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Master Thesis

Analysis of automation of tasks through computer programming
in VBA: What are the benefits of it?



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Abstract

Nowadays we are living in a world which is in a continuous change, where the technology is constantly advancing, faster than in other eras of the humanity. In other words, we are entering in the *Fourth Industrial Revolution* or *Industry 4.0*.

“Industry 4.0 can be defined as the incorporation and management of intelligent products in the realm of physical processes, management, and information/digital” (Bernardo Nicoletti, 2020).

So, the humanity is in the brink of welcoming a new industrial revolution and the advancements made by the previous revolutions taught us that this new revolution will also make our lives much easier and comfortable as it has never been before (Thien & Tu, 2019).

That is why many companies around the world are excited about their digital transformation initiatives, trying to transform its business into the digital world. Some are developing their own applications, digitalizing their business model, and also executing a new digital commerce strategy (Leibold & Voelpel, 2018).

Like other companies, the company Accredia (an Italian company) wanted to automatize some of their processes through the computer programming. The *Departamento di Taratura* from the company looked for a programmer who was able to automatize some tasks through a little software developed in VBA. So, this work describes the process through this program was developed step by step.

This work will start defining some concepts that are important to know before start talking about the preparation of the program, then the company will be presented with the department who has commissioned this project and the way how the progress was shown. Also, the old method that the company wants to automatize and the failures that we have found about it will be exposed (reasons why the company wants to automatize the process), and then the explanation how the program was developed step by step with a deep conceptual explanation in the most important parts with literary references to help in the illustration of this process.

After an explanation how the program was realized, the thesis will explain how the variables of the program must be setting up to guarantee the correct functionality of it by the future user. Then an analysis of the program and an important comparison between both methods will be developed to see which of them is considered better in this job and why. So, the advantages of this automation will be shown and clearly the disadvantages of the previous method will be exposed to see which of these disadvantages have been overcome by the automation.

At the end there will be a conclusion of the job developed to understand better the advantages of this new digital method over the previous one. Also, new improvements over this new method will be analyzed to see if this program could be more independent from the human intervention (if the company wants to continue improving the automation degree).

Index

Introduction	7
1 Basic concepts	9
1.1 Automation.....	9
1.2 Computer Programming	11
1.3 Visual Basic for Applications (VBA).....	13
1.4 Definitions	15
1.5 Programs used to complete the software	17
2 Accredia: The Italian Accreditation Body	20
2.1 Calibration Laboratories Department (Laboratorio di Taratura) ---	22
2.2 Specifications of the company	22
2.3 Norms	24
2.4 International Organization for Standardization	25
3 The methodology before the program	27
3.1 Problems of the old method	28
4. The program developed	31
4.1 Preparing Excel before programming	31
4.2 FIRST PROGRAM: Downloading the files	33
4.3 Second Program: Reading the files and connecting to Internet ---	37
4.4 Third program: Automatize sending emails	44
5 How to use the Program	48
5.1 Program testing and results	51
5.2 Comparison with the old method	53
5.3 Analysis of the program	56
6 Conclusion	59
Bibliography	62

Introduction

The purpose of this work is showing benefits from an automation of different activities thought computer programming inside a company or in different environments where humans do activities. On this case, this work reflects the project's results, which was realized for the *Departamento di Taratura* from the company *Accredia*. This department wanted to develop a little software to automatize certain tasks. Bringing a new tool to their employees to make their jobs easier than before and the company can assign better its resources.

The Programming language that was chosen it is "Visual Basics for Applications" (VBA) in Excel. VBA is a programming language developed by Microsoft which is included in all the Office's programs, although in this case the program uses the Excel functions, so it was developed mostly with this application. There were other more powerful languages as options to choose instead of VBA, however this task was not requiring a more complicated language, so VBA was ideal to complete the job. Also, VBA is included in all the computers with some Windows's operating system. In this way, we can guarantee that VBA is free (not all the programming languages are free). Because Windows's operating systems are the most used operating systems around the world currently according to StatCounter, so doing on VBA will guarantee that the program can be used in different devices. The development of this task needed certain skills in some topics inside the world of the programming such as Web Scraping, Data Base, Analysis of Data, Etc. (these skills will be defined and explained in detail in the rest of the thesis).

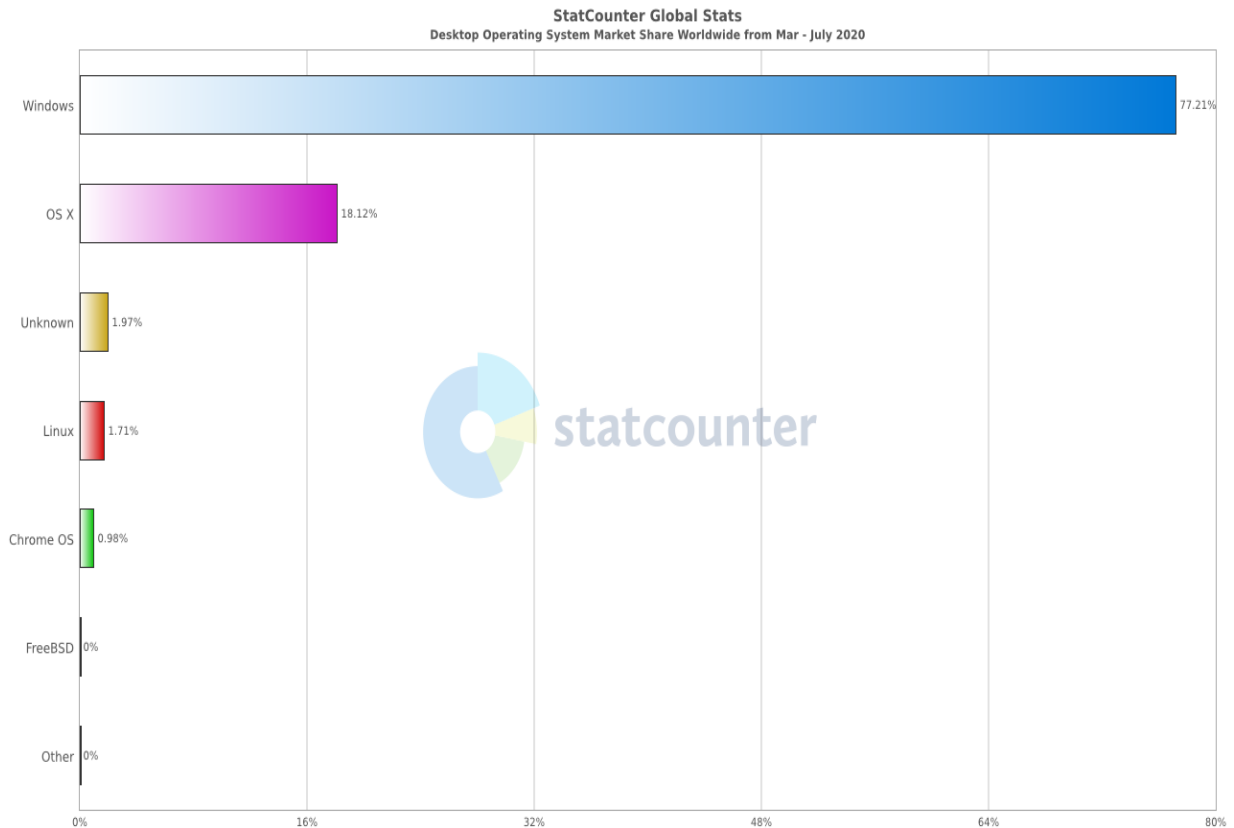


Figure 1.1 Desktop Operating System Market share around the world from May to July 2020

This thesis will be divided into five chapters in which we explain a little bit about the company, some definitions before starting and then the development of the program and analysis of it, and then a conclusion, giving an analysis of the results obtained after finishing the software. After the conclusion, the bibliography will be at the end to see the origin of the information was obtained to complete this task.

So, the goal of this project is:

- to show the benefits of the automation on the project that was developed
- to analyze the possibility of increasing the degree of automation in this task.

1 Basic Concepts

In this chapter will be a definition of a group of important concepts that helps the explanation of the purpose of this work. The chapter will define concepts such as: Automation, computer programming and VBA. Also, a little bit of history of these concepts will be explained.

Then there will be more definitions of different functions and words used in Visual Basics. At the end, the different programs used to complete this project will be described in a short explanation.

1.1 Automation

Before start describing the job, what was done it is important to define some concepts to understand better the idea of the project.

The word automation comes from a Greek word “automatos”, which it means self-acting. This word was adopted during the 40s by the automobile industry in the USA for talking about the automatic handling of parts in the industry between the machines in the production process, together with their continuous processing at the machines (Gupta et al., 2007).

The automation allows the operators which less skills to produce items necessary for the company and at a lower cost (Serope Kalpakjian, Steven R, 2002).

