

# **POLITECNICO DI TORINO**

Master of Science in Engineering and Management

## **Master Thesis**

Automated data analysis of ACCREDIA calibration  
laboratories



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## ***Acronyms and Abbreviations***

NC	Non-conformity
OSS	Observation
COM	Comment
CAB	Conformity Assessment Body
VBA	Visual Basic for Applications
VBE	Visual Basic Editor
Rilievo (i)	Each requirement evaluated in the on-site assessment

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## ***Introduction***

The importance of automating and systemizing processes is a necessity in nowadays enterprises, considering that these techniques facilitate the execution of the work, the analysis of the results, and improve the overall efficiency of the processes, reducing the time in which the activities are carried out. Besides these benefits, the automation of a process is a company significant innovative improvement that causes a reduction of human errors that can affect the performance of the processes.

This work presents the automated solution proposed and implemented in the professional training performed in ACCREDIA, the Italian Accreditation Body in charge of the inspection, verification, and accreditation of laboratories (CABs) that verify conformity to the standards of goods and services in Italy. In this work, the main objective was to develop a Macro using the Microsoft Excel tool VBA to perform a statistical analysis of the conformity assessment of calibration laboratories performed in 2019.

ACCREDIA has been operating since 2009, and to date, it did not have an automatic method to generate a statistical analysis corresponding to the conformity assessments of calibration laboratories. The current method performed by the technical officers of the company consists of executing a complex revision of each one of the reports made in the on-site assessment visits to the calibration laboratories to generate some annual indicators and evaluate the laboratory's performance in the conformity assessment process. Because of this complicated and tricky process, the automation of this task was necessary, aiming to facilitate the process and to improve and increase the statistical indicators needed to evaluate more deeply the performance of the laboratories in the accreditation process and the performance of the inspectors who execute the conformity assessment.

This thesis will focus on the explanation of the solution implemented in ACCREDIA and the results obtained from the data corresponding to 46 reports of the calibration laboratories conformity assessments made in 2019. This document is divided into six chapters; the first and second chapters focus in the overview of the company and the importance of the accreditation in the industry; following the third and fourth chapters described the actual method to analyze the

laboratories conformity assessment and its criticalities, and the fifth and sixth chapters explained the improvement actions, the results obtained and the recommendations to improve the usability of the macro created.

# 1 ACCREDIA overview

ACCREDIA is The Italian Accreditation Body (see Figure 1); it has been operating since 2009 and was created by the Italian government following the regulation EC 765/2008 and the international standard ISO / IEC 17011. Its main goal is to ensure the competence, independence, and impartiality of Conformity Assessment Bodies (CABs), these refer to certification, inspection, verification, testing and calibration laboratories, which verify conformity to the standards of goods and service (ACCREDIA, 2017)<sup>1</sup>.



Figure 1. ACCREDIA trademark

The certification of CABs is a very important process because the body certificated guarantees a high level of reliability in the quality and safety of its products or services and ensures recognition in the international market place.

All the ACCREDIA services ensure the following company principles:

- Impartiality and Independence;
- Absence of conflicts of interest;
- Competence;
- Responsibility;
- Confidentiality;
- Handling of complaints.

## 1.1 Departments

ACCREDIA is divided into three departments, each one situated in a different city in Italy: the first one is Certification and Inspection with headquarters in Milan, Testing Laboratories with a center of operations in Rome, and Calibration

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<sup>1</sup> ACCREDIA. (2017). *About Us*. Obtained from <https://www.accredia.it/en/about-us/>

Laboratories with a base of operations in Turin (ACCREDIA, 2017)<sup>2</sup>; the last one is the department in which this project was developed.

Every single department mentioned above oversees the accreditation activities of different bodies:

- **Certification and Inspection Department:** is in charge of the accreditation of certification bodies, inspection bodies, verification and validation bodies;
- **Testing Laboratories Department:** is in charge of the accreditation of testing laboratories, medical laboratories, and proficiency testing providers;
- **Calibration Laboratories Department:** is in charge of the accreditation of calibration laboratories, reference materials producers and measurement reference laboratories in the medical area.

Nowadays, ACCREDIA has accredited 417 certification and verification bodies, 1,250 testing laboratories, and 195 calibration laboratories and has a group of assessors and experts composed of 579 people (ACCREDIA, 2017).

Focusing on the Calibration Laboratories Department, this one has the intention of accrediting calibration laboratories with the aim of ensures the long-term metrological traceability of national or international samples (ACCREDIA, 2017)<sup>3</sup> and the reduction of errors and variance in the measurements.

Some of the most used standards by ACCREDIA to realize the accreditation in calibration laboratories are:

- **UNI CEI EN ISO/IEC 17025:2005:** general requirements for the competence of testing and calibration laboratories;
- **UNI CEI EN ISO/IEC 17025:2018:** general requirements for the competence of testing and calibration laboratories;

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<sup>2</sup>ACCREDIA. (2017). *Organization*. Obtained from <https://www.accredia.it/en/about-us/organization/>

<sup>3</sup>ACCREDIA. (2017). *Accredited Services*. Obtained from <https://www.accredia.it/en/accredited-services/calibrations/>

- **RT-25**: requirements for the accreditation of Calibration Laboratories;
- **RG-09**: regulation for the use of the ACCREDIA mark;
- **RT-36**: requirements for the accreditation of Calibration Laboratories related to PT/ILC (proficiency testing/interlaboratory comparison);
- **IO-09-DT**: operative instruction on issuing a calibration certificate by a Calibration Centre accredited by ACCREDIA-DT.

## **1.2 Organization**

ACCREDIA is an entity formed by 68 members representing all the organizations and people involved or interested in accreditation and assessment activities carried by bodies and laboratories (ACCREDIA, 2017). Among the most important stakeholders are:

- Public entities and ministries (Economic, Development, Environment, Defense, Infrastructures and Transport, Internal Affairs, Education, Labour, Agriculture, and Health);
- National and international standardization bodies;
- Business and commercial entities;
- Associations of accredited certification and inspection bodies;
- Associations of testing and calibration laboratories;
- Associations of consultants and consumers;
- Suppliers of public services (transport and energy).

### **1.2.1 Organizational structure**

ACCREDIA follows a functional structure, in Figure 2 is shown the entire organizational chart, where people with most authority in the entity stand out as: assembly members, president, general director, director and vice directors of each one of the three departments.

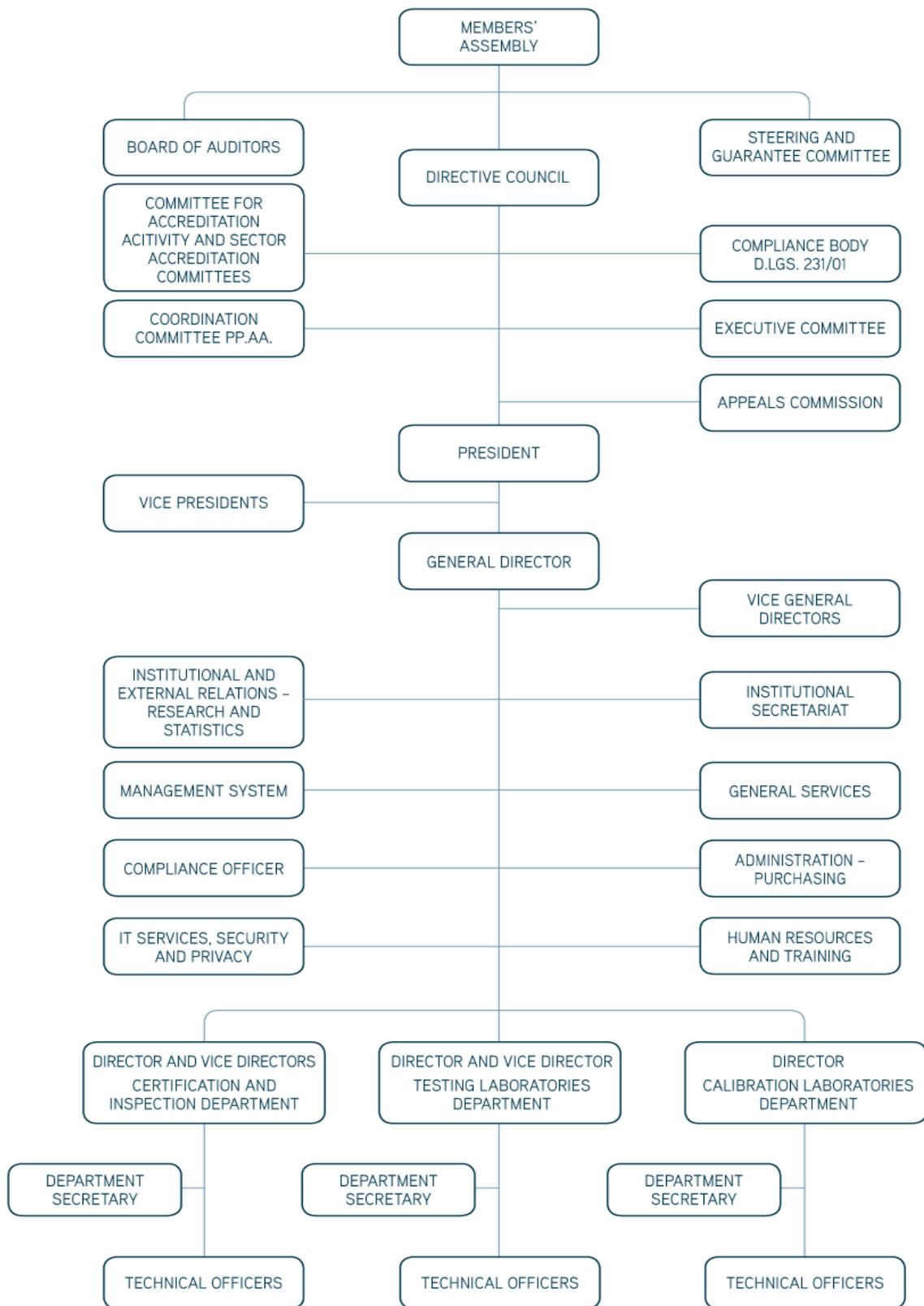


Figure 2. ACCREDIA organizational chart<sup>4</sup>

4 ACCREDIA. (2017). *Organization, Organizational Chart*. Obtained from <https://www.accredia.it/en/about-us/organization/>

This project was done following indications of a Calibration Laboratories Department Technical Officer (Paola Pedone) and twice with the participation of the Calibration Laboratories Department Director (Rosalba Mugno), who was evaluating the progress and the performance of the project.

### **1.3 International network**

The importance of ACCREDIA being part of an international accreditation body network is that this ensures that its services operate under established standards, allowing for efficient data comparison and frequent improvement of procedures.

