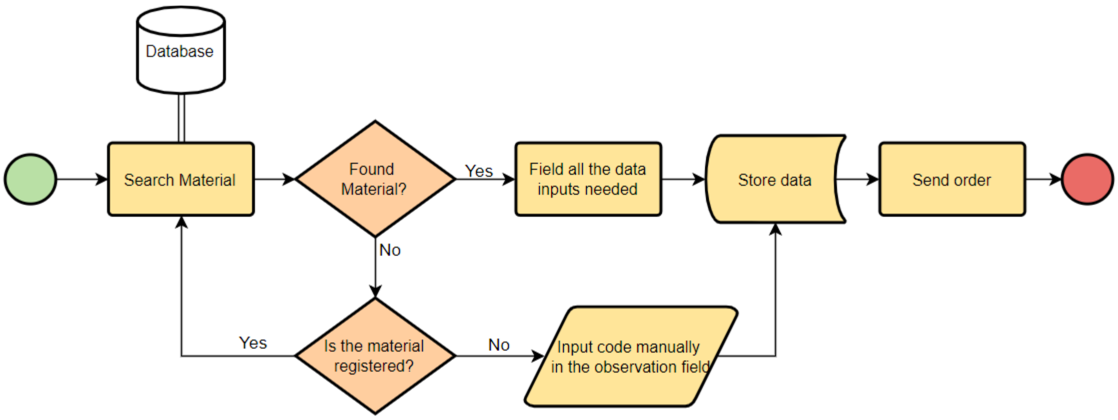


Diagram 8 - Order Materials Information System Flowchart

Activity Diagram

The Activity Diagram (AD), observed in Diagram 9, represents an end-to-end activity flow for processing an order.

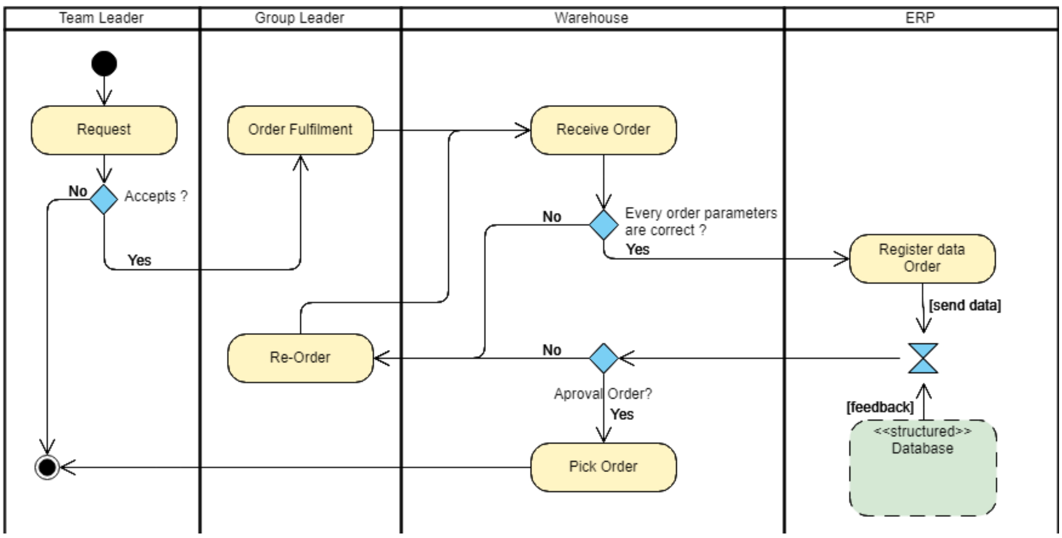


Diagram 9 - Order Materials Information System Activity Diagram

As shown in the diagram, a requested order is an input of activity. After the order being accepted and all required information filled in, update ERP data transactions was done, then the process was packed and finally the materials were shipped.

Sequence Diagram

The sequence diagram main goal is to show the different object interactions arranged in time sequence. As seen in the Diagram 10, it started from the customer (in this case, the GL), who created an order.

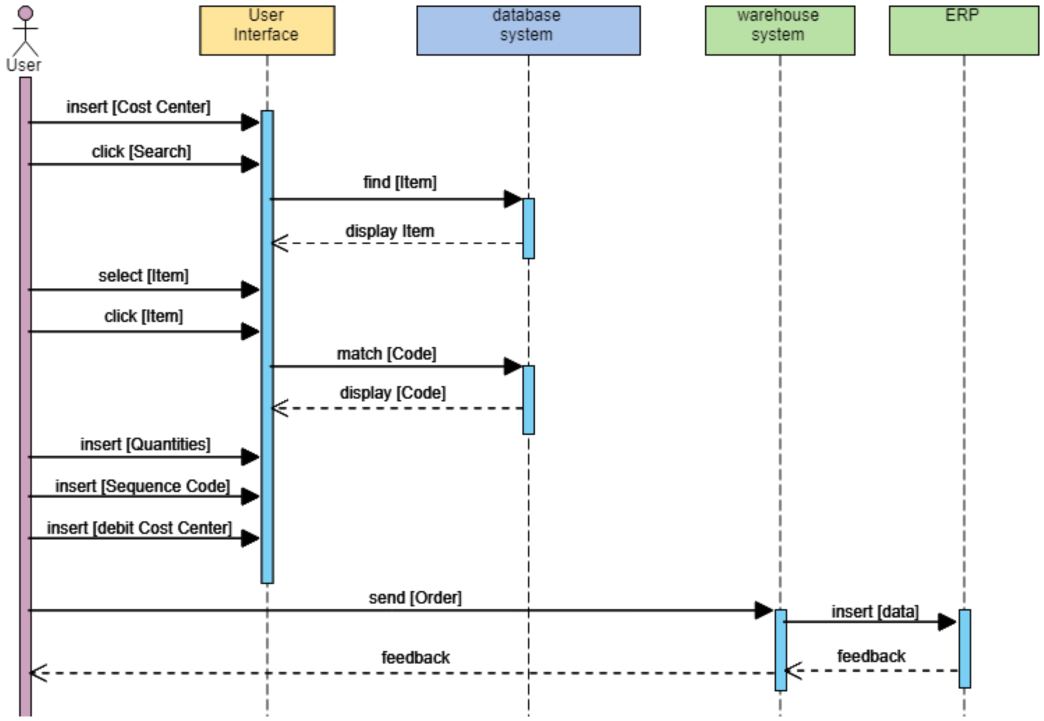


Diagram 10 - Order Requisition Information System Sequence Diagram

For each material needed, the GL had to field the respective name with the needed quantity. Usually, all the materials listed in the supported database were available on the warehouse. After the necessary fields being completed, the order was able to be sent to the warehouse, for immediate data insertion into the company ERP.

Entity Relationship Diagram

The Entity Relationship Diagram (ERD) shows the different data connectivity between several parts of the entire system, see Diagram 11.

An order could be composed by different products and it was done by only one customer. The products could be selected by a database searching engine algorithm available on the application. In this specific context, this user (internal customer) was an employee from the organization, more specifically the person responsible for each cost center. The payment from each order is automatically associated with the cost center from each GL.

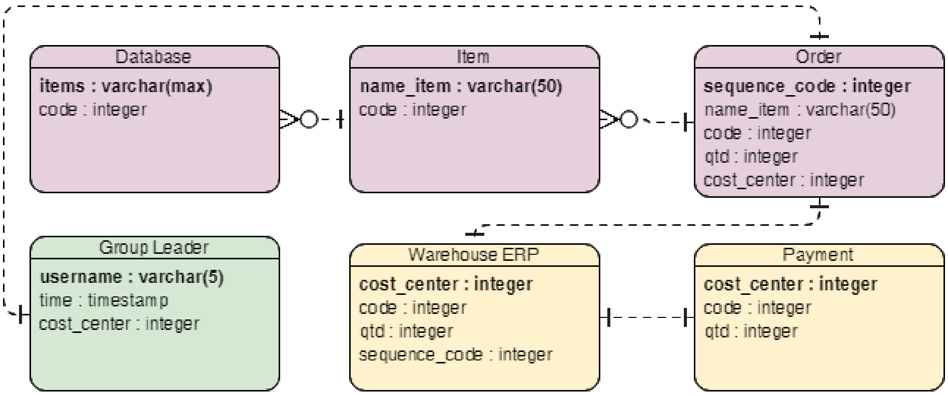


Diagram 11 - Entity Relationship Diagram

Class Diagram

The Class Diagram (CD) provides a structural view of systems which capture the static structure rather than how they behave. It identifies what classes exist, how they interrelate and how they interact. The system developed was composed by five different classes, as seen in Diagram 12.

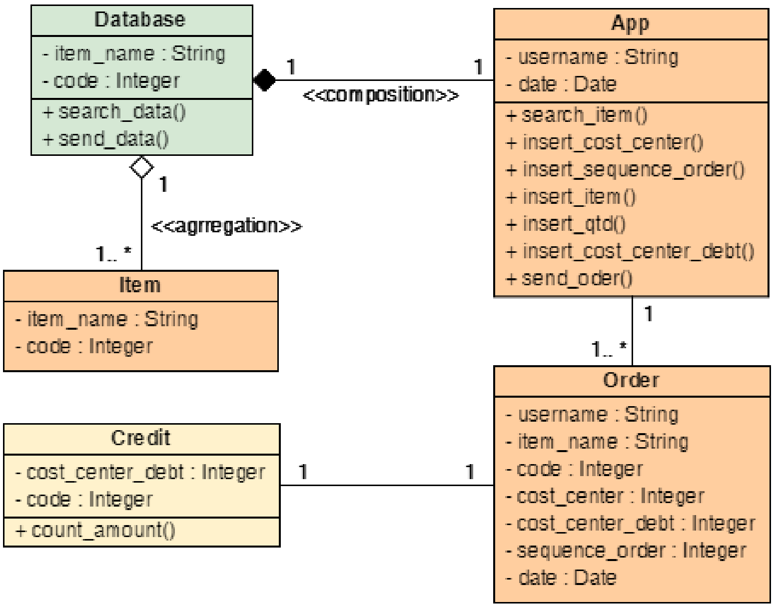


Diagram 12 - Class Diagram

A customer, in this case, a GL, could make one or several orders. Each order had to have, at least, one material listed and could be extended until 24 materials. For each selected material, it was possible to order any amount, if stock was available. A payment was debited for each order done.

Package System Diagram

For an easier and better understanding of whole picture scope of the system, a Package System Diagram (PSD) illustrates it, in Diagram 13. Four different packages are seen: on the left, the UI application composed by the core processes' system and it orders procedure and the warehouse materials database. On the right side, the warehouse process structure, composed by the shipping procedure which was dependent from the ERP data input.

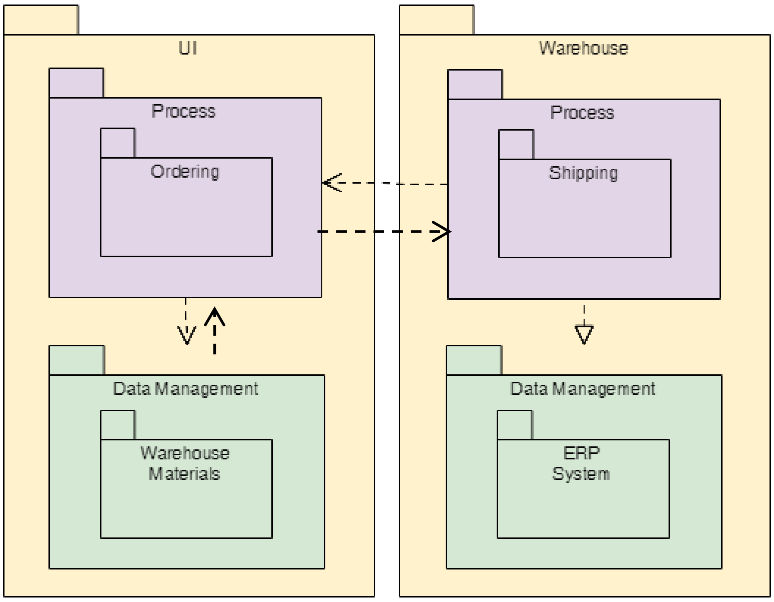


Diagram 13 - Package System Diagram

5.2 Business Process Modeling and Notation for the 2nd System

The following BPMN diagram shows all the process workflow of the DMS decision support for the LC70 database organization and maintenance.

A whole scope of the process can be seen in Diagram 14. It began with the login authentication. If this authentication was approved, the system would open the correspondent interface, according to the login done.

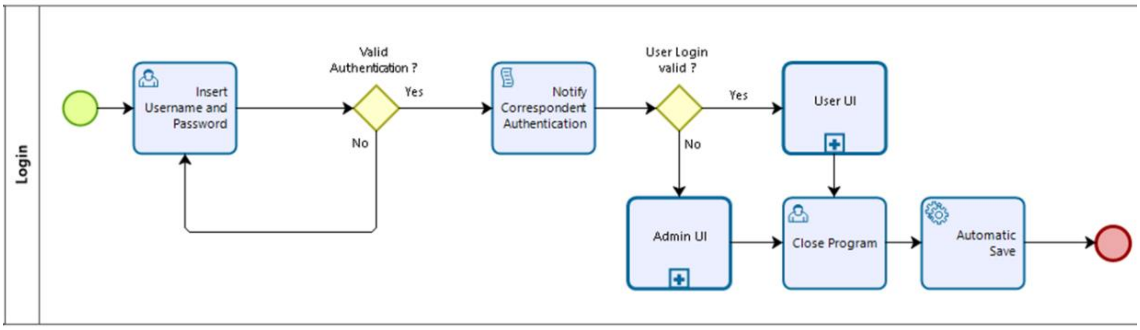


Diagram 14 - 2nd Project Workflow process

The sub-systems could release the user or administrator interface, providing different capabilities to the correspondent users.

Relatively to the User UI, it is shown, in Diagram 15, the workflow behind all this sub-system. Here, the user was able to search and select the needed item in order to verify and analyse the associated characteristics. All this User UX is connected in real time to the main database. A user login was also registered to the historic field, providing a better traceability for the system's administrators.

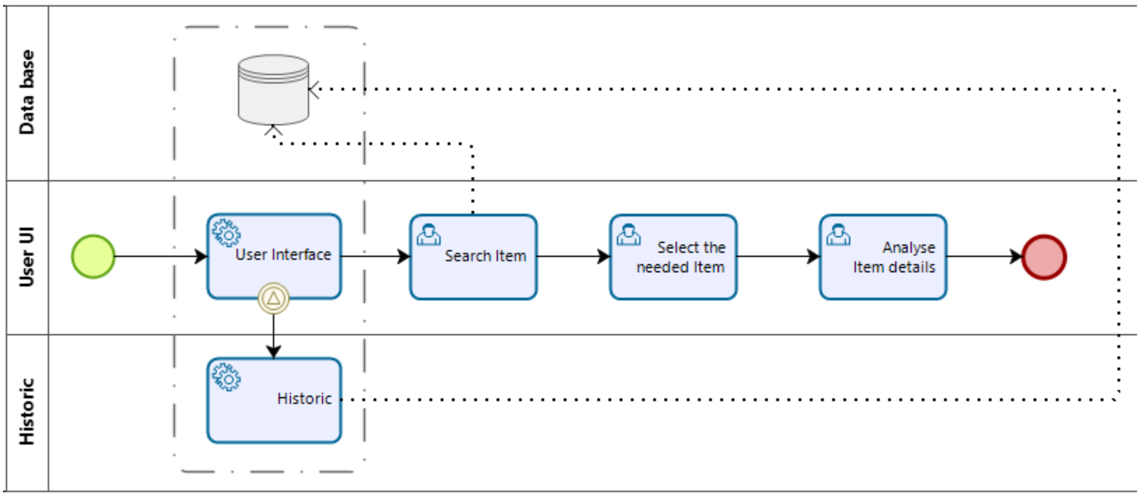


Diagram 15 - 2nd Project User Interface

On the other hand, in Diagram 16, it can be seen the Administrator UI process workflow.

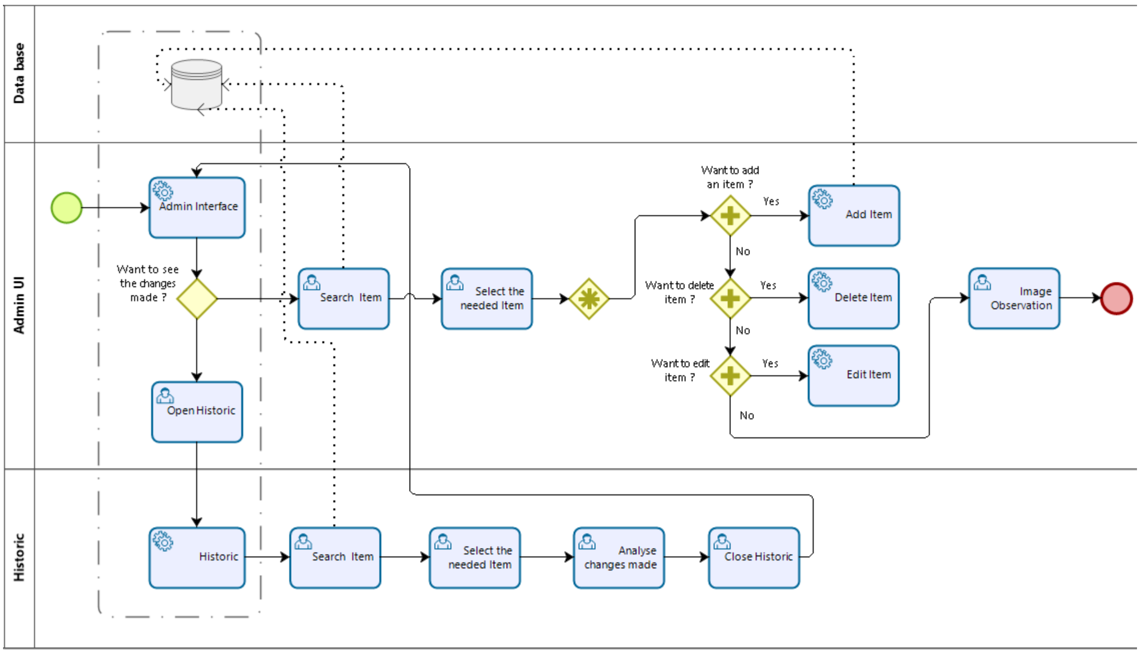


Diagram 16 - 2nd Project Admin Interface

In the same way as the User UI, all data was connected in real time to the main database. Here, the administrator was able to choose several types of actions, from historic observation for traceability and organization purposes, to several maintenance functions for reliable information.

Concerning to the maintenance, the administrator was able to add, delete or edit the needed items. He could also search only for specification analysis, with the correspondent image from each database item.

Data Flow Diagram

The DFD, seen in Diagram 17,was developed as a preliminary step to create an overview of the system without going into detail. This DFD shows the main structure of the different User and Administrator UX and how the information flows throughout the entire system.

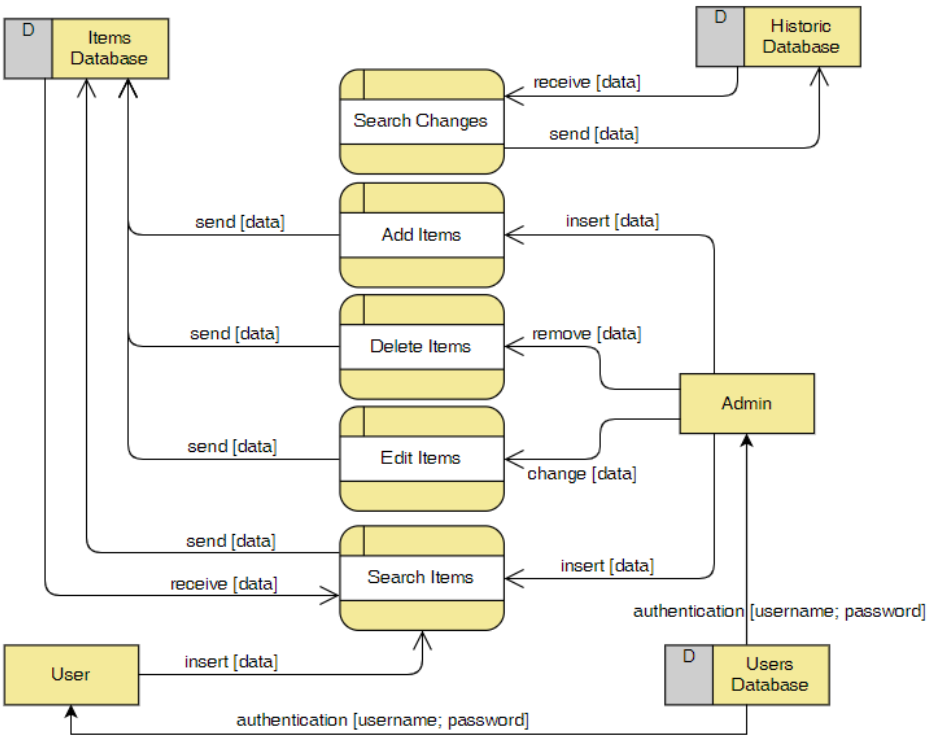


Diagram 17 - LC70 Database Information System Data Flow Diagram

Use Case Diagram

In the second project, there were three different actors: the User, the Administrator and the Developer. The User's two main actions available by the developed program can be observed on Diagram 18.

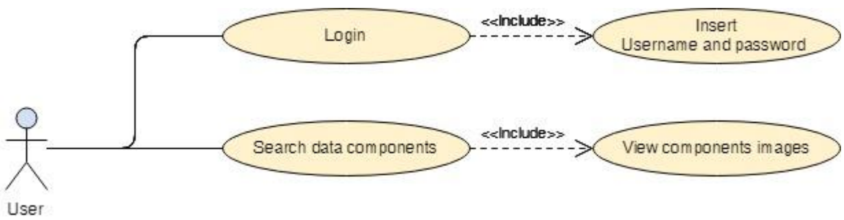


Diagram 18 - LC70 Database User UCD

First, the Login had to be done and authenticated, a process explained further ahead. After user authentication, the user was able to take advantage of the created IS for searching components data, thus serving as decision-making support.

Regarding the administrator authentication, Diagram 19, it is seen that besides the user actions, the administrator had the possibility to preview historic authentication plus the changes made, allowing better data security and traceability. The components data edition could also be done by the administrator, since he was responsible for the system's maintenance.

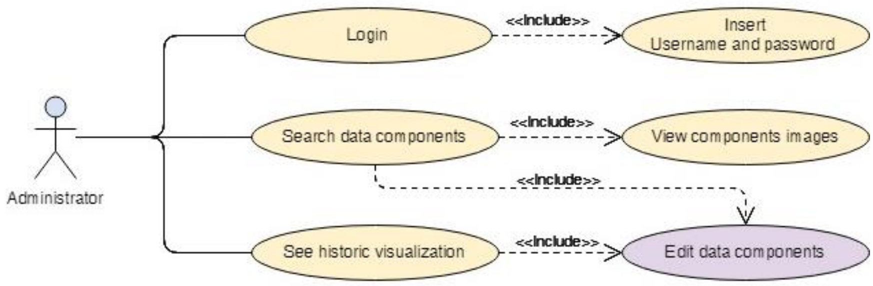


Diagram 19 - LC70 Database Admin UCD

Finally, the developer actions are described in Diagram 20. The developer maintained and created new events in the system. If necessary, he could also redesign the entire stream, depending on those same changes.

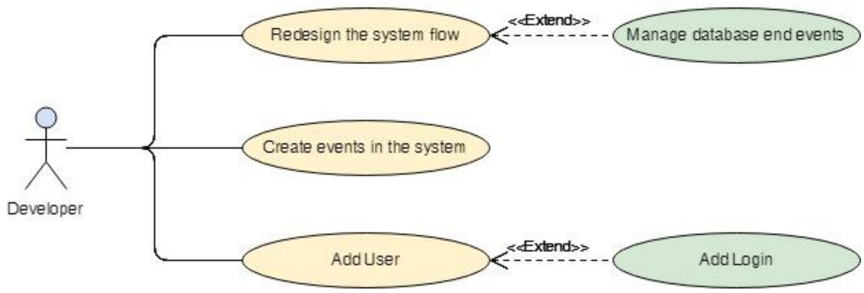


Diagram 20 - LC70 Database Developer UCD

Flowchart

The information system flow related with the second project can be seen in Diagram 21

After the login verification, a UI was opened depending on whether you were a common user or administrator. The common user's standard procedure was to search the component by Part No. or Part Name, where the data started being filtered. They could verify the searched components by clicking on the respective data. An image related to the selected item was provided, assuring better item recognition. On the other hand, the administrator's procedure included, plus the edition of the component and the visualization of the historic search from the users, providing an easier maintenance, organization and a better traceability and data security.