During the 20th century, the concept into account on a little scale to talk about some machines working by their self in production process, but the concept became more practical nowadays with the computers.

Automation can be defined “as the process of following a predetermined sequence of operations with little or no human labor, using specialized equipment and devices that perform and control processes” (Gupta, 2007).

So, the automation reduces the human intervention in activities, in this way the person who did a certain task has more time to do other activities by assigning these tasks to machines, like computers.

In the recent years, the technology has evolved a lot. This technology evolution has created new equipment and machines, such as the current computers (New computers have become smaller but much more efficient) (HAQ. KAMAR, 2018).

This technological evolution can be a product of meeting our perceived needs or the human desires, because according to French philosopher Gaston Bachelard, the humans are creation of desire, people are stimulated by desire (George Basalla, 1990).

The technology innovation helps people to develop new techniques of controlling, monitoring, and other actions that the humans can do to improve their production processes (Moore et al., 2018).

Currently the world is living in a new digital era (Majumder & SenGupta, 2020).

The new technologies (computers, the new equipment to work) change the nature of work and job demand and resources diversify through this change. The design, production, and distribution system has also changed (Onyina, 2019).

The new technologies have led to benefits to society and improving the well-being for most people in the world. Reducing the necessity of humans to perform many tedious and dangerous tasks that they must do them manually, as many of these can be automated by computer programs.

These advances in computer technologies leads to an increase in productivity, giving humans to engage in more creative, productive, and rewarding tasks (Gerard O'Regan, 2008).

This computer automatization was incentivized by an important reduction in the real cost in the storage of information by a 50% during 1969 and 2005 (International Monetary Fund, 2017).

A software is created with programming, so through programming we can create softwares which we can automatize tasks in our jobs. People can automatize any repetitive task thought the programming with a computer and its different language programming.

So, automatization tends to eliminate the routine tasks but also creates new, more complex, ones (Seppo Poutanen, 2019).

1.2 Computer Programming

We have seen that through the programming we can automatize a lot of repetitive tasks inside a system. However, what is computer programming? We can define it as “The process of creating a program” (John M. Zelle, 2003) (program is also called software). So, programming allows us creating different type of softwares to help people to perform their tasks day by day. A program is “a detailed “step-by step” set of instructions telling a computer exactly what

to do.” (John M. Zelle,2003). These programs can be done in different programming languages. The programmer (the person who develops a program) can choose the language that he considers better to make a program that solves a certain problem.

A programming language is “an artificial formalism in which algorithms can be expressed” (Gabbrielli & Martini, 2010). Every language around the world, the languages of programming are composed in three major areas of studying: Grammar (the part of description of a language which determines the alphabet, which words are correct in that language), semantics (it attributes a significance to every correct phrase) and pragmatics (it analyses the different meanings of the same sentence) (Gabbrielli & Martini, 2010).

As in the world there are many languages such as: Python, Java, C, VBA, etc. As we have said, the programmer chooses the language that fits better to solve the problem that he has in a moment.

So, the programming has the advantage to automatize processes do by humans, but this happens if the program is done well. However, a program (which carries out, in a good way, its function for which it has been created) possess many errors developed by the programmer.

These errors can be classified in four type of them: Insignificant (Errors that does not affect the correct operation of the program, most of them are aesthetics errors for the program), compile time (errors in the syntax of the programming language), run time (Errors that does not appear until you run the program, causing the program to crash) and semantic (Errors that causes

the program to not do what the programmer wants, these errors are not notified) (Dirk Henkemans and Mark Lee, 2001).

The compile-time and the run-time errors are notified in the moment, but the other ones are not. So, if the programmer did not notice a semantic error will be a problem for the user of the program in the future. A big problem would be if the user and the programmer are not in contact after the software was finished (Dirk Henkemans and Mark Lee, 2001).

That is why it is optimal that the code should be clean and organize, because maybe the original programmer is not in the moment to check an eventual error. So, another person (maybe the user) is going to correct it (it is going to be easier correct an organize and clean code than a messy one).

1.3 Visual Basic for Applications (VBA)

VBA is a programming language created by Microsoft, which is included in every application of the Microsoft Office.

The first version of this language developed by Microsoft was in 1975, called Microsoft BASIC and its successor Quick BASIC, these two products got a big popularity in those days. Quick BASIC was available for Windows, but it was not so easy to code a Windows-style interface. In response, Microsoft developed a new product combining the popular and easy to learn BASIC language and this new environment that enabled programmers to graphically create the user interface for a program. This program was the first version of Visual Basic, Visual Basic 1.0 (Duncan Mackenzie, 2002).

Nowadays, the language has been improved and this is the tool that programmers choose to develop software on Excel. In a nutshell, this is the tool that people use to create programs that control Excel's functions (Michael Alexander and John Walkenbach, 2018). Excel is the program most used to develop the program for Accredia.

So, VBA can be used to create programs to automatize different tasks. To do this the programmer goes to "Developer", then he looks for the button "Visual Basic" and clicking on it, the VBA editor is open (Richard Mansfield, 2019).

In the editor, the programmer can write the code to develop different programs, also called "Macros" (abbreviation of macroinstruction) and this macro is saved in a "Module" created in the Workbook where the macro is saved (McGrath, 2017).

A macro is a program consisting of a few instructions that involve underlying functions. A macro is a "super instruction" because a single instruction results in a large program segment (Gordon B. Davis, 1999).

So this programming language allows the user to do many things such as: automatize repetitive tasks, realize activities of search and replacement, create forms for the user in the Excel's sheet, modify the Excel's functions and create other ones, link the Excel application with other applications in the computer, and other things. These are the main functions that the programmer can do with VBA (there are more) when he writes a code (Díaz, 2014).

Now we must explain how to run the macro after writing it. There are many forms to run it.

The first way the user can run the macro by pressing F5 in the VBA editor. Alternatively, the user can choose “Run” (a green arrow) on the Standard toolbar in the Visual Basic Editor (Mansfield, 2019).

Another one is from the Excel’s sheet, the person must click on the Ribbon the button “Developer”, then more buttons will appear, and the user must click on “Macros”. After that, a new little window with the list of all the macros saved in that Excel file appears and finally the user clicks on the macro that he wants to run and then clicks on “Run” (Korol, 2008).

There is another form, when the programmer assigns the macro inside a Button (which is on the Excel’s Sheet). The programmer can create the button from the Ribbon clicking on “Developer” and then “Insert” put it wherever he wants and then he assigns a macro to that button. Or the programmer can create a macro that when he runs it, the macro creates a button to run another different macro inside it (Carlos Casas Antúnez, 2020).

To develop the Accredia’s project most of the things mentioned about VBA were used to complete the program. There are more things about this language and Excel that will be mentioned later inside this work when the situation requires an explanation.

1.4 Definitions

After explaining what VBA is, but before explaining how this project was done, we must define what are the variables used in VBA and another important definition such as different methodologies and skills needed to complete the job assigned by the company.

Web scrapping	“It is the process of extracting a structural representation of data from a website.” (Olgun Aydin, 2018).
Data base	“It is a systematic collection of data, which supports the storage and manipulation of that data” (AMC College, 2019).
URL	<p>The Uniform Resource Location was defined by Tim Berners Lee (the inventor of the World Wide Web) in 1994 and it is “a reference to a web resource that specifies its location on a computer network and a mechanism for retrieving it” (Jens Oliver Meiert, 2020).</p> <p>The URL is used most to refer to a web page, but it can be also used for file transfer, emails, and many other applications (Jens Oliver Meiert, 2020).</p>
String	<p>“VBA string is simply a collection of bytes” (Ken Getz, Mike Gilbert, 2006).</p> <p>There are two types of strings in VBA: fixed length and dynamic strings. The fixed is always the same length, it cannot change. The dynamic can vary its length (The macros were developed with the dynamic ones) (Ken Getz, Mike Gilbert, 2006).</p>
Long	“long data type is for integer numeric values larger or smaller than those the Integer data type can handle” (Guy Hart-Davis, 2006).
Boolean	“It is used to indicate yes or not, true or false and on or off. You can use this type to work with any two-state information.” (John Paul Mueller, 2007).

Object variable	“Object variables are variables that reference an object of a specific type, such as databases, record sets, forms, controls and even objects created in other applications” (Balter, 2007)
Range	“A Range object is contained in a Worksheet object and consists of a single cell or range of cells on a single worksheet” (John Walkenbach, 2010).
PDF files	Portable Document Format was developed by the company Adobe Systems as a means for exchanging digital files. The main idea is to enable all computer users to be able to open, review, and print the documents inside these files (Harvey, 2003).