ACCREDIA is part of the international network of Accreditation Bodies, which are governed by the international standard ISO / IEC 17011, along with regulation EC 765/2008 for EU accreditation bodies. Besides, ACCREDIA is a member of the EA (European cooperation for Accreditation), the IAF (International Accreditation Forum), and the ILAC (International Laboratory Accreditation Cooperation) (ACCREDIA, 2017)<sup>5</sup>.

ACCREDIA is a member of the mutual agreements between EA, IAF, and ILAC; this means that, for example, the accreditation of an EA mutual agreement member is reliable enough to be recognized and approved by the IAF and the ILAC, this double recognition facilitates the accreditation processes of goods and services because there is no need for these to be re-calibrated, re-tested, re-inspected or re-certified in each country they are imported and sold (EUROPEAN ACCREDITATION, 2019)<sup>6</sup>, in this way, international trade is encouraged.

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<sup>5</sup> ACCREDIA. (2017). International Network. Obtained from <https://www.accredia.it/en/about-us/international-network/>

<sup>6</sup> EUROPEAN ACCREDITATION. (2019). IAF/ILAC Recognition. Obtained from <https://european-accreditation.org/mutual-recognition/iaf-ilac-recognition/>

## 2 Importance of accreditation

As said before, accreditation is a process that generates greater confidence about the quality and safety of a product or service, and this has positively affected the economy since consumers feel calmer when purchasing goods or services that have some accreditation standard.

This previous reason can explain the positive tendency in the accreditation of laboratories; as shown in Figure 3, year by year, a higher number of calibration laboratories are accredited by ACCREDIA. Although this trend also appears in the other two departments of the organization, this thesis gives more importance to the Calibration Laboratories Department because it is the division of the entity where this project was performed.

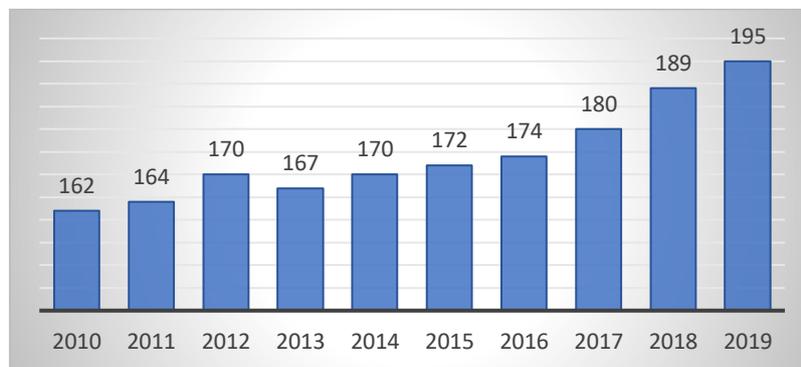


Figure 3. Evolution of accredited calibration laboratories by ACCREDIA<sup>7</sup>

### 2.1 Benefits of accreditation

The increasing tendency mentioned above refers to the laboratories understanding of the importance of being accredited in a modern world and a demanding market. Many authors have talked about this before and have explained the main benefits of the accreditation. Considering the information exposed by (Tabor, 2004)<sup>8</sup>, (Khodabocus and Balgobin, 2011)<sup>9</sup> and

<sup>7</sup> ACCREDIA, 2019, Relazione Anuale 2019

<sup>8</sup>Tabor, A., Raczka, M. and Kowalski, M. (2004), Quality Methods and Tools, Normalization, Accreditation, Certification, Centre of Training and Organization in Quality System of Cracow Technical University Publication, Cracow.

<sup>9</sup> Khodabocus, F. and Balgobin, K. (2011), "Implementation and practical benefits of ISO/IEC 17025:2005 in a testing laboratory", University of Mauritius Research Journal, Vol. 17 No. 1, pp. 27-60.

(Halevy,2003)<sup>10</sup>, it can be said that the main benefits for an accredited calibration laboratory are:

- Minimizing the probability of re-testing inducing a reduction of quality costs;
- International recognition of test results;
- Minimizing the risk of unreliable results;
- Improving the functioning of the laboratory processes;
- Learning from other laboratories performance;
- Reducing customers complain;
- Ensuring the laboratory performs according to a standard;
- Improving the efficiency and effectiveness of the laboratory;
- Improving the personnel performance and technical skills in planning and executing an accurate, reliable, and efficient measurement process;
- Developing more precise and more detailed documentation;
- More suitable maintenance of the laboratory equipment;
- Enhancing organizational learning by developing corrective and preventive activities;
- Inciting workers to bring to the organization new and better ideas;
- Improving customer confidence and satisfaction regarding the performance of the services or products;
- Generating a work environment with better internal communication and a better flow of information;
- Improving the relationship with the consumer and understanding better his needs;
- Enhancing the competitiveness and reputation of the laboratory.

The accreditation process can be self-motivated by the own laboratory or conducted by the pressure of the market or by a regulating authority (Halevy, 2003); in the past, the last was the most common reason for a laboratory to be

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<sup>10</sup> Halevy Avner (2003), "The benefits calibration and testing laboratories may gain from ISO/IEC 17025 accreditation", Accreditation and Quality Assurance, 2003, Vol.8(6), pp.286-290.

interested in acquiring the accreditation, but now the former reason is the most usual one, as the laboratories have realized about the advantages of the accreditation. This argument is supported by the study made to 155 laboratories in the American Continent in 2016. Figure 4 shows that most of the surveyed laboratories carried out accreditation as an institutional decision; a lower percentage of them expressed been pressured by some external institutions (Grochau, Caten and Camargo, 2018)<sup>11</sup>.

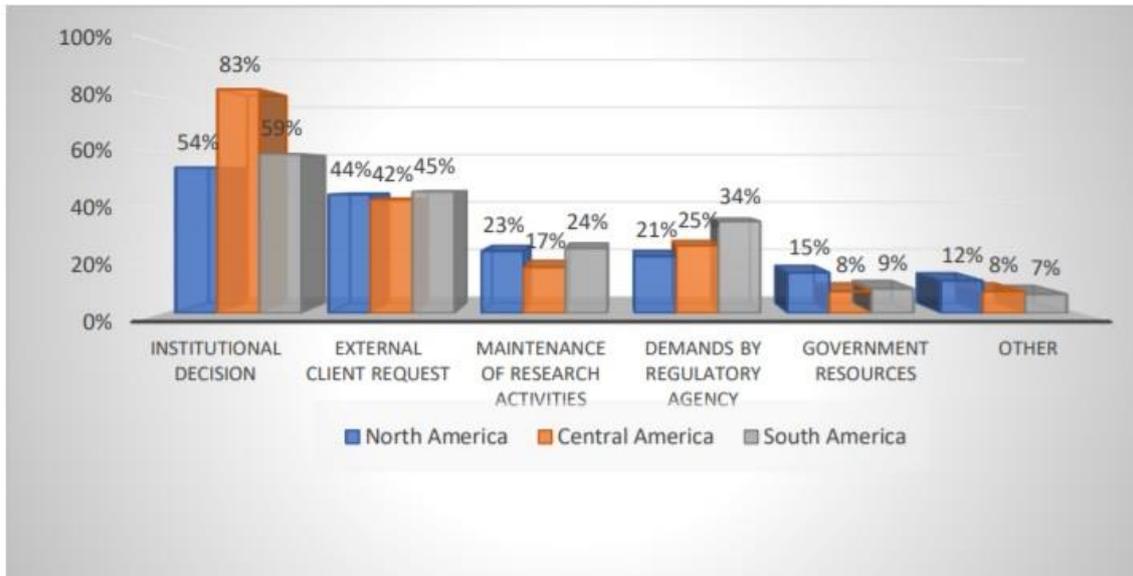


Figure 4. Motivation to obtain accreditation per region

## 2.2 Accreditation process

Declaration by a national accreditation body certifying that a conformity assessment body (CAB) meets the requirements set by standards to carry out a specific conformity assessment activity, so the CAB assures its procedures are performed providing a competent, coherent, and impartial service, as it results from full compliance with the reference rules and regulations (ACCREDIA, 2019)<sup>12</sup>.

<sup>11</sup> Grochau, I.H., Caten, C.S.t. & de Camargo Forte, M.M. Motivations, benefits, and challenges on ISO/IEC 17025 accreditation of higher education institution laboratories. Accreditation and Quality Assurance 23, 183–188 (2018).

<sup>12</sup> ACCREDIA, 2019, Regulation for the accreditation of Calibration Laboratories. RG-13 rev.08.

All laboratories and bodies seeking to be certified by ACCREDIA must carry out a process that consists of eight steps to obtain the certification. ACCREDIA, as the national accreditation body, ensures to accompany them during the entire process until the certification is granted with a validity of four years (ACCREDIA, 2017)<sup>13</sup>. The steps of the process are described as follows in Table 1:

<p><b>1. Application:</b> it must be done by filling in two forms; the first is the general application format (D4-00), and the other one corresponds to the specific assessment activities to be performed under the accreditation. In this first step is necessary to present all the relevant documents requested for accreditation, which must be signed by a laboratory authorized representative.</p>
<p><b>2. Document review:</b> all the documents mentioned above must be revised and approved by a technical officer of the staff; if the laboratory meets all the requirements, it will be notified, and ACCREDIA will send a service cost estimate.</p>
<p><b>3. On-site assessment:</b> this process is carried out by inspectors who are part of ACCREDIA's expert staff; they deal with the evaluation of all the applicant's procedures to ensure if these are performed according to the established requirements and technical regulations.</p> <p>At the end of the visit, a report is written by the inspector where observations, comments, or non-conformities can be presented. If the report only presents observations and comments, the process can continue without problems; on the contrary, if non-conformities are presented, the accreditation process can be stopped since inconsistency is evident between the process carried out by the laboratory and the process allowed by the standard. If the assessment result is favorable, the summary is passed to be analyzed by the Sector Accreditation Committee.</p>

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<sup>13</sup> ACCREDIA, 2017, Accreditation. Obtained from <https://www.accredia.it/en/accreditation/the-path-to-accreditation/>

<p><b>4. Witness assessment:</b> this step follows the same procedures explained in the on-site assessment described above. If the assessment result is favorable, the summary is passed to be analyzed by the Sector Accreditation Committee.</p>
<p><b>5. Decision for accreditation:</b> The Sector Accreditation Committee makes the decision; their participants analyze the result of the previous two steps; if the accreditation is granted, the process is formalized by an agreement between ACCREDIA and the accredited laboratory, and the certification is issued with a validity of four years.</p>
<p><b>6. Periodic surveillance:</b> throughout the four-year accreditation time, ACCREDIA conducts periodic surveillance evaluations to verify that the laboratory is operating according to the accreditation's technical requirements.</p>
<p><b>7. Extension of accreditation:</b> over the four-year accreditation time, the laboratory may apply for an extension to reach the accreditation to new activities and operative locations. For example, a calibration laboratory may cover new metrological sectors and reference materials, diversify the measurement fields, or reduce measurement uncertainties.</p>
<p><b>8. Renewal of accreditation:</b> this process must be carried out before the current accreditation's expiration date, and the same process described above will be followed.</p>

Table 1. Accreditation process

Just as the accreditation process brings many benefits described in the item above, some CABs also tend to present difficulties throughout this process, the most commons are illustrated in Figure 5 thanks to the surveys made to 155 laboratories for a study conducted in the American Continent in 2016 (Grochau, Caten and Camargo, 2018). As is shown in Figure 5, just 16% of the surveyed laboratories have not presented any problem in the accreditation process. At the same time, the majority were affected by the lack of financial resources to subsidize it.