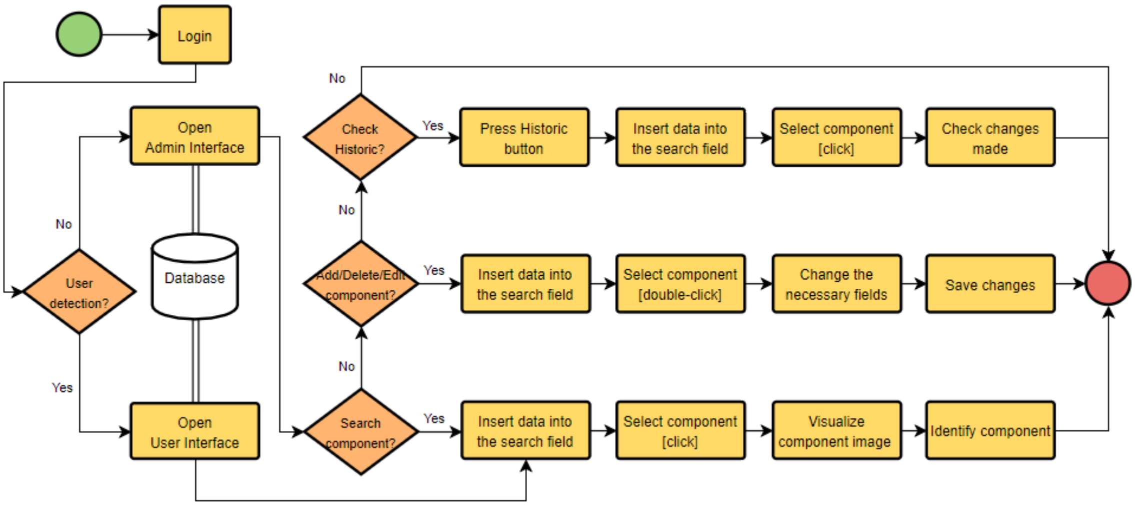


Diagram 21 - 2nd Project Flowchart

Activity Diagram

This Activity diagram illustrates the system functionality flow. This diagram defines the workflow of what activities and tasks occurred during the process. It is seen, in Diagram 22, two diferent actvivities sections. In one side, the authentication and database synchronization activities. On the other, the UI activities from both intervinients, the User and the Administrator.

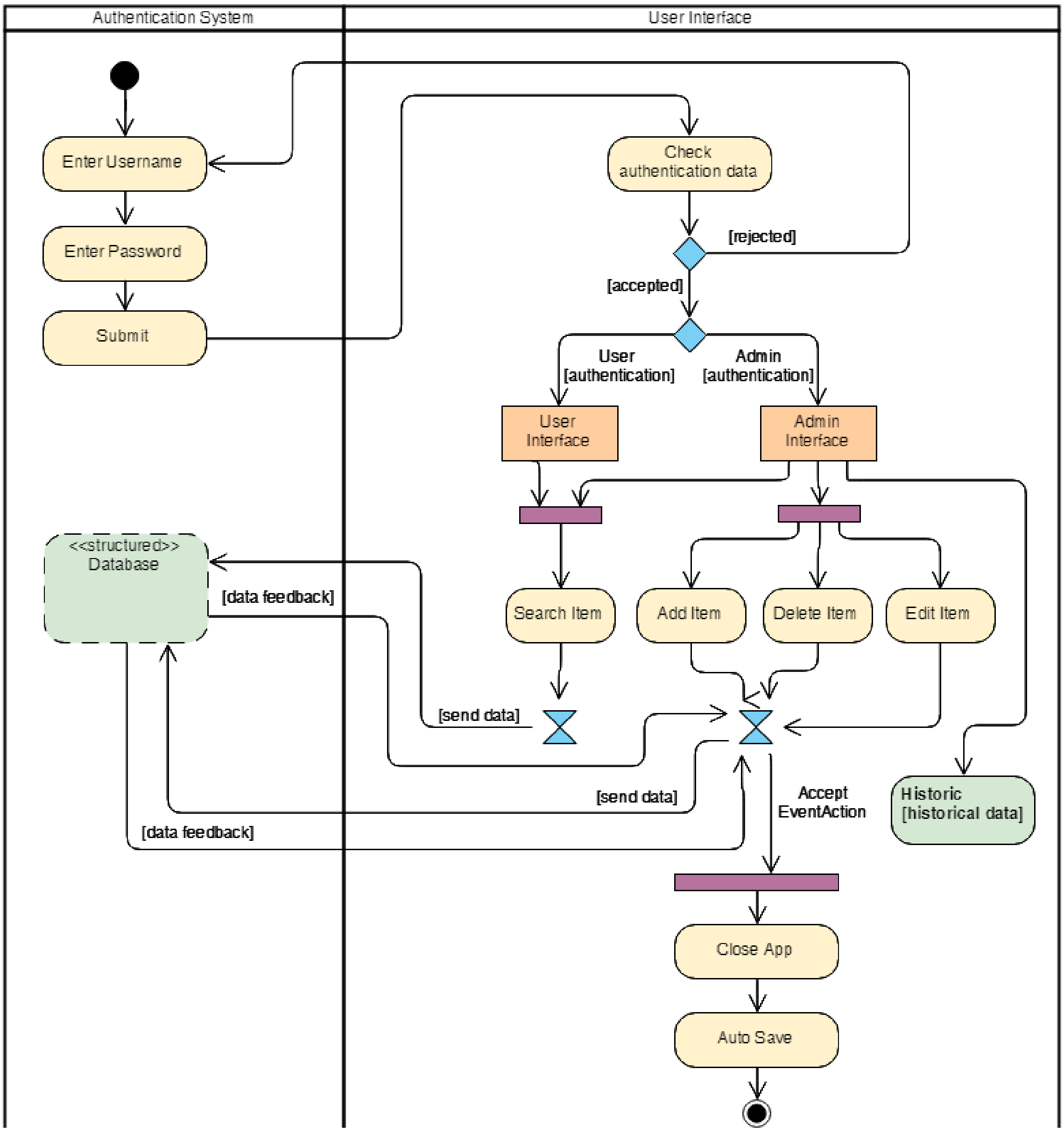


Diagram 22 - LC70 Database Information System Activity Diagram

Sequence Diagram

Relatively to the users' point of view, there were three different objects in this second system, which can be seen in Diagram 23.

The User could only search for the needed item and respective specifications. This action had an algorithm behind, synchronizing the input data and retrieving the correspondent output information and image.

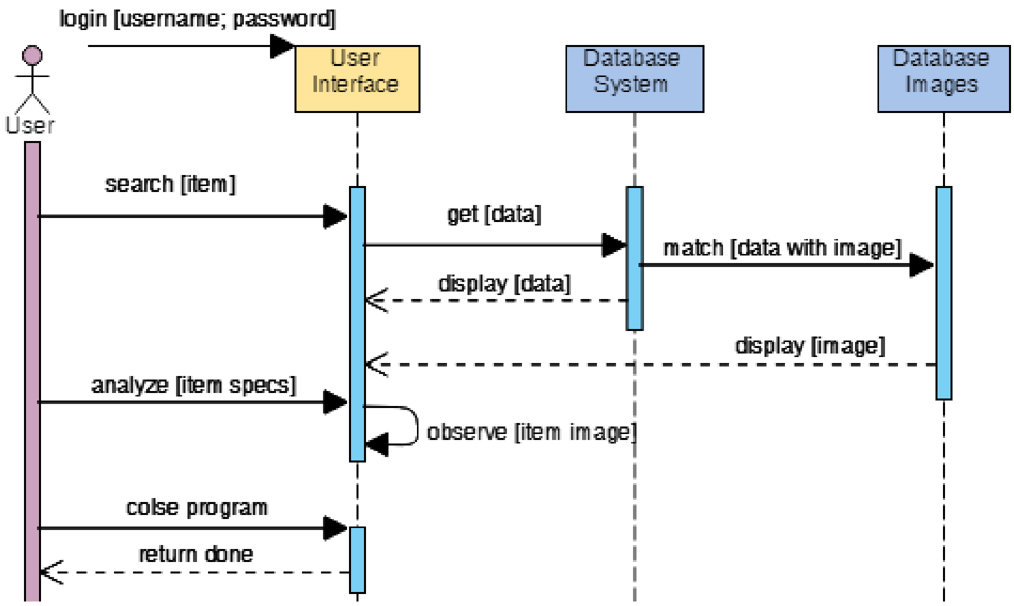


Diagram 23 - LC70 Database User Sequence Diagram

On the other hand, the Administrator not only could search for an item, but could also create, eliminate and edit it, shown in Diagram 24. All these actions mentioned before were connected, in real-time, with the system database. Due to this synchronization, an easier and more accurate maintenance of all data system was provided.

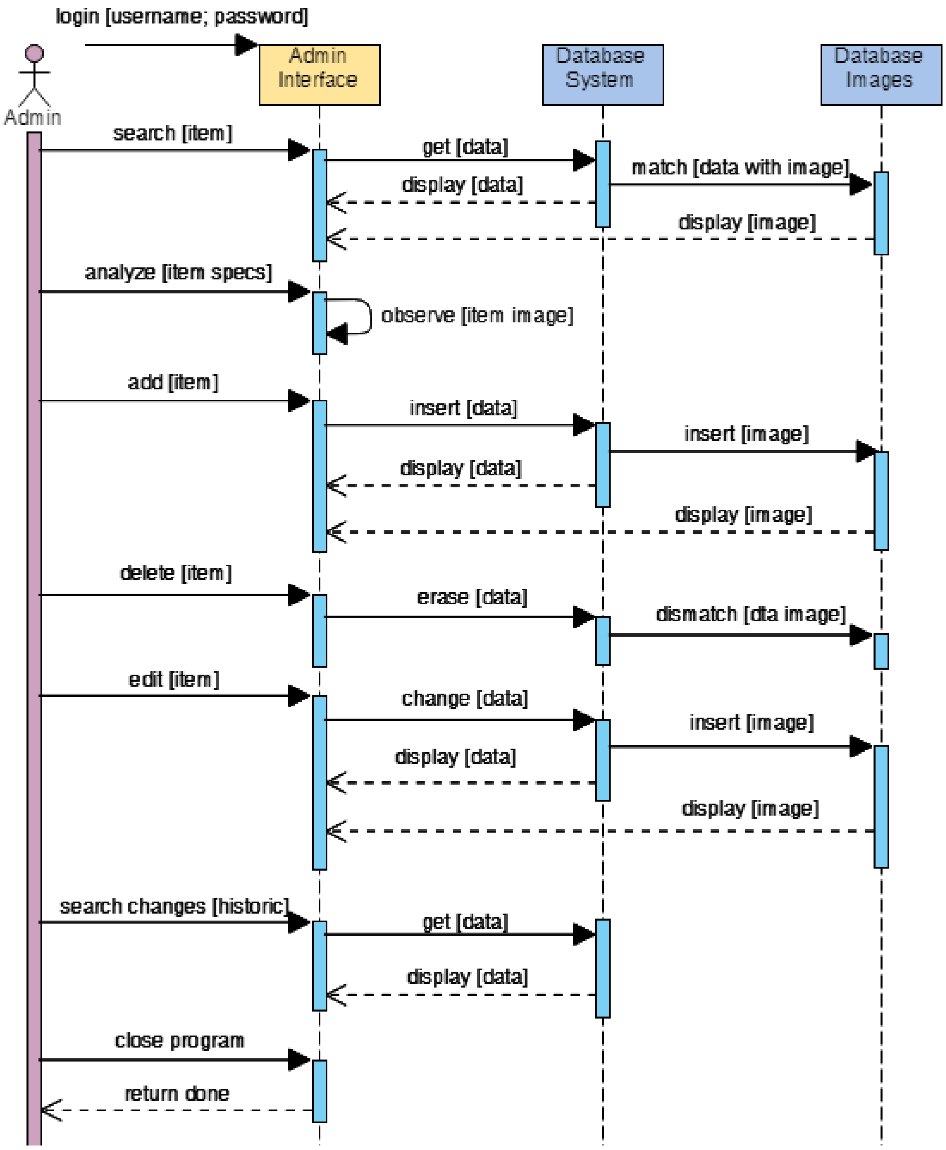


Diagram 24 - LC70 Database Admin Sequence Diagram

Entity Relationship Diagram

The ERD related with this second system can be seen in Diagram 25. There was one main database where all items data were inserted. From that, another database was built to support the historic field, which access was only possible by the administrator.

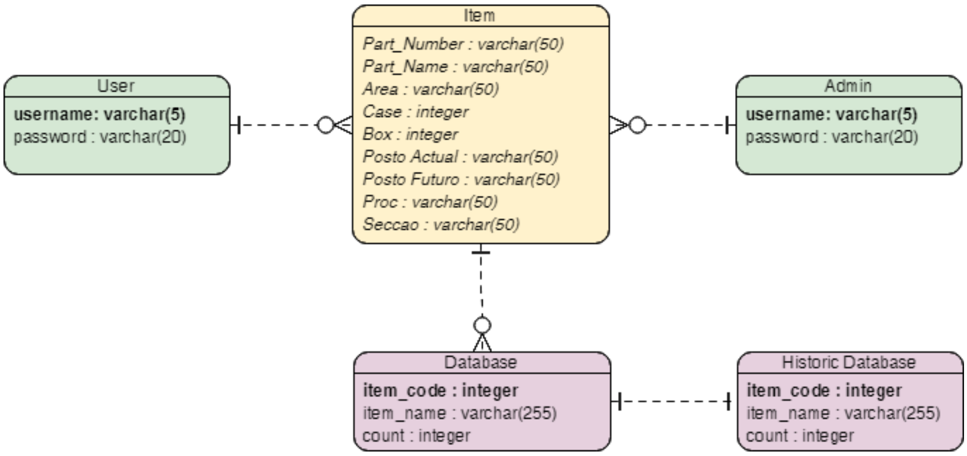


Diagram 25 - LC70 Database Entity Relationship Diagram

Class Diagram

In the following diagram, there are three different main classes: the item and user database classes, the UI and UX classes of the program created and the verification and modification classes. The application, as seen in Diagram 26, was composed by the different classes, UI and UX, where all the components details were displayed and all the created actions could be executed, respectively.

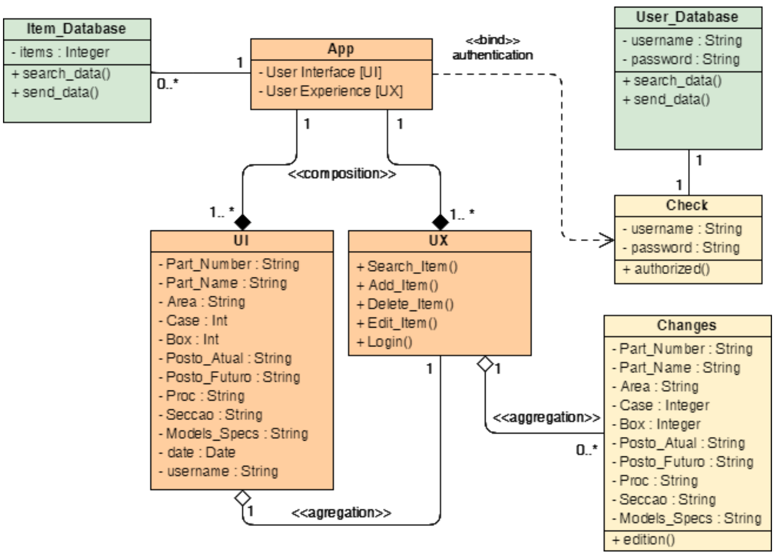


Diagram 26 - LC70 Database Class Diagram

The different authentications influenced the UI and UX. In the UI, more than one item detail could be seen. The same applied to the UX, where more than one change could be made.

Package System Diagram

It can be seen, in Diagram 27, that the application UI package was composed by the UX package interconnection and synchronization with the database management. The add, delete and edit action sent data information to the custom database created, being then displayed into the UI.

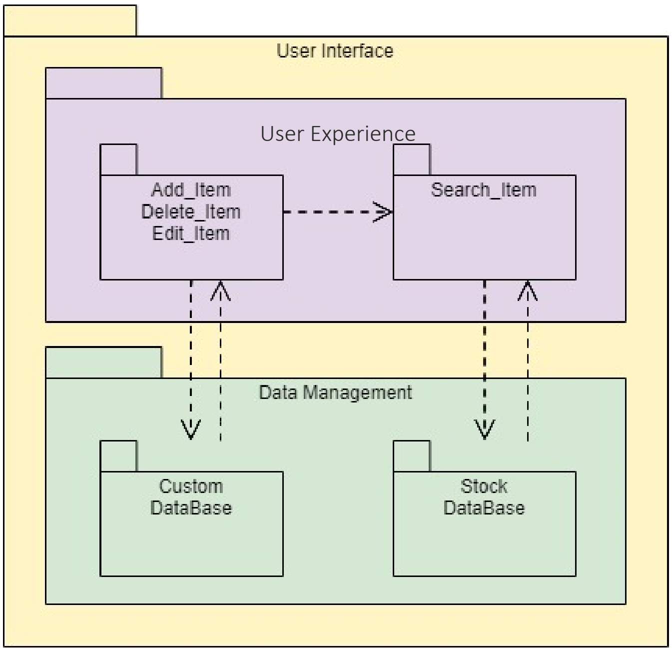


Diagram 27 - LC70 Database Package System Diagram

6 Concept Solution

In the following chapter, the developed solutions are presented. To better characterize the execution process, the developed programs' UI (User Interface) and UX (User Experience) are described.

6.1 1st System concept solution

The initial system was studied and analysed to collect the most amount of raw data necessary to understand its workflow. After this stage, several lists of possible solutions were registered followed by a brainstorming meeting to decide which one could be more related to the factory's vision and mission.

The initial solution decision was detailed strategically to be able to communicate with the stakeholders constantly, providing them an easy view to a better understanding of the sub- processes involved. The new system was designed and built accordingly to the managers criteria and standards.

To resolve the problem, it was developed an application in VBA programming language, as a front-end development, supported by an excel database with all active warehouse materials and respective SAP code, as a back-end development.

All system, from the input to the output, was supported by an application to better track all the variables around it. The application UI is shown, in Figure 25. When the application is opened, the user windows login was immediately field into a cell. The date was also registered.

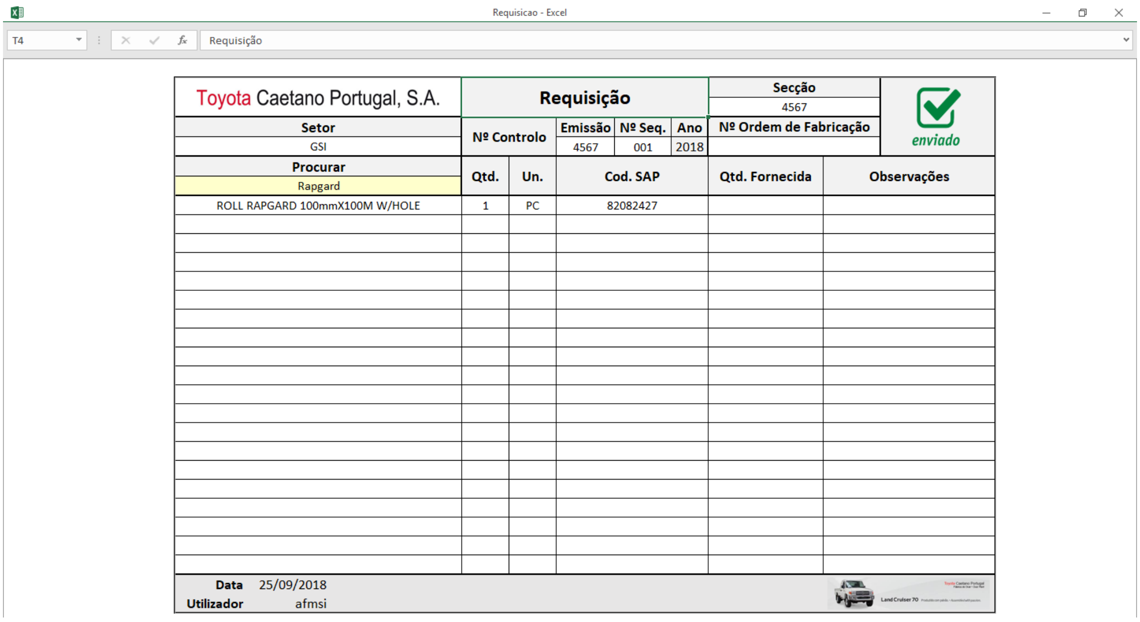


Figure 25 – Application layout

A dropdown data list was used to provide the user with all needed information. It is seen in Figure 26, that the field *"Setor"* had associated all TCAP – Ovar cost centers. This was essential in order to define who was going to order the material.

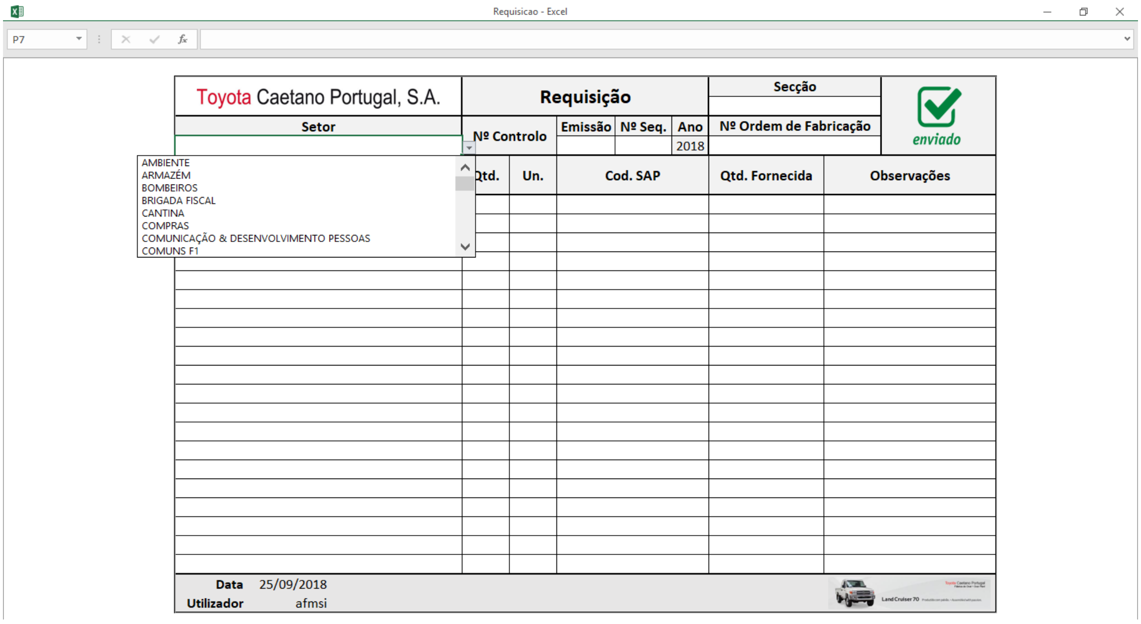


Figure 26 – Dropdown data list of all TCAP – Ovar cost centers

It was developed a search algorithm to be allocated into a specific cell, for faster material detection. The search data engine is seen yellow-shaded in Figure 27, providing an easier identification. With this development, the system became more flexible an agile for the users, see Figure 28.