Table 1.1 List of important definitions to understand better the project developed

1.5 Programs used to complete the software

The project was developed using different softwares complementing the use of VBA and to contact with the company too. Because, for programming successfully the software it was needed a contact with the final user to know the specifications that she wants into the program. Maybe, the programmer has an idea about what the client wants but this idea could be wrong. That is why, a periodic contact with the client to show the progress in the product (the program) it is optimal. In this project to get the contact with the user, an application was used to make these meetings.

“You cannot develop successful software using the structured methodology. There has to be the empowerment and flexibility, and most important the continual contact between the programmer and the user to develop good software”(Heath, 2016).

These programs are:

Adobe Acrobat Pro X	It is a product designed to publish or edit documents for distribution in electronic format. The Pro version Adobe can create PDF documents from within AUTOCad, Microsoft Project and Microsoft Visio (Sahlin, 2008).
Microsoft Excel	“It is a spreadsheet which allows us to manage different type of data, to do calculations, to make graphs and tables. Also, it is a tool to analyze, share and manage information” (Lucas Padin, 2007).
Internet Explorer	“It is a software application that consists of many components, designed to allow the user to explore the full potential of the Internet” (CIA Training Ltd., 2002).
Outlook	It is a software that is used as an information manager as a part of the Microsoft Office Suite. The user can use it as a mail application, containing a task manager, calendar, contact manager, journal and web browsing (Scott Casterson , 2016).
Skype	Skype is a computer application that allows the user to: call or receive calls, make live video calls, send or receive files over the Internet to and from fellow skypers, initiate a

	group chat, share the screen during a call, and it has more functions (Loren Abdulezer, Susan Abdulezer, 2011).
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Table 1.2 Programs used to complete the project

2 Accredia: The Italian Accreditation Body

Accredia was born in 2009 from the combining of the competencies and the merge of Sit, Sinal and Sincert, the National Accreditation Body has developed its activities with the experiences and skills of many professionals who have been developers of a new project for the country. People like Giacomo Elias, (President of UNI) called for a new push towards the harmonization of technical standards and towards the development of the Italian Quality System.

Accredia is the sole national accreditation body disposed by the Italian government to follow the European Regulation 765/2008, attesting the competence, independence and impartiality of certification, inspection, and verification bodies, as well as testing and calibration laboratories.



Figure 2.2 Accredia's logo

Accredia's personnel structure consists of directive bodies, institutional positions, and other personnel. It is divided into three departments for bodies operating in the various conformity assessment sectors. CERTIFICATION AND INSPECTION, TESTING LABORATORIES and CALIBRATION LABORATORIES. The

department of Calibration Laboratories (Laboratorio di Taratura) deals with the accreditation of: Calibration laboratories, Reference materials producers and Measurement reference laboratories in the medical area.

This accreditation guarantees that the certification, inspection, verification bodies, testing and calibration laboratories follow all the rules in the tasks that they do, in which they use the standards. These different bodies or laboratories verify different products, services, or management systems, and certify their compliance with the voluntary and mandatory standards. So, these bodies or laboratories can apply to the accreditation.

The accreditation was created with the objective of satisfying the growing demand for quality and safety. This generates trust on institutions, businesses, and consumers when they operate in the market and it stimulates the free movement of goods and services.

To apply for an accreditation the organism which wants this must follow a process for accreditation of many steps, these are: the application, the document review, on-site assessments, witness assessments and the decision for accreditation. After this moment, a certificate is given to the organism and it has a validity of four years. But during the validity of this four years, the company realizes other activities to ensure compliance of the standards.

During the four years of accreditation. Accredia undertake periodic surveillance assessment over the activities of the accredited body to verify the maintenance of the competence requirements. Also, before the expiry date of the certificate, the company accredited can start the renewal process with the same modalities as for initial accreditation.

2.1 Calibration Laboratories Department (Laboratorio di Taratura)

The calibration laboratories department was the section of the company which commissioned the project. As it has been mentioned, this department deals with the accreditation of:

- Calibration laboratories
- Reference Materials Producers
- Measurement reference laboratories in the medical area

Today, this department has accredited 194 calibration laboratories and only reference material producers (there is no medical laboratory accredited). It has 947 days of assessment done by its 82 assessors and experts who work in this department, verifying all the laboratories that were mentioned.

Considering the three departments of Accredia, this is the newest. It has far fewer worked days compared with the other two. And it has much less accreditations done in comparison.

2.2 Specifications of the company

Before a programmer starts a job, the programmer needs to know what the user wants. The programmer needs to know every detail before she will make the customer happy with the job (G. Perry & Miller, 2013).

A proper user-programmer agreement is essential for all areas of programming, also for programmers who work in a company, they will need

to have detailed specifications before they can start working (G. Perry & Miller, 2013) .

During the development of this job, the contact with Accredia was done through an engineer who works in the *Laboratorio di Taratura* (because the software was designed for this department, they will be the end-users). The specifications and details of the program was given by the engineer.

A meeting with the engineer was held every week to see the progress in the program. In this way, she could tell what things she did not like about the program to continue modifying it.

These meetings were done through Skype because this application allows the user to share the screen of the computer with all the people who are in the call. So, the progress in the program could be seen by the engineer in the moment and she could communicate in detail what she did not like about the software to modify these imperfections. Instead of telling what the software was able to do, she could check in the moment of running.

“Live Screen Sharing the main benefit is the interactive dynamics, you are discussing the content while employing it, it is not static, does not necessarily require detailed step by step storyboarding” (Lekacos, 2010).

It is important to keep the lines of communication open with the end-users. Let them know what is happening. Informing them weekly of the progress in the program is a good idea (Greg Anderson, David Ferro, 2010).

2.3 Norms

That they are technical standards created by international organizations, standardization bodies. Some examples of these organizations can be the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), American Society for Testing and Materials (ASTM) and other. But what are standards? A standard is a document which provides, inter alia, requirements, rules, and guidelines, for a process, product, or service. These requirements are sometimes complemented by a description of the process, products, or services. And the process of implementing these ones is called standardization (UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, 2006).

This process of standardization has many aims to implement it and benefits for who implement the norms to standardize. The principle objectives of standardization are: fitness for purpose (the ability of the process, product or service to fulfil a defined purpose under specific conditions), interchangeability (The suitability for a process, product or service to be used in place of another to fulfil a relevant requirement), variety reduction, compatibility, guarding against factors that affect the health and safety of consumers, better utilization of resources, environmental protection, better communication and understanding, transfer of technology and removal of trade barriers. Implementing these standardized norms also has many benefits to the company which are adopting and for the society too (UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, 2006).

These benefits are different for each part of the society, they can be divided into four type of benefits: for manufacturers (rationalize the manufacturing process, reduce wasteful material or labor, reduce inventories of raw material and finished products and decrease the cost of manufacture), for customers (Assure the quality of goods purchased and services received, provide better value for money and they are convenient for settling disputes with suppliers), for traders(Provide a workable basis for acceptance or rejection of goods or consequential disputes and minimize delays resulting from inaccurate or incomplete specification of materials or products) and for technology (Provide starting points for research and development for further improvement of goods and services).

2.4 International Organization for Standardization

To get carry out this project it was necessary to know and study the websites of the following International Standards Organizations:

Deutsches Institut für Normung (DIN)	It is the German Institute for Standardization, is a private organization registered as a non-profit association. Its members come from industry, associations, public authorities, commerce, the trades, and research organizations.
The International Electrotechnical Commission (IEC)	It is the world’s leading organization that prepares and publishes International Standards for all electrical, electronic, and related technologies.

International Organization for Standardization (ISO)	It is a worldwide federation of national standards bodies with the objective to promote the development of standardization in public or private organizations.
American Society for Testing and Materials (ASTM)	It is a nonprofit organization that generates a global forum to create standards for materials, products, systems, and services. These standards are accepted and used in the investigation and development, product testing, quality systems and commercial transactions.
The International Organization of Legal Metrology (OIML)	It is a worldwide, intergovernmental organization whose goal is to coordinate the regulations and metrological controls applied by the national metrological services of its Member States.

Table 2.2 The international standard organizations that were studied to complete the program



Figure 2.3 The logos of ISO, IEC, and ASTM

These were the type of standards that were found in the reports from the laboratories, so these are the standards followed by the laboratories. These norms were studied with their websites to develop the program.

3 The methodology before the program

Before the creation of this program using the programming language which is VBA (it is a programming language provided by Microsoft Office, it is included in the Excel), the task which we want to automatize was done completely manually.

A person oversaw viewing all the reports sent by the laboratories (First, this person must download these reports). Downloading each report takes time, because the person must look for it on the website one by one. After downloading the file, this person opens it and checks the norms used in each process that are described in that file. Then, the person must enter on Internet and look for the website of the standard that was in that file (depending, which was the norm used, the person entered in the site of that standard). After that, the person navigates on the website looking for the specific norm, checking that the standard is still available. If the norm was not available, this person will look for the new norm that replaces the old one. And in this second scenario, he must check which was the sector of the norm and he must inform to an inspector by an email that one laboratory is working with a norm that is not available anymore, specifying the name of the laboratory, the sector, the old norm and the new one.