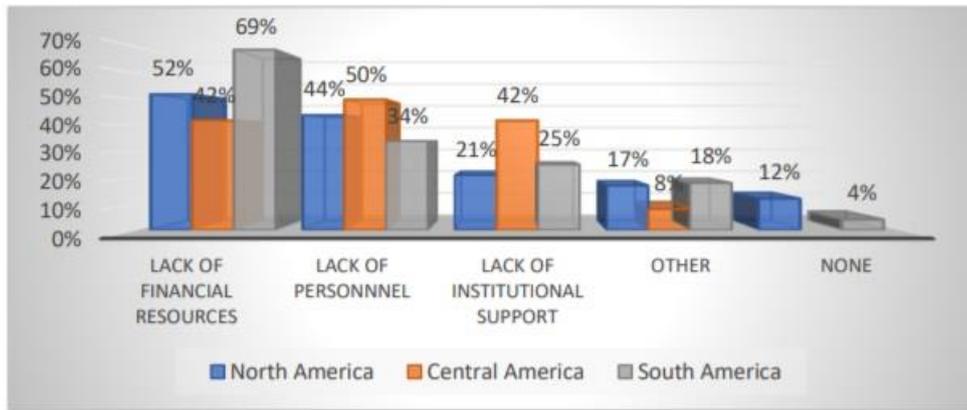


Figure 5. Main difficulties toward accreditation per region

For some CABs, the obstacles presented in the process are mainly generated by the accreditation bodies, because according to them, usually generate unnecessary difficulties (Halevy,2003); for example, they complain about:

- Cumbersome documentation;
- Exaggerated requirements;
- Slowly accreditation process;
- Short time to implementation;
- High accreditation cost;
- Requirements too harsh;
- Low commitment of assessors.

Despite the difficulties described above, as mentioned before, over the years the accreditation trend is increasingly positive, and this is demonstrated not only in Figure 3 but also in Figure 6, where is shown that in the American continent the tendency for accreditation has been also increasing through the years (Grochau, Caten and Camargo, 2018).

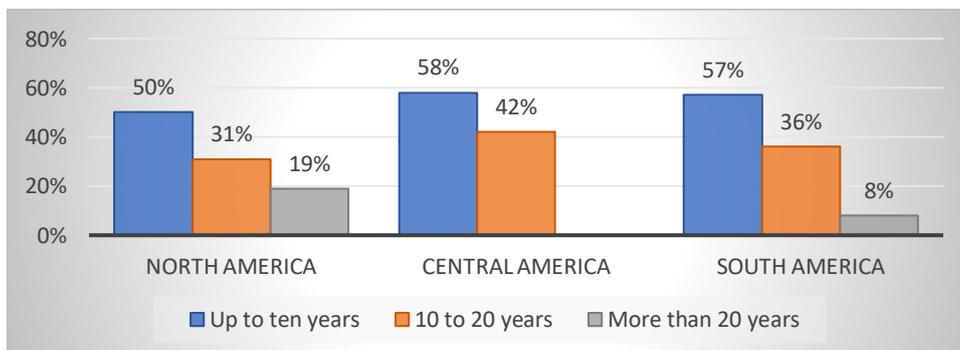


Figure 6. Years since laboratories became accredited per region

### ***3 The current method to analyze the laboratories conformity assessment process***

Currently, ACCREDIA has carried out two methods to assess the performance of two important parties involved in the accreditation process, the first one is referring to the evaluation of the inspector's performance in his task of the on-site assessment, and the second one is related with the laboratory's performance evaluation when is visited by the technical/system inspector.

#### ***3.1 Inspector assessment***

So far, the ACCREDIA staff has developed a computer tool using the program "Film Maker" to evaluate the annual performance of all the inspectors who execute on-site visits to CABs. This system was made to obtain some qualitative indicators related to the inspector's performance, and its functioning is based on the insertion of important information (obtained from the report made at the end of each visit to a CAB) to the system such as the inspector's reformulated classifications. In the end, a score is obtained for each inspector that reflects their average yield in the accreditation process.

#### ***3.2 Laboratory assessment***

Recently, ACCREDIA has implemented a method called Risk Analysis to identify which points of the ISO / IEC 17011: 2017 standard are intended to be covered by the risk analysis performed on the CAB.

The analysis is used to plan scheduled and unscheduled assessment activities, such as the unannounced visits to laboratories in 2019/2020. Therefore, considering that the risk is the effect in an activity and in the evaluation program that can derive from certain aspects of the CAB, the following risk indicators have been defined. (ACCREDIA,2020)<sup>14</sup>.

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<sup>14</sup> ACCREDIA, 2020, Note sull'analisi del rischio- ACCREDIA DT Anno 2019.

- Number of accredited sites;
- Number of technical non-conformities;
- Number of system non-conformities in the last visit;
- Number of self-suspensions;
- Number of negative outcomes, for which corrective action has been requested, in measure comparison process;
- Number of sanctioning measures;
- Number of extraordinary surveillances;
- Number of certificates issued grouped by thousands;
- Guaranteed traceability through internal calibrations for sizes other than those accredited;
- Guaranteed traceability using suppliers.

Following the detection and assessment of the risk indicators mentioned above, is assigned a value to each one of them and these values are summed to know the total risk of the CAB; this final number defines the classification of the CAB that might be: low, medium or high risk (ACCREDIA, 2020) as is shown in Table 2.

<b>Low-risk CABs:</b> values between 0 and 8 corresponding to laboratories without or with few criticalities.
<b>Medium-risk CABs:</b> values between 9 and 16 corresponding to laboratories with a moderate number of criticalities.
<b>High-risk CABs:</b> values higher than 16 corresponding to laboratories with a considerable number of criticalities.

Table 2. Type of CABs risk

Knowing the CAB's type of risk, ACCREDIA can define the type of evaluation technique necessary to carry out in the next visit to the laboratory and the number of days necessary to execute it. The values set in Table 3 are used to plan the assessments in the accreditation process and to forecast the audit days correctly (ACCREDIA, 2020):

Risk indicator	Corresponding audit days
Number of accredited sites	Each secondary site must be evaluated at least twice in the accreditation process.
Number of technical non-conformities	If greater than 5 for the same metrological area, results in an additional 0.5 days to the technical inspector visit.
Number of system non-conformities in the last visit	If greater than 5 means an additional 0.5 days to the system inspector visit.
Number of self-suspensions	If greater than 2 per metrological area, results in an additional 0.5 days to the technical inspector visit.
Number of negative outcomes, for which a corrective action has been requested, in measure comparison process	If greater than 2 for the same metrological area, means an additional 0.5 days to the technical inspector visit.
Number of sanctioning measures	If greater than 1 total or partial for the same metrological area, results in an additional 0.5 days to the technical inspector visit.
Number of extraordinary surveillances	If greater than 1 entails an additional 0.5 days to the system inspector visit.
Number of certificates issued grouped by thousands	If greater than 1000 entails an additional 0.5 days to the system inspector visit.
Guaranteed traceability through internal calibrations for sizes other than those accredited	At least one evaluation in the accreditation process.
Guaranteed traceability using suppliers	At least one evaluation in the accreditation process.

Table 3. Audit days corresponding to each risk indicator

The previous analysis was done for the laboratories evaluated in 2019, and it was sent a communication on January 2020 to announce to each CAB their category of risk identified based on the previously listed parameters.

## **4 Criticalities of the previous method**

The criticalities about the current method mentioned before are described as follows:

- The principal problem is that all the process is carried out manually, this means that to proceed with the annual performance analysis of laboratories and inspectors, the ACCREDIA staff must revise all the on-site assessment reports one by one to obtain the information necessary to evaluate the performance of the parties in the accreditation process, this constitutes a long and cumbersome process as can be extended to the manual analysis of all the Excel files corresponding to the accredited laboratories (206 in total);
- The inspector's indicators obtained using the computer tool developed in Film Maker are qualitative, this means that the reality about the performance of the inspector is poorly measured and is not objective because the ACCREDIA staff cannot obtain statistics and numbers from the current indicators;
- The current method does not measure the number of CABs that have and have not substituted the oldest version of the standard UNI CEI EN ISO/IEC 17025:2005 for the new one UNI CEI EN ISO/IEC 17025:2018, that establish the general requirements for the competence of testing and calibration laboratories;
- The current method does not measure the performance of the technical functionary in the accreditation process;
- The existing method is not capable of measuring the number of requirements that have been reformulated by the inspector;
- The current method does not generate any outcome related to the standard and the requirements evaluated in the on-site assessment;

- The existing method cannot analyze multiple on-site assessment reports at the same time, so cannot generate graphs and statistics related to the comparisons of the performance of the same CAB through time or between different CABs, neither between inspectors or technical functionaries;
- The current method does not provide statistics and graphs about the three existing classifications that can be assigned to the requirements evaluated (NC: non-conformity, COM: comment, and OSS: observation), this makes difficult the analysis of the laboratory's performance.

At this time is important to define each one of the three classifications mentioned in the last item because these are widely used in the rest of the document.

**NC (Non-conformity):** refers to a finding indicating the presence of a deviation or lack of the mandatory requirements according to the accreditation and produces:

- A threat in the reliability of the results/performances/services produced by the laboratory;
- A threat in the Management System's ability to achieve the established quality level of conformity assessments or indicates a failure in the operation of the Management System.

The ACCREDIA inspector formulates the NC through clear identification of the finding and the reference to the specific requirement that has been violated. NC may lead a sanctioning measure like a reduction or suspension in the accreditation (ACCREDIA, 2019).

