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Reducing Mobile Phone Repair Cycle Time at NOS

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Master in Management of Services and Technology

Supervisor:
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Abstract

Developing process efficiencies that result in shorter cycle times (i.e., the time elapsed between starting and completing a job) is a mechanism that organisations often use to achieve competitive advantage, operational efficiency, and lower costs.

This research examines how NOS, a national telecoms company, is working to reduce its repair process cycle time through an action research project, in which researchers work alongside company employees to develop and implement practical solutions. Given the specific objective of reducing the cycle time of its existing repair processes across multiple sites, NOS selected the Lean Six Sigma methodology. It began by mapping processes, analysing measurement systems, and collecting cycle time data. As well as establishing a baseline measurement, this data will be analysed to identify the sub-process steps with the longest cycle times. These aspects will then be analysed to determine the causes of waste in the process. Next, ideas will be developed on how to reduce/eliminate the causes of waste, these ideas will be evaluated using decision tools, and the most suitable solutions will be implemented. Finally, a control plan will be established to facilitate behavioural change in the employees working on the process and to monitor the best performance of the process to ensure long-term cost savings from the reduced cycle time.

Keywords: After-sales Services, Action Research, Cycle Time, Lean Six Sigma

JEL Classification:

C18- Methodological Issues: General

L96- Telecommunications

O31- Innovation and Invention: Processes and Incentives

Resumo

Desenvolver eficiências de processo que resultam em tempos de ciclo mais curtos (ou seja, o tempo decorrido entre o início e a conclusão de um trabalho) é um mecanismo que as organizações utilizam frequentemente para alcançar uma vantagem competitiva, eficiência operacional e menores custos.

Esta investigação examina como a NOS, empresa nacional de telecomunicações, está a trabalhar para reduzir o seu tempo de ciclo do processo de reparação através de um projeto de investigação de ação, no qual os investigadores trabalham lado a lado com os funcionários da empresa para desenvolver e implementar soluções práticas. Dado o objetivo específico de reduzir o tempo de ciclo dos seus processos de reparação existentes em múltiplos locais, a NOS selecionou a metodologia Lean Seis Sigma. Começou com o mapeamento dos processos, a análise dos sistemas de medição e a recolha de dados de tempo de ciclo. Para além de estabelecer uma medição de base, estes dados serão analisados para identificar as etapas do subprocesso com os tempos de ciclo mais longos. Estes aspetos serão então analisados para determinar as causas dos resíduos no processo. Em seguida, serão desenvolvidas ideias sobre como reduzir/ eliminar as causas dos resíduos, estas ideias serão avaliadas utilizando ferramentas de decisão, e as soluções mais adequadas serão implementadas. Finalmente, será estabelecido um plano de controlo para facilitar a mudança de comportamento dos empregados que trabalham no processo e monitorizar o melhor desempenho do processo para assegurar a redução de custos a longo prazo.

Palavras-chave: Serviço de pós-venda, Investigação- ação, Tempo do ciclo, Lean Six Sigma,

Classificação JEL:

C18- Questões metodológicas: Geral

L96- Telecomunicações

O31- Inovação e invenção: Processos e Incentivos

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Glossary of Acronyms

AR- Action Research

CAT- Technical Support Center

CT- Cycle Time

DMAIC- Define, Measure, Analyze, Improve and Control

FMI- Find my iPhone

GSX- Global Service Exchange

KM- Knowledge Management

LSS- Lean Six Sigma

NFF- No-Fault-Found

PFMEA- Process of Failure Mode Effect Analysis

SIPOC- Suppliers, Inputs, Process, Outputs, Customers

TCT- Total Cycle Time

VOC- Voice of costumer

VSM- Value Stream Mapping

Contents

CHAPTER I

Introduction

With economic growth, globalization and easy access to new products, customer demands have been increasing. The success of an organization depends fundamentally on the level of quality of its services in order to satisfy the demands of its public (Legnani et al., 2009). Often in the literature, the terms "product-related services" and "supplementary services" refer to services that are directly linked to the main product and are an integral part of it (Rigopoulou et al., 2008).