Finally, the inspector must notify the laboratory about this norm, in this way the laboratory must change the standard that was followed in that process for the new one.

This is not so much if it was only one standard, but the employee must do for a lot of laboratories and hundreds of standards, and writing a new email every

time that a not available standard is found it is a lot. It is obvious that this task takes a lot of time and it must be considered that all the reports are different between them. Some of them are fast to check, other ones are long to see and read.

Clearly this job is much faster to do only pressing a button and let the computer working by itself. So, the company thought to develop a software to do these operations much faster for the employees in the company. The computers are much faster than humans to develop activities, so the program will be finish before a person (the test of this is in the chapter 5).

Also, it is possible to consider the motivational problems of an employee who is doing the same job every moment. It is known that the employees who develop standardized jobs, repetitive tasks, they can suffer motivation problems (Sims et al., 2001).

3.1 Problems of the old method

The method used by the company has a set of disadvantages in comparison with an automatization developed by the computer program. These disadvantages can generate economics and quality issues such as:

The human error: “Human error is an action or decision that was not intended, that involved a deviation from an accepted standard, and that led an undesirable outcome” (Rodriguez-Perez, 2018).

In this case a person enters the data, check it, and send an email with that information. They can enter the wrong data or make mistakes when they are

checking the information on the files or on the Internet (Alison Page, David Water, 2016).

This generates problems inside the company sending wrong emails to the inspectors.

The method takes a lot of time: We have seen that the method that is used by the company takes a lot of time.

In economics, time is a resource that can be saved, spend, and allocated to different tasks. When you allocate a person to a task you are also allocating time (Doing certain tasks do not allow the company to do other ones), and that employee who is doing one task does not allow the company to assign him another task. As any resource the time is a scarce commodity (Goldsmith, 2013).

In this case, this task is developed by a person who the company pays. So, replacing this method by another one faster can allow the company to use the time in a better way. If the employee finishes this task faster, the company can assign this person another issue.

An inspector cannot know when a norm has been replaced: People cannot know everything (Rohrer, 2009), the possibility that one standard has been replaced and one of the inspectors does not know about this exists. Because with the method that the company was using before the implementation of the software, inspectors had to continuously be checking the norms carefully for any change that could appear. Also, a human error can be involved too, one of the inspectors could confuse himself about something he reads on the Internet (For example, he could see that a norm is still available, but it is not).

Possible demotivation: As we have already explained, developing repetitive tasks can cause on the employee a demotivation in realizing its job (It is not possible to affirm that occurs in the company, but it could be possible). The repetitive tasks in the jobs may become bored and complaisant in the work, leading to a loose in productivity and job dissatisfaction (Bryan & Bird, 2016).

This demotivation caused by doing repetitive tasks can be solved by giving more autonomy, task significance or variety in the job developed, these are the characteristics of motivating work proposed by the job characteristic model. It is more probable that these characteristics were in a complex task than in a simple one (Gully & Philips, 2011).

4 The program developed

Before describing how to use the project, we should understand a little bit how it is composed. First, we can divide it into 3 little programs, the last one will be divided into two more sub-programs (but it is included in the same module of the macro).

So, this chapter will be divided into four parts. The last three will explain how the three macros were developed, step by step including some literature support to explain better some functions the VBA and what these functions allow us to do.

The first part explains how to set up the libraries in VBA before we can start programming. Setting up the libraries is important because allows us to unlock a set of functions and variables that makes the job easier than without them. In this part we set up different references in VBA that enable controlling other applications on the computer of the user.

4.1 Preparing Excel before programming:

Before programming the references of VBA were set up. They allow us to control other software with this programming language.

The Excel VBA can declare a reference to an external object library, an object library “is a collection of objects provided by a specific application” (Duane Birnbaum, 2002).

In this case, we have used references to use the libraries of Adobe, Internet Explorer, and other ones that from more programs or use certain commands that are blocked. We can view, add or eliminate references by going to the

bottom “Tools” and in there clicking “References”. We have activated nine references in total: “Visual Basics for Applications”, “Microsoft Excel 16.0 Object Library”, “OLE Automation”, “Microsoft Office 16.0 Object Library”, “Adobe Acrobat 10.0 Type Library”, “Microsoft XML, v6.0”, “Microsoft Internet Controls” and “Microsoft Outlook 16.0 Object Library”.

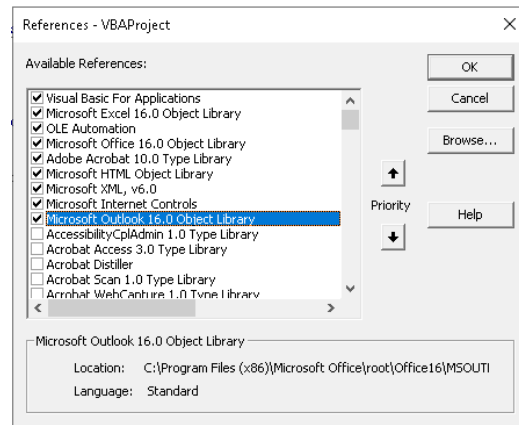


Figure 4.1 The VBA references

The Object libraries allow us to use the concept of Early Binding to connect different applications. In Early Binding the programmer creates the object by setting a reference to the Object library, instead of creating an Object variable before (John Walkenbach, 2010).

During all the project we have always connected the applications by early binding.

Using this method has many benefits like:

- The code is much faster.
- All the constants defined in the object library can be used.
- VBA displays all the content of the library when you reference it (John Walkenbach, 2010).

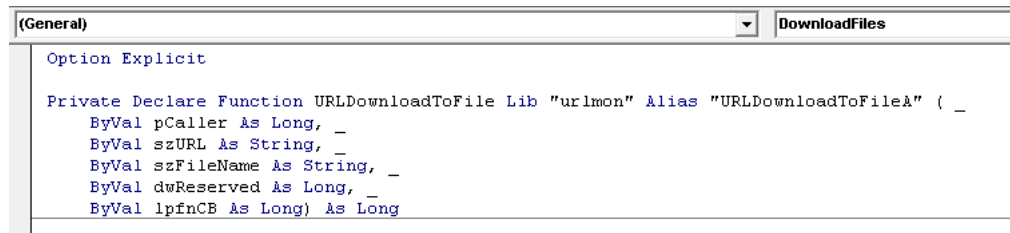
It is important that the company download all the programs mentioned in the table in chapter 2 (excepts for Skype). If the company does not have the programs in the computers where the macros will be run, the macros will not work. The majority of them are included in all the computers with Windows, the only one that the company maybe need to download is Adobe X Pro, this one is not included in a standard computer (in the majority of the cases).

4.2 FIRST PROGRAM: Downloading the files

The first macro oversees downloading all the files that the laboratories send to Accredia, which contain all the data that the program must manage. This program was developed by using one of the Window's API (application programming interface) function. "An API is a group of standards functions that are packaged together and made available to application programmers" (Teresa Hennig, 2010), one of the best known is WIN 32, which is included in Windows. This Windows API consists of many DLLs which make up the operating system. In this case, we have used the function "*urldownloadtofile*", which is included in the DLL called "URLMON".

First, we started this first program by a private declare function on the top of the module. The function is called *urldownloadtofile* and then we call the folder where the function is included (URLMON) by typing the word "Lib" and then the name of this folder. After that we must give an "Alias" to this function (because an user can use the same function many times, to download different things, so the user must call them with different names), we have chosen the alias "URLDownloadToFileA". After that we have defined the variables that make up the function: *pCaller* as long, *szURL* as string, *szFileName* as string,

dwReserved as long and *lpfnCB* as long. Then, we have only changed the value of the variables that are *strings*, the other type of variables was turned off them by adding a 0 to their value. The URL is the hyperlink to the website to download the file that the user wants, and the file name is the place inside the user's computer where the file will be saved.



```
(General) DownloadFiles
Option Explicit
Private Declare Function URLDownloadToFile Lib "urlmon" Alias "URLDownloadToFileA" ( _
    ByVal pCaller As Long, _
    ByVal szURL As String, _
    ByVal szFileName As String, _
    ByVal dwReserved As Long, _
    ByVal lpfnCB As Long) As Long
```

Figure 4.2 The URLDownloadToFile function with all its variables

Also, the program uses a table created to complete the hyperlink to the website which contains the number of the laboratory in the first column, in the second and third columns there are codes that Accredia uses in the hyperlink of the website where the report is contained (these are contained inside Accredia's website). So, this table is used by the program to create the URL to visit Accredia's website using the Window's function that was mentioned before. As well, there is a fourth column which indicates whether the download was successful or not (this is useful for the person who runs the program indicating if the program has correctly done its job).