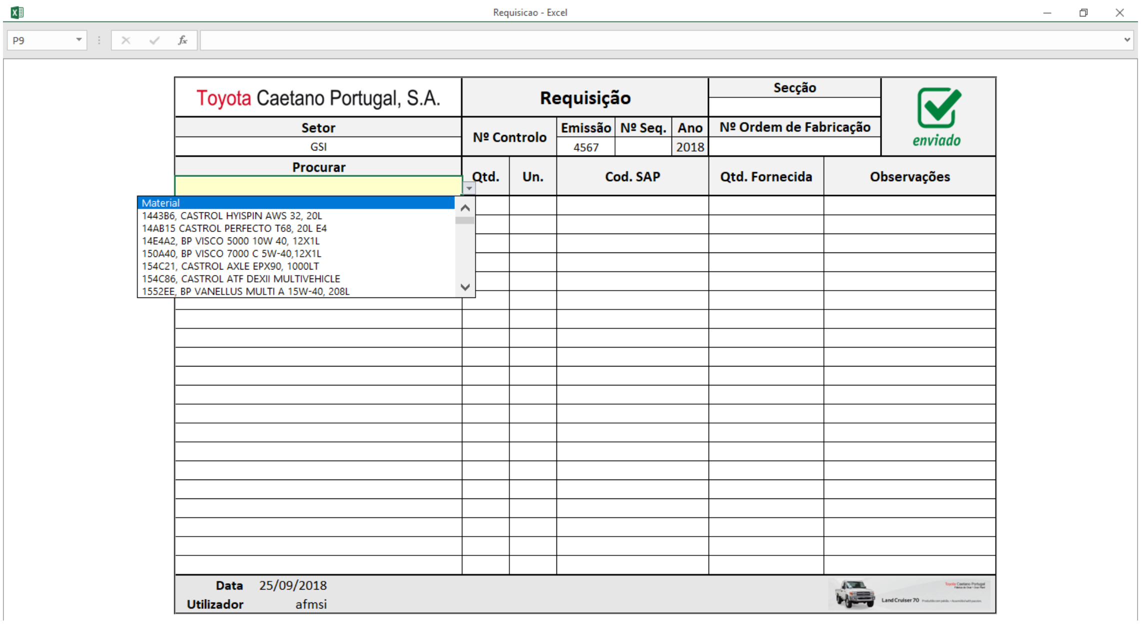


Figure 27 – Dropdown data list of all materials

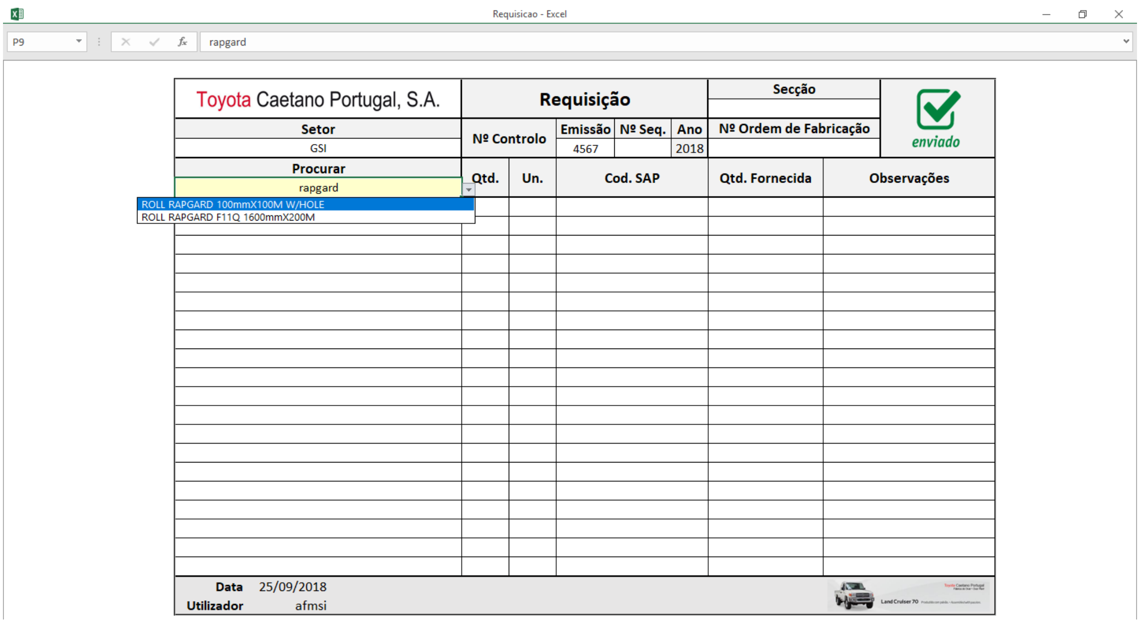


Figure 28 – Search field usability

After the search being done, a dropdown list was available in all data cell bellow the search field. Here, the user had to select the needed material to be ordered. After the selection being done, the SAP code with the respective unit of the chosen material was automatically inserted, as seen in Figure 29.

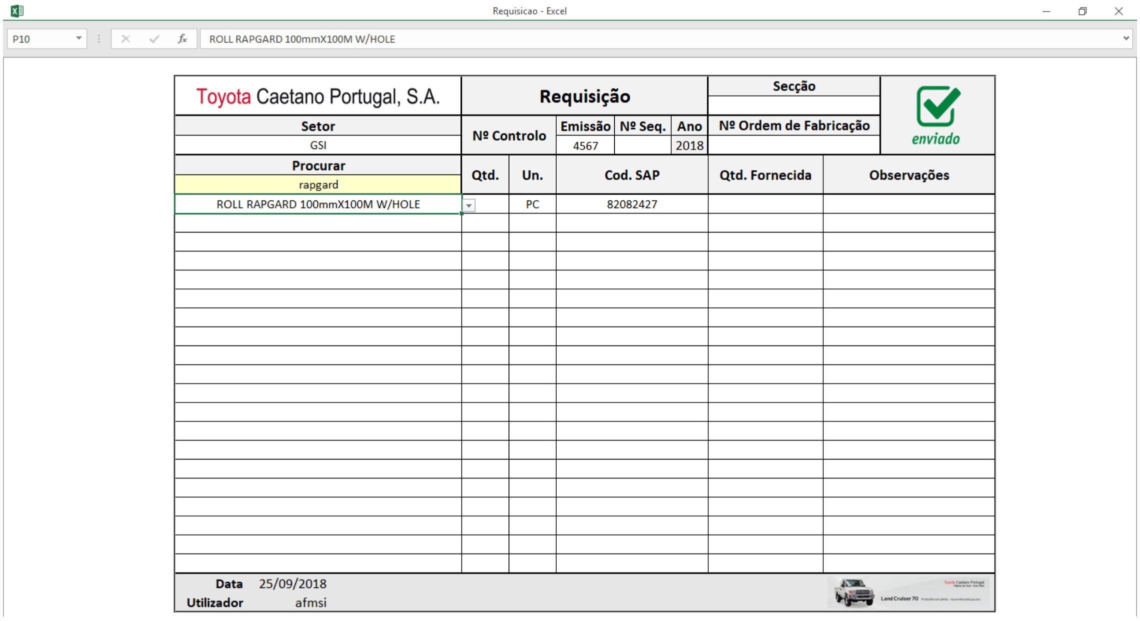


Figure 29 – SAP code automatic insertion after material selection

If the user tried to send the order, an alert of the quantities empty field was shown into the UI, see Figure 30. The same procedure happened to the empty sequence field and to the debited cost center, shown in Figure 31 and Figure 32, respectively.

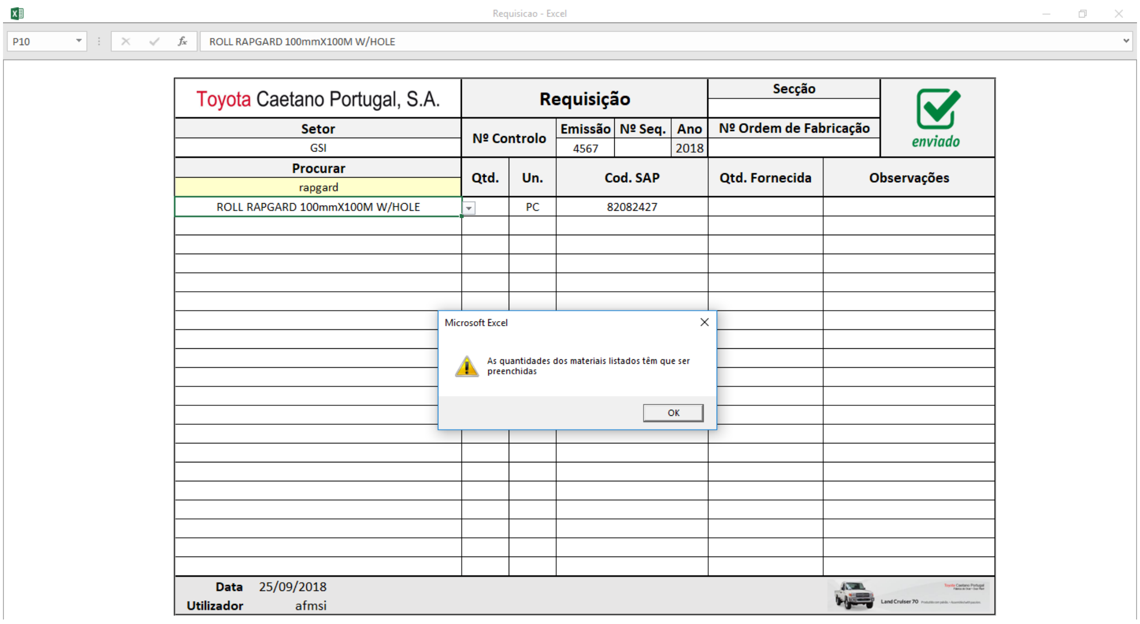


Figure 30 – Quantity alert to be field

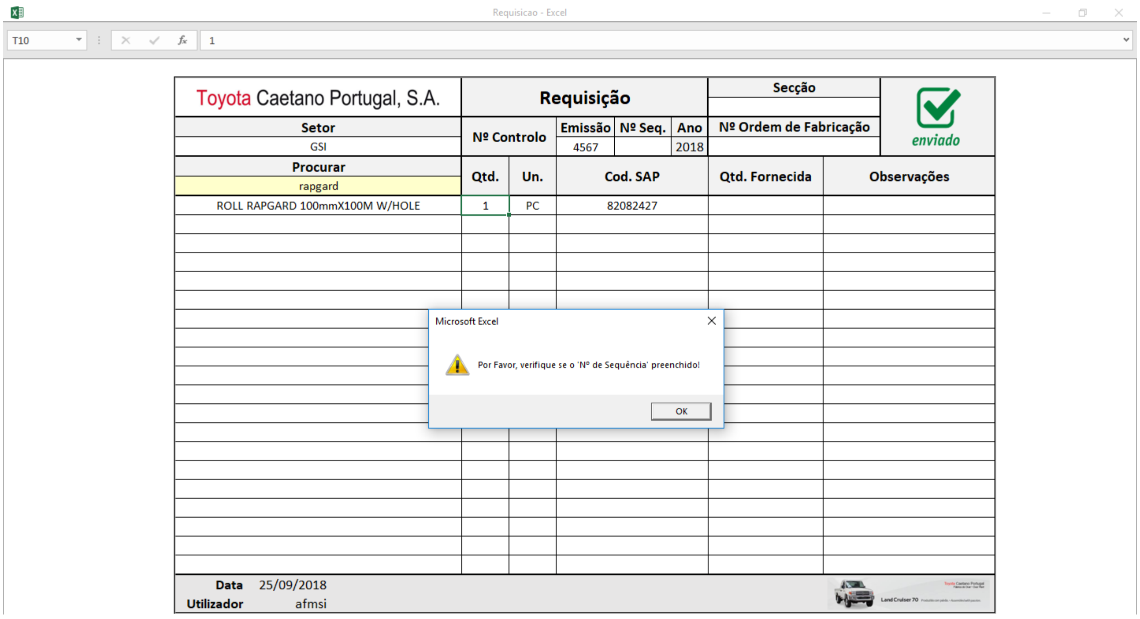


Figure 31 – Sequence order alert to be field

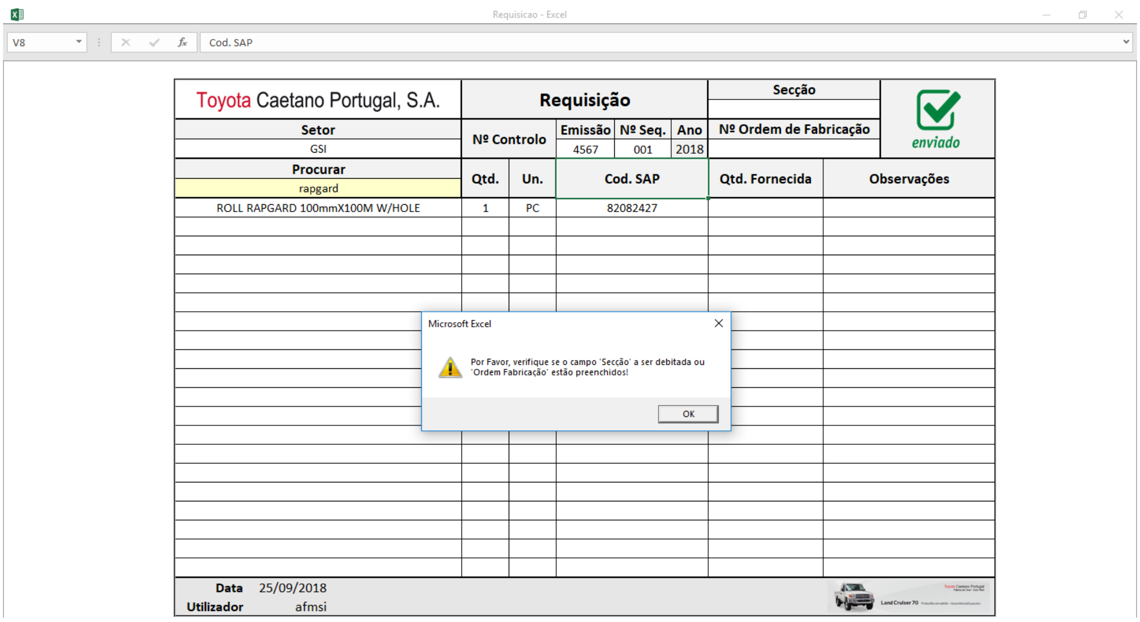


Figure 32 – Cost center to debited or order fabrication alert to be field

After the all needed fields were verified and completed, Figure 33, the user was able to finish the order by clicking into the icon "*enviado*".

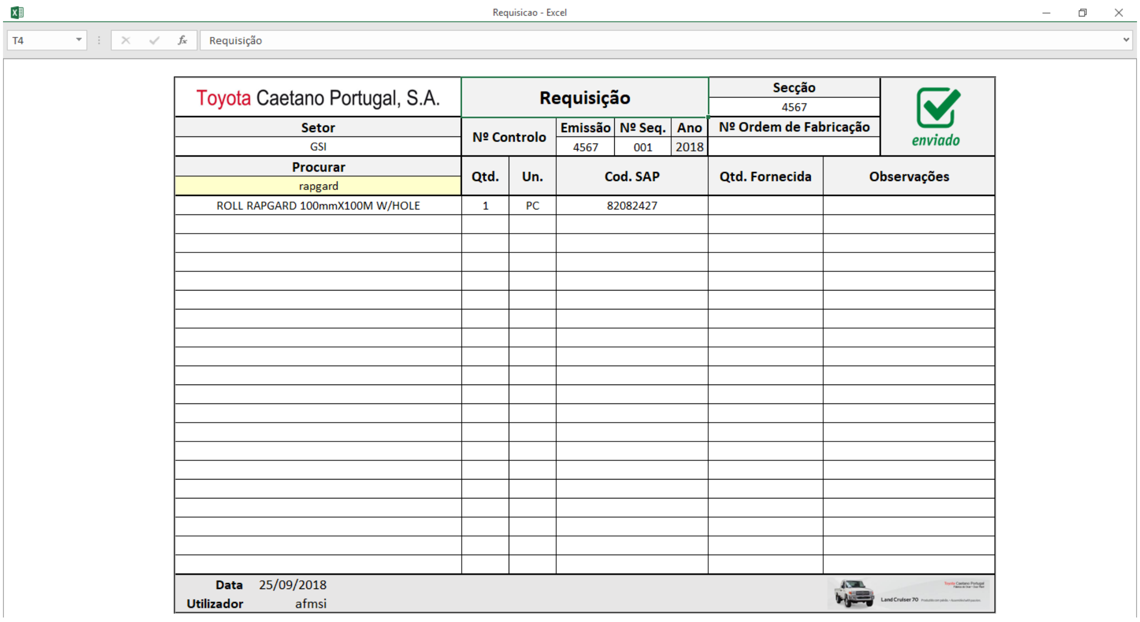


Figure 33 – An example of a completed order

This had a developed function to generate a *.pdf* file and to send automatically an email with a *.xlsx* order file to the warehouse, see Figure 34 and Figure 35, respectively.

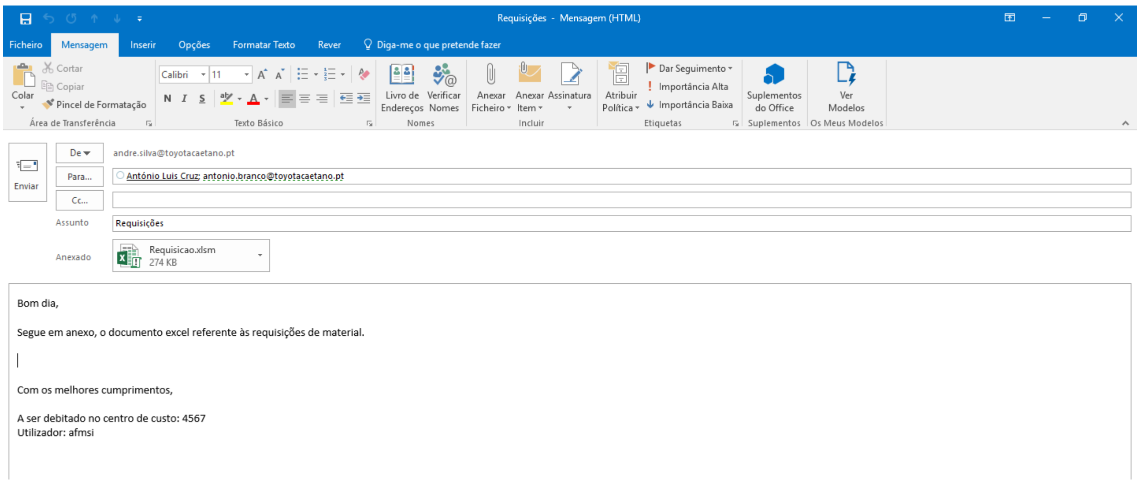


Figure 34 – Outlook email with order file attached

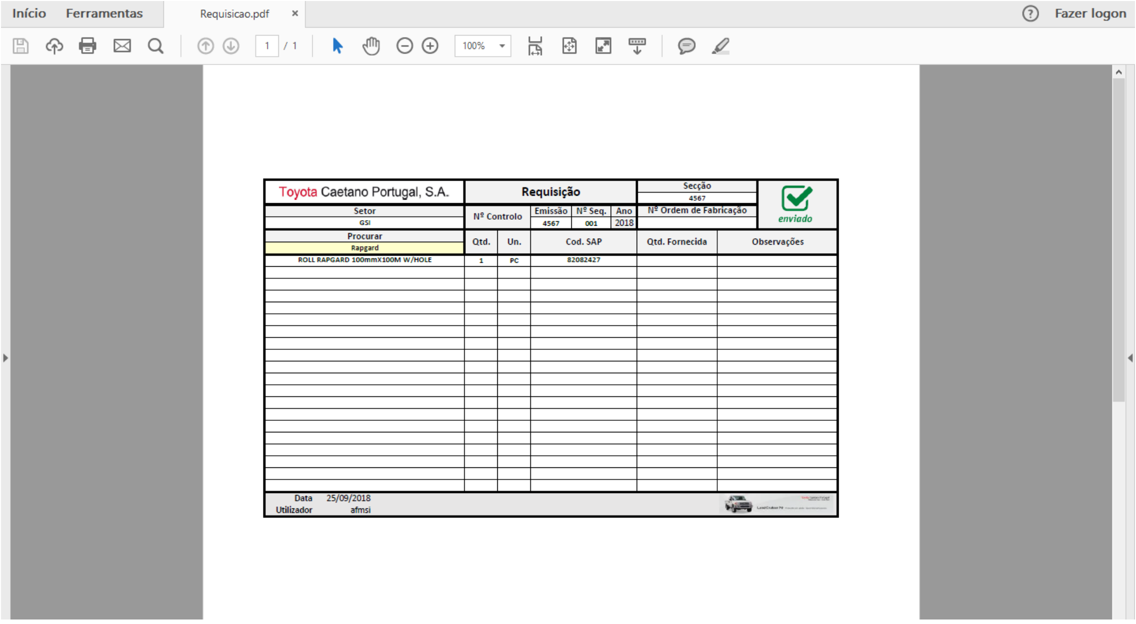


Figure 35 – PDF file output

For users support, an Excel sheet database was developed for the materials code searching, see Figure 36. It complemented the developed application, since it could only search for the materials name.

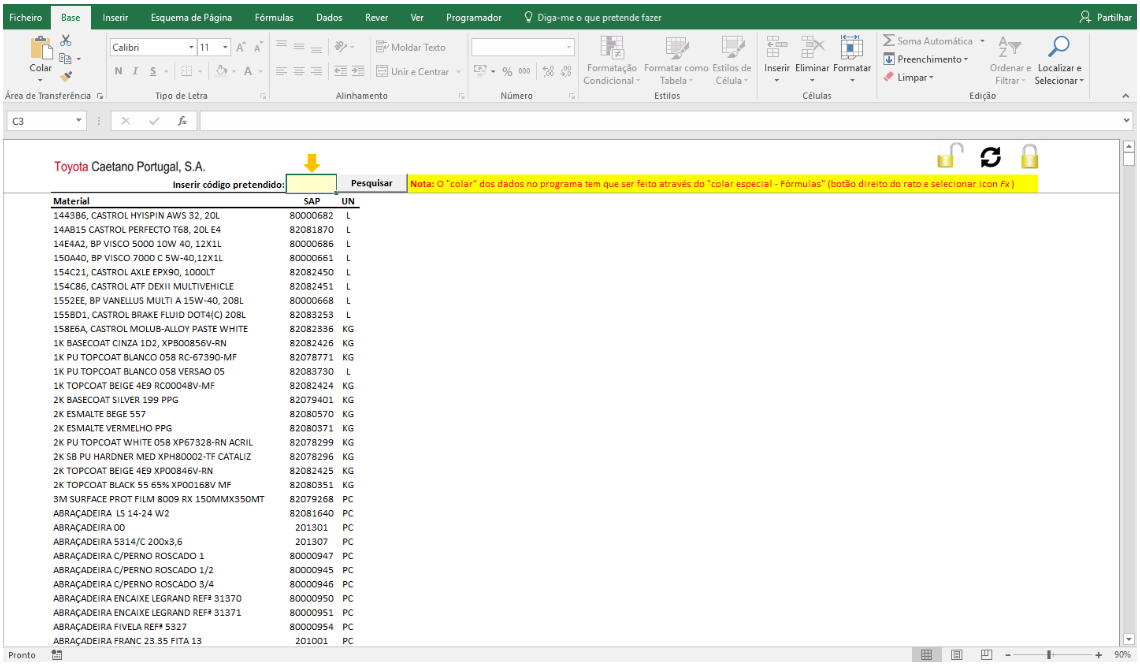


Figure 36 – Excel database for SAP material code search

The correspondent document, describing the occurred changes with the results optimization of this new system, are presented into to the Annex I – Register sheet of the 1st developed system. The developed code, which supports all this system, can be seen in Annex IV – 1st system develop code.

6.2 2nd System concept solution

Due to a non-suitable and flexible UI, finding and editing any component was a complex task. Therefore, it was decided to model and design an entire new system, for better data organization and decision-making.

With this development, it was intended to provide and optimize the execution of activities like component addition, elimination, edition, duplication and search.

An historical record of changes was created, based on the user authentication. This allowed a better and easier maintenance for the administrator and consequently a data traceability. It is seen, in Figure 37, the login UserForm (UF) development, to provide security restriction into the system's access. The people able to access the new developed system was defined by the main administrator, from the engineering team. After login data insertion, the system authenticated the user.

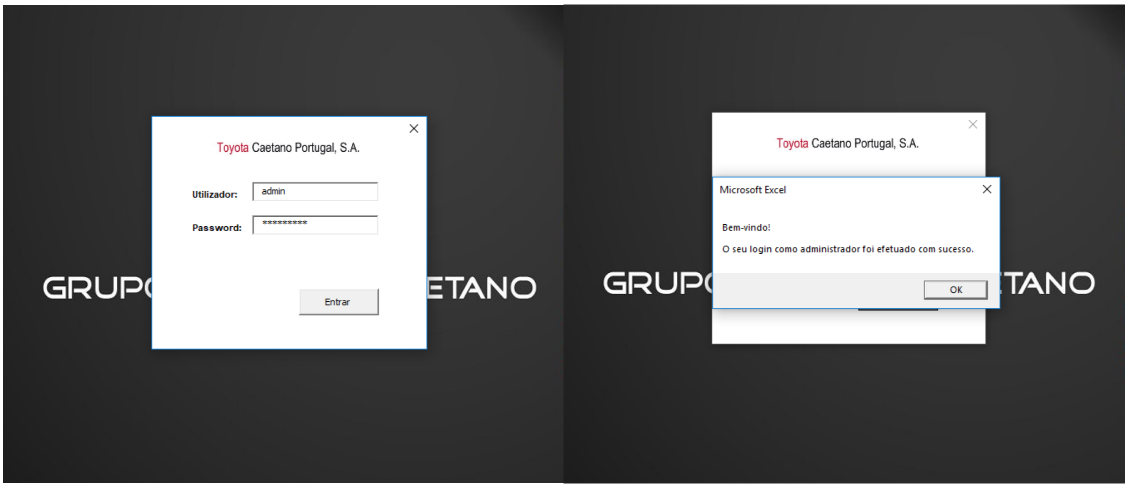


Figure 37 – Login UF and authentication detection

For security purposes, the office tools had a macro enable protection. To be able to open the desire UI, an implemented content had to be activated. A sheet was created only to advise the user to accept the required macro activation, shown in Figure 38. Then, the UI was opened, as seen in Figure 39.