**OSS (Observation):** refers to a finding caused by a partial implementation of a requirement, but which does not affect or is likely to affect directly or immediately the quality of CAB performance and results. The ACCREDIA inspector formulates OSS by clearly identifying the finding and the reference to the specific requirement that has been violated; if the observation is not solved before a subsequent periodic evaluation can be reclassified as NC (ACCREDIA, 2019).

**COM (Comment):** is a classification that is not resulting from the finding of an objective failure to meet a requirement, but to prevent such a situation from occurring and/or to provide guidance for the improvement of documents and/or operational methods of the CAB (ACCREDIA, 2019).

All the findings classified as NC or OSS must be notified by ACCREDIA and reviewed by the CAB to present a plan to correct and improve the actions within ten days from the notification receipt.

## **5 Improvement actions and results**

The principal goal to achieve with the improvement actions was to develop a macro to allow the data consolidation of multiple excel files corresponding to the reports made by the inspectors in the visit to laboratories that are carrying out the accreditation process, and the posterior generation of useful graphs to analyze the performance of the laboratories, inspectors, and technical functionaries of ACCREDIA.

Improvement actions developed in this project will be explained below:

### **5.1 Use of VBA**

Microsoft VBA (Visual Basic for Applications) was the programming language used to develop the improvement actions, with the principal goal to carry out the analysis of multiple excel files corresponding with the on-site assessments visits to calibrations laboratories and the subsequent statistical analysis necessary to measure the performance of the parties involved in the accreditation process (laboratory, inspectors and technical functionaries). Visual Basic for Applications is a programming language developed by Microsoft Office, allowing users to create their functions, automate Excel tasks, and build customized code (University of British Columbia, 2016)<sup>15</sup>. For this project was necessary to use the VBE (Visual Basic Editor) to create the code (the macro).

Visual Basic for Applications (VBA) has been chosen as the programming language software to develop improvement actions in ACCREDIA because its use has some crucial advantages for the ACCREDIA staff and for the developer of the code, as is shown as follows:

- **Easy to use for the code developer:** VBA generates a comfortable programming environment for the code developer. As the goal was to manage a lot of excel files corresponding to the format generated in the on-site visits to the calibrations laboratories, the most indicated language

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<sup>15</sup> University of British Columbia Okanagan, 2016, Introduction to Data Analytics - Excel VBA. Obtained from <https://docplayer.net/21831558-Data-301-introduction-to-data-analytics-microsoft-excel-vba-dramon-lawrence-university-of-british-columbia-okanagan.html>

programming software to use was VBA because it allows automating tasks in Excel and enables to work with Office files without the necessity of using other software;

- **Easy to use for the ACCREDIA staff:** VBA is an Excel tool, this makes it more accessible and easier to use for the ACCREDIA staff for two reasons; first one they are very used to use Microsoft Excel for their daily labor tasks, and the second one is that with its use they do not need to have previous knowledge about the use of a different software. As it is an instrument to automate Excel tasks, its use will save them a lot of time analyzing on-site visit reports.

## **5.2 Anonymize excel files**

Before creating the programming code, it was necessary to have the Excel files from the technical officer Paola Pedone; she delivered 57 files; each of these corresponds to the final report of the laboratory visit made in 2019. The next step was to execute an anonymization process of all the excel files, thus avoiding revealing the identities of the inspectors and the names of the laboratories in the reports. For this, working together with the technical officer Paola Pedone was done a coding process, so we developed a database assigning to each one of the 165 inspectors a code from A1 to A165, the same codification process was done for the 206 laboratories, so was assigned to each laboratory a code from B1B to B206B.

Following the creation of the database mentioned above, a macro was developed using VBA and the VBE, with the aim of encoded the reports automatically and removed the unnecessary information (which is not the subject of analysis in this project).

Figure 7 exhibits the definition of the variables, the definition of the database created before with the codes corresponding to inspectors and laboratories, and the elimination of two sheets of the original file (report file) that have not necessary information for this project.

```

Sub replace()
Application.ScreenUpdating = False
Const str As String = "PERSONE COINVOLTE DEL CAB"
Dim rC1 As Range, ws As Worksheet, LastRow As Long, dbWS As Worksheet
Dim Val As String, arr As Variant, arr2 As Variant, i As Long, x As Long
Set dbWS = Sheets("DataBase")
arr = dbWS.Range("A2", dbWS.Range("A" & Rows.Count).End(xlUp)).Resize(, 3).Value
arr2 = dbWS.Range("D2", dbWS.Range("D" & Rows.Count).End(xlUp)).Resize(, 2).Value
For Each ws In Sheets(Array("Giudizio sintetico", "Riepilogo"))
    If Evaluate("isref("'" & ws.Name & "'!A1)") Then
        Application.DisplayAlerts = False
        ws.Delete
        Application.DisplayAlerts = True
    End If
Next ws

```

Figure 7. Part 1 of the code to anonymize excel files

Figure 8 exhibits the original information's replacement with the codes in the database and the elimination of some existing information non-necessary for the analysis, all this considering the sheets called "*Anagrafica audit*" and "*report stampabile*" which are the sheets that contain the important information for the project.

```

With Sheets("Anagrafica audit")
    Set rC1 = .UsedRange.Find(str, LookIn:=xlValues, lookat:=xlWhole)
    LastRow = .Cells.Find("**", SearchOrder:=xlByRows, SearchDirection:=xlPrevious).Row
    .Range("A" & rC1.Row + 2 & ":C" & LastRow).ClearContents
    For i = 1 To UBound(arr2, 1)
        .Range("B4").replace "?" & arr2(i, 1), arr2(i, 2)
    Next i
    .Range("b3:c3").UnMerge
    .Range("b3").ClearContents
    .Range("b5:c5").UnMerge
    .Range("b5").ClearContents
    For i = 1 To UBound(arr, 1)
        Val = arr(i, 2) & " " & arr(i, 1)
        .Cells.replace Val, arr(i, 3)
        Sheets("report stampabile").Cells.replace Val, arr(i, 3)
    Next i
End With

With Sheets("report stampabile")
    For x = 14 To 104 Step 10
        .Range("P" & x & ":S" & x).UnMerge
        .Range("P" & x).ClearContents
    Next x
End With
Application.ScreenUpdating = True
End Sub

```

Figure 8. Part 2 of the code to anonymize excel files

The rest of the project was carried out with the excel files already encoded.

### 5.3 Data consolidation

This was the most critical phase of the project, as the significant issue of ACCREDIA was the inexistence of a process to analyze multiple excel files simultaneously. To get over this problem, the code developer created an option allowing the staff to upload at the same time multiple excel files; for this reason, was built a code that enables to open a dialog box where the functionary can select the files he wants to analyze.

Figure 9 exhibits the definition of all the variables of the code and the name of the sheet that will be created "Report," which will contain all the relevant information extracted from the uploaded files. Besides, the headlines of the "Report" sheet are also established. For this project was considered necessary the following information:

- **Laboratory:** refers to the code of the laboratory;
- **Evaluation date:** describes the date in which the on-site laboratory visit was performed;
- **Type of evaluation:** makes reference to a renewal of the accreditation or due to some surveillance visit;
- **Technical functionary:** refers to the name of the technical functionary in charge of the laboratory's accreditation;
- **Classification:** these can be OSS, NC or COM and refer to the inspector's classification given to the requirement evaluated in the laboratory;
- **Inspector:** describes the code of the inspector who performed the visit;
- **Inspector 2:** some visits may be carried out by two inspectors, in this cell is written the code of the second inspector if he was present;
- **Technical inspector:** inspectors can be of two types, system or technical; this cell is filled just in case the inspector who made the visit was a technical inspector;
- **System inspector:** this cell is filled just in case the inspector who made the visit was a system inspector;
- **Standard:** refers to the name of the standard to be accredited;
- **Requirement:** refers to the standard's requirement that was evaluated in the laboratory;

- **Classification rilievo:** after a subsequent visit, the inspector can keep the original classification or can change it, in this cell is written the final classification for the evaluated requirement;
- **Rilievo reformulated:** this cell is filled with “Not reformulated” if the requirement keeps the same classification or “Reformulated” if the classification changes;
- **Rilievi with two inspectors:** this cell is filled with “One inspector” if a single inspector carried out the visit or “Two inspectors” if two inspectors performed the visit.

Figure 9 also shows the GetOpenFileName command, which allows displaying a dialog box to select and open the excel files from which the information will be extracted and analyzed.

```

Sub Consolidate_Data()
Application.ScreenUpdating = False
Dim wb As Workbook, sh As Worksheet, dsh As Worksheet, File_Name As Variant, i As Long, lr As Long, x As Long, y As Long
Dim desWS As Worksheet, srcWS As Worksheet, angWS As Worksheet, r As Long: r = 6
Set dsh = ThisWorkbook.Sheets("Report")
dsh.UsedRange.ClearContents
dsh.Range("A1").Resize(, 14) = Array("Laboratory", "Evaluation Date", "Type of Evaluation", "Technical Functionary")
dsh.Range("A1").Resize(, 14) = Array("Classification", "Inspector", "Inspector 2", "Technical Inspector")
dsh.Range("A1").Resize(, 14) = Array("System Inspector", "Standard", "Requirement", "Classification Rilievi")
dsh.Range("A1").Resize(, 14) = Array("Rilievo Reformulated", "Rilievi with two inspectors")
File_Name = Application.GetOpenFilename("Excel Files (*.xl*),*.xl*", , "Select Excel Files To Consolidate", , True)
For i = LBound(File_Name) To UBound(File_Name)
y = 2
Set wb = Workbooks.Open(File_Name(i))
For Each sheet In wb.Worksheets
If sheet.Name = "compilazione & aggiornamenti" Then
Sheets("compilazione & aggiornamenti").Move After:=wb.Sheets(wb.Sheets.Count)
End If
Next
Next

```

Figure 9. Part 1 of the code to consolidate data

In Figure 10 is defined a new sheet called “ExtractedData,” this sheet will be placed in the first position in all the open files that were selected with the command explained above, and will have all the information extracted from the report files; the headlines explained before are also placed in this new sheet.

```

If Not Evaluate("isref('" & "ExtractedData" & "'!A1)") Then
    Sheets.Add before:=Sheets(1)
    With ActiveSheet
        .Name = "ExtractedData"
        .Range("A1").Resize(, 14) = Array("Laboratory", "Evaluation Date", "Type of Evaluation", "Technical Functionary")
        .Range("A1").Resize(, 14) = Array("Classification", "Inspector", "Inspector 2", "Technical Inspector")
        .Range("A1").Resize(, 14) = Array("System Inspector", "Standard", "Requirement", "Classification Rilievi")
        .Range("A1").Resize(, 14) = Array("Rilievo Reformulated", "Rilievi with two inspectors")
    End With
    Columns.AutoFit
Else
    With ActiveWorkbook.Sheets("ExtractedData")
        .UsedRange.Offset(1).ClearContents
        .Range("A1").Resize(, 14) = Array("Laboratory", "Evaluation Date", "Type of Evaluation", "Technical Functionary")
        .Range("A1").Resize(, 14) = Array("Classification", "Inspector", "Inspector 2", "Technical Inspector")
        .Range("A1").Resize(, 14) = Array("System Inspector", "Standard", "Requirement", "Classification Rilievi")
        .Range("A1").Resize(, 14) = Array("Rilievo Reformulated", "Rilievi with two inspectors")
    End With
End If

```

Figure 10. Part 2 of the code to consolidate data

Figure 11 exhibits the definition of the sheets to be used to obtain the information from the report files “*report stampabile*” and “*Anagrafica audit*”, and the sheet in which the extracted information will be placed “ExtractedData.” Besides, in the following items is shown the extraction process from the sheet “*report stampabile*” to the “ExtractedData” sheet.