After calling this function and preparing the table, we define the variables of the program. These ones are going to collect information from the table to get their value. The name which the file is going to be saved, the URL, and some MSXML variables (which are taken from the MSXML library to navigate on the Internet) are formed with the table's columns. The MSXML (Microsoft XML

Core Services) “is a COM-based library of components that consume and generate XML” (Cliff Binstock, 2003). This library is included in the Microsoft Excel and it allows us to navigate on the Internet by using some variables and object that are contained on it. This library helps the user to control functions of Internet Explorer, allowing him inspecting different websites around Internet. Also, we took variables from the library MSHTML, “it is an OLE Activate Document that loads, parses and displays HTML content” (Matthew Crowley, 2011). The MSHTML allows us to control a Web window and extract information from it, with the Object in the library called “*HTMLDocument*” we are able to connect to Internet and then with “*HTMLElement*” we can find specific elements on a website that we are visiting.

At the beginning of this program, we used the function “*For*” to repeat the next process during all the table we have mentioned before. In this process we created the string “*File*”, completing the blanks in that string with the information from the table. This string contains the name of the hyperlink of the website to download the report from one specific and unique laboratory. After the program creates that hyperlink, it uses one object from the MSXML library that allow us to enter on the website without opening Internet Explorer. Because, when the computer does not open the web browser the process is much easier for it, and it is also much faster. After that, we equalize this function from MSXML folder with one from the MSHTML folder (in this way the control of the web browser is yielded to MSHTML, so the objects in this library can be used to examine a website). Then, we looked for a specific element with the method *GetElementsbyClassName* (), *GetElementsbyTagName* () or *GetElementbyID* (). The two first methods return

a list of all the elements in a website with that tag name or class. The last one returns exactly that specific element with the ID (if an element has an ID, this one is unique). We have used the method with *tagname* to find a specific message that occurs only when the website does not exist (this has been done to avoid any error that could happen if the link addresses does not exist and the download fails). So, this part is a solution of a possible error that occurs when the website does not exist.

Then we have used the instruction *if*, if the message that we got in that tag name is exactly like one we have written in the instruction *if* (the message given when the website is not found), the code moves to another part using the command *goto*.

The command *goto* allows the programmer to go anywhere in the code. Many programmers consider that the instruction *goto* should not be used, because this command tempts programmers to write messy codes. Theorist considers that the command *goto* allows programmers to create bad software (Sorin, 2013).

Beyond these prohibitions, the statement *goto* has been used to complete this project. In this program the command *goto* is used to send the user to a part that is impossible to arrive by another way, used to show an error in the column number four of the table in Excel (this column shows whether the download was successful or not). If the message is different, the code will continue running in a normal way.

The last part shows how the program verify that the website has been successfully found. Now, it is going to be explained how the program downloads the files.

After that, the program creates the string called *DestinationFile* (the direction where the report will be saved in the computer). Then, the program uses the API function *URLDownloadToFile* (which was mentioned before), completing in brackets all the variables of this function. And when the program downloads successfully the file, the fourth column is completed with “Download successful” and the string called *DestinationFile* is completed in a cell which the row is equal to the number of the loop *For* and the column is the number eight. This last information is going to be used in the second program (it is the address of a file in the computer, the second program uses it to open them).

	A	B	C	D	E	F	G	H	I	J	K	L
1	laboratorio	rev	codigo	success								
2	15	17	3009	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\015.pdf				
3	20	14	3012	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\020.pdf				
4	21	15	3014	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\021.pdf				
5	39	19	3024	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\039.pdf				
6	42	16	3026	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\042.pdf				
7	49	17	3029	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\049.pdf				
8	69	13	3051	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\069.pdf				
9	70	11	3052	download succesfull				C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\070.pdf				

Figure 4.3 The table to construct the URL to download the files, the column that shows the success and then the addresses in the computer of the files

4.3 SECOND PROGRAM: Reading the files and connecting to Internet.

The second program is the largest one and it was the most difficult to create. This program is the one which extracts the information from the pdfs creating a data base on the WorkSheet 2 of the Excel’s file. The data base, created at

the end of this program, has the form of a table in which, the first column indicates the number of the laboratory of the file that the program is reading, the second one shows the name of one “area metrologica” of the laboratory, the third column is the sector of the area metrologica and the fourth column indicates the name of the norm that the program analyzes. The column number five and six are completed after comparing the norm with information from Internet. This information is obtained by web scrapping to complete the data base with the data extracted from the website of the standard that the program is analyzing.

First, a lot of variables have been defined (*strings*, *longs* and other ones that will later be mentioned) and more libraries have been activated to control more programs. For example, in this program is used the Adobe Acrobat Pro and the Internet connection. This program has a library that allows us to open a pdf file, read it, extract information, and change the pages of the file (it allows to do more things but these are the principals that the program uses).

The program uses again the libraries to connect to the internet (MSXML) and the one that it is used to inspect a website and copy information from it (MSHTML). So, in this new macro, we have used the same variables and objects than in the first program (from these two libraries). From the Acrobat’s library three variables have been created: one to open the program, another to open the file and a last one to select the text from the file. Then we have created other variables such as: *a*, *b*, *c*, *d*, *e*, *f*, *l*, *j*, *w* and etcetera, that have been defined as *Long* and they have been used as counters or to enter in special parts of the code with an instruction *if* (depending the value of the variable *Long*).

We have chosen to use the *Long* data type instead of *Integer* data type, because the *Long* data type can manage higher and smaller value of numbers than the *Integer* data type (*Long* variables can handle numbers from -2147483648 to 2147483648 and the *Integer* variables can only handle numbers from -32768 to 32767) (Guy Hart-Davis, 2006).

It is clearly visible that is better to use the *Long* variable instead of the *Integer* one to avoid possible problems in the future using the program. Then, other variables that are *strings* were defined, to copy information from the pdf or from Internet.

The program starts with a loop created with a *For*, to repeat the process exactly the number of times equally to the number of pdfs we have. Then the code extracts information from the Sheet1 (copying the names of the pdf files that the program one has downloaded before), copying one direction from the column eight (where all the pdf directions were saved), and the string *pdf_file* takes the name of the address of that pdf. Then the program opens the Adobe Acrobat Pro. After that, the Sheet 2 is activated (so, all the work is saved in this sheet) and the name of the laboratory is copied from the string *pdf_file* and the program saves it in the first column of the table. After taking the name (number) of the laboratory, the program starts a new loop *for*, from $i = 0$ to $pdf_doc.GetNumPages - 1$, this means that i represents the current page in the pdf file, so this loop goes from the first page (page zero, because in VBA the first element from a list is the element zero) to the last one. Then we set three other items called *PageNumber* (this one shows the page that we are working in the pdf) , *PageContent* (this represents the content of the pdf, the current word that we are reading in that moment), and *sel_text* (this select the

current word that the program is reading, this will copy a specific word on a specific moment).

After we have Set these three variables (from the Adobe library), we open a new loop for from $j=8$ to $sel_text.GetNumText - 1$, so it will finish in the last word from the current page that the program will be reading. The loop starts on 8, because we are going to create eight strings (they are called *Contentn1* to *Contentn8*). The first one, *Contentn1*, is equal to $sel_text.GetText(j-7)$, this string is equal to seven words before the current word that the program pdf reads in that moment, and *Contentn8* is equal to $sel_text.GetText(j)$, this allows the program to copy a group of words instead of only one (the current word). Also, copying exactly the words that we want. Because the name of the norms is composed by many words and when the program detects a specific word, we want to copy many words at the same time (the other 6 *Contentn* are in the middle of these two).

At this point, the program has many strings to copy each word or phrase that is needed, the number of the laboratory completed and created the system to pass between each word inside the pdf. Now an instruction *if* was created to define the area metrological, when the *Contetn7* is equal to the word "Settore", four new strings are created (because the name of the area metrologica can be composed by many words, not only by one) that are composed by the *Contentns*. The word "Settore" was chosen for that, because after every name of the area metrologica, the word "Settore" is the next one. The idea is to choose a word that is repeated in all the cases, we noticed that the word "Settore" is always at the end of the area metrologica, so we have chosen *Contentn7* for this. Then, we created four *if* to check if this four strings,

which contain the name of an area metrological, are equal to one area metrological, this string is completed in the column number two of our table in the Excel file.

Now, we determined the name of the different sectors in each area metrologica. To do it we started with an *if* when *Contentn5* is “field” the *long g = 1* (we used this *g* as an activator) because then we created another *if* when *g=1* the string *SETTORE = SETTORE + Contentn6* this process continues in each word of the file until an *if* where “if *Contentn7*” is equal to the word “Misurando” or “Strumento”, the *g=0* and the string *SETTORE* is completed in the column three of our table and, at the end *SETTORE = Empty*, in that way the string *SETTORE* has no value.