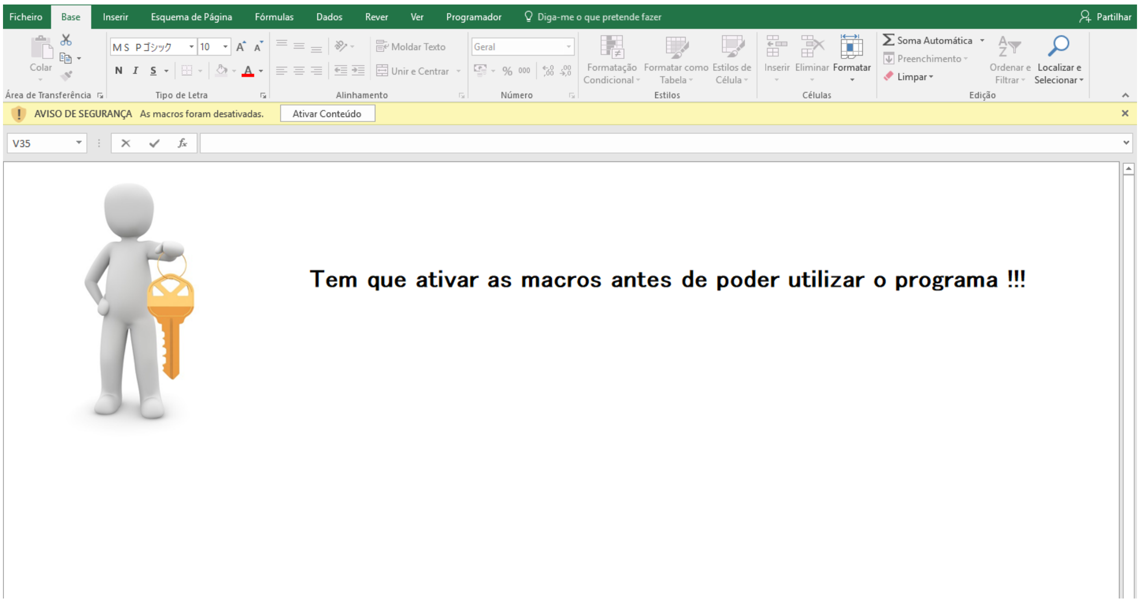


Figure 38 – Macro activation alert before displaying the UI

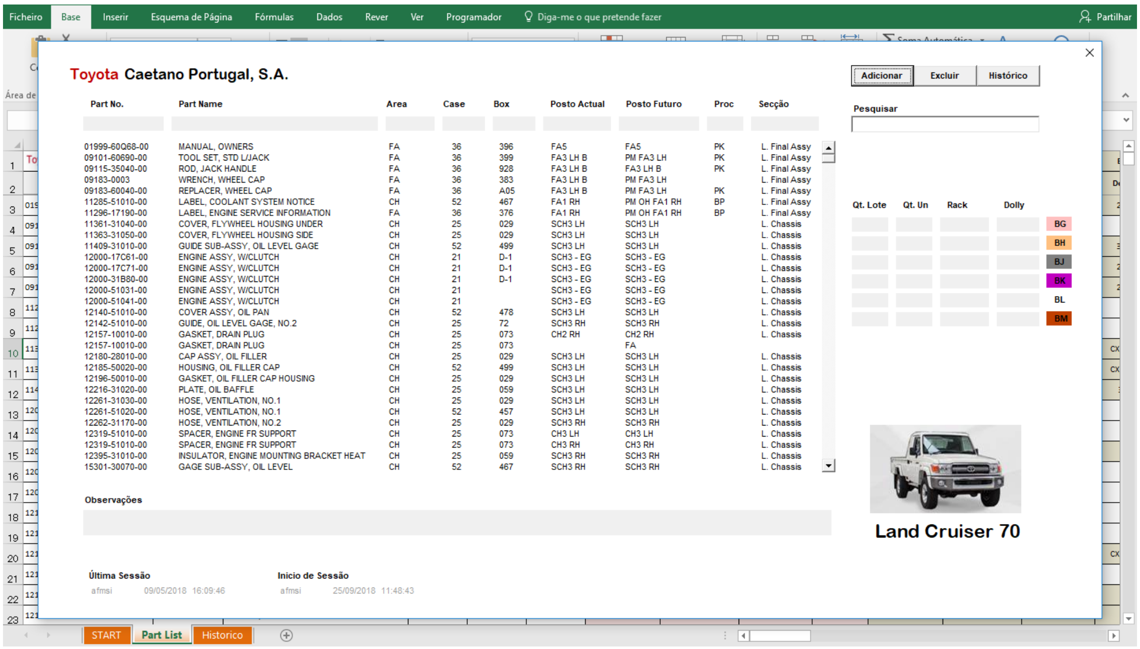


Figure 39 – Administrator UI

By clicking into the data display, all the specifications were displayed into the correspondent field, as seen in Figure 40.

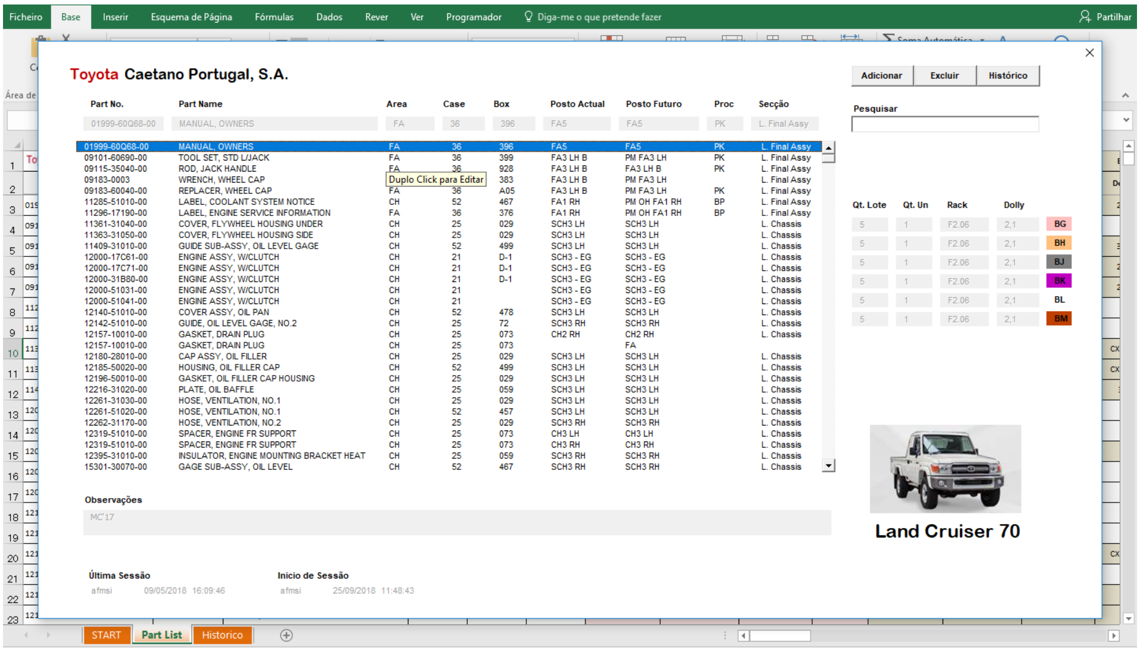


Figure 40 – UI component's specifications

If the user wanted to edit the components specs, a double-click was needed. A UF was opened, Figure 41, providing all the corresponding specs available to be edited, cleaned and duplicated.

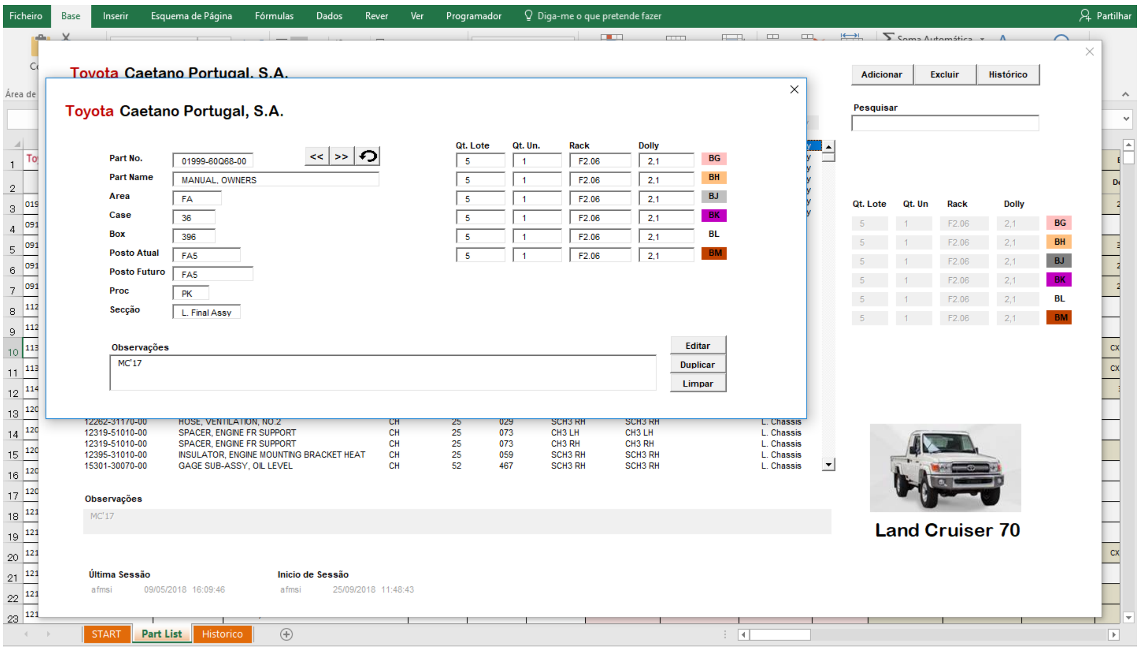


Figure 41 – UF for specification's edition

A similar UF was also opened, Figure 42, when the addition of a new component occurred.

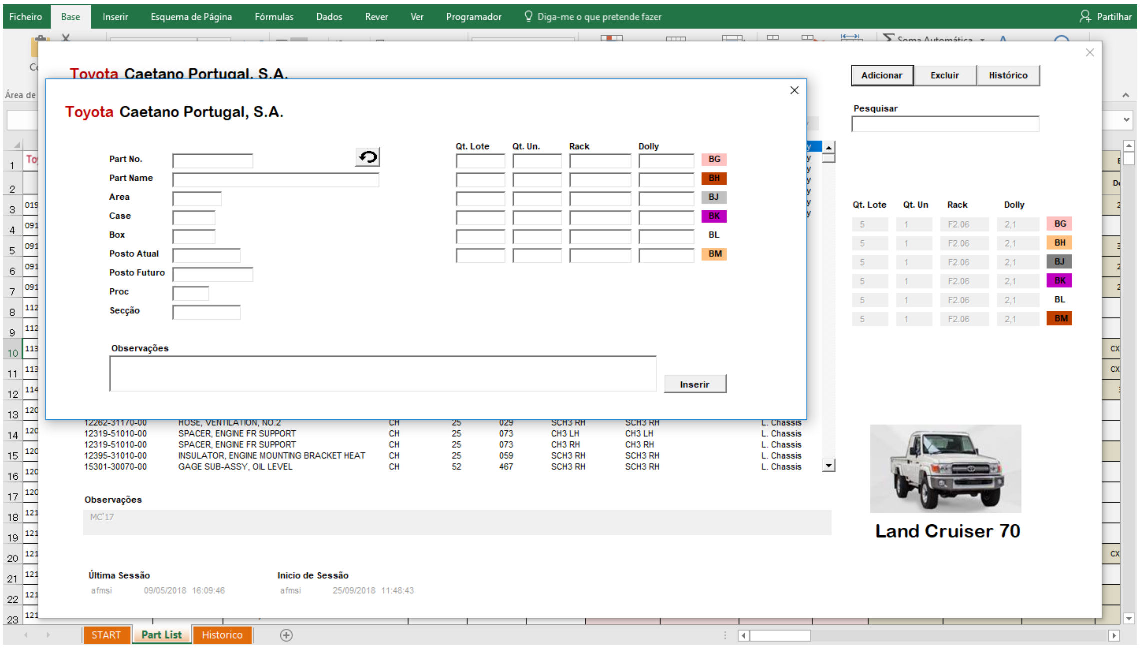


Figure 42 – UF for item's addition

The administrator, besides all these available functions, had also an historic UF to trace all the data changes, see Figure 43. The last visitor of the system was also notified by the main UF, with the corresponding date and hour.

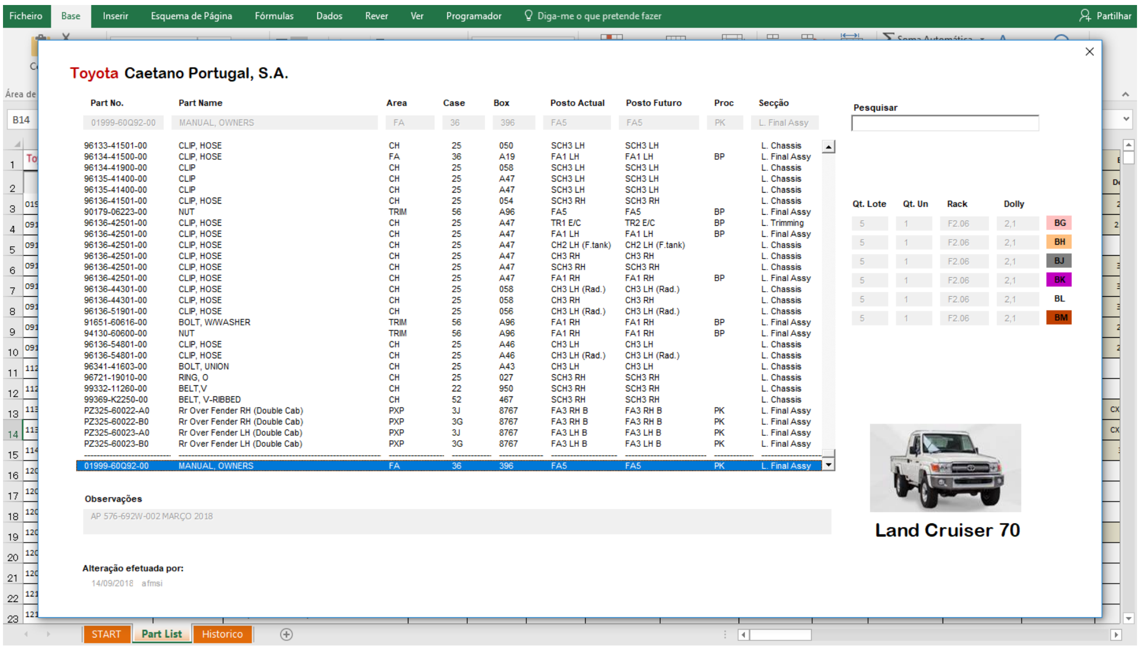


Figure 43 – UF for historic data visualization

In Figure 44 can be seen the excel database which was the motor support of the UF data association. This sheet was only able to be seen by the administrator.

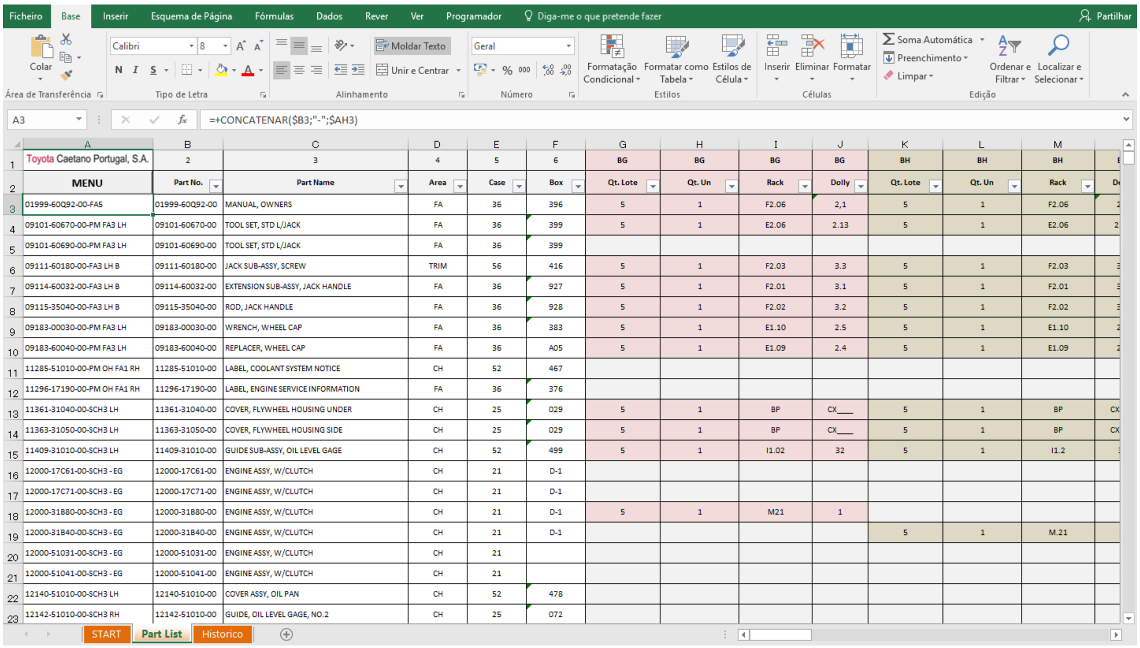


Figure 44 – Excel sheet database

Relatively to the user UF, it was only able to search for the needed component, see Figure 45. This search, as well as in the admin UF, could and should be done into the search engine field, by component *Part No.* and *Part Name*.

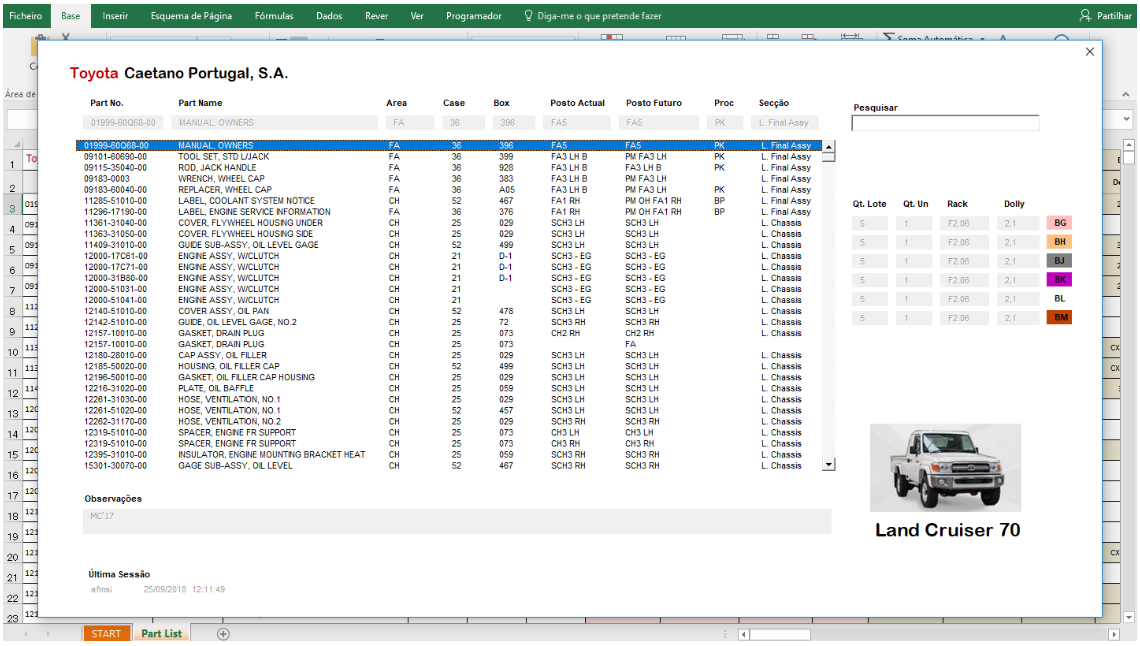


Figure 45 – User's UI

The correspondent document, describing the occurred changes with the results optimization of this second system, is presented into to the Annex V – Register sheet of the 2nd developed system. The developed code, which supported all this system, can be seen in Annex VIII – 2nd system develop code.

6.3 Process Management

After testing the integration and posterior implementation of both systems, a vertical analysis was done in order to detect any entropy in the process. Subsequently, space for optimization was detected. Therefore, actions and procedures were planned in order to keep the continuous improvement methodology on each project management.

Implemented kaizen for the 1st system developed

After three months of the system implementation, it was verified that from the user's point of view, the system did not have any entropy, complying with the initial stipulated requirements. However, from the point of view of the Administrator, the one that proceeded the maintenance and the developing of whole system, there was an effective but not efficient process, due to the excessive tasks for database maintenance.

After this opportunity of improvement, "*Kaizen*", it was then analysed and designed, being the process workflow detailed. Therefore, it was verified that by changing the entire engine of the system, from Excel to Access database, seen in Figure 46, along with a macro creation for real time data update, an optimization would be needed. As result, after the needed maintenance, the macro action synchronization was done, being the administrator able to manually send several packages to different sector folders through the enterprise cloud.

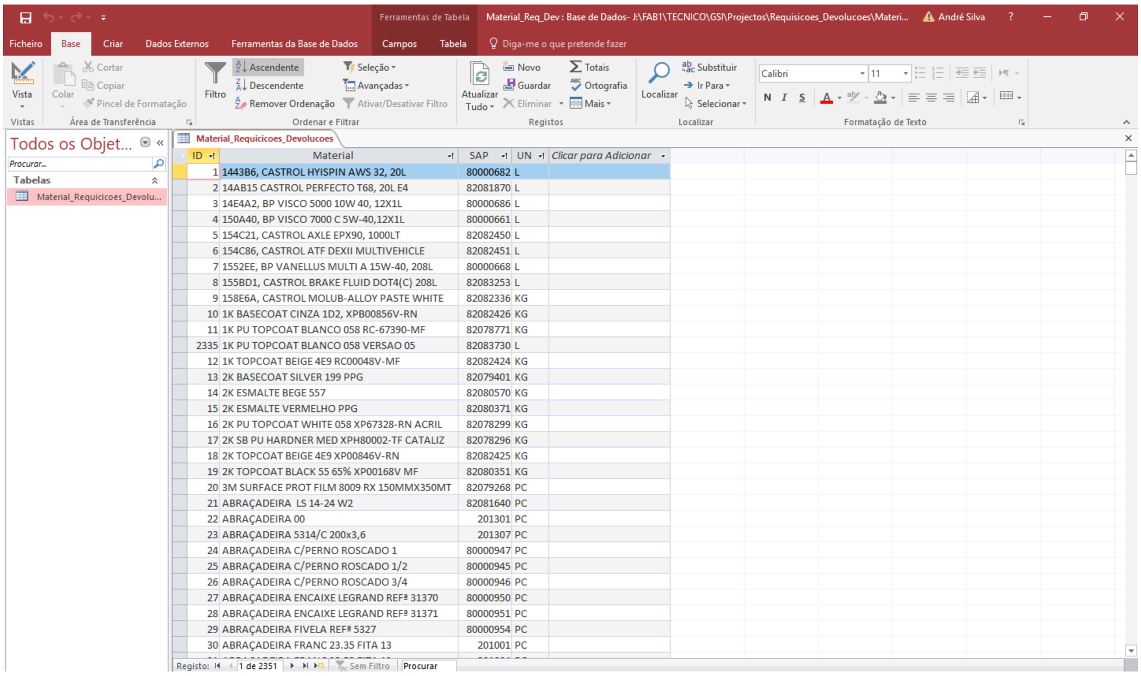


Figure 46 – Access material database

The kaizen built was also supported by a document for optimization register, see Annex II – Register sheet of the 1st developed system kaizen. These documents were needed due to all continuous improvement philosophy of the company.

Implemented kaizen for the 2nd system developed

After the implementation of the second system, several observations from the administrator's point of view were discussed. Therefore, it was verified that images' insertion of the components, according to their selection, were a most for the user and the administrator, see Figure 47, optimizing the recognition and identification ability of the components.