However, it is not possible to determine how investments in after-sales service translate into sales (Kurata & Nam, 2010), taking this into account, as well as the need for after-sales service, this appears as the "necessary evil" (Gaiardelli et al., 2007).

According to the Kano model, after-sales service can be considered a mandatory quality, where the presence of this quality attribute would not create customer satisfaction but would lead to customer dissatisfaction if it were not present. Since the sale of a piece of equipment is expected to offer an after-sales service. Consumers often downgrade high-quality products because of poor customer service and unresolved post-purchase complaints. The result is dissatisfaction followed by lost sales (Asugman *et al*., 1997).

To reduce operational costs, it is necessary to understand waste and, through process improvements, achieve greater operational efficiency. Increasing operational efficiency will reduce total cycle time. Reducing the cycle time of the repair process contributes to increased capacity, as the time saved can be reinvested in other tasks (Kovach & Dash, 2019) and in cost reduction (Ahmed, 2010). According to Gaiardelli et al., (2007), reducing internal waiting times leads to greater flexibility and productivity in procedural terms, increasing repair and response capacity.

The project is developed at NOS, which is a telecommunications company, in an After-Sales team, this company has more than 4.8 million mobile customers. The After-Sales Service team is responsible for managing the offer, through close contact with workshops and brands, as well as providing support to the workshop and line service teams. The after-sales team's priority is to offer a service or product that best matches the customer's interests compared to the competition.

After-sales service arises from the need to support the business, in the Portuguese market, due to warranty legislation, all sellers need to guarantee that during the 3 years, if the equipment presents any damage, it will be resolved (Decree-Law no. 84/2021). As the cost of warranty services directly affects the manufacturer's profit, finding an effective strategy to reduce the cost of warranty services has become an important issue for manufacturers and intermediaries (Shafiee & Chukova, 2013).

1.1. General Objective

This thesis aims to identify and implement improvements in the processes of a telecommunications company that seeks for efficient practices in after-sales. To achieve this goal, the following process will be followed:

- Identify the alternatives for process improvements.
- Collect company data to use as baseline inputs to assess the characteristics of the current operation.
- Observe the operation and establish a close relationship with the teams to understand which processes fail and which proposed solutions make sense for the company to implement.
- Compare the results obtained to measure the impact of process improvement.

1.2. Objectives and research questions

As a result of the challenges faced by the after-sales team at NOS company, this research aims to assess how processes can be improved so that the cycle time smartphone repairs can be reduced. To this end, it is necessary to answer two questions:

Question 1: What are the components of the cycle time of the current repair process?

Specific objective: To understand the current performance of NOS' repair process, considering the total cycle time, using company data.

Question 2: Where are process improvements required so that a reduction of the cycle time of the repair process is achieved?

Specific Objective: To understand which processes, cause the greatest inefficiency in the operation, and thus understand where changes should be implemented to reduce the total cycle time.

1.3. Methodology

To reply to the questions of this study, a combined approach that analyzes practical challenges along with scientific methods is necessary (Seniuk Cicek, et al. 2019). Hence, in this research, an action research approach is chosen to be followed to combine the experience and insights of practitioners of the company under analysis with scientific qualitative and quantitative methods related to process improvements. Action research is a generic term, encompassing many forms of action-oriented research, which results into action and research that, unlike traditional positivist science, aim only to create knowledge (Coughlan & Coghlan, 2002).

Within the framework action research , this study followed the Lean Six Sigma methodology to solve the problem described in Question 2 because this approach combines both the waste-reduction methods of Lean, which are typically knowledge and experience-oriented, with the variation reduction methods of Six Sigma, which are typically data-analysis–oriented, to support organizations in improving performance and achieving their strategic objectives (Pepper & Spedding, 2009).

1.4. Project structure

This introductory chapter presents the framework, justification, objective, and general methodology of the research. The following chapter, Chapter 2, presents the Literature Review. Chapter 3 presents the case study, the methodology applied, the scope of the project, and the current state of the process. Chapter 4 applies the Action Research methodology and DMAIC. Finally, the dissertation is concluded (Chapter 5), considering the methodology used and the limitations of the work carried out, and launching avenues for future work.