Area metrologica Metrological area		Accelerazione				
Settore / Calibration field		(SAC-01) Catena accelerometrica				
Strumento Instrument	Misurando Measurand	Campo di misura Measurement range	Condizioni Additional parameters	Incertezza Uncertainty	Metodo/Procedura Method / Procedure	Sede Location
Catene accelerometriche	Accelerazione (sensibilità in tensione o in carica)	da 4 m·s ⁻² a 100 m·s ⁻²	da 10 Hz a 20 Hz	2 · 10 ⁻²	ISO 16063-21:2003	A
Trasduttore triassiale			da 20 Hz a 1 kHz	1,5 · 10 ⁻²		
	da 1 kHz a 5 kHz	2 · 10 ⁻²				
		da 4 m·s ⁻² a 100 m·s ⁻²	da 10 Hz a 5 kHz	2 · 10 ⁻²		

Figure 4.4 Example of a report from a laboratory: The red oval is the Area Metrologica, the light blue rectangle is the sector, and the orange oval shows the norm

Currently, the largest part of the program (and the most important one) starts. This is the part of the program that reads and copies the norms. We created a different *if* instruction for each type of standards that we are talking about, when the program detects a specific word from a norm enters into that *if*, completing the column four in the table in Excel and then changing the value

of one *long* variable (the *long* variables are used as “keys” to enter into different *if* statements to go to different websites) to then navigating on Internet to check if that norm is still valid or not. So, when the program detects a norm, after copying the standard, the macro also changes the value of a *long*, in this way the program enters on a specific *if* to navigate to a specific website then. For example, the ISO norms, when the program detects the word “ISO”, the program enters on the *if* instruction of ISO STANDARDS, completing the cell of the column number four with *contentn5*, *contentn6* and *contentn7* (ISO, the number of the norm and the year, it is only an example). Then the variable $a=0$ changes for $a=1$, a is a *long*. This process is repeated for all the different types of the norms, in the norms DIN, the program detects the word “DIN”, in IEC the macro looks for the word “IEC”, etc. For all these type of standards, different *long* variables were chosen to determine then the *if* statement that goes to a specific website (for example, on IEC norms $c=0$ changes to $c=1$, in OIML $o=0$ changes to $o=1$).

After all the *if* instructions for each type of norm have been created, the *if* instructions to navigate on Internet have been written. From these new set of *if* statements, each one connects to the website of each type of a standard organization. Repeating ISO example, there is an *if* $a=1$ then it enters to a part when *URL* is completed with the strings *contentn5*, *contentn6* and *contentn7* to enter the specific website. Then, we used the XML to connect to Internet and the HTML to extract the elements from the website. Depending on the website, different techniques to find the specific norm were needed. Because not all the websites are created in the same way, so a user needs to examine it before using web scrapping (For example, OIML has a website with a table

were all the norms are there). So, a previous analysis of the website was needed to know what to do and to know where to find the information.

After the norm was found, we must determine if it is available or not, to do that we compare the year in the website or we look for a message in the website that says the norm is still available. In that case, the column number six is completed with the message that the norm is available. If the norm was replaced or removed, the program looks for a message confirming that, or the macro compares the year on the Internet with the year in pdf file. When the availability of the standard is completed, first that is completed in the column six and then the program looks for (using the methods with the HTML library) the norm that replaces it.

This sequence is repeated for all standards in the file by the program, word by word of the pdf. The form by which is found the norm on the website is different depending the website, because not all the websites are equal, and they were not built in the same way. In the case that an error occurs when the program is entering on Internet, the program uses the command *goto* to move to a special part of the program, completing the column six with a message to tell the user to check the website manually.

After this part is finished, before moving to the next word and repeating this process again, the program automatically change all the variables to 0 (long variables) or empty (string variables equal empty) them, except *i* and *j* that determine the page number and the current word on current page.

Then, after all the loops were finished, the Adobe program is closed and all the variables that the program setted from the Adobe library are disactivated and this second program ends here.

	A	B	C	D	E	F
1	Laboratory	Area metrologici	Settore	Norma	Stato	Nuova norma
2		Pressione	(SPR-01) Trasduttori di pressione in mezzo liquido in condizione relativa/ass	EURAM ET cg- 17 ver. 4.0	IN VIGORE	
3			(SPR-02) Trasduttori di pressione in mezzo gassoso in condizione relativa/ass	EURAM ET cg- 17 ver. 4.0	IN VIGORE	
4				EURAM ET cg- 17 ver. 4.0	IN VIGORE	
5			(SPR-03) Trasduttori di pressione in mezzo gassoso in condizione relativa neg	EURAM ET cg- 17 ver. 4.0	IN VIGORE	
6			(SPR-04) Bilance di pressione in mezzo liquido in condizione relativa	EURAM ET cg-3 ver. 1.0	IN VIGORE	
7			(SPR-05) Bilance di pressione in mezzo gassoso in condizione relativa	EURAM ET cg-3 ver. 1.0	IN VIGORE	
8			(SBF-19) Sicurezza elettrica			
9	256		(SQS-05) Strumentazione per misurazione analitica	ISO 13964.1 998	IN VIGORE	

Figure4. 5 Data base built by the second program

4.4 Third program: Automatize sending emails

This third program was created by two functions in the same macro. The first one sends emails automatically and the second creates a button to use the first function by clicking it (this one is in the Excel's sheet number 3). The buttons are used to call a macro, the user can assign a macro to a button.

This first program uses the Outlook library to make possible sending the emails. Many variables have been created from the Outlook library, then we activate the Sheet2 on Excel to use the database created in the second program.

First, a loop *for* is created, equal to the length of the data base created in the last program, then this new program goes through the column 6 examining

which standards have been expired (because we are only interested to send emails to the inspectors about the standards that have been replaced or removed). So, every norm that is not available anymore, the program enters in an *if* instruction. Also, the program takes the sector, the number of the laboratory and the new standard (to autocomplete the message of the email).

In the case of sending the emails, Late binding have been used (When you declare a variable as Object or as Variant, Visual Basic uses *late binding*. It means that VBA does not associate the Object with the Automation object at design time but waits until the programmer run the procedure (Korol, 2019)).

“*SendEMail* has input parameters for the e-mail address of the recipient and the filename of the attachment for the e-mail. A new mail item is created using the *CreateItem* method. Text is added for the subject line and the body of the e-mail and the recipient and attachment are specified. The *Send* method send the e-mail” (Paul T. Kimmel, Stephen Bullen, John Green, Rob Bovey, 2004).

```

-----
Set miOL = applOL.CreateItem(0)
  With miOL
    .To = inspetore2
    .Importance = 0
    .Subject = MailSubject
    .body = MailMessage
    .ReadReceiptRequested = False
    .send
  End With
-----

```

Figure 4.6 The different variables to complete the email created by Outlook

Then, a new table is created. It is completed like: the name of the laboratory in the first column, the column two we write the sector, the column three is the norm that was substituted, the column four we write that it was

substituted or that was eliminated and in the column number 5 the norm that substituted the last one. In the column 6 are the buttons (when you click one it automatically sends an email with the information from the other columns in the same row). The emails are completed with the information of this new table. When the user clicks one button, the program uses the information from the row where the button was clicked.

After the buttons have been created, we must assign a function to them. So, the second function called *btn()* is created (the “btn” is an abbreviation for button). For this function, many strings to auto-complete the body of the email have been created (These emails use the information from the new table). Then the program opens a new file in which are the email addresses of all the inspectors from Accredia. Each sector has a group of inspectors controlling them, so to determine which inspectors will receive the emails, the program looks for the inspectors who work on that sector. Then, it copies the emails of that inspectors. At the end, the software automatically sends the email to all the inspectors when the user click the button and it closes the second file. So, the program creates buttons for the user, and he decides when to send the email.