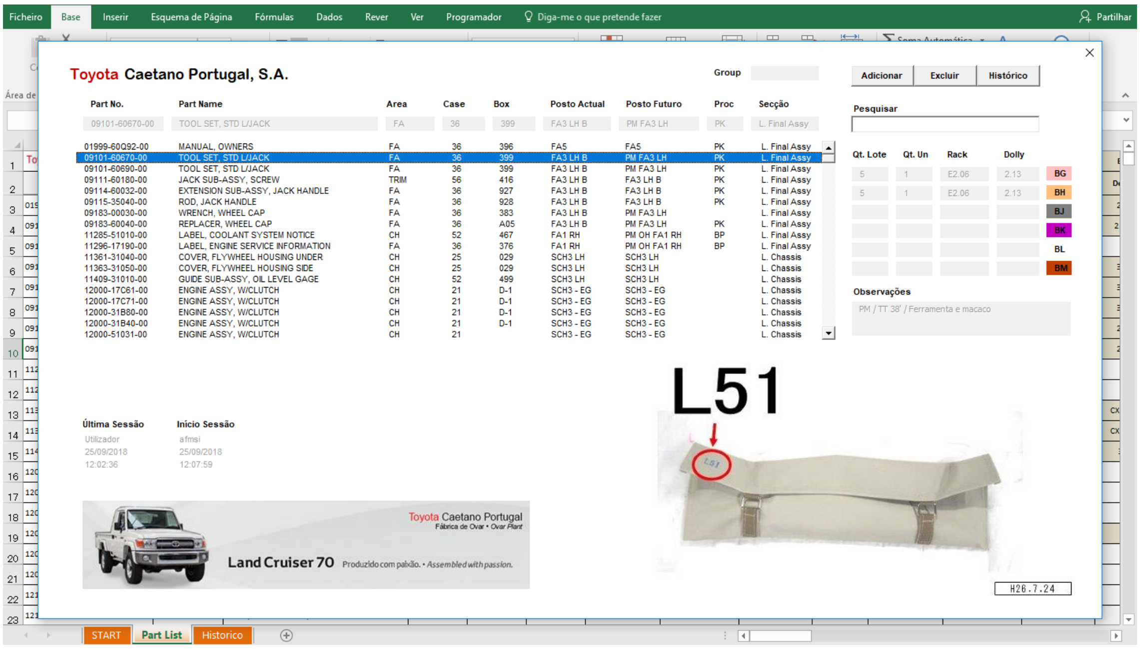


Figure 47 – Administrator UI after kaizen implementation

As result, a new process of code development to be incorporated in this subsystem was created. The way how the administrator maintains these images was also considered. It was only necessary to insert the *.jpeg* format picture into a specific folder and give the correspondent *Part No.* of the component. Then, the developed algorithm was able to synchronize the picture path with the correspondent database's item.

All this system's optimization reduced even more the time decision making and the probability of error information.

In the same way, as the first system kaizen implementation, the correspondent document describing the occurred changes with the results optimization is presented into to the Annex VI – Register sheet of the 2nd developed system kaizen.

CONCLUSIONS

7 Conclusion

In this chapter, the conclusions regarding the general status of both systems implemented were discussed.

The results obtained were studied and analysed, making the link between the development and implementation phase of the created IS.

Future optimizations were also exposed to promote a whole philosophy of continuous improvement, with a view to improve the implemented systems.

7.1 Project's Analysis

Nowadays, to compete in a highly demanded market, it is essential that the organization takes into its performance, the challenge of continuous improvement. The constant demand for process optimization allows the organization to respond to the growing needs of its own customers. The goal is to manufacture the best product at the lowest cost as quickly as possible, in a sustainable way.

The elaboration of this project demonstrated that, to achieve relevant improvements, there is not always a need for substantial investments or complex solutions. Using the resources available by the company, it was possible, in the allotted time, to reach the defined objectives and to present results that support the improvements obtained.

After a requirement analysis, an initial brainstorming occurred. With the participation of the directors from the Engineering and Planning Department, it became simple to identify the existing problems. Subsequently, through the application of lean methodologies and tools, it was possible to detect the causes that were at the root of the problems and to start looking for the best solution to be applied in the context of the project. Engineering requirements were listed, being then able to model the different process and procedures of the new developed system.

The achieved results show the fulfilment of the objectives and the constraints proposed. With the implementation, it was demonstrated that the developed solutions were accessible to all stakeholders in the process. The simple management was classified by the employees involved as enjoyable.

7.2 Results Presentation

As seen before, two different projects were implemented in TCAP - Ovar, both related with decision making optimization and workflow data organization. The first one was related with DMS, since one of the principal goals was the physical paper reduction by passing all the physical information process to an electronic one. The second was an application development to better monitor the LC70 database components, providing higher data traceability and security.

After the implementation of the mentioned projects, result's analysis was done to find and observe entropies and register the improvements that could be done in a near future. This way, the method could be continuously improved, which is the one of the main pillars of the TPS philosophy.

Next, the obtained results from each project were described and analysed in an objective point of view.

7.2.1 1st System implementation result analysis

This project's main goal was to provide functionality and time optimization of the entire materials' requirement process from the warehouse, to satisfy the line production needs. A DMS was created, providing a better organized way for all the workflow inherent to this process. It also provided decision support and data organization, where input data for order support could be done and sent automatically to the warehouse, for posterior receiving. Before this implementation, all process was done by filling a paper for each require order and then, every team member would receive the package. After the new IS implementation, all the process was changed, passing to electronic documents with historic data, being restricted for the GL only use.

As results of this IS implementation, it was noticed that in a worst-case scenario, 4538 paper sheet's consumption per year are going to disappear, having a cost reduction of about 208,00 €.

It is shown in, Table 26, that the DMS implemented brought several reduction costs. The reduce of the overall paper consumption was equivalent to less 0,10€ per unit produced and the optimization of the time execution process by the user and the warehouse operators meant less 2,09€ per unit produced.

The drastic time reduction to perform the entire process and the associated costs constitute a very positive feedback. The estimated annual reduction of about 4538€, due to factors such as runtime optimization and used paper reduction, implies a gain of 2,19€ per unit.

All this project analysis was documented into an A3 size paper sheet, see Annex III – A3 register sheet of the 1st developed system, as a cost reduction project for the company.

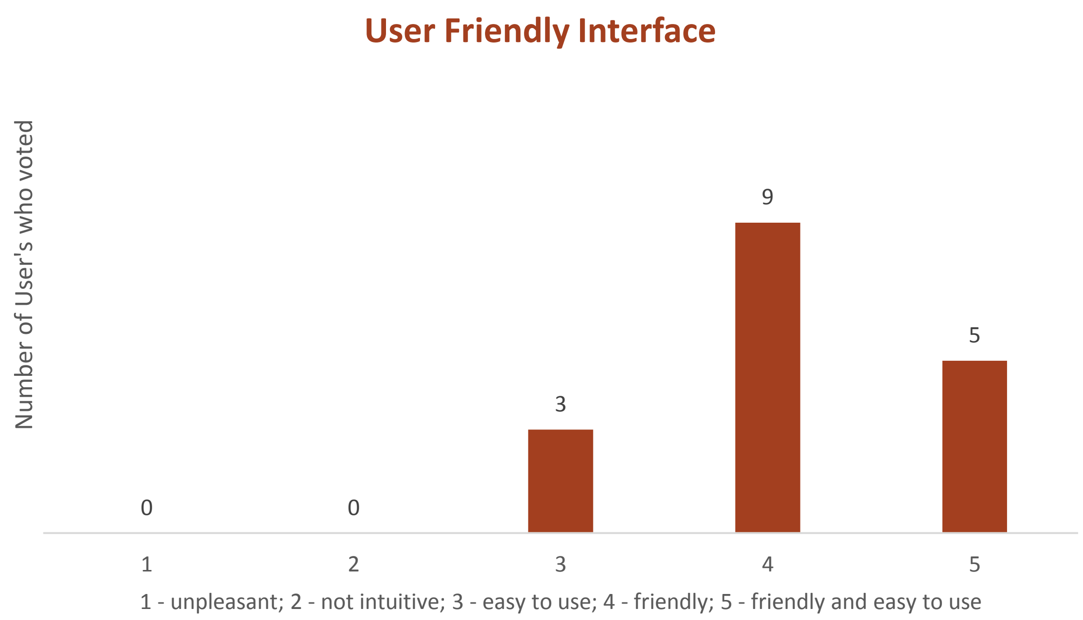
Table 26 - Results from Materials Requisition and Returns Information System implemented

Variables	Before	After	Reduction (€ / hour)	Reduction (€ / year)	Reduction (€ / unit)
Paper	7800 (un)	650 (un)	----	-208	-0,10
User	45 (min)	25 (min)	-1,17	-2471	-1,19
Warehouse	30 (min)	15 (min)	-0,88	-1859	-0,90
Total	----	----	-2,05	4538	-2,19

Note: All the obtained results are based on the next assumptions: Annual production of 2070 units; Average salary of 3,5 € per hour; Block of sheets price of 4,16 €; Average consumption of 52 blocks per year.

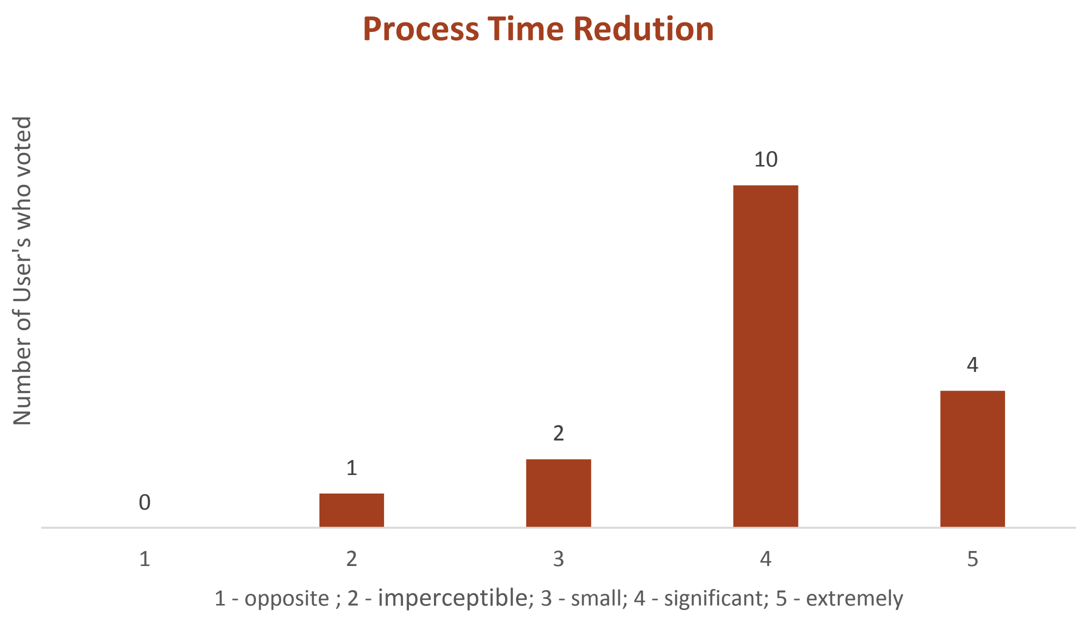
On the other hand, the necessary adjustment from the employees in relation to the application standard names assigned in the ERP used, SAP, were obvious difficulties experienced. Then, a survey was done to collect the users and stakeholders' opinions relatively to the new developed system and its workflow.

Next, several questions to the users were done, being able to provide some graphics' results and answers, for better analysis. Graphic 1 shows that the users considered the new application's interface friendly and easy to use.



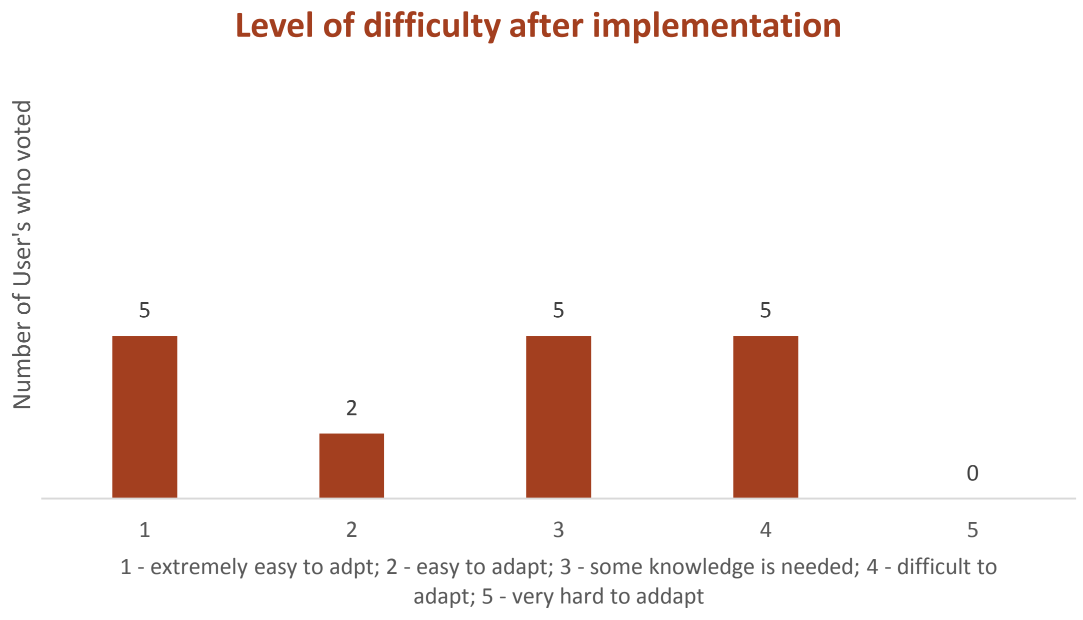
Graphic 1 - User friendly interface question (survey results)

It can be seen, in Graphic 2, a successful process time reduction from the new system application, considered by the users.



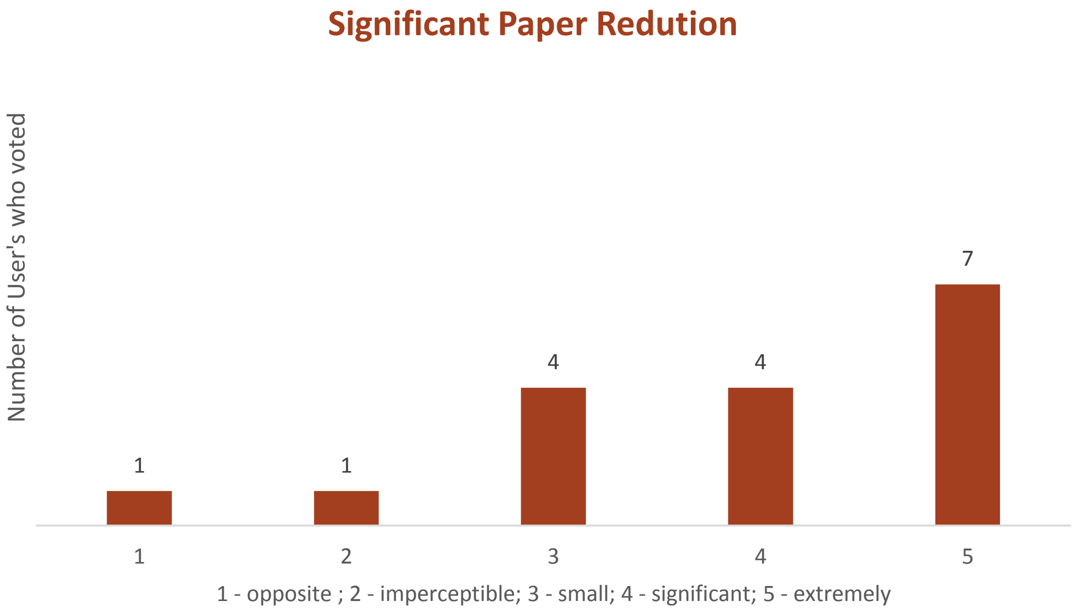
Graphic 2 - Reduction of time associated with whole process question (survey results)

Graphic 3 shows a very distinctive opinion relatively to the new system adaptation. This diversity was associated with each user's entropy to the new technologies.



Graphic 3 - Level of difficulty felt after implementation of the new system

It can be seen, in Graphic 4, that the users considered a significant paper reduction by this new system implementation.



Graphic 4 - Significant reduction of paper survey

From the user point of view, had the implemented system facilitated the entire process, allowing better organization, traceability and accessibility of information? Why?

- Yes. The IS created has optimized the whole order and return process.
- Yes. Reduction of paper (Environment kaizen) and consequent reduction of costs.
- Yes. Better organization / management of orders and time waiting reduction for lifting the material.
- Yes. It allowed only few people to access the order and avoided the trip to the warehouse.
- Yes. It allowed to make a digital file easy to consult.
- Yes. Minimized the error (data insertion), reduced routes, attenuated paper consumption and increased efficiency in the service provided.
- Yes, it streamlines and systematizes the order material process.
- No, process update missing with new codes.
- Yes, providing easy digital files access and friendly search for everyday products.

From the user point of view, what improvements need to be made in the system and / or process?

- Creation of a standardization process for sending information about new materials inserted in SAP, allowing an easier and faster maintenance by the systems' administrator.
- It is difficult in the database to detect the desired material without knowing the exact SAP code.
- If the rules initially envisaged are fulfilled, the process will be increased by 30%.
- Automatic filling of requisition sequence number.
- Database maintenance log to SAP.
- In the process it is necessary to ensure that all stakeholders know to use the form and follow the procedure.

7.2.2 2nd system implementation result analysis

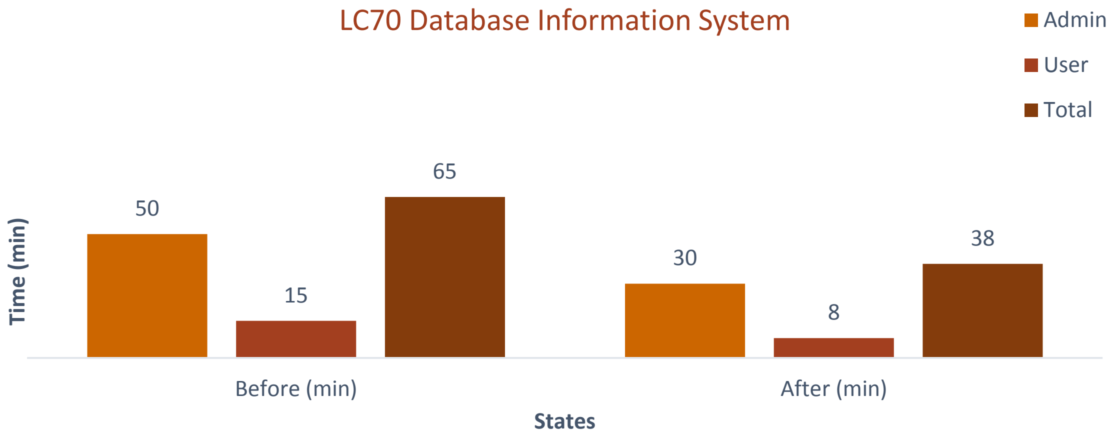
The existence database maintenance of the LC70 components was made in an Excel sheet, consisting of 3000 lines and 40 columns, leading to a lack of traceability, very little flexible/agile data research and edition and none historic record of changes. Then, it was developed and IS, which allowed the user to add, edit, duplicate, delete and search in a flexible and fast way every data needed, leading to an increase of productivity. The user, when searching by component, had also access to the corresponding image for better identification and decision making. The administrator was the one responsible for all the database maintenance, in a very intuitive and effective way.

The results, presented on Table 27, show that the IS development was successfully implemented by providing a better workflow of information and reducing the time decision-making from the user.

Table 27 - Results from LC70 components database Information System implemented

Variables	Before (min)	After (min)	Reduction (€ / hour)	Reduction (€ / year)	Reduction (€ / unit)
Admin	50	30	-1,17	-2464	-1,19
User	15	8	-0,41	-862	-0,42
Total	65	38	-1,58	-3326	-1,61

It was observed, in the previous table, that the DMS for decision support reduced the time decision making from the user and administrator, as well as the maintenance time associated. This system optimization led to a reduction from 64 to 38 min, which meant a cost reduction of 1,61€ per unit built.



Graphic 5 – LC70 database final results

When the user searched, edited or deleted an original item in the database, the output was received instantaneously. However, when the user selects the "add action" and the "duplicate action" of an item, the output delayed around 5 seconds. This small set back was related to the data synchronization with the *.jpeg* image.

As applied to the first project, an A3 size document was created, see Annex VII – A3 register sheet of the 2nd developed system, in order to present a cost reduction project for the company.

7.3 Future Optimization

Since all methodology of continuous improvement is adjacent to the Toyota spirit, the projects carried out will never be necessarily completed and there is always room for continuous improvement over time. The IS created should be optimized to improve the performance, increasing the ability of decision-making, the organization and traceability of information, having consecutively data protection and a substantial reduce of the physical paper used.

The first developed workflow system was very well stablished, providing zero waste of information, due to digital storage archive. However, the data search process still has space for improvement, since the standard components' names match with the respective code, making the identification hard. This problem was built, due to the different labor's dialects used compared to the standard one. Related images could also be implemented, providing a better identification process.

The creation of an action which leads to a document print of all necessary items list, with a filtered algorithm by different specifications, is one of the possible future optimizations. It provides time optimization for the logistic user, by selecting only the number of needed components for better all-around movement into the *gemba*.

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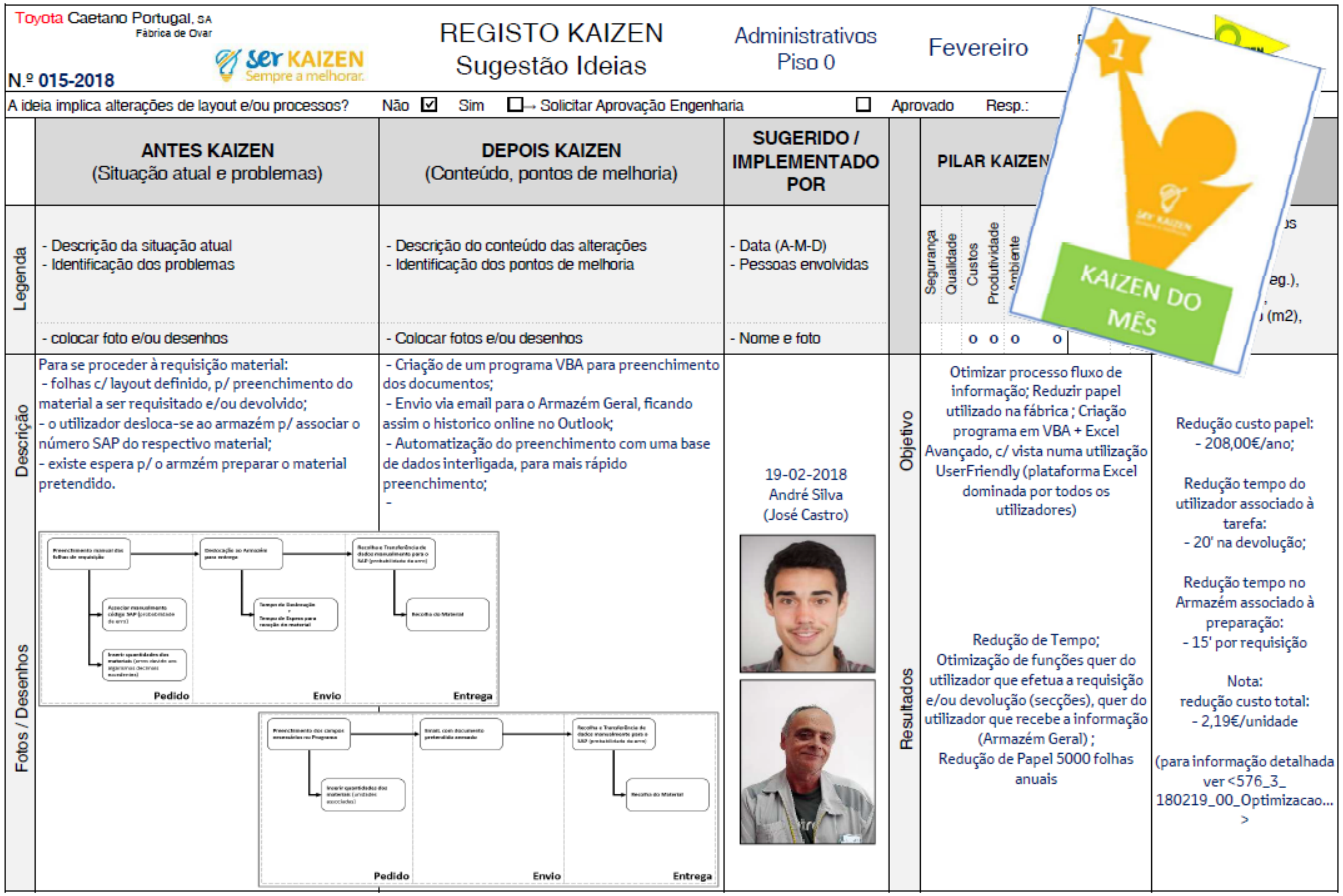
ANNEXES

Annex

Annex I – Register sheet of the 1st developed system



Toyota Caetano Portugal, SA
Fábrica de Ovar
N.º 015-2018
Ser KAIZEN Sempre a melhorar.
REGISTO KAIZEN
Sugestão Ideias
Administrativos
Piso 0
Fevereiro

A ideia implica alterações de layout e/ou processos? Não ☑ Sim ☐→ Solicitar Aprovação Engenharia ☐ Aprovado Resp.:

	ANTES KAIZEN (Situação atual e problemas)	DEPOIS KAIZEN (Conteúdo, pontos de melhoria)	SUGERIDO / IMPLEMENTADO POR
Legenda	- Descrição da situação atual - Identificação dos problemas - colocar foto e/ou desenhos	- Descrição do conteúdo das alterações - Identificação dos pontos de melhoria - Colocar fotos e/ou desenhos	- Data (A-M-D) - Pessoas envolvidas - Nome e foto
Descrição / Fotos / Desenhos	Para se proceder à requisição material: - folhas c/ layout definido, p/ preenchimento do material a ser requisitado e/ou devolvido; - o utilizador desloca-se ao armazém p/ associar o número SAP do respectivo material; - existe espera p/ o armzém preparar o material pretendido. Pedido / Envio / Entrega	- Criação de um programa VBA para preenchimento dos documentos; - Envio via email para o Armazém Geral, ficando assim o historico online no Outlook; - Automatização do preenchimento com uma base de dados interligada, para mais rápido preenchimento; - Pedido / Envio / Entrega	19-02-2018 André Silva (José Castro)

PILAR KAIZEN: Segurança, Qualidade, Custos, Produtividade, Ambiente

Objetivo	Otimizar processo fluxo de informação; Reduzir papel utilizado na fábrica ; Criação programa em VBA + Excel Avançado, c/ vista numa utilização UserFriendly (plataforma Excel dominada por todos os utilizadores)	Redução custo papel: - 208,00€/ano; Redução tempo do utilizador associado à tarefa: - 20' na devolução; Redução tempo no Armazém associado à preparação: - 15' por requisição Nota: redução custo total: - 2,19€/unidade (para informação detalhada ver <576_3_180219_00_Optimizacao... >
Resultados	Redução de Tempo; Otimização de funções quer do utilizador que efetua a requisição e/ou devolução (secções), quer do utilizador que recebe a informação (Armazém Geral) ; Redução de Papel 5000 folhas anuais	

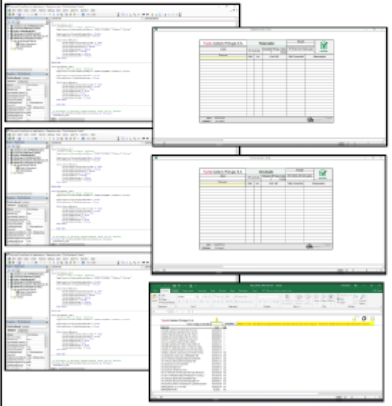
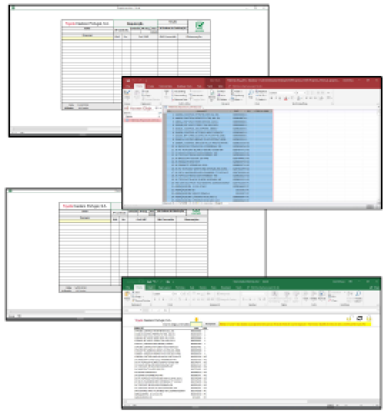
Annex II – Register sheet of the 1st developed system kaizen

Toyota Caetano Portugal, SA
Fábrica de Ovar
Ser KAIZEN Sempre a melhorar.