- ***Cells(y, "A").Resize(, 2).Value = \_***  
***Array(srcWS.Range("P" & x).Offset(-3), srcWS.Range("P" & x).Offset(-2, -7))***

With this line are extracted the code of the laboratory and the date in which the visit was performed;

- ***Cells(y, "E").Resize(, 2).Value = \_***  
***Array(srcWS.Range("P" & x), srcWS.Range("P" & x).Offset(6, -12))***

With this line is extracted the code of the inspector who performed the visit;

- ***Cells(y, "G").Resize(, 1).Value = \_***  
***Array(srcWS.Range("P" & x).Offset(9, -12))***

With this line is extracted the code corresponding to the second inspector who carried out the visit;

- `Cells(y, "J").Resize(, 2).Value = _  
Array(srcWS.Range("P" & x).Offset(1, -13), srcWS.Range("P" & x).Offset(1, -9))`

With this line of code are extracted the standard and the requirement evaluated in the laboratory.

```
Set desWS = ActiveWorkbook.Sheets("ExtractedData")
Set srcWS = ActiveWorkbook.Sheets("report stampabile")
Set angWS = ActiveWorkbook.Sheets("Anagrafica audit")
lr = srcWS.Cells.Find("*", SearchOrder:=xlByRows, SearchDirection:=xlPrevious).Row
For x = 5 To lr Step 10
    Select Case srcWS.Range("P" & x).Value
        Case "NC", "OSS", "COM"
            With desWS
                .Cells(y, "A").Resize(, 2).Value = _
                    Array(srcWS.Range("P" & x).Offset(-3), srcWS.Range("P" & x).Offset(-2, -7))
                .Cells(y, "E").Resize(, 2).Value = _
                    Array(srcWS.Range("P" & x), srcWS.Range("P" & x).Offset(6, -12))
                .Cells(y, "G").Resize(, 1).Value = _
                    Array(srcWS.Range("P" & x).Offset(9, -12))
                .Cells(y, "J").Resize(, 2).Value = _
                    Array(srcWS.Range("P" & x).Offset(1, -13), srcWS.Range("P" & x).Offset(1, -9))
            End With
        End Select
    Next x
Next y
```

Figure 11. Part 3 of the code to consolidate data

Figure 12 shows the extraction of the following information: technical functionary name, classification rilievi, and the type of evaluation, also was established a mathematical condition statement to compare the original classification with the final one, to know if the classification was reformulated or not.

```
With ActiveWorkbook.Sheets(r)
    Select Case .Range("P5").Value
        Case "OSS", "NC", "COM"
            desWS.Cells(y, "D") = Sheets(r).Range("E18")
            If Sheets(r).Range("S13") = "" Then
                desWS.Cells(y, "L") = Sheets(r).Range("P5")
            Else
                desWS.Cells(y, "L") = Sheets(r).Range("S13")
            End If
            desWS.Cells(y, "A") = Sheets(r).Range("P2")
            desWS.Cells(y, "B") = Sheets(r).Range("H3")
            desWS.Cells(y, "C") = Sheets(r).Range("P3")
            r = r + 1

            If desWS.Cells(y, "L") = desWS.Cells(y, "E") Then
                desWS.Cells(y, "M") = "Not Reformulated"
            Else
                desWS.Cells(y, "M") = "Reformulated"
            End If
        End Select
    End With
```

Figure 12. Part 4 of the code to consolidate data

Figure 13 shows the mathematical conditions established to define the type of inspector who performed the visit (technical or system) and the number of inspectors who carried out the on-site visit to the laboratory.

```

If desWS.Cells(y, "F") <> "" And desWS.Cells(y, "F") = angWS.Range("A12") Then
    desWS.Cells(y, "I") = "System"
End If
If desWS.Cells(y, "F") <> "" And desWS.Cells(y, "F") <> angWS.Range("A12") Then
    desWS.Cells(y, "H") = "Technical"
End If
If desWS.Cells(y, "G") <> "" And desWS.Cells(y, "G") <> angWS.Range("A12") Then
    desWS.Cells(y, "H") = "Technical"
End If
If desWS.Cells(y, "G") <> "" And desWS.Cells(y, "G") = angWS.Range("A12") Then
    desWS.Cells(y, "I") = "System"
End If
If desWS.Cells(y, "G") <> "" Then
    desWS.Cells(y, "N") = "Two inspectors"
Else
    desWS.Cells(y, "N") = "One inspector"
End If

```

Figure 13. Part 5 of the code to consolidate data

Finally, in Figure 14 are closed all the commands opened it before, and using the option "Copy" all the information extracted and placed in sheet "ExtractedData" of the report files uploaded with the dialog box is copied and positioned in the sheet called "Report". This process generates a consolidated report with all the essential information of the Excel files in just one-sheet.

```

        End With
        y = y + 1
    End With
End Select
Next x
With desWS
    .Columns.AutoFit
    .UsedRange.Offset(1).Copy dsh.Cells(dsh.Rows.Count, "A").End(xlUp).Offset(1)
End With
'wb.Close False
r = 6
Next i
With dsh
    .Columns.AutoFit

End With
dsh.Columns(2).NumberFormat = "dd/mm/yyyy"
desWS.Columns(2).NumberFormat = "dd/mm/yyyy"
Application.ScreenUpdating = True
End Sub

```

Figure 14. Part 6 of the code to consolidate data

As was said before, the macro opens all the files selected by the ACCREDIA employee to extract the information; when the extraction process has finished, the open files are no longer useful, so it was added a short line of code (see Figure 15) to close all the files without saving any change, this means keep the original files free from the changes previously done by the code. With this code, the only open excel file will be the one containing the macro.

```
Sub Close_All_Files_No_Save ()

Dim wb As Workbook
For Each wb In Application.Workbooks
    If wb.Name <> ThisWorkbook.Name Then
        wb.Close SaveChanges:=False
    End If
Next wb
End Sub
```

Figure 15. Code to close all files without saving changes

#### **5.4 Automatic table**

After creating the “Report” corresponding to the data consolidation mentioned in the previous item, it was done a macro to create an automatic table containing all the information placed in sheet “Report”. This is very useful as the information would change every time a different set of excel files are inserted in the dialog box by the ACCREDIA staff, so at the same time the “Report” sheet changes the automatic table do so, besides this use, this table will be the database used to create all the pivot tables and pivot charts necessary to execute the posterior performance analysis. Figure 16 shows the code to create an automatic table.

```
Sub CreateTable ()
Application.ScreenUpdating = False
Dim MyTable As ListObject
Set MyTable = ThisWorkbook.Worksheets ("Table").ListObjects ("DataBase")

If MyTable.ListRows.Count > 0 Then MyTable.DataBodyRange.Delete
ThisWorkbook.Worksheets ("Report").Range ("A2").CurrentRegion.Copy
ThisWorkbook.Worksheets ("Table").Range ("A1").PasteSpecial xlPasteValues
DoEvents

ThisWorkbook.RefreshAll
DoEvents

Set MyTable = Nothing

Application.ScreenUpdating = True
Columns (2).NumberFormat = "dd/mm/yyyy"
With MyTable
    Columns.AutoFit
End With
End Sub
```

Figure 16. Code to create an automatic table

## 5.5 Results

Starting with the 57 excel files obtained at the beginning of the internship corresponding to calibration laboratories on-site visits performed in 2019, 46 were successfully analyzed by the macro created, corresponding to the extraction of the information equivalent to 318 standard requirements. Relevant results are shown below.

### 5.5.1 Report

Figures 17, 18, and 19 represent the first 20 out of the 318 data presented in the "Report" sheet. Figure 17 shows the extracted data corresponding to the laboratory, evaluation date, type of evaluation, technical functionary, classification, and inspector. Figure 18 exhibits the information obtained regarding inspector 2, technical inspector, system inspector, and standard. Figure 19 represents the extracted data corresponding to requirement, classification rilievi, rilievo reformulated, and rilievi with two inspectors.

These figures give a more comfortable and clear understanding of what was done in the data consolidation process described in item 5.3.

	A	B	C	D	E	F
1	Laboratory	Evaluation Date	Type of Evaluation	Technical Functionary	Classification	Inspector
2	B162B	2019-11-25 e 26	Sorveglianza 1	Giulia SURIANI	NC	A22
3	B162B	2019-11-25 e 26	Sorveglianza 1	Giulia SURIANI	OSS	A165
4	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
5	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	COM	A165
6	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
7	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
8	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
9	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
10	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A32
11	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
12	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
13	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	COM	A32
14	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
15	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
16	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
17	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
18	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139
19	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139
20	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139
21	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	COM	A139

Figure 17. Part 1 extracted data report

	G	H	I	J
1	Inspector 2	Technical Inspector	System Inspector	Standard
2	A165	Technical	System	UNI EN ISO/IEC 17025:2005
3			System	UNI EN ISO/IEC 17025:2005
4			System	UNI EN ISO/IEC 17025:2005
5			System	UNI EN ISO/IEC 17025:2005
6			System	UNI EN ISO/IEC 17025:2005
7			System	UNI EN ISO/IEC 17025:2005
8			System	UNI EN ISO/IEC 17025:2005
9		Technical		UNI EN ISO/IEC 17025:2005
10	A165	Technical	System	UNI EN ISO/IEC 17025:2005
11	A165	Technical	System	UNI EN ISO/IEC 17025:2005
12	A165	Technical	System	UNI EN ISO/IEC 17025:2005
13		Technical		UNI EN ISO/IEC 17025:2005
14	A130	Technical	System	UNI EN ISO/IEC 17025:2018
15			System	UNI EN ISO/IEC 17025:2018
16			System	UNI EN ISO/IEC 17025:2018
17			System	UNI EN ISO/IEC 17025:2018
18		Technical		UNI EN ISO/IEC 17025:2005
19		Technical		UNI EN ISO/IEC 17025:2005
20		Technical		UNI EN ISO/IEC 17025:2005
21			System	UNI EN ISO/IEC 17025:2005