A	B	C	D	E	F
Laboratory	Settore	Norma	Stato	Nuova norma	Buttons
93 (SFO-06)		OIML R-60:2000	SOSTITUZIONE	2017	botonnn2
93 (SFO-06)		ASTM E74:2018	SOSTITUZIONE	ASTM E74 - 18e1	botonnn3
93 (SFO-06)		ASTM E74:2018	SOSTITUZIONE	ASTM E74 - 18e1	botonnn4
93 (SFO-06)		ASTM E74:2018	SOSTITUZIONE	ASTM E74 - 18e1	botonnn5
98 (SFO-01)		UNI EN 12390-4:2002	RITIRATA CON SO	UNI EN 12390-4:2019	botonnn6
98 (SFO-01)		ASTM E4-16	SOSTITUZIONE	ASTM E4 - 20	botonnn7
99 (SRI-01)		UNI ISO 4037-1:20	RITIRATA CON SO	UNI ISO 4037-1:2019	botonnn8
99 (SRI-01)		UNI ISO 4037-2:20	RITIRATA CON SO	UNI ISO 4037-2:2019	botonnn9
99 (SRI-01)		UNI ISO 4037-3:2009	RITIRATA CON SO	UNI ISO 4037-3:2019	botonnn10
99 (SRI-03)		UNI ISO 4037-1:20	RITIRATA CON SO	UNI ISO 4037-1:2019	botonnn11
99 (SRI-03)		UNI ISO 4037-2:20	RITIRATA CON SO	UNI ISO 4037-2:2019	botonnn12
99 (SRI-03)		UNI ISO 4037-3:2009	RITIRATA CON SO	UNI ISO 4037-3:2019	botonnn13
99 (SRI-03)		UNI ISO 4037-1:20	RITIRATA CON SO	UNI ISO 4037-1:2019	botonnn14
99 (SRI-03)		UNI ISO 4037-2:20	RITIRATA CON SO	UNI ISO 4037-2:2019	botonnn15
99 (SRI-03)		UNI ISO 4037-3:2009	RITIRATA CON SO	UNI ISO 4037-3:2019	botonnn16
99 (SRI-04)		UNI ISO 4037-1:20	RITIRATA CON SO	UNI ISO 4037-1:2019	botonnn17

Figure 4.7 Last data base to automatize email sending with the buttons

5 How to use the Program

After explaining how the program was developed, it is important to teach how to use it. First, the user must complete the three columns of the table to use the first macro created. In this way, the program can create the hyperlink to download the laboratories' reports.

After completing the table (the table is shown in Figure 4.6), this user must change the range in the loop *for* to cover all the table (because, the user could have added more rows to this table, and the range of *for* does not get these new rows).

Finally, the user must change the content in the *string* called *DestinationFile*. She decides in which part of the computer the files will be saved.

```
DestinationFile = Mid(File, InStr(File, "=") + 1, 3)  
DestinationFile = "C:\Users\Lenovo\Documents\UNIVERSIDAD\Tesis\" & DestinationFile & ".pdf"
```

Figure 5.1 The string DestinationFile: it is created to save the file in a specific place in the computer. At the end, the ".pdf" to save it in that format

After completing these three steps, the user runs the first macro from the Macro dialog box, which is displayed on Excel when the user clicks on Macros in the Code group on the Developer tab (Pierce & Evelyn, 2011).

In this way all the reports will be downloaded successfully to the directions specified in the *DestinationFile*.

Then, in the second program, the user must change the range of the first loop *for*, the same length as many reports have been downloaded.

Then the user must run this macro in the same way the first one was run. The result will be a table with the laboratories, the area metrological, each sector

of each area and the standards used. If any of these norms were not available anymore, the program displays a message next to that norm, and next to this message of “non availability” the norm which replaces the old one will appear. If the norm is available, the program will write “IN VIGORE” next to the norm. As we said, the third macro is composed by two little programs (one creates the button to run the second one). In these programs, the user must do some changes before running them. In the program of the button, the user does not have to do significant changes. Only, the person can change the name of the buttons if he considers it.

```
Set t = ActiveSheet.Range(Cells(num, 7), Cells(num, 7))
Set btn = ActiveSheet.Buttons.Add(t.Left, t.Top, t.Width, t.Height)
With btn
    .OnAction = "btns"
    .Name = "Boton" & num
    .Caption = "botonnn" & num
End With
num = num + 1
```

Figure 5.2 The code to create a button in the Sheet of VBA

If he desires, the user must re-write the value in. Caption, to change the name that the buttons will show to the user in the Excel's Sheet. This is only an aesthetical alteration; it does not generate any change in the functionality of the software.

An important modification to be made by the user is to change the value of the range of the loop *for* at the beginning of this program. As in the last two programs, the user must change this value, to get all the norms that are in the table created by the second program. So, the user should check the number of rows of the table created by the second program.

In the other one, the user must complete the direction of the file with all the information of the inspectors (the Excel file that the program opens, the program will read it and take the information to send the emails, it will). In the VBA editor, the user must look for the expression *Set objWorkbook = Workbooks.Open* because “to add an existing workbook file to the *Workbooks* collection, you use the open method” (Kimmel et al., 2004), and after the *Open* the user must write that direction of the file between brackets (This new Workbook opened will be assigned to the Object Variable *objWorkbook*). If the user does not do that, the program will not access to the file and the program will show an error.

```
Set objWorkbook = Workbooks.Open("C:\Users\Lenovo\Downloads\DT_ReportCompetenzeIspettori_Tesi.xlsx")  
For j = 2 To 1000  
    sector2 = Cells(j, 8)
```

Figure 5.3 The direction of the new Workbook opened and below the loop For that the user must change depending the length of the table in program 2

“File access is the process of locating files on disk and opening them in the application, file manipulation is the process of reading and writing to files” (Rogers, 2001).

The other important changes are about the message that the email will send to the inspectors. This person who uses the program should look for two other *strings*.

```
MailMessage = "Buenas, el labo " + labo + " tiene la norma " + norma  
MailSubject = "norma cambiada en " + labo
```

Figure 5.4 MailMessage is the body of the email and MailSubject the subject of an email

The first is *MailMessage* this string will be the message in the email, the user must change what he wants to send to the inspectors (the user should not change the *strings* inside this one that completes with information of the norms and the sector).

The second one is *MailSubject* which is the subject of the email send, the user can change it by whatever she wants to see in the subject of the email.

These are the changes that the user must do before using any of the three programs. In case of not doing these changes, the program will not run, showing an error in VBA. Because it cannot find the place to send or copy fundamental information for the correct functionality of these Macros.

5.1 Program testing and results

After finishing these changes in each program, the user will run it. But before delivering it to the final user, the program has been tested to see any possible error.

“Because it does not matter how good the programmer is, the errors could be always presents in a program” (Mackenzie, D., & Sharkey, K., 2003).

First, we must define what is understood by “testing” a program:

“Testing is the process reviewing and executing a program with the intent of detecting errors” (Balaguruswamy, 2008).

So, it is always a good idea to test any macro created. Pressing Ctrl+I the macro will be run (or the person can use another method to run a macro). If the macro has been correctly developed it should work correctly (Bill Jelen, 2010).



Figure 5.5 Clicking the green button at the top of the window, the user runs the macro. Also, there are two more ways to run them

Every program was checked before delivering them. The first and the third program were checked only at the last time. But the second program (the longest one) was checked after each part was completed.

A good way to test a program, the programmer should try extreme values or extreme situations, type bad input, and try the best to make the program to fail. Programmers should also try every option available in the program, using different combinations to see what happens in all situations (G. M. Perry, 2001).

In the case of the first program, the correct function of the fourth column (column that shows the successful of the downloading of the reports) by completing wrong values in the other columns, to check if the program notices when the report was not downloaded (it was successfully tested). Then the program was checked completely, if all the reports were downloaded and the name of these files (the names where important for the second program).

The second program was tested (as we said) part by part (running it completely). Because it is the longest one and the one which could have the highest number of errors. The method was to run the program report by report, to see different errors that could happen. The objective was to see how the program copies the standards from the PDF file and how it copies the information from Internet, checking it to see if it is correct. Sometimes there

were errors detected by VBA (many times mistakes in the code), but other times where errors that VBA cannot detect (for example, not detecting that a norm was not available anymore or copying a wrong word from the PDF). So, all the reports were proved, one by one to see it. It is important to know that is impractical to find all the errors (Balaguruswamy, 2008).

The third one was tested in two parts. First, the creation of the buttons was checked (where they were created, in which moment and the name of them). Secondly, we checked how the emails were sent. There was checked the message in the email, the subject and if all the information was correctly completed in the email sent.

The program has been tested with all the reports and it worked correctly; all the errors detected were solved in the moment. But we cannot say that is perfect, as everything in the real world, it has more errors that they could not been detected. We have proved all the reports that were in that moment, but it can appear more that would generate a problem in the program. "It was proven that complete testing is impossible. Meaning that is that is impossible to test all values of each possible input, valid or invalid" (Rana Farid Mikhail, Donald Berndt, 2010).

5.2 Comparison with the old method

After the program setting up and the test was done. It is optimal to compare both methods to finally see the advantages of one method over the second one.

To do this comparison the idea was to choose one report file from one laboratory and check how much time take to the program to check all the standards inside it in comparison to do the same process manually. In the case of downloading the files, the user will not have any trouble if the website does not change the codes in the link, so the table for the first program will not have to be modified and the program is much faster than if a person has to download each report one-by-one.

The file that was chosen is the laboratory number 98, and its file has 11 norms to verify. So, like it was described, we are going to implement both methods on the same file. In this way we can run a test of the program.