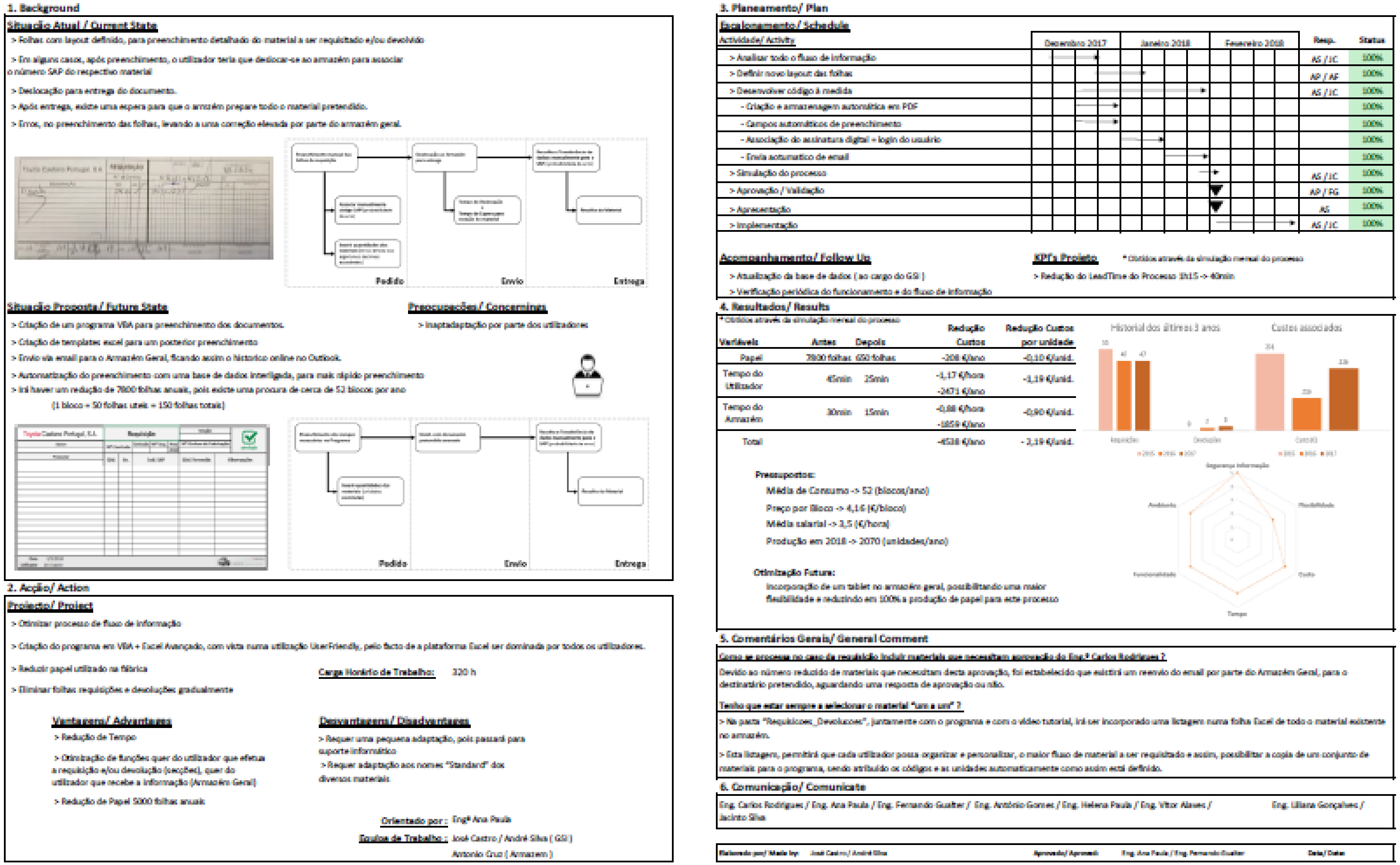
N.º 054-2018

REGISTO KAIZEN Sugestão Ideias	Administrativos Piso 0	Maio	Revisão 07 2018-01-03

A ideia implica alterações de layout e/ou processos? Não ☑ Sim ☐→ Solicitar Aprovação Engenharia ☐ Aprovado Resp.:

	ANTES KAIZEN (Situação atual e problemas)	DEPOIS KAIZEN (Conteúdo, pontos de melhoria)	SUGERIDO / IMPLEMENTADO POR		PILAR KAIZEN	SUB-PILAR	BENEFÍCIO (Quantificar)
Legenda	- Descrição da situação atual - Identificação dos problemas - colocar foto e/ou desenhos	- Descrição do conteúdo das alterações - Identificação dos pontos de melhoria - Colocar fotos e/ou desenhos	- Data (A-M-D) - Pessoas envolvidas - Nome e foto		Segurança: o; Qualidade; Custos: o; Produtividade: o; Ambiente; Ergonomia; Inovação: o	Ação Preventiva; KY Prev. Acidente; HH Prev. Incidente; 5 S: o	Quantificar os ganhos obtidos: custos (€), tempo trabalho (seg.), deslocações (m), espaço ocupado (m2), etc.
Descrição / Fotos / Desenhos	Toda a manutenção da base de dados dos programas Requisições/Devoluções era efetuada nos proprios programas, sendo necessário alterações de linhas de código. Isto leva a uma formação e aprendizagem a quem por definição ficará encarregue de efetuar essa mesma manutenção. 	Foi criada base dados em Access, servindo de motor aos programas Requisição/ Devolução. Esta criação leva a uma otimização na simplificação manutenção dados e consecutivamente a rapidez da mesma. Os programas estarão interligados c/ a base em Access, permitindo que a alteração dados seja efetuada apenas neste último. 	30-05-2018 André Silva  José Castro 	Objetivo	Permitir uma mais rápida e menos complexa manutenção dos programas relativo ao processo de Requisição e Devolução de material ao armazém geral.		
				Resultados	Otimização do tempo de realização de todo o processo, passando de uma manutenção de cerca de 30min para 10min (otimização de 66%), estando uma redução de custo inerentes.		

Annex III – A3 register sheet of the 1st developed system



1. Background

Situação Atual / Current State

> Folhas com layout definido, para preenchimento detalhado do material a ser requisitado e/ou devolvido

> Em alguns casos, após preenchimento, o utilizador teria que deslocar-se ao armazém para associar o número SAP do respectivo material

> Deslocação para entrega do documento.

> Após entrega, existe uma espera para que o armzém prepare todo o material pretendido.

> Erros, no preenchimento das folhas, levando a uma correção elevada por parte do armazém geral.

Pedido | Envio | Entrega

Situação Proposta / Future State

> Criação de um programa VBA para preenchimento dos documentos.

> Criação de templates excel para um posterior preenchimento

> Envio via email para o Armazém Geral, ficando assim o historico online no Outlook.

> Automatização do preenchimento com uma base de dados interligada, para mais rápido preenchimento

> Irá haver um redução de 7800 folhas anuais, pois existe uma procura de cerca de 52 blocos por ano

(1 bloco = 50 folhas uteis = 150 folhas totais)

Preocupações / Concernings

> Inaptadaptação por parte dos utilizadores

Pedido | Envio | Entrega

2. Acção/ Action

Projecto/ Project

> Otimizar processo de fluxo de informação

> Criação do programa em VBA + Excel Avançado, com vista numa utilização UserFriendly, pelo facto de a plataforma Excel ser dominada por todos os utilizadores.

> Reduzir papel utilizado na fábrica

> Eliminar folhas requisições e devoluções gradualmente

Carga Horário de Trabalho: 320 h

Vantagens/ Advantages

> Redução de Tempo

> Otimização de funções quer do utilizador que efetua a requisição e/ou devolução (secções), quer do utilizador que recebe a informação (Armazém Geral)

> Redução de Papel 5000 folhas anuais

Desvantagens/ Disadvantages

> Requer uma pequena adaptação, pois passará para suporte informático

> Requer adaptação aos nomes "Standard" dos diversos materiais

Orientado por: Engª Ana Paula

Equipa de Trabalho: José Castro / André Silva (GSI)
Antonio Cruz (Armazem)

3. Planeamento/ Plan

Escalonamento/ Schedule

Actividade/ Activity	Dezembro 2017	Janeiro 2018	Fevereiro 2018	Resp.	Status
> Analisar todo o fluxo de informação				AS / JC	100%
> Definir novo layout das folhas				AP / AF	100%
> Desenvolver código à medida				AS / JC	100%
- Criação e armazenagem automática em PDF					100%
- Campos automáticos de preenchimento					100%
- Associação da assinatura digital = login do usuário					100%
- Envio automatico de email					100%
> Simulação do processo				AS / JC	100%
> Aprovação / Validação				AP / FG	100%
> Apresentação				AS	100%
> Implementação				AS / JC	100%

Acompanhamento/ Follow Up

> Atualização da base de dados (ao cargo do GSI)

> Verificação periódica do funcionamento e do fluxo de informação

KPI's Projeto * Obtidos através da simulação mensal do processo

> Redução do LeadTime do Processo 1h15 -> 40min

4. Resultados/ Results

* Obtidos através da simulação mensal do processo

Variáveis	Antes	Depois	Redução Custos	Redução Custos por unidade
Papel	7800 folhas	650 folhas	-208 €/ano	-0,10 €/unid.
Tempo do Utilizador	45min	25min	-1,17 €/hora -2471 €/ano	-1,19 €/unid.
Tempo do Armazém	30min	15min	-0,88 €/hora -1859 €/ano	-0,90 €/unid.
Total			-4538 €/ano	- 2,19 €/unid.

Pressupostos:

Média de Consumo -> 52 (blocos/ano)

Preço por Bloco -> 4,16 (€/bloco)

Média salarial -> 3,5 (€/hora)

Produção em 2018 -> 2070 (unidades/ano)

Otimização Futura:

Incorporação de um tablet no armazém geral, possibilitando uma maior flexibilidade e reduzindo em 100% a produção de papel para este processo

5. Comentários Gerais/ General Comment

Como se processa no caso da requisição incluir materiais que necessitam aprovação do Eng.º Carlos Rodrigues ?

Devido ao número reduzido de materiais que necessitam desta aprovação, foi estabelecido que existirá um reenvio do email por parte do Armazém Geral, para o destinatário pretendido, aguardando uma resposta de aprovação ou não.

Tenho que estar sempre a selecionar o material "um a um" ?

> Na pasta "Requisicoes_Devolucoes", juntamente com o programa e com o video tutorial, irá ser incorporado uma listagem numa folha Excel de todo o material existente no armazém.

> Esta listagem, permitirá que cada utilizador possa organizar e personalizar, o maior fluxo de material a ser requisitado e assim, possibilitar a copia de um conjunto de materiais para o programa, sendo atribuído os códigos e as unidades automaticamente como assim está definido.

6. Comunicação/ Comunicate

Eng. Carlos Rodrigues / Eng. Ana Paula / Eng. Fernando Gualter / Eng. António Gomes / Eng. Helena Paula / Eng. Vitor Alaves / Eng. Liliana Gonçalves / Jacinto Silva

Elaborado por/ Made by:	José Castro / André Silva	Aprovado/ Aproved:	Eng. Ana Paula / Eng. Fernando Gualter	Data/ Date:

Annex IV – 1st system develop code

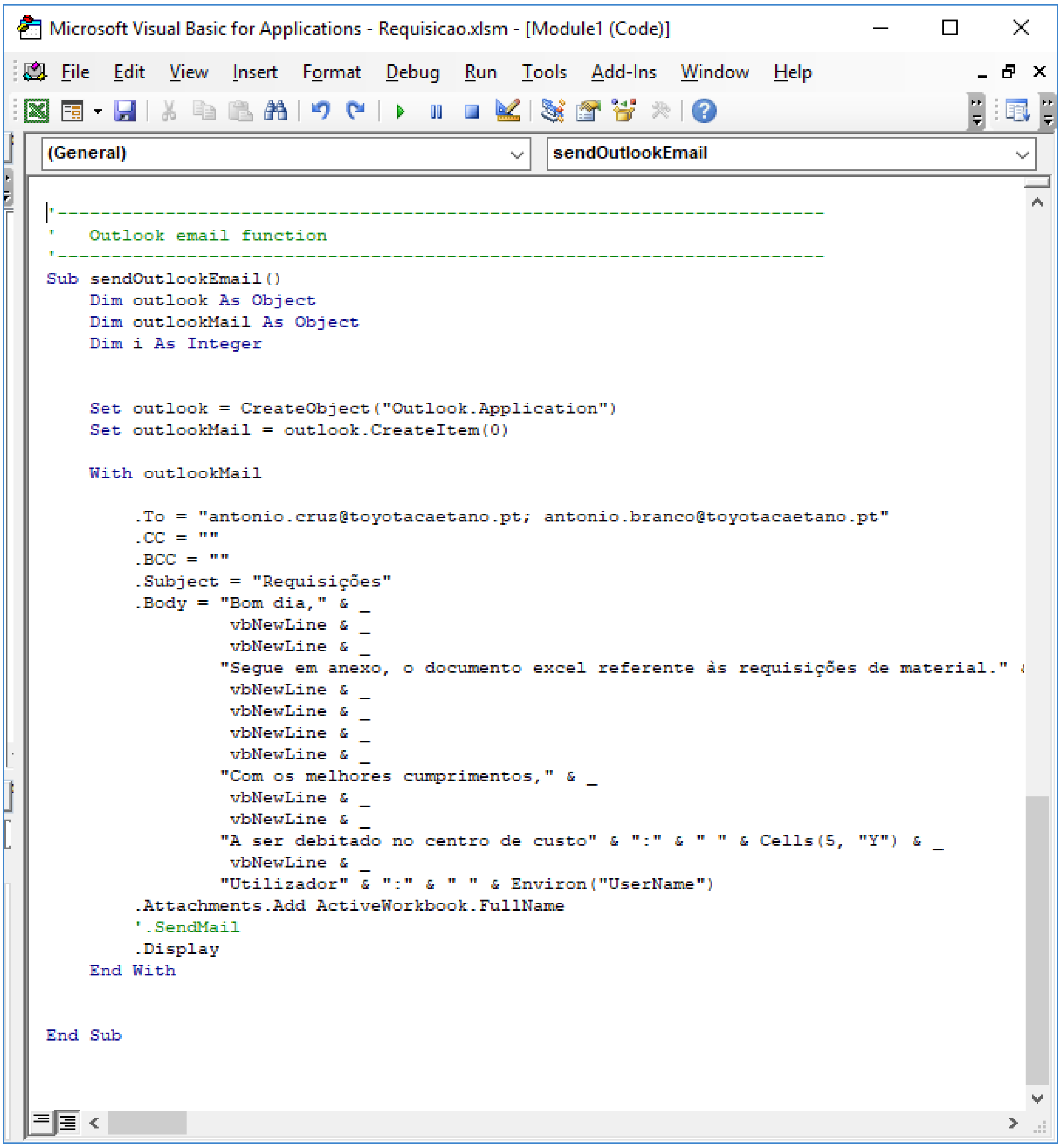
Microsoft Visual Basic for Applications - Requisicao.xlsm - [ThisWorkbook (Code)]

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

Workbook | Open

```
'Hide all Menus(Ribbons)
Sub TelaCheia_On()
    Application.ExecuteExcel4Macro "SHOW.TOOLBAR(""Ribbon"",False)"
    Application.DisplayFormulaBar = False
    ActiveWindow.DisplayHeadings = False

    With ActiveWindow
        .DisplayHorizontalScrollBar = True
        .DisplayVerticalScrollBar = False
        .DisplayWorkbookTabs = False
        .DisplayHeadings = False
        .DisplayZeros = False
        .DisplayHeadings = False
        .DisplayGridlines = False
    End With

End Sub

'Show all Menus(Ribbons)
Sub TelaCheia_Off()
    Application.ExecuteExcel4Macro "SHOW.TOOLBAR(""Ribbon"",True)"
    Application.DisplayFormulaBar = True
    ActiveWindow.DisplayHeadings = True

    With ActiveWindow
        .DisplayHorizontalScrollBar = True
        .DisplayVerticalScrollBar = True
        .DisplayWorkbookTabs = True
        .DisplayHeadings = True
        .DisplayZeros = True
        .DisplayHeadings = True
        .DisplayGridlines = True
    End With

    End Sub
'The document is imediatly saved before being closed
Private Sub Workbook_BeforeClose(Cancel As Boolean)
 TelaCheia_Off
 If Me.Saved = False Then Me.Save
End Sub


Private Sub Workbook_Open()
   TelaCheia_On
   'Unprotect sheet, for login input synchronization
   Sheets("Requisicao").unprotect
   'Attach username to the unprotect document
   Sheets("Requisicao").Cells(31, 17) = Environ("UserName")
   'Protection action activated
    Sheets("Requisicao").protect
End Sub
```

Annex IV – 1st system develop code (continuation)

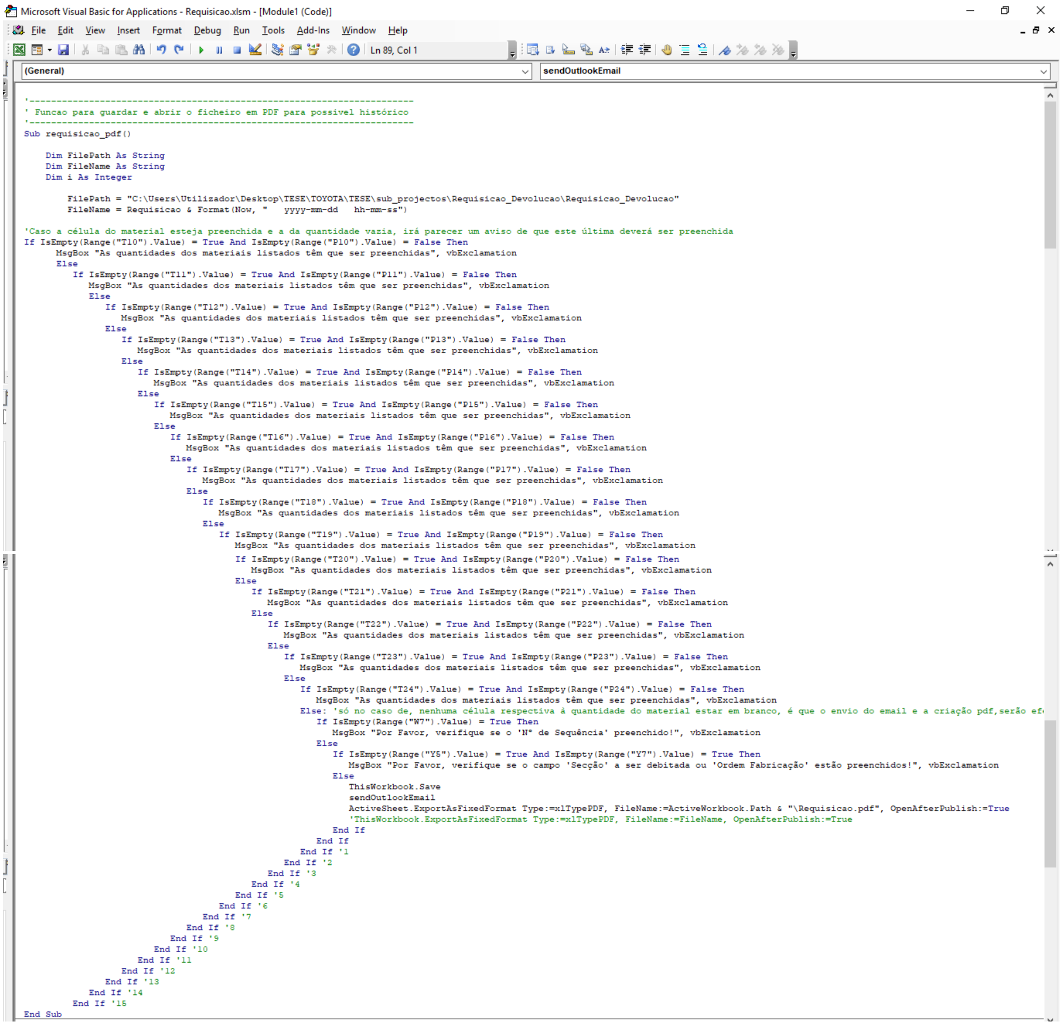


Microsoft Visual Basic for Applications - Requisicao.xlsm - [Module1 (Code)]

(General) | sendOutlookEmail

```
'-----------------------------------------------------------------------
'    Outlook email function
'-----------------------------------------------------------------------
Sub sendOutlookEmail()
    Dim outlook As Object
    Dim outlookMail As Object
    Dim i As Integer


    Set outlook = CreateObject("Outlook.Application")
    Set outlookMail = outlook.CreateItem(0)

    With outlookMail

        .To = "antonio.cruz@toyotacaetano.pt; antonio.branco@toyotacaetano.pt"
        .CC = ""
        .BCC = ""
        .Subject = "Requisições"
        .Body = "Bom dia," & _
                 vbNewLine & _
                 vbNewLine & _
                "Segue em anexo, o documento excel referente às requisições de material." &
                 vbNewLine & _
                 vbNewLine & _
                 vbNewLine & _
                 vbNewLine & _
                "Com os melhores cumprimentos," & _
                 vbNewLine & _
                 vbNewLine & _
                "A ser debitado no centro de custo" & ":" & " " & Cells(5, "Y") & _
                 vbNewLine & _
                "Utilizador" & ":" & " " & Environ("UserName")
        .Attachments.Add ActiveWorkbook.FullName
        '.SendMail
        .Display
    End With


End Sub
```

Annex IV – 1st system develop code (continuation)