CHAPTER II

Literature review

The chapter begins by presenting the framework of performance indicators in after-sales service and then analyses previous studies that aimed to analyse process improvements and reduce process cycle times. The literature review reveals how approaches such as action research (AR), Lean and Lean Six Sigma (LSS) have resulted in process improvement and cycle time reduction in previous cases.

2.1.After-sales service

Gaiardelli *et al.* (2007) propose a framework (Figure 1) that allows for a comprehensive measurement of after-sales performance. This framework has four distinct levels, each of which contributes to a comprehensive measurement of after-sales performance. The first level focuses on the company's strategic domain, where a detailed analysis is made of financial performance, which is determined not only by market results, market share, and penetration, which directly influence revenue but also by resource utilization and cost management. The second level concerns procedural aspects. This level includes several different activities carried out by different actors along the supply chain. These activities are analyzed in terms of customer satisfaction, adaptability, and efficiency. Further down, the activity level analyses the performance of the organizational unit, where a clear distinction is made between front-office operations, which have a tangible impact on customer satisfaction, and back-office functions, which are mainly responsible for operational efficiency and on-time delivery. At this level, five key performance dimensions are considered: reliability, responsiveness, internal delivery times, waste, costs, and optimal resource utilization. Finally, there is the development and innovation dimension. This dimension seeks to encompass the factors that are fundamental to guaranteeing competitive and financial results.

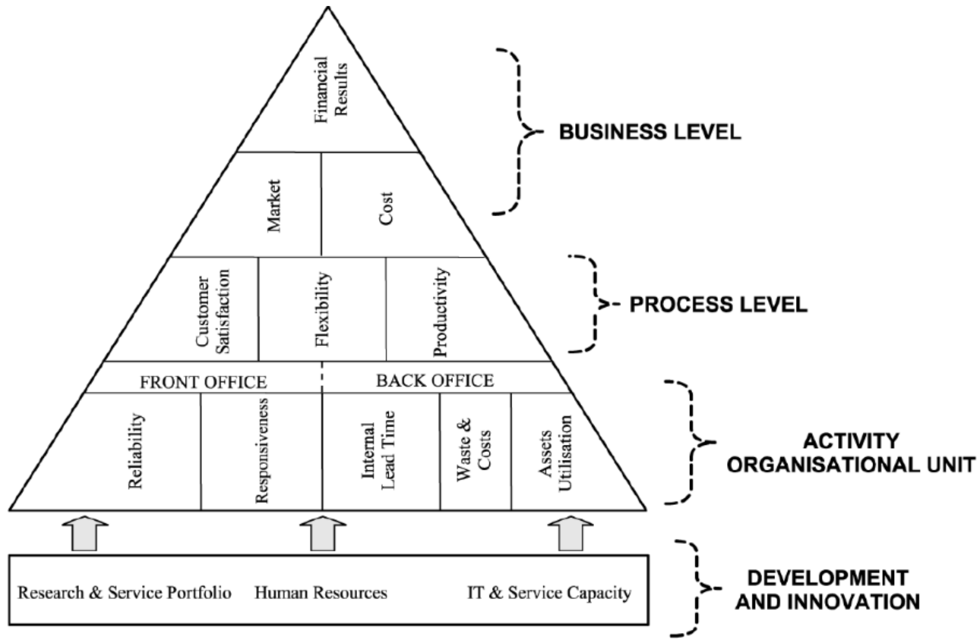


Figure 1-The After-Sales performance measurement framework.

Source:

2.2.Action research

Action research (AR) can be defined as a research process in which applied knowledge from scientific fields is combined with existing organisational knowledge and applied to solve real organisational problems. Action research is concerned simultaneously with bringing about change in organisations, developing communication, cooperation and inter-help skills in the business environment and contributing to scientific knowledge (Shani, 1985).

As an emergent research process, action research involves a developing narrative, where the data changes as a result of the intervention and where it is not possible to predict or control what happens. It centers problems or issues in real operations rather than issues created especially for research purposes. It works in the field of people in systems, where applied knowledge from behavioural and organizational sciences is used and put into practice. The quality of the relationship between system members and researchers is paramount, since the focus is on the research process and the implementation process (Coughlan and Coghlan, 2002).