Like it was supposed before doing the test, the program is extremely much faster than doing it manually. Doing this task manually has taken approximately 5 minutes (300 seconds), taking the norms from the file, copying them in a Excel sheet and checking on Internet if they are available or not, that is much more than the time was taken by the program, that it was only 19 seconds (it is much less).

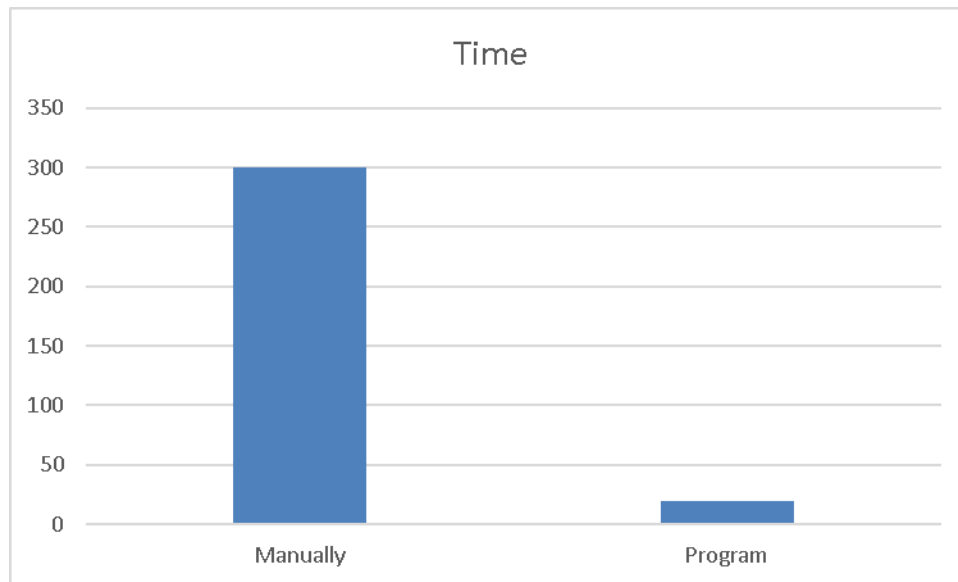


Figure 5.6 The time difference between both methods (the time is on seconds)

In the case of the third program. Clearly the program is a better method than writing the same email (but changing the name of the sector and the norm that is not available anymore) each time that the employee finds a standard that is no longer available.

In this case, the user must write only one single time the email, then the same email will be replicated every time that the person clicks the button to send one. It is much faster, for this example, during the test of the program only one email has been written. But, doing it manually 4 emails would have been written, in which the person would have to change the inspectors, check if the emails were correct, change the important information in all of them and send them.

Also in the case writing them manually, a person can commit orthographic errors, or the user can write incorrectly the email of one inspector and in that possible scenario the inspector will never receive the email and she cannot

complete her job. There are possible mistakes that could happen in many undesired scenarios for the company that could be avoided using this little program.

5.3 Analysis of the program

At this moment we are ready to identify some advantages about the automation produced by the program. The first (clearly) advantage is the extremely time reduction of the task by using the program instead of doing it manually.

Because, through the automation of data management, the department gains many benefits, by reducing the manual time and effort required to complete a task (Don Jones, 2006).

Also, it is decreased the human intervention in this activity. Reducing the human error in this way. Less tasks that are done by a person, this reduces the possibility of an error carry out by a human. There are many possible mistakes that the person who was doing this task manually could commit, such as:

- Sending bad an email: it was the possibility that the user commit a mistake in the email of one inspector (in this case, the inspector will never receive the email) or the information in the email was wrong (the name of the new norm or a norm that was not removed was sent like that).
- Confuse on the information: The user cannot see well and commit a mistake checking the availability of a standard or when he is watching a report from a laboratory.

At this point we can say that the automation of the task has achieved its main purpose, to reduce the human error and make the work more efficient.

“The aim of the automation is to aid and to assist, to even make the work more efficient and reduce human error” (Svensson, 2020).

But the automation has not only saved costs by reducing time, it has also increased the quality of the process that develops this task, because it reduces the quantity of errors that can appear.

“The idea is that automation is not only about the cost of goods or a reduction in throughput, but also about a reduction in hands on time, increased quality, and an increased consistency and integrity of the data that are generated”(National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, Board on Health Sciences Policy, 2017).

Also, it is possible to say that this automation has made work easier not only for the person in charge of the activity, for the inspectors too. The software can check the availability of a norm by itself, so the inspectors does not have to check it by themselves anymore. They have just to study the new norm (which replaces the old one) that they have received in the email send by the program.

The program (as we have seen) has a lot of advantages in comparison with the old method. It has solved many problems that the company has with the old way of performing this task, but it has not solved all of them. It is tempting to say that the job of a programmer is to eliminate all the errors (that would be an ideal), however, in the real world that is not feasible. The programmer

should minimize the errors as much as he can and try to construct a very good software but it will never be perfect (Bjarne Stroustrup, 2014).

The change of the method solved some problems, but it can create new ones. Because automation is able to create new types of errors that needs to be taking into account and addressed (Svensson, 2020).

A new error could be if one of the websites from where the program takes information changes the position of the information in some time of the future. This possible scenario could generate a problem in the functionality of the software. In this scenario, the method of web scrapping would suffer a failure. Because, to apply web scrapping the code written that extract data from a website must be precise, this condition makes it vulnerable to break easily (Nikhil Abraham, 2016).

Another new error (which is related also with Internet managing) could be generated by the change in a website's URL. A change in the name of a website will create a new error which the company will have to manage if it appears.

Like these examples can be a lot more than have not been discovered yet. "Perfectly correct programs are virtually nonexistent. Due to their complexity, virtually every significant piece of software has errors, or "bugs" in it" (Jessen Havill, 2016).

6 Conclusion

After this little project that we have developed we can conclude that the automation of tasks brings great benefits for a company. Also, the advance of the technology brings new tools to help workers to complete its job in an easier way.

From the company point of view, this brings a reduction of human intervention and a decrease in time of completing a task, improving the efficient of the jobs incurred. This allows an organization to save resources that can be assigned to other more productive jobs and in a cost reduction of their operations. Because, the cost of human labor is decreased (Rajkishore & Rajiv, 2017).

Also, this automation applied for the process of the company generates a reduction of errors and this improves the quality of the processes. When the opportunities of errors are decreased the quality of the process is increased (Chris A. Ortiz, 2009).

In the employee's point of view, this new program is a new tool to facilitate his job. This person will not lose a lot of time doing this task anymore, time that he can invest in doing more productive jobs for the company. Also, the repetitive task is eliminated, now an employee can click a button and the program will run, he has only wait until it finishes. That time can be used to do other activities. So, instead of doing the same repetitive and boring task, the company can give the employee other set of tasks that can be more complex. In the case that a motivation problem exists, this can be a solution (maybe the company replaces this task by another one repetitive, it is impossible to know this information).

However, as it was mentioned, there are not only benefits. New errors can appear in the method after its implementation. But the advantages of this new method clearly outweigh the disadvantages.

We have concluded that the automation was a success. But the grade of automation can be improved, at a point of no depending of an employee to do this task. Maybe increasing the grade of automation could create new jobs for other tasks but that is out of this analysis.

At this point the worker has only to run the macros and click to send the emails which have been written before. But VBA allows the possibility to run a macro automatically at a certain moment of the day or increasing the range of days. (For example, setting it up to run it one time per month). “VBA offers the *OnTime* method for running any VBA procedure at a specific time of day or after a specific amount of time has passed” (Jelen & Syrstad, 2013). So, in this way, the company could reduce even more the human intervention in this process.

And to eliminate completely the human intervention (in the case that no one verifies the correct functionality of the program) it would be the possibility of putting together the second program with the third one. So, when the program detects that one norm is not available anymore and after scrapping the information from internet (knowing the new norm) it can automatically send the email (Avoiding the creation of the third program and the buttons that a person has to click).

This could be only some other possible implementations to increase the grade of automation that we have not been implemented due to that Accredia wants the program in the way that was developed.

In the case of increase the grade of this automation by the other possible implementations, the company can give these employee more productive tasks or (if this was his only task in the company) take him out to reduce the labor costs inside the company.

The automation allows the company to reduce the number of employees (or keep the same number but assigning them more productive tasks), because many employees are needed to cover the same number of tasks developed (sometimes more productive tasks are created because of the automation) (Carlsson, 2012).

In the case that the employee lose its job the history teaches us that the workers displaced from their old jobs by the technological advance have moved rapidly into new jobs that have been better paid. (United States. President's Advisory Committee on Labor-Management Policy, 1962).

So, we can still maintain the idea that the automation (a technological advance) has more benefits than disadvantages.

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