Figure 18. Part 2 extracted data report

	K	L	M	N
1	Requirement	Classification Rilievi	Rilievo Reformulated	Rilievi with two inspectors
2	§5.5.2 Apparecchiature	NC	Not Reformulated	Two inspectors
3	§4.11.2 Azioni correttive - Analisi delle cause	OSS	Not Reformulated	One inspector
4	§5.3.4 Luogo di lavoro e condizioni ambientali	OSS	Not Reformulated	One inspector
5	§5.2.1 Personale	COM	Not Reformulated	One inspector
6	§4.13.1 Tenuta sotto controllo delle registrazioni - Generalità	OSS	Not Reformulated	One inspector
7	§4.3.1 Tenuta sotto controllo delle documentazione - Generalità	OSS	Not Reformulated	One inspector
8	§4.3.2 Tenuta sotto controllo delle documentazione - Approvazione e diffusione dei documenti	OSS	Not Reformulated	One inspector
9	§5.10.2 Presentazione dei risultati - Rapporti di prova e certificati di taratura	NC	Not Reformulated	One inspector
10	§5.9.1 Assicurazione della qualità dei risultati di prova e di taratura	OSS	Not Reformulated	Two inspectors
11	§5.9.1 Assicurazione della qualità dei risultati di prova e di taratura	NC	Not Reformulated	Two inspectors
12	§5.5.2 Apparecchiature	NC	Not Reformulated	Two inspectors
13	§5.4.3 Metodi di prova e di taratura e validazione dei metodi - Metodi sviluppati dal laboratorio	COM	Not Reformulated	One inspector
14	§6.2.2 Requisiti relativi alle risorse - Personale	OSS	Not Reformulated	Two inspectors
15	§6.4.1 Dotazioni	OSS	Not Reformulated	One inspector
16	§6.4.1 Dotazioni	OSS	Not Reformulated	One inspector
17	§ 7.11.6 Controllo dei dati e gestione delle informazioni	OSS	Not Reformulated	One inspector
18	§5.4.2 Metodi di prova e di taratura e validazione dei metodi - Selezione dei metodi	NC	Not Reformulated	One inspector
19	§4.3.2 Tenuta sotto controllo delle documentazione - Approvazione e diffusione dei documenti	NC	Not Reformulated	One inspector
20	§5.5.2 Apparecchiature	NC	Not Reformulated	One inspector
21	§4.3.1 Tenuta sotto controllo delle documentazione - Generalità	COM	Not Reformulated	One inspector

Figure 19. Part 3 extracted data report

### 5.5.2 Automatic table

Figures 20, 21, and 22 represent the first 20 out of the 318 data presented in the “Table” sheet. Figure 20 shows the automatic table's information corresponding to the laboratory, evaluation date, type of evaluation, technical functionary, classification, and inspector. Figure 21 represents the information regarding inspector 2, technical inspector, system inspector, and standard. Figure 22 exhibits the automatic table's information corresponding to requirement, classification rilievo, rilievo reformulated, and rilievi with two inspectors.

These figures give a more comfortable and clear understanding of what was done in the creation of the automatic table described in item 5.4.

	A	B	C	D	E	F
1	Laboratory	Evaluation Date	Type of Evaluation	Technical Functionary	Classification	Inspector
2	B162B	2019-11-25 e 26	Sorveglianza 1	Giulia SURIANI	NC	A22
3	B162B	2019-11-25 e 26	Sorveglianza 1	Giulia SURIANI	OSS	A165
4	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
5	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	COM	A165
6	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
7	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
8	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A165
9	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
10	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	OSS	A32
11	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
12	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	NC	A32
13	B194B	03/06/2019	Sorveglianza 1	Giulia SURIANI	COM	A32
14	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
15	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
16	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
17	B197B	2019-07-01e02	Sorveglianza 2	Giulia SURIANI	OSS	A110
18	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139
19	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139
20	B160B	12/03/2019	Sorveglianza 1	Rosalba MUGNO	NC	A139

Figure 20. Part 1 automatic table information

	G	H	I	J
1	Inspector 2	Technical Inspector	System Inspector	Standard
2	A165	Technical	System	UNI EN ISO/IEC 17025:2005
3			System	UNI EN ISO/IEC 17025:2005
4			System	UNI EN ISO/IEC 17025:2005
5			System	UNI EN ISO/IEC 17025:2005
6			System	UNI EN ISO/IEC 17025:2005
7			System	UNI EN ISO/IEC 17025:2005
8			System	UNI EN ISO/IEC 17025:2005
9		Technical		UNI EN ISO/IEC 17025:2005
10	A165	Technical	System	UNI EN ISO/IEC 17025:2005
11	A165	Technical	System	UNI EN ISO/IEC 17025:2005
12	A165	Technical	System	UNI EN ISO/IEC 17025:2005
13		Technical		UNI EN ISO/IEC 17025:2005
14	A130	Technical	System	UNI EN ISO/IEC 17025:2018
15			System	UNI EN ISO/IEC 17025:2018
16			System	UNI EN ISO/IEC 17025:2018
17			System	UNI EN ISO/IEC 17025:2018
18		Technical		UNI EN ISO/IEC 17025:2005
19		Technical		UNI EN ISO/IEC 17025:2005
20		Technical		UNI EN ISO/IEC 17025:2005

Figure 21. Part 2 automatic table information

	K	L	M	N
1	Requirement	Classification Rilievi	Rilievo Reformulated	Rilievi with two inspectors
2	§5.5.2 Apparecchiature	NC	Not Reformulated	Two inspectors
3	§4.11.2 Azioni correttive - Analisi delle cause	OSS	Not Reformulated	One inspector
4	§5.3.4 Luogo di lavoro e condizioni ambientali	OSS	Not Reformulated	One inspector
5	§5.2.1 Personale	COM	Not Reformulated	One inspector
6	§4.13.1 Tenuta sotto controllo delle registrazioni - Generalità	OSS	Not Reformulated	One inspector
7	§4.3.1 Tenuta sotto controllo delle documentazione - Generalità	OSS	Not Reformulated	One inspector
8	§4.3.2 Tenuta sotto controllo delle documentazione - Approvazione e diffusione dei documenti	OSS	Not Reformulated	One inspector
9	§5.10.2 Presentazione dei risultati - Rapporti di prova e certificati di taratura	NC	Not Reformulated	One inspector
10	§5.9.1 Assicurazione della qualità dei risultati di prova e di taratura	OSS	Not Reformulated	Two inspectors
11	§5.9.1 Assicurazione della qualità dei risultati di prova e di taratura	NC	Not Reformulated	Two inspectors
12	§5.5.2 Apparecchiature	NC	Not Reformulated	Two inspectors
13	§5.4.3 Metodi di prova e di taratura e validazione dei metodi - Metodi sviluppati dal laboratorio	COM	Not Reformulated	One inspector
14	§6.2.2 Requisiti relativi alle risorse - Personale	OSS	Not Reformulated	Two inspectors
15	§6.4.1 Dotazioni	OSS	Not Reformulated	One inspector
16	§6.4.1 Dotazioni	OSS	Not Reformulated	One inspector
17	§ 7.11.6 Controllo dei dati e gestione delle informazioni	OSS	Not Reformulated	One inspector
18	§5.4.2 Metodi di prova e di taratura e validazione dei metodi - Selezione dei metodi	NC	Not Reformulated	One inspector
19	§4.3.2 Tenuta sotto controllo delle documentazione - Approvazione e diffusione dei documenti	NC	Not Reformulated	One inspector
20	§5.5.2 Apparecchiature	NC	Not Reformulated	One inspector
21	§4.3.1 Tenuta sotto controllo delle documentazione - Generalità	COM	Not Reformulated	One inspector

Figure 22. Part 3 automatic table information

### 5.5.3 Pivot tables and pivot charts

From the automatic table created in item 5.4, were developed 28 pivot tables and 24 pivot charts with the most relevant information for ACCREDIA. At the beginning of the project, the company tutor delivered the requested statistics list described as follows:

- Number of rilievi per standard;
- Number of NC per standard;
- Number of OSS per standard ;
- Number of COM per standard;
- Number of NC per inspector;
- Number of OSS per inspector;
- Number of COM per inspector;
- Number of rilievi with two inspectors;
- Total NC;
- Total OSS;
- Total COM;
- Number of reformulated rilievi per inspector;

- Number of reformulated rilievi per standard;
- Number of reformulated rilievi per technical functionary;
- Reformulated rilievi starting from NC;
- Reformulated rilievi starting from OSS;
- Reformulated rilievi starting from COM.

In addition to the statistics mentioned above, were also done statistics relevant to the requirements evaluated, the laboratory, and the evaluation date. The following figures represent the most relevant pivot tables and their corresponding pivot chart.