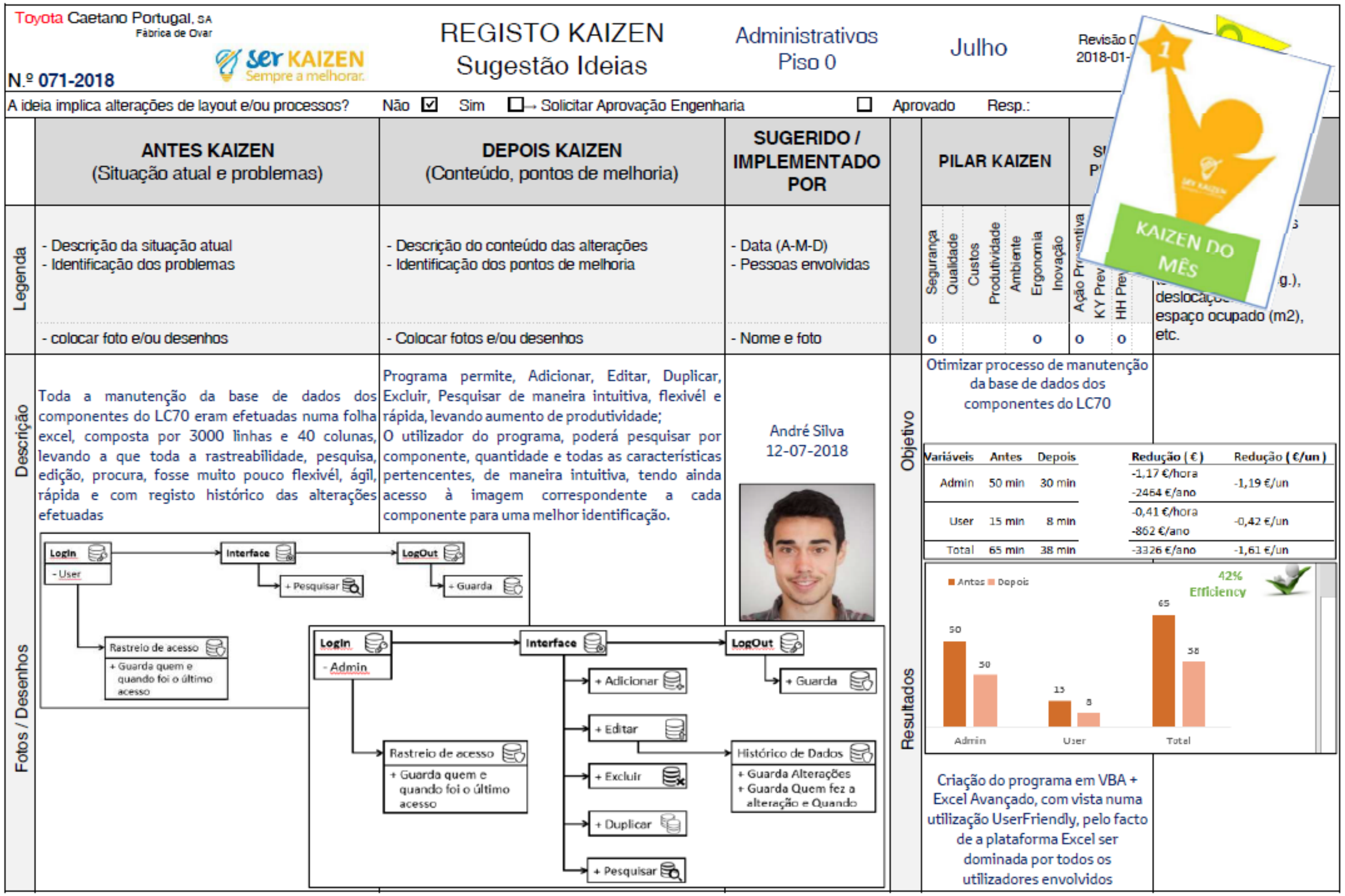


Microsoft Visual Basic for Applications - Requisicao.xlsm - [Module1 (Code)]

(General) sendOutlookEmail

```
'-----------------------------------------------------------------------
' Funcao para guardar e abrir o ficheiro em PDF para possivel histórico
'-----------------------------------------------------------------------
Sub requisicao_pdf()

    Dim FilePath As String
    Dim FileName As String
    Dim i As Integer

        FilePath = "C:\Users\Utilizador\Desktop\TESE\TOYOTA\TESE\sub_projectos\Requisicao_Devolucao\Requisicao_Devolucao"
        FileName = Requisicao & Format(Now, "   yyyy-mm-dd   hh-mm-ss")

'Caso a célula do material esteja preenchida e a da quantidade vazia, irá parecer um aviso de que este última deverá ser preenchida
If IsEmpty(Range("T10").Value) = True And IsEmpty(Range("P10").Value) = False Then
      MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
      Else
         If IsEmpty(Range("T11").Value) = True And IsEmpty(Range("P11").Value) = False Then
            MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
            Else
               If IsEmpty(Range("T12").Value) = True And IsEmpty(Range("P12").Value) = False Then
                  MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
               Else
                  If IsEmpty(Range("T13").Value) = True And IsEmpty(Range("P13").Value) = False Then
                     MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                  Else
                     If IsEmpty(Range("T14").Value) = True And IsEmpty(Range("P14").Value) = False Then
                        MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                     Else
                        If IsEmpty(Range("T15").Value) = True And IsEmpty(Range("P15").Value) = False Then
                           MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                        Else
                           If IsEmpty(Range("T16").Value) = True And IsEmpty(Range("P16").Value) = False Then
                              MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                           Else
                              If IsEmpty(Range("T17").Value) = True And IsEmpty(Range("P17").Value) = False Then
                                 MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                              Else
                                 If IsEmpty(Range("T18").Value) = True And IsEmpty(Range("P18").Value) = False Then
                                    MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                 Else
                                    If IsEmpty(Range("T19").Value) = True And IsEmpty(Range("P19").Value) = False Then
                                       MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                       If IsEmpty(Range("T20").Value) = True And IsEmpty(Range("P20").Value) = False Then
                                          MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                       Else
                                          If IsEmpty(Range("T21").Value) = True And IsEmpty(Range("P21").Value) = False Then
                                             MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                          Else
                                             If IsEmpty(Range("T22").Value) = True And IsEmpty(Range("P22").Value) = False Then
                                                MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                             Else
                                                If IsEmpty(Range("T23").Value) = True And IsEmpty(Range("P23").Value) = False Then
                                                   MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                                Else
                                                   If IsEmpty(Range("T24").Value) = True And IsEmpty(Range("P24").Value) = False Then
                                                      MsgBox "As quantidades dos materiais listados têm que ser preenchidas", vbExclamation
                                                   Else: 'só no caso de, nenhuma célula respectiva à quantidade do material estar em branco, é que o envio do email e a criação pdf,serão ef
                                                      If IsEmpty(Range("W7").Value) = True Then
                                                         MsgBox "Por Favor, verifique se o 'Nº de Sequência' preenchido!", vbExclamation
                                                      Else
                                                         If IsEmpty(Range("Y5").Value) = True And IsEmpty(Range("Y7").Value) = True Then
                                                            MsgBox "Por Favor, verifique se o campo 'Secção' a ser debitada ou 'Ordem Fabricação' estão preenchidos!", vbExclamation
                                                         Else
                                                            ThisWorkbook.Save
                                                            sendOutlookEmail
                                                            ActiveSheet.ExportAsFixedFormat Type:=xlTypePDF, FileName:=ActiveWorkbook.Path & "\Requisicao.pdf", OpenAfterPublish:=True
                                                            'ThisWorkbook.ExportAsFixedFormat Type:=xlTypePDF, FileName:=FileName, OpenAfterPublish:=True
                                                         End If
                                                      End If
                                                   End If '1
                                                End If '2
                                             End If '3
                                          End If '4
                                       End If '5
                                    End If '6
                                 End If '7
                              End If '8
                           End If '9
                        End If '10
                     End If '11
                  End If '12
               End If '13
            End If '14
         End If '15
End Sub
```

Annex V – Register sheet of the 2nd developed system


Toyota Caetano Portugal, SA
Fábrica de Ovar
ser KAIZEN Sempre a melhorar.
N.º 071-2018
REGISTO KAIZEN
Sugestão Ideias
Administrativos
Piso 0
Julho
Revisão 0
2018-01-

A ideia implica alterações de layout e/ou processos? Não ☑ Sim ☐→ Solicitar Aprovação Engenharia ☐ Aprovado Resp.:

ANTES KAIZEN (Situação atual e problemas)
DEPOIS KAIZEN (Conteúdo, pontos de melhoria)
SUGERIDO / IMPLEMENTADO POR
PILAR KAIZEN

Legenda
- Descrição da situação atual
- Identificação dos problemas
- colocar foto e/ou desenhos

- Descrição do conteúdo das alterações
- Identificação dos pontos de melhoria
- Colocar fotos e/ou desenhos

- Data (A-M-D)
- Pessoas envolvidas
- Nome e foto

Segurança, Qualidade, Custos, Produtividade, Ambiente, Ergonomia, Inovação, Ação Preventiva, KY Prev, HH Prev

deslocações, espaço ocupado (m2), etc.

Descrição

Toda a manutenção da base de dados dos componentes do LC70 eram efetuadas numa folha excel, composta por 3000 linhas e 40 colunas, levando a que toda a rastreabilidade, pesquisa, edição, procura, fosse muito pouco flexível, ágil, rápida e com registo histórico das alterações efetuadas

Programa permite, Adicionar, Editar, Duplicar, Excluir, Pesquisar de maneira intuitiva, flexível e rápida, levando aumento de produtividade;
O utilizador do programa, poderá pesquisar por componente, quantidade e todas as características pertencentes, de maneira intuitiva, tendo ainda acesso à imagem correspondente a cada componente para uma melhor identificação.

André Silva
12-07-2018

Objetivo
Otimizar processo de manutenção da base de dados dos componentes do LC70

Variáveis	Antes	Depois	Redução (€)	Redução (€/un)
Admin	50 min	30 min	-1,17 €/hora -2464 €/ano	-1,19 €/un
User	15 min	8 min	-0,41 €/hora -862 €/ano	-0,42 €/un
Total	65 min	38 min	-3326 €/ano	-1,61 €/un

Fotos / Desenhos

Resultados
Criação do programa em VBA + Excel Avançado, com vista numa utilização UserFriendly, pelo facto de a plataforma Excel ser dominada por todos os utilizadores envolvidos

Annex VI – Register sheet of the 2nd developed system kaizen

Toyota Caetano Portugal, SA
Fábrica de Ovar

N.º 082-2018

Ser KAIZEN Sempre a melhorar

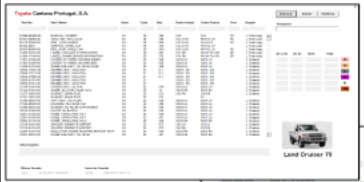
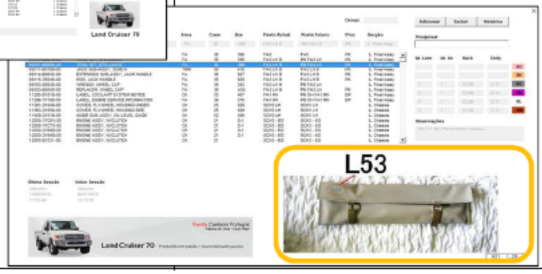
REGISTO KAIZEN
Sugestão Ideias

Administrativos
Piso 0

Agosto

Revisão 07
2018-01-03

A ideia implica alterações de layout e/ou processos? Não ☑ Sim ☐→ Solicitar Aprovação Engenharia ☐ Aprovado Resp.:

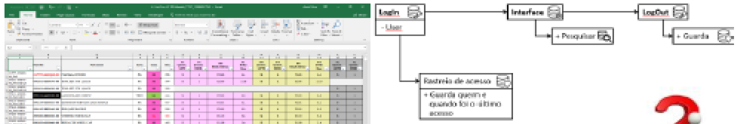
	ANTES KAIZEN (Situação atual e problemas)	DEPOIS KAIZEN (Conteúdo, pontos de melhoria)	SUGERIDO / IMPLEMENTADO POR		PILAR KAIZEN	SUB-PILAR	BENEFÍCIO (Quantificar)
Legenda	- Descrição da situação atual - Identificação dos problemas - colocar foto e/ou desenhos	- Descrição do conteúdo das alterações - Identificação dos pontos de melhoria - Colocar fotos e/ou desenhos	- Data (A-M-D) - Pessoas envolvidas - Nome e foto		Segurança, Qualidade, Custos, Produtividade (o), Ambiente, Ergonomia, Inovação	Ação Preventiva, KY Prev. Acidente, HH Prev. Incidente, 5 S	Quantificar os ganhos obtidos: custos (€), tempo trabalho (seg.), deslocações (m), espaço ocupado (m2), etc.
Descrição	> O sistema de informação efetuado para gerir toda a base de dados do LC70, apesar de ter benificiado drasticamente da tomada de decisão, a verificação e manutenção dos materias, poderá vir a ser melhorada, pelo facto de ser inserido a imagens correspondente de cada componente.	> Foi desenvolvido e inserido um campo, onde a imagem correspondente a cada item fosse apresentada em tempo real, enquanto o user fosse pesquisando. > Esta otimização permite uma melhor tomoda de decisão, pois permite ao user saber exatamente qual o componente que pesquisou	01-08-2018 André Silva	Objetivo	Aumento da eficácia e eficiência na execução de todo o processo envolvido, quer de manutenção por parte do administrador, quer de tomada de decisão por parte do utilizador no sector logístico.		> Assumindo que o custo por hora de um trabalhador é de cerca de 3,5 euros/hora: 2 min de redução = 0,10 euros; > Redução do tempo perdido na procura do componente especifico em cerca de 2min (50% de otimização)
Fotos / Desenhos		 L53	 José Castro 	Resultados	Aumento da produtividade, devido ao aumento da velocidade de execução relacionado com a certaza na pesquisa efetuada.		

Annex VII – A3 register sheet of the 2nd developed system

1. Background

Situação Atual / Current State

> Toda a manutenção da base de dados dos componentes do LC70 eram efetuadas numa folha excel, composta por 3000 linhas e 40 colunas, levando a que toda a rastreabilidade, pesquisa, edição, procura, fosse muito pouco flexivél, ágil, rápida e com registo histórico das alterações efetuadas



Situação Proposta/ Future State

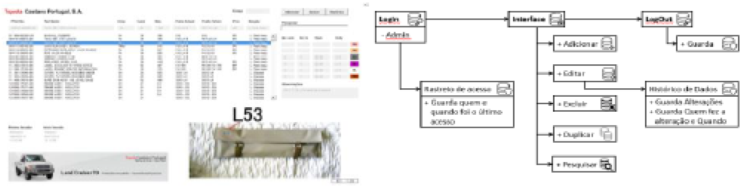
> Programa permite, Adicionar, Editar, Duplicar, Excluir, Pesquisar de um maneira bastante intuitiva, flexivél e rápida, levando assim a um aumento de produtividade, devido um aumento da tomada de decisão por parte dos utilizadores.

> O administrador, será aquele que irá fazer toda a mantenção da base de dados, de maneira bastante intuitiva e eficaz.

> Quanto ao utilizador comum do programa, poderá pesquisar pelo componente, para saber a sua localização, quantidade e todas as características pertencentes, de uma maneira bastante intuitiva, tendo ainda acesso à imagem correspondente a cada componente para uma melhor identificação.

Preocupações/ Concernings

> Lentidão no servidor pode causar conflito na utilização do programa



2. Acção/ Action

Projecto/ Project **Carga Horária de Trabalho:** 528 h

> Otimizar processo de manutenção da base de dados dos componentes do LC70, para uma posterior otimização da toma de decisão por parte do departamento logístico

> Criação do programa em VBA + Excel Avançado, com vista numa utilização UserFriendly, pelo facto de a plataforma Excel ser dominada por todos os utilizadores envolvidos

Vantagens/ Advantages

(+) Monitorização num único ecrã
(+) Edição mais rápida e flexivel
(+) Restrição de Acesso
(+) Rastreabilidade
(+) Maior Segurança de Dados
(+) Manutenção não necessária
(+) Melhor identificação visual do componente

Desvantagens/ Disadvantages

(-) Caso a utilização do programa seja feita dentro da pasta partilhada, poderá ocorrer alguma lentidão devido a factores externos de partilha de rede

Orientado por : Engº Fernando Gualter
Equipa de Trabalho : José Castro / André Silva (GSI)

3. Planeamento/ Plan

Escalonamento/ Schedule

Actividade/ Activity	Mar 18'	Apr 18'	May 18'	Resp.	Status
> Analisar todo o fluxo de informação				JC/AS	100%
> Design do novo sistema				JC/AS	100%
> Desenvolver código à medida				AS	100%
- Input's de dados para a UserForm (Interface) criada				AS	100%
- Gestão da Base de Dados				AS	100%
- Criação de uma plataforma de Login				AS	100%
- Criação de um sistema de Histórico de acções				AS	100%
- Incorporação das imagens correspondentes a cada item				AS	100%
> Simulação do processo				RM/AS	100%
> Aprovação / Validação				FG/AG/RM/SP/JC	100%
> Apresentação				JC/AS	100%
> Implementação				RM/SP/JC/AS	100%

Acompanhamento/ Follow Up

> Correção de "Bugs" no sistema (ao cargo do GSI)
> Verificação periódica do funcionamento e do fluxo de informação

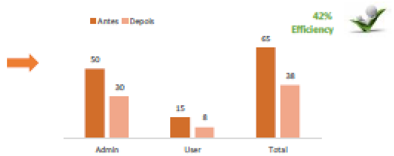
KPI's Projeto

> Redução do LeadTime do Processo 65 min -> 38 min *
* Obtidos através da simulação do processo

4. Resultados/ Results

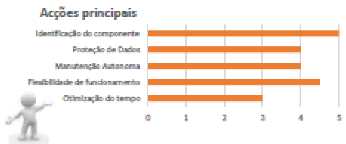
* Obtidos através da simulação do proces:

Variáveis	Antes	Depois	Redução (€)	Redução (€/un)
Admin	50 min	30 min	-1,17 €/hora -2464 €/ano	-1,19 €/un
User	15 min	8 min	-0,41 €/hora -862 €/ano	-0,42 €/un
Total	65 min	38 min	-3326 €/ano	-1,61 €/un



Pressupostos:

> Média salarial -> 3,5 (€/hora)
> Produção em 2018 -> 2070 (unidades/ano)



Otimização Futura:

> Criação de um sistema que imprima todo o layout dos componentes consoante o filtro utilizado de pesquisa

5. Comentários Gerais/ General Comment

Como se processa no caso de aparecimento de um "Bug" no programa ?

> Deverá ser registado o tipo de problema ocorrido e descreve-lo através do ServiceDesk.

Como é feita a manutenção do programa ?

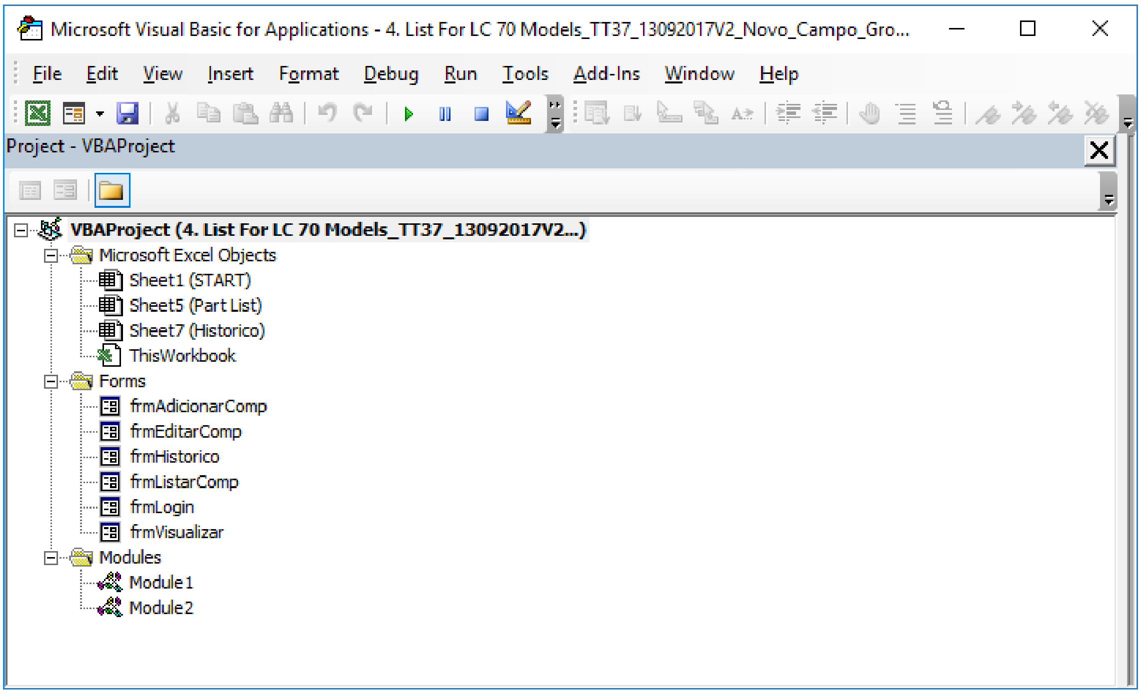
> O programa foi desenvolvido de maneira a que toda a manutenção necessária ao mesmo, fosse realizada pelo admininstrador do mesmo, nas acções necessárias ao seu trabalho.

6. Comunicação/ Comunicate

Eng. Carlos Rodrigues / Eng. Ana Paula / Eng. Fernando Gualter / Eng. António Gomes / Rui Mané / Sérgio Paulo

Elaborado por/ Made José Castro / André Silva **Aprovado/ Aproved** Eng. Fernando Gualter / Eng. António Gomes **Data/ Date:**

Annex VIII – 2nd system develop code



Annex VIII – 2nd system develop code (continuation)

Microsoft Visual Basic for Applications - 4. List For LC 70 Models_TT37_13092017V2_Novo_Campo_Gro...