Given the complexity of the after-sales service, it is necessary for everyone involved in the operation to contribute to the project. In the Hales, *et al.* (2006) study, even though a formal method has been developed to prioritize process improvement efforts, without cooperation and information sharing, all efforts are in vain. Everyone needs to be involved and communicate so that objectives are aligned, and everyone contributes to the same goal.

Marques (2020) with the main purpose of improving the repairing service carried out by the technical support department's technical team, used AR to identify the points to be improved, a list of solutions was drawn up for the category of process change, priorities and scheduling the changes and visualization of control information. All these suggestions emerged to obtain a greater competitive advantage, offering greater efficiency and difference in the level of service provided to the client.

2.3.Lean

According to Shah & Ward (2007), Lean is an integrated socio-technical system whose main objective is to improve productivity and work quality, along with reducing customer waiting time, cycle time and manufacturing costs, eliminating waste while reducing or minimising supplier, customer, and internal variability.

Lean has been used as a methodology in various sectors, from the service sector (Ahmed, 2010), in hospitals (Bagum *et al.*(2021)) and in maintenance for an aviation company, always with the aim of improving processes in order to reduce cycle times.

The goal of the study of Ahmed (2010) was to introduce Lean as a business improvement initiative in Egyptian service sector organizations, throughout focusing on processes that create customer value and eliminate of all kinds of waste. The first phase included training and educational programs for all employees involved in the organisation. The second phase involved mapping of current workflow (AS-IS) to allow the management as well as the workers to understand which processes were value-adding and which processes could be eliminated (non-value adding). A throughout analysis was then performed to find the root cause of the problem using tools such as ‘5 why’s’, fishbone diagram and Pareto charts.

Later Bagum *et al.* (2021) studied the inefficient management of the resources in a Hospitals of Bangladesh using Lean tool and Simulation. The tool was Value Stream Mapping (VSM) to appraise the current condition of the test process and to use simulation model to propose alternatives which reduces the steps, waiting time, bottleneck present in the process. The results of the current state simulation run were used to suggest two improved alternative future state models which significantly reduced the waiting time from 376.05 minutes to 231.6 minutes, hence the total process time from 419 minutes to 276 minutes.

Lastly, Siva, *et al.* (2017) have study the maintenance service in an aviation company to achieve continuous improvement, to reduce cycle time by mapping current state VSM, takt time, and with Lean tools such as Poke-Yoke, Jidoka, 5S. To reduce bottleneck operations and non-value-added activities, the visual management tool was used, which through the association of images of what "to do" and what "not to do" are placed in all processes to avoid errors, the 5S tool was implemented to reduce electronic waste, Poke yoke is introduced through the design of error detection and prevention in the process, with Jidoka, processors can frequently monitor several baselines (reducing labour costs) and many quality problems can be detected. As a result of the implementation of all these tools, Cycle Time (CT) decreased from 2,5 day to 2,2 hours.

Although Lean is an effective methodology for product and service development, Feld (2001) points out as limitations, the difficulty of adapting Lean to companies with deeply rooted cultures resistant to change, the tendency to "over-engineer" in situations where Lean is applied in an extreme way, resulting in products or services that may not meet customer needs and finally the undervaluation of some important tasks for project success, such as testing and quality assurance, when the emphasis is only on eliminating waste and increasing efficiency.

2.4.Lean Six Sigma

As already mentioned, the Lean vision continues to focus on the individual product and its value stream (identifying value-added and non-value-added activities), and to eliminate all waste (Pepper & Spedding, 2009). The term "Six Sigma" refers to a statistical measure of the rate of defects in a system. Based on statistical techniques, it presents a structured and systematic approach to process improvement, with the aim of reducing the defect rate. Both Lean and Six Sigma can be integrated to form a coherent management tool for improving business processes.

Application of Lean Six Sigma in various industries is well documented in the literature. Examples in the subsea oil and gas industry Deithorn and Kovach (2018) and in services sector Kovach and Dash (2019), Kovach