CLASSIFICATION FOR EACH STANDARD	
Standard	Sum of Classification Rilievi
RT_25_rev_6	3
OSS	3
(Blank)	1
OSS	1
RG_09	3
OSS	3
RT_25_rev_5	2
OSS	2
RT_36	1
OSS	1
IO_09_DT	1
NC	1
UNI EN ISO/IEC 17025:2005	175
COM	31
NC	35
OSS	109
UNI EN ISO/IEC 17025:2018	132
COM	19
NC	20
OSS	93
<b>Grand Total</b>	<b>318</b>

Figure 23. Pivot table corresponding to classification for each standard

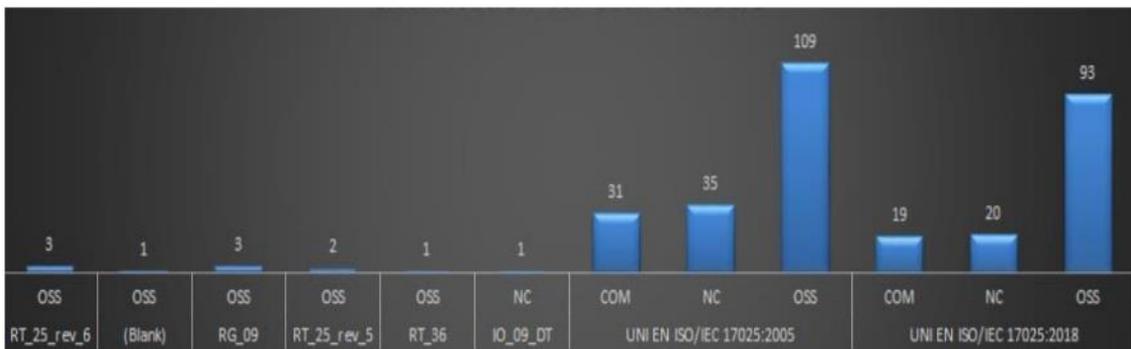


Figure 24. Pivot chart corresponding to classification for each standard

As shown in Figures 23 and 24, the most evaluated standard was the old version of the UNI-EN ISO/IEC 17025, corresponding to the year 2005. This discovery demonstrates that most laboratories evaluated in 2019 have not yet substituted the past standard to the current one corresponding to the year 2018. Also, the figures show that the most common assigned classification is OSS, independent of the standard evaluated

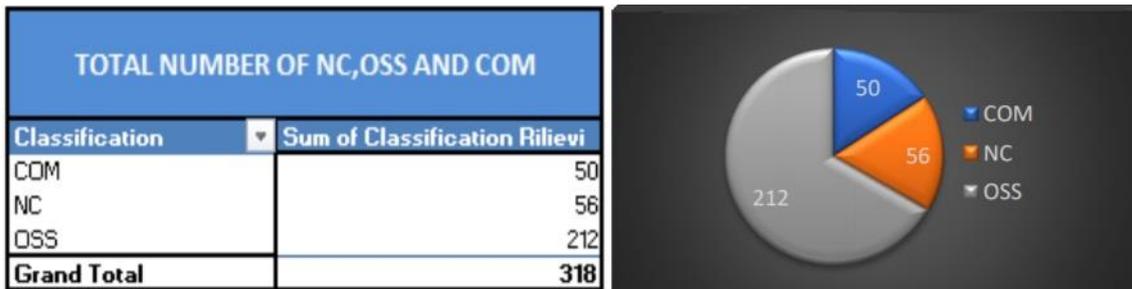


Figure 25. Pivot table and pivot chart corresponding to the total number of NC, OSS and COM

As is represented in Figure 25 from the 318 rilievi evaluated, 212 belong to the classification OSS representing the 66,7% of all the data, following by a 17,6% of NC and 15,7% COM. These values represent that, the lowest percentage corresponds to the COM classification, this can represent a concern for ACCREDIA as from the 318 requirements evaluated just 50 were totally fulfilled by the CABs and the rest were partially or not fulfill at all.

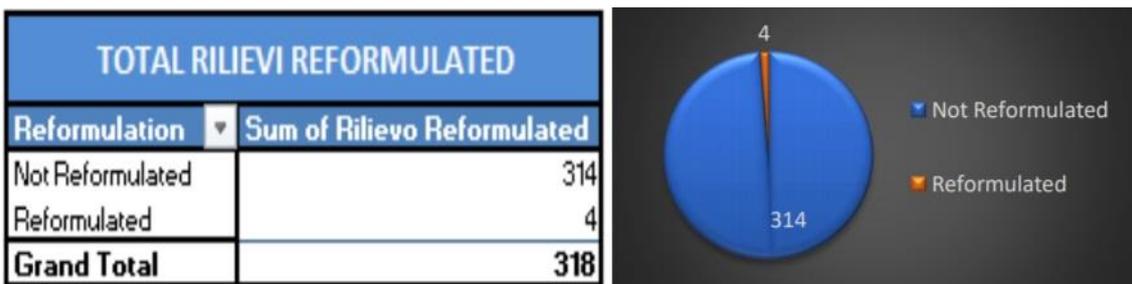


Figure 26. Pivot table and pivot chart corresponding to the total number of reformulated and not reformulated rilievi

Figure 26 represents that from the 46 excel files and their corresponding 318 rilievi analyzed using the macro, the inspectors reformulated just four rilievi. This is a good number as ACCREDIA intends to reduce this statistic as much as

possible; the result obtained shows that a little bit more of 1% of the data analyzed suffered a reformulation.

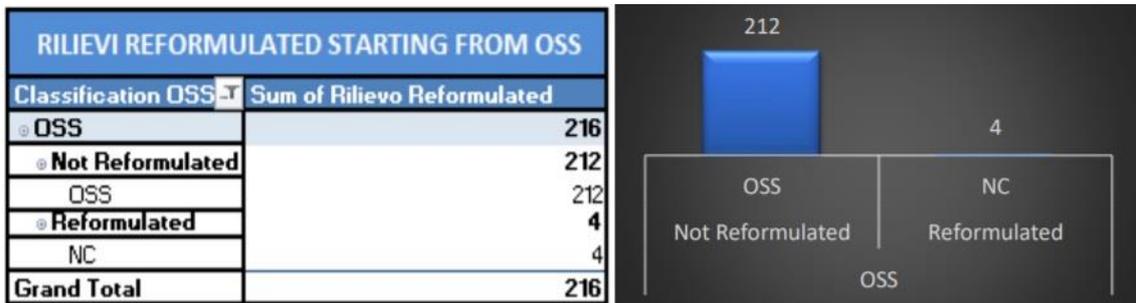


Figure 27. Pivot table and pivot chart corresponding to reformulated rilievi starting from a classification OSS

The macro built has the capacity of recognizing the first classification assigned to the rilievo and the new classification after the reformulation. In this case, all the reformulated rilievi went from being OSS (observations) to NC (non-conformity) (see Figure 27). Also, the macro identifies which standard was reformulated, as is demonstrated in Figures 28 and 29, two reformulated rilievi correspond to the UNI-EN ISO/IEC:2005 and the other 2 to the UNI-EN ISO/IEC:2018.

RILIEVI REFORMULATED FOR EACH STANDARD	
Standard	Sum of Rilievo Reformulated
RT_25_rev_6	3
Not Reformulated	3
(Blank)	1
Not Reformulated	1
RG_09	3
Not Reformulated	3
RT_25_rev_5	2
Not Reformulated	2
RT_36	1
Not Reformulated	1
IO_09_DT	1
Not Reformulated	1
UNI EN ISO/IEC 17025:2005	175
Not Reformulated	173
Reformulated	2
UNI EN ISO/IEC 17025:2018	132
Not Reformulated	130
Reformulated	2
<b>Grand Total</b>	<b>318</b>

Figure 28. Pivot table corresponding to reformulated rilievi for each standard

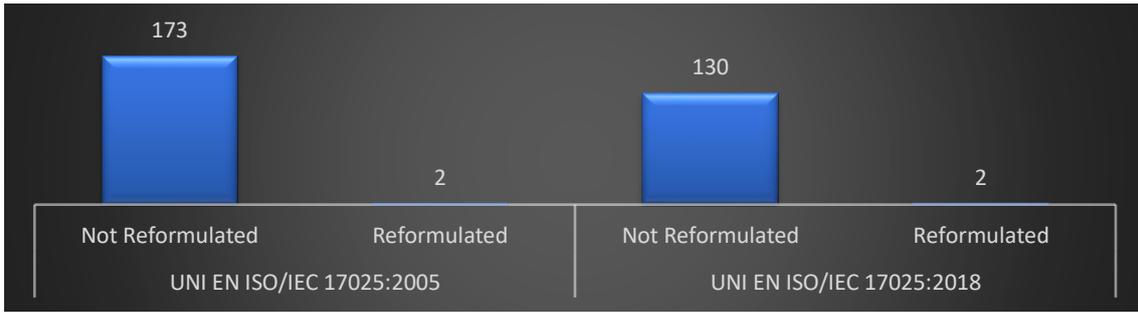


Figure 29. Pivot chart corresponding to reformulated rilievi for each standard

Besides the identification of the standard corresponding to the reformulated rilievi, the macro is capable of identifying the requirements that were reformulated (see Figures 30 and 31), the inspectors who performed reformulations (see Figure 32), and the technical functionary in charge of the laboratory where the reformulation occurred (see Figure 33 y 34).

REQUIREMENTS REFORMULATED	
Requirements	Sum of Rilievo Reformulated
<b>Reformulated</b>	<b>4</b>
\$5.4.2 Metodi di prova e di taratura e validazione dei metodi - Selezione dei metodi	1
\$5.6.1 Riferibilità delle misure - Generalità	1
\$8.7.1 Azioni correttive (Opzione A)	1
\$7.11.1 Controllo dei dati e gestione delle informazioni	1
<b>Grand Total</b>	<b>4</b>

Figure 30. Pivot table corresponding to reformulated requirements

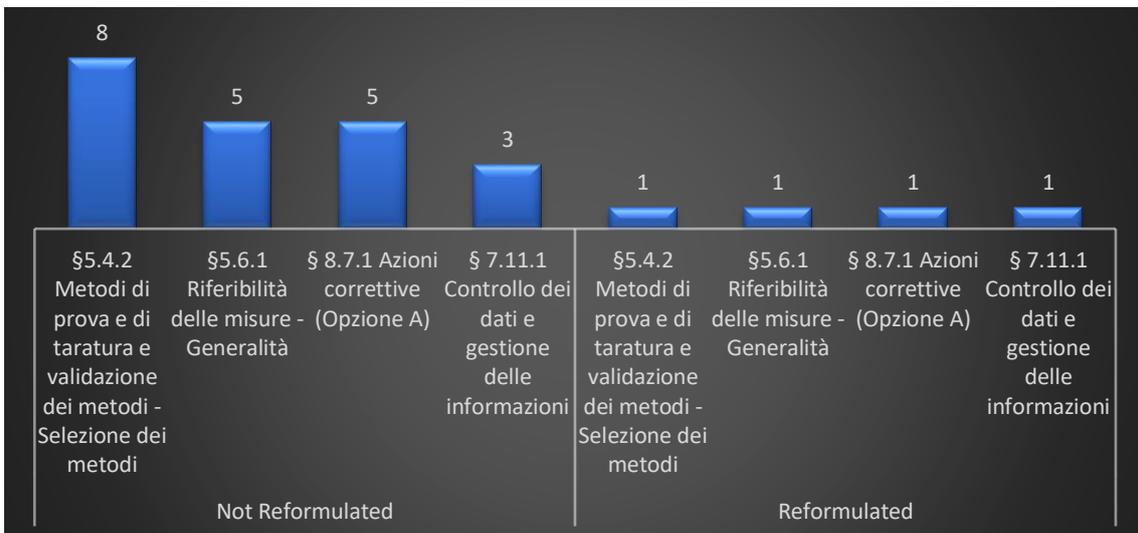


Figure 31. Pivot chart corresponding to reformulated requirements



Figure 32. Pivot table and pivot chart corresponding to reformulated rilievi by each inspector