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

ctrlz | Click

```
'------------------------------------------------------------------------------------------
'Add Item Process
'------------------------------------------------------------------------------------------
Private Sub cmdInserir_Click()
If Me.text_Part_No.Text = "" Then
'Warning! Part No must be field
MsgBox "Deverá preencher o Part No", vbExclamation, "AVISO"
Exit Sub
Else
    If Me.text_Part_Name.Text = "" Then
    'Warning! Part Name must be field
    MsgBox "Deverá preencher o Part Name", vbExclamation, "AVISO"
    Else
        If Me.text_Area.Text = "" Then
        'Warning! Area must be field
        MsgBox "Deverá preencher a Area", vbExclamation, "AVISO"
        Else
            If Me.text_Case.Text = "" Then
            'Warning! Case must be field
            MsgBox "Deverá preencher a Case", vbExclamation, "AVISO"
            Else
                If Me.text_Box.Text = "" Then
                'Warning! Box must be field
                MsgBox "Deverá preencher a Box", vbExclamation, "AVISO"
                End If
            End If
        End If
    End If
End If

    Adicionar 'Call Funtion

    With frmListarComp
    '-Details-------------------------------------------------------------------------------
    .List_Equipamentos.AddItem Me.text_Part_No.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 1) = Me.text_Part_Name.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 2) = Me.text_Area.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 3) = Me.text_Case.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 4) = Me.text_Box.Text
    '-BG------------------------------------------------------------------------------------
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 5) = Me.text_qt_Lote_BG.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 6) = Me.text_qt_Unidade_BG.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 7) = Me.text_Rack_Adress_BG.Tex
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 8) = Me.text_Dolly_Box_BG.Text
    '-BH------------------------------------------------------------------------------------
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 9) = Me.text_qt_Lote_BH.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 10) = Me.text_qt_Unidade_BH.Tex
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 11) = Me.text_Rack_Adress_BH.Te
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 12) = Me.text_Dolly_Box_BH.Text
    '-BJ------------------------------------------------------------------------------------
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 13) = Me.text_qt_Lote_BJ.Text
    .List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 14) = Me.text_qt_Unidade_BJ.Tex
```

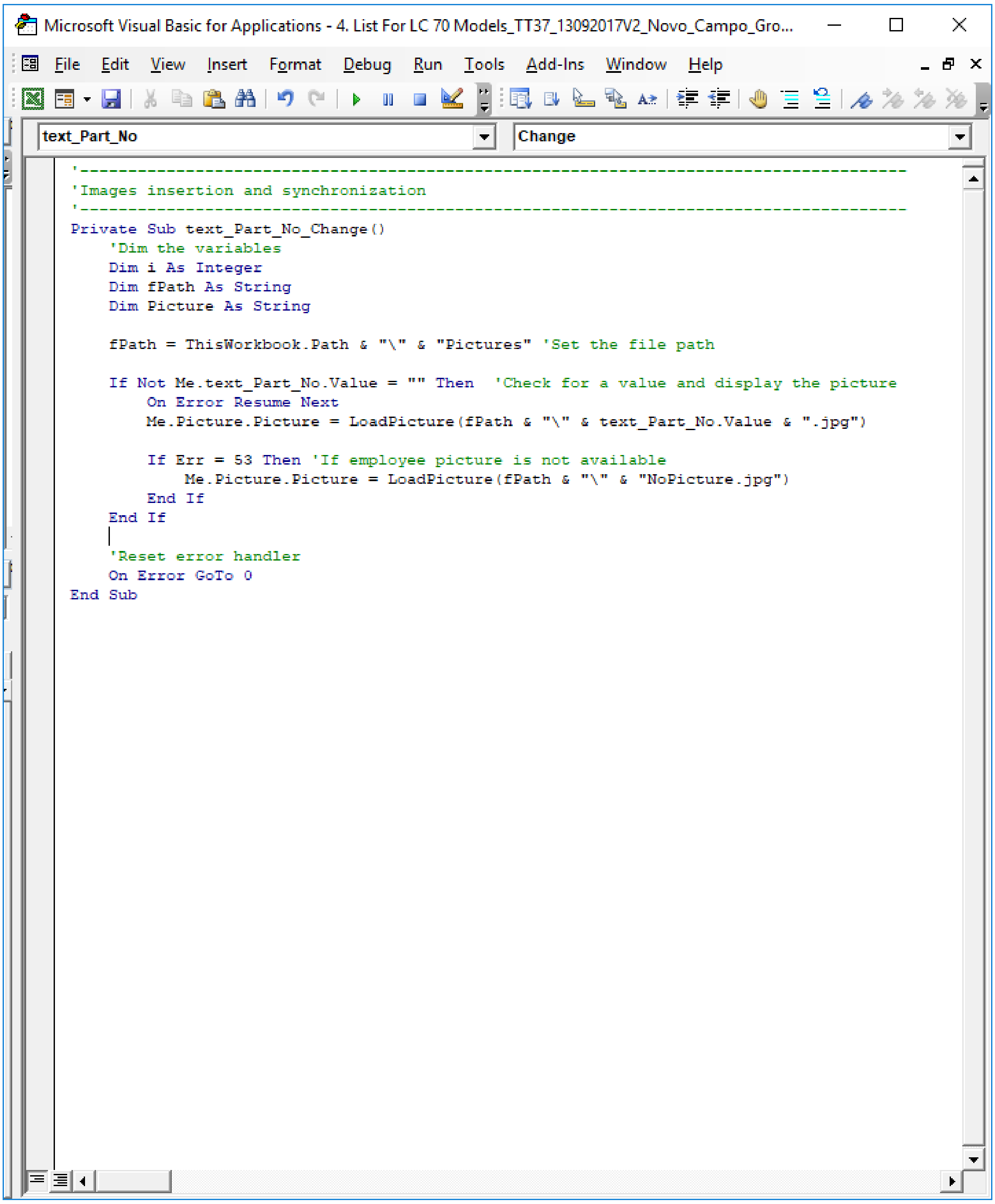
Annex VIII – 2nd system develop code (continuation)

Microsoft Visual Basic for Applications - 4. List For LC 70 Models_TT37_13092017V2_Novo_Campo_Gro...

cmdInserir | Click

```
    Adicionar 'Call Funtion

With frmListarComp
'-Details--------------------------------------------------------------------------------
.List_Equipamentos.AddItem Me.text_Part_No.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 1) = Me.text_Part_Name.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 2) = Me.text_Area.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 3) = Me.text_Case.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 4) = Me.text_Box.Text
'-BG-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 5) = Me.text_qt_Lote_BG.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 6) = Me.text_qt_Unidade_BG.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 7) = Me.text_Rack_Adress_BG.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 8) = Me.text_Dolly_Box_BG.Text
'-BH-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 9) = Me.text_qt_Lote_BH.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 10) = Me.text_qt_Unidade_BH.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 11) = Me.text_Rack_Adress_BH.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 12) = Me.text_Dolly_Box_BH.Text
'-BJ-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 13) = Me.text_qt_Lote_BJ.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 14) = Me.text_qt_Unidade_BJ.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 15) = Me.text_Rack_Adress_BJ.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 16) = Me.text_Dolly_Box_BJ.Text
'-BK-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 17) = Me.text_qt_Lote_BK.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 18) = Me.text_qt_Unidade_BK.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 19) = Me.text_Rack_Adress_BK.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 20) = Me.text_Dolly_Box_BK.Text
'-BL-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 21) = Me.text_qt_Lote_BL.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 22) = Me.text_qt_Unidade_BL.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 23) = Me.text_Rack_Adress_BL.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 24) = Me.text_Dolly_Box_BL.Text
'-BM-------------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 25) = Me.text_qt_Lote_BM.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 26) = Me.text_qt_Unidade_BM.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 27) = Me.text_Rack_Adress_BM.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 28) = Me.text_Dolly_Box_BM.Text
'-Details--------------------------------------------------------------------------------
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 29) = Me.text_Posto_Actual.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 32) = Me.text_Posto_Futuro.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 33) = Me.text_Proc.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 34) = Me.text_Seccao.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 35) = Me.text_Group_Code.Text
.List_Equipamentos.List(.List_Equipamentos.ListCount - 1, 36) = Me.text_observacoes.Text

End With
Historico_Adicionar 'função que envia componente para o histórico
MsgBox "Novo componente adicionado com sucesso!", vbInformation, "ExcelPratic"
Unload frmAdicionarComp 'fecha a UserForm e regressa para o menu principal
End Sub
```

Annex VIII – 2nd system develop code (continuation)




```
'-------------------------------------------------------------------------------------------
'Images insertion and synchronization
'-------------------------------------------------------------------------------------------
Private Sub text_Part_No_Change()
    'Dim the variables
    Dim i As Integer
    Dim fPath As String
    Dim Picture As String

    fPath = ThisWorkbook.Path & "\" & "Pictures" 'Set the file path

    If Not Me.text_Part_No.Value = "" Then  'Check for a value and display the picture
        On Error Resume Next
        Me.Picture.Picture = LoadPicture(fPath & "\" & text_Part_No.Value & ".jpg")

        If Err = 53 Then 'If employee picture is not available
            Me.Picture.Picture = LoadPicture(fPath & "\" & "NoPicture.jpg")
        End If
    End If

    'Reset error handler
    On Error GoTo 0
End Sub
```

Annex VIII – 2nd system develop code (continuation)

Microsoft Visual Basic for Applications - 4. List For LC 70 Models_TT37_13092017V2_Novo_Campo_Gro...

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

UserForm | Initialize

```
'-------------------------------------------------------------------------------
'DataSheet synchronization
'-------------------------------------------------------------------------------
Private Sub UserForm_Initialize()
Application.Visible = True
BloquearOpcoes
    With frmListarComp

        .Group_Code_.Text = Sheet5.Cells(2, 37)
        .Part_No_.Text = Sheet5.Cells(2, 2)
        .Part_Name_.Text = Sheet5.Cells(2, 3)
        .Area_.Text = Sheet5.Cells(2, 4)
        .Case__.Text = Sheet5.Cells(2, 5)
        .Box_.Text = Sheet5.Cells(2, 6)
        .qtd_lote.Text = Sheet5.Cells(2, 7)
        .qtd_un.Text = Sheet5.Cells(2, 8)
        .rack.Text = Sheet5.Cells(2, 9)
        .dolly.Text = Sheet5.Cells(2, 10)

        .BG.Text = Sheet5.Cells(1, 7)
        .BH.Text = Sheet5.Cells(1, 11)
        .BJ.Text = Sheet5.Cells(1, 15)
        .BK.Text = Sheet5.Cells(1, 19)
        .BL.Text = Sheet5.Cells(1, 23)
        .BM.Text = Sheet5.Cells(1, 27)

        .Posto_Atual_.Text = Sheet5.Cells(2, 31)
        .Posto_Futuro_.Text = Sheet5.Cells(2, 34)
        .Proc.Text = Sheet5.Cells(2, 35)
        .Seccao.Text = Sheet5.Cells(2, 36)

        .text_login_1.Text = Environ("UserName")
        .text_login.Text = Sheet5.Cells(2, 44)
         text_login.Enabled = False

        .text_data_1.Text = Format(Date, "dd/mm/yyyy")
        .text_data.Text = Sheet5.Cells(2, 45)
         text_data.Enabled = False

        .text_hora_1.Text = Format(Time, "hh:mm:ss")
        .text_hora.Text = Format(Sheet5.Cells(2, 46), "hh:mm:ss")
         text_hora.Enabled = False

    End With
List_Equipamentos.Clear
List_Equipamentos.ColumnCount = 38
List_Equipamentos.ColumnWidths = _
"90;200;60;45;50;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;70;0;0;85;45;50;0;0;0"
i = Sheet5.UsedRange.Rows.Count
frmListarComp.List_Equipamentos.List = Sheet5.Range("B3:AL" & i).Value
End Sub
```

Annex VIII – 2nd system develop code (continuation)

Microsoft Visual Basic for Applications - 4. List For LC 70 Models_TT37_13092017V2_Novo_Campo_Gro...

Button_Excluir | Click

```
'-------------------------------------
'Call frmAdicionarComp UserForm
'-------------------------------------
Private Sub Button_Cadastrar_Click()
    frmAdicionarComp.Show
End Sub
'----------------------------------
'Call frmEditarComp UserForm
'----------------------------------
Private Sub Button_Editar_Click()
    frmEditarComp.Show
End Sub
'-----------------------------------------------------------
'Data click to delete the item
'-----------------------------------------------------------
Private Sub Button_Excluir_Click()
    If Me.Lbl_ID.Caption = "" Then
        MsgBox "Equipamento não selecionado" & Chr(13) & "Click para selecionar o equipamento
        Exit Sub
    Else
        DesligaEventos  'Call Function
        j = Me.List_Equipamentos.ListIndex + 3
        Lbl_ID.Caption = Me.List_Equipamentos.ListIndex
        With Sheet5
            Rows(j).EntireRow.Delete
        End With
        LigaEventos 'Call Function
        MsgBox "Componente excluido com sucesso!", vbInformation
        Upgrade 'Call Function
        BloquearCampos
    End If
End Sub
'-----------------------------------------------------------------------
' Data click to see the item details
'-----------------------------------------------------------------------
Private Sub List_Equipamentos_Click()
Dim i As Integer
i = Me.List_Equipamentos.ListIndex
Me.List_Equipamentos.Selected(i) = True
Lbl_ID.Caption = frmListarComp.List_Equipamentos.ListIndex
    With frmListarComp 'Output data into User Interface

        .text_Part_No.Text = .List_Equipamentos.Column(0, i)
        .text_Part_Name.Text = .List_Equipamentos.Column(1, i)
        .text_Area.Text = .List_Equipamentos.Column(2, i)
        .text_Case.Text = .List_Equipamentos.Column(3, i)
        .text_Box.Text = .List_Equipamentos.Column(4, i)
        .text_qt_Lote_BG.Text = .List_Equipamentos.Column(5, i)
        .text_qt_Unidade_BG.Text = .List_Equipamentos.Column(6, i)
        .text_Rack_Adress_BG.Text = .List_Equipamentos.Column(7, i)
        .text_Dolly_Box_BG.Text = .List_Equipamentos.Column(8, i)
        .text_qt_Lote_BH.Text = .List_Equipamentos.Column(9, i)
```

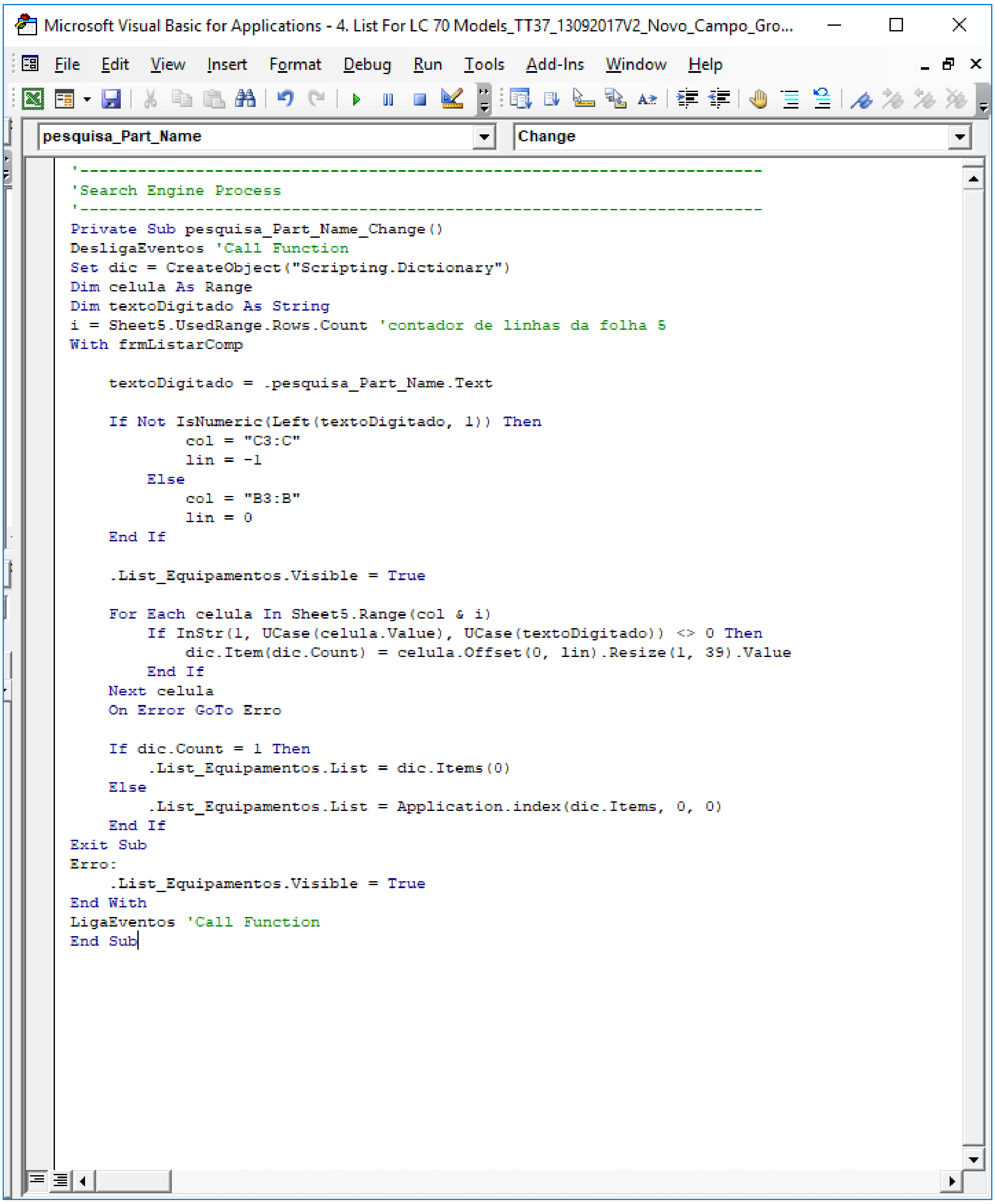
Annex VIII – 2nd system develop code (continuation)

```
'------------------------------------------------------------------------
' Data click to see the item details
'------------------------------------------------------------------------
Private Sub List_Equipamentos_Click()
Dim i As Integer
i = Me.List_Equipamentos.ListIndex
Me.List_Equipamentos.Selected(i) = True
Lbl_ID.Caption = frmListarComp.List_Equipamentos.ListIndex
    With frmListarComp 'Output data into User Interface

        .text_Part_No.Text = .List_Equipamentos.Column(0, i)
        .text_Part_Name.Text = .List_Equipamentos.Column(1, i)
        .text_Area.Text = .List_Equipamentos.Column(2, i)
        .text_Case.Text = .List_Equipamentos.Column(3, i)
        .text_Box.Text = .List_Equipamentos.Column(4, i)
        .text_qt_Lote_BG.Text = .List_Equipamentos.Column(5, i)
        .text_qt_Unidade_BG.Text = .List_Equipamentos.Column(6, i)
        .text_Rack_Adress_BG.Text = .List_Equipamentos.Column(7, i)
        .text_Dolly_Box_BG.Text = .List_Equipamentos.Column(8, i)
        .text_qt_Lote_BH.Text = .List_Equipamentos.Column(9, i)
        .text_qt_Unidade_BH.Text = .List_Equipamentos.Column(10, i)
        .text_Rack_Adress_BH.Text = .List_Equipamentos.Column(11, i)
        .text_Dolly_Box_BH.Text = .List_Equipamentos.Column(12, i)
        .text_qt_Lote_BJ.Text = .List_Equipamentos.Column(13, i)
        .text_qt_Unidade_BJ.Text = .List_Equipamentos.Column(14, i)
        .text_Rack_Adress_BJ.Text = .List_Equipamentos.Column(15, i)
        .text_Dolly_Box_BJ.Text = .List_Equipamentos.Column(16, i)
        .text_qt_Lote_BK.Text = .List_Equipamentos.Column(17, i)
        .text_qt_Unidade_BK.Text = .List_Equipamentos.Column(18, i)
        .text_Rack_Adress_BK.Text = .List_Equipamentos.Column(19, i)
        .text_Dolly_Box_BK.Text = .List_Equipamentos.Column(20, i)
        .text_qt_Lote_BL.Text = .List_Equipamentos.Column(21, i)
        .text_qt_Unidade_BL.Text = .List_Equipamentos.Column(22, i)
        .text_Rack_Adress_BL.Text = .List_Equipamentos.Column(23, i)
        .text_Dolly_Box_BL.Text = .List_Equipamentos.Column(24, i)
        .text_qt_Lote_BM.Text = .List_Equipamentos.Column(25, i)
        .text_qt_Unidade_BM.Text = .List_Equipamentos.Column(26, i)
        .text_Rack_Adress_BM.Text = .List_Equipamentos.Column(27, i)
        .text_Dolly_Box_BM.Text = .List_Equipamentos.Column(28, i)
        .text_Posto_Actual.Text = .List_Equipamentos.Column(29, i)
        .text_Posto_Futuro.Text = .List_Equipamentos.Column(32, i)
        .text_Proc.Text = .List_Equipamentos.Column(33, i)
        .text_Seccao.Text = .List_Equipamentos.Column(34, i)
        .text_Group_Code.Text = .List_Equipamentos.Column(35, i)
        .text_observacoes.Text = .List_Equipamentos.Column(36, i)

    End With
End Sub
```

Annex VIII – 2nd system develop code (continuation)

```
'-----------------------------------------------------------------------------------
' data double click for item edition
'-----------------------------------------------------------------------------------
Private Sub List_Equipamentos_DblClick(ByVal Cancel As MSForms.ReturnBoolean)
Dim i As Integer
i = Me.List_Equipamentos.ListIndex
Me.List_Equipamentos.Selected(i) = True
    With frmListarComp

        frmEditarComp.text_Part_No.Text = .List_Equipamentos.Column(0, i)
        frmEditarComp.text_Part_Name.Text = .List_Equipamentos.Column(1, i)
        frmEditarComp.text_Area.Text = .List_Equipamentos.Column(2, i)
        frmEditarComp.text_Case.Text = .List_Equipamentos.Column(3, i)
        frmEditarComp.text_Box.Text = .List_Equipamentos.Column(4, i)
        frmEditarComp.text_qt_Lote_BG.Text = .List_Equipamentos.Column(5, i)
        frmEditarComp.text_qt_Unidade_BG.Text = .List_Equipamentos.Column(6, i)
        frmEditarComp.text_Rack_Adress_BG.Text = .List_Equipamentos.Column(7, i)
        frmEditarComp.text_Dolly_Box_BG.Text = .List_Equipamentos.Column(8, i)
        frmEditarComp.text_qt_Lote_BH.Text = .List_Equipamentos.Column(9, i)
        frmEditarComp.text_qt_Unidade_BH.Text = .List_Equipamentos.Column(10, i)
        frmEditarComp.text_Rack_Adress_BH.Text = .List_Equipamentos.Column(11, i)
        frmEditarComp.text_Dolly_Box_BH.Text = .List_Equipamentos.Column(12, i)
        frmEditarComp.text_qt_Lote_BJ.Text = .List_Equipamentos.Column(13, i)
        frmEditarComp.text_qt_Unidade_BJ.Text = .List_Equipamentos.Column(14, i)
        frmEditarComp.text_Rack_Adress_BJ.Text = .List_Equipamentos.Column(15, i)
        frmEditarComp.text_Dolly_Box_BJ.Text = .List_Equipamentos.Column(16, i)
        frmEditarComp.text_qt_Lote_BK.Text = .List_Equipamentos.Column(17, i)
        frmEditarComp.text_qt_Unidade_BK.Text = .List_Equipamentos.Column(18, i)
        frmEditarComp.text_Rack_Adress_BK.Text = .List_Equipamentos.Column(19, i)
        frmEditarComp.text_Dolly_Box_BK.Text = .List_Equipamentos.Column(20, i)
        frmEditarComp.text_qt_Lote_BL.Text = .List_Equipamentos.Column(21, i)
        frmEditarComp.text_qt_Unidade_BL.Text = .List_Equipamentos.Column(22, i)
        frmEditarComp.text_Rack_Adress_BL.Text = .List_Equipamentos.Column(23, i)
        frmEditarComp.text_Dolly_Box_BL.Text = .List_Equipamentos.Column(24, i)
        frmEditarComp.text_qt_Lote_BM.Text = .List_Equipamentos.Column(25, i)
        frmEditarComp.text_qt_Unidade_BM.Text = .List_Equipamentos.Column(26, i)
        frmEditarComp.text_Rack_Adress_BM.Text = .List_Equipamentos.Column(27, i)
        frmEditarComp.text_Dolly_Box_BM.Text = .List_Equipamentos.Column(28, i)
        frmEditarComp.text_Posto_Actual.Text = .List_Equipamentos.Column(29, i)
        frmEditarComp.text_Posto_Futuro.Text = .List_Equipamentos.Column(32, i)
        frmEditarComp.text_Proc.Text = .List_Equipamentos.Column(33, i)
        frmEditarComp.text_Seccao.Text = .List_Equipamentos.Column(34, i)
        frmEditarComp.text_Group_Code.Text = .List_Equipamentos.Column(35, i)
        frmEditarComp.text_observacoes.Text = .List_Equipamentos.Column(36, i)

    End With
frmEditarComp.Show
End Sub
```

Annex VIII – 2nd system develop code (continuation)




```
'------------------------------------------------------------------------
'Search Engine Process
'------------------------------------------------------------------------
Private Sub pesquisa_Part_Name_Change()
DesligaEventos 'Call Function
Set dic = CreateObject("Scripting.Dictionary")
Dim celula As Range
Dim textoDigitado As String
i = Sheet5.UsedRange.Rows.Count 'contador de linhas da folha 5
With frmListarComp

    textoDigitado = .pesquisa_Part_Name.Text

    If Not IsNumeric(Left(textoDigitado, 1)) Then
            col = "C3:C"
            lin = -1
        Else
            col = "B3:B"
            lin = 0
    End If

    .List_Equipamentos.Visible = True

    For Each celula In Sheet5.Range(col & i)
        If InStr(1, UCase(celula.Value), UCase(textoDigitado)) <> 0 Then
            dic.Item(dic.Count) = celula.Offset(0, lin).Resize(1, 39).Value
        End If
    Next celula
    On Error GoTo Erro

    If dic.Count = 1 Then
        .List_Equipamentos.List = dic.Items(0)
    Else
        .List_Equipamentos.List = Application.index(dic.Items, 0, 0)
    End If
Exit Sub
Erro:
    .List_Equipamentos.Visible = True
End With
LigaEventos 'Call Function
End Sub
```

Annex VIII – 2nd system develop code (continuation)

Microsoft Visual Basic for Applications - 4. List For LC 70 Models_TT37_13092017V2_Novo_Campo_Gro...

File Edit View Insert Format Debug Run Tools Add-Ins Window Help

pesquisa_Part_Name | Change

```
    For Each celula In Sheet5.Range(col & i)
        If InStr(1, UCase(celula.Value), UCase(textoDigitado)) <> 0 Then
            dic.Item(dic.Count) = celula.Offset(0, lin).Resize(1, 39).Value
        End If
    Next celula
    On Error GoTo Erro

    If dic.Count = 1 Then
        .List_Equipamentos.List = dic.Items(0)
    Else
        .List_Equipamentos.List = Application.index(dic.Items, 0, 0)
    End If
Exit Sub
Erro:
    .List_Equipamentos.Visible = True
End With
LigaEventos 'Call Function
End Sub
'------------------------------------------------------------------------
'Turn-Off events
'------------------------------------------------------------------------
Public Sub DesligaEventos()
    With Application
        .ScreenUpdating = False
        .EnableEvents = False
        .DisplayStatusBar = False
    End With
End Sub
'------------------------------------------------------------------------
'Turn-On events
'------------------------------------------------------------------------
Public Sub LigaEventos()
    With Application
        .ScreenUpdating = True
        .EnableEvents = True
        .DisplayStatusBar = True
    End With
End Sub
'---------------------------------------------------------------------------------
'Images insertion and synchronization
'---------------------------------------------------------------------------------
Private Sub Button_Historico_Click()
    frmHistorico.Show
End Sub
'---------------------------------------------------------------------------------
'Images insertion and synchronization
'---------------------------------------------------------------------------------
Private Sub Undo_Click()
    UndoLastAction
End Sub
```