RILIEVI REFORMULATED FOR TECHNICAL FUNCTIONARY	
Technical Functionary	Sum of Rilievo Reformulated
Giulia SURIANI	31
Not Reformulated	31
Rosalba MUGNO	24
Not Reformulated	24
Fabrizio MANTA	67
Not Reformulated	66
Reformulated	1
Paola PEDONE	49
Not Reformulated	48
Reformulated	1
Enrica PESSANA	147
Not Reformulated	145
Reformulated	2
<b>Grand Total</b>	<b>318</b>

Figure 33. Pivot table corresponding to reformulated rilievi by each technical functionary

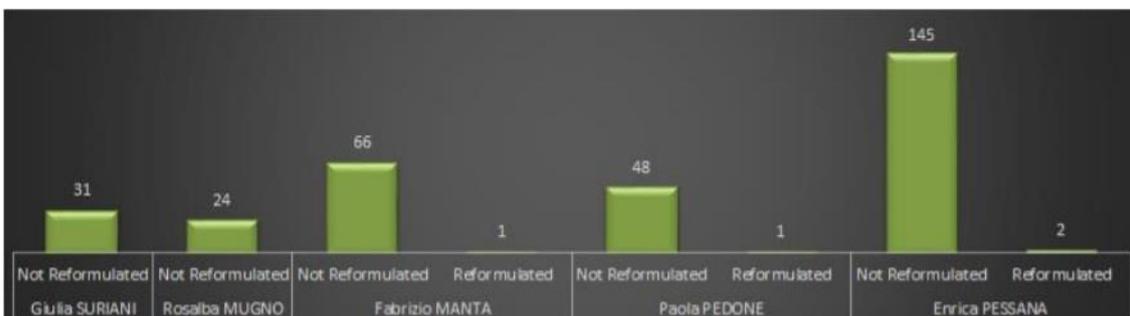


Figure 34. Pivot chart corresponding to reformulated rilievi by each technical functionary

Other important statistic obtained with the macro were the number of technical and system comments, non-conformities and observations, these results (see Figures 35 y 36) make easier the process explained in the item 3.2 corresponding to the laboratory assessment and its identification of risk level (high, medium or low).

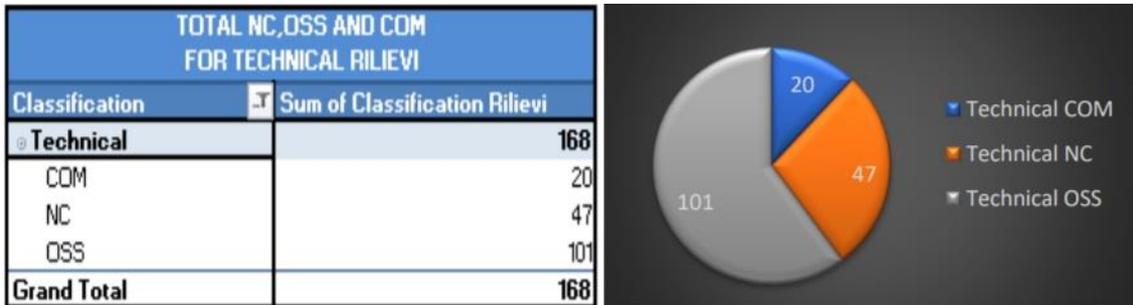


Figure 35. Pivot table and pivot chart corresponding to the total number of technical NC, OSS and COM.



Figure 36. Pivot table and pivot chart corresponding to the total number of system NC, OSS and COM

## **5.6 Verification**

This section verifies that the solution created and presented in this thesis has been already used by some technical officers from ACCREDIA and has been useful as the analysis of the on-site assessment reports its been simplified by the use of the macro.

Throughout the project, the company tutor regularly verified the code's construction and the macro's progress. According to the statistics requested by her, at the end of the internship (June 11th), the software created contained 24 pivot tables and 24 pivot charts.

Later, on July 10th, we had a skype meeting, where I explained to her the functioning of the entire macro and the results obtained for the laboratory assessment reports made in 2019. She needed to know this information because, in that week, she had to run by herself the macro with the reports corresponding to this current year to present the results in an inspection course given to the ACCREDIA staff. She was delighted with the work done, but we discovered an error in the table charts, so it was necessary to correct it and send it immediately.

After the inspection course on July 22nd, we had a second skype meeting where she expressed, she successfully ran the macro with 90 reports, and everybody at the conference was pleased with the work. Additionally, she communicated the necessity to add a new statistic regarding the number of visits performed by each inspector, intending to determine their real performance.

For this reason, were added four more pivot tables (28 in total) in the final delivery of the macro on July 27th. The most relevant findings of these new tables are shown below in Figures 37 and 38:

NUMBER OF RILIEVI PER VISIT CORRESPONDING TO EACH INSPECTOR	
Inspector	Sum of Evaluation Date
<b>A110</b>	<b>29</b>
2019-04-30 e 2019-05-03	2
2019-06-03 e 2019-06-13	1
2019-06-10e11	1
2019-07-01e02	4
2019-07-22e23	5
2019-09-23,24 e 25	1
2019-10-28e29	6
2019-11-26e27	5
28/06/2019	3
31/10/2019	1
<b>A114</b>	<b>32</b>
2019-05-20/21 e 2019-05-23/24	3
2019-06-10e11	4
2019-10-30/31	3
2019-11-28/29	4
2019-12-02/03	2
30/01/2019	4
03/07/2019	2
04/09/2019	5
30/09/2019	4
29/10/2019	1
<b>A165</b>	<b>42</b>
2019/09/05-11-12	4
2019-05-14-15	4
2019-06-17 e 18	5
2019-07-11 e 12	6
2019-09-03-4	6
2019-11-25 e 26	1
2019-12-03 e 04	6
03/06/2019	5
23/07/2019	4
10/09/2019	1
<b>A91</b>	<b>23</b>
2019-07-02/04 e 2019-07-08/09	5
2019-10-16 e 17	2
2019-12-02/03	5
2019-12-17 e 19, 2020-01-08	3
03/07/2019	3
04/09/2019	2
30/09/2019	3
<b>Grand Total</b>	<b>126</b>

Figure 37. Inspectors who performed many visits

NUMBER OF RILIEVI PER VISIT CORRESPONDING TO EACH INSPECTOR	
Inspector	Sum of Evaluation Date
<b>A116</b>	<b>1</b>
26-27/09/2019 - 02-03/10/2019	1
<b>A142</b>	<b>1</b>
2019-12-02/03	1
<b>A159</b>	<b>1</b>
2019-07-02/04 e 2019-07-08/09	1
<b>A23</b>	<b>1</b>
2019-09-03-4	1
<b>Grand Total</b>	<b>4</b>

Figure 38. Inspectors who performed few visits

From the 165 existing inspectors in the database of ACCREDIA, 35 were present in the reports analyzed; from that 35 inspectors, four evaluated more than 40% of the total requirements (126), three of them performed ten visits and one seven visits (see Figure 37). Another four inspectors made only one visit, and each one of them evaluated only one requirement (see Figure 38).

The information presented in the last two figures shows that the on-site assessment has been carrying out unequally, as few inspectors are doing many visits while others are not performing so much work.

Apart from the use of the macro in the inspection program explained above, on September 15th was communicated that the macro would be used in preparation for the online training course created by ALPI (Laboratories Association and Certification and Inspection bodies) and led by a technical officer from ACCREDIA. The course will be held on October 21<sup>st</sup>, and it aims to support the Calibration Laboratories in adopting a quality management system compliant with the standard UNI CEI EN ISO / IEC 17025: 2018. The session will focus on the transition and the main changes of the UNI CEI EN ISO / IEC 17025: 2018 standard.

## 6 Recommendations to ACCREDIA

Through the entire development of my internship at ACCREDIA, while I was developing the automation macro, I could find some repetitive and common mistakes in the compilation of the laboratories on-site assessment reports; these errors affected the correct running of the macro and were communicated to the ACCREDIA staff for them to correct it in the future, and in that way maximize the use of the software created. Mistakes are described below:

- **Empty Excel files:** if an empty excel file is uploaded to be analyzed by the software, the macro does not extract any information and will generate an empty row in the "Report" sheet;
- **Empty Excel sheets:** if there is an empty excel sheet corresponding to a rilievo sheet, the macro cannot extract the information and will generate an empty row in the "Report" sheet and may stop the correct reading of all the other excel files;
- **Missing information:** if there are cells that the macro use to obtain data without information, the macro cannot extract the information so will generate an empty cell in the "Report" sheet and may stop the correct reading of all the other excel files;
- **Typographic errors:** this error can be present in the name of the sheets and will generate a warning box with "Error 9" and could also be in the name of the classification generating an empty cell in the report sheet;
- **Information incongruence in the Excel sheets:** the number of compiled rilievi has to be the same in the "*Anagrafica audit*" sheet and the sheets corresponding to each rilievo; if this number is different, the macro may stop the correct reading of that excel file and the followings.

Finally, it is very important to establish a unique format for all the on-site assessment reports and a standard to fill them, because there were few files with a different format that unfortunately could not be recognized by the macro, so is extremely important that all inspectors use the same format to use the macro with all the reports. Also, it is recommended to write the days of the visit in a date format; in this way, it is possible to add other statistical options such as "Timeline" to facilitate the data analysis.

## ***Conclusion***

This thesis presents the solution implemented in ACCREDIA, The Italian Accreditation Body, regarding the statistical analysis of the calibration laboratories on-site assessment reports made in 2019, also shows the results obtained after the evaluation of 46 reports.

ACCREDIA faced a problem in the development of the annual analysis of the reports, as this was a manual long and complicated process; for this reason, was created an automated process using the Microsoft Excel tool VBA to facilitate the analysis, improve and increase the statistical indicators that represent the performance of the parties involved in the accreditation process (laboratories, inspectors, and technical functionaries). The solution allows the ACCREDIA staff to upload multiple reports simultaneously, creating a report, tables, and charts with the essential information extracted from the files. Thanks to the macro created, the technical officers of the company will be able to analyze the reports from calibration laboratories more simply, saving much time and obtaining more detailed and useful information from the statistical analysis.

For the creation of the solution, through the entire internship period were performed activities such as database management, statistical analysis, definition of statistical indicators for continuous monitoring of the accreditation process, and code development using VBA functions; these activities were weekly monitored by the company tutor Paola Pedone one of the technical officers from the ACCREDIA team.

As consideration for further improvements in the company, it would be helpful to apply a solution of this kind in the other ACCREDIA departments, Certification and Inspection, and Testing Laboratories, to avoid the manual complex processes; also its extremely important to create and promote a culture of order and standardization of processes in the company, as in the development of this work most of the problems were generated by the lack of standards established in the process of filling the reports by the inspectors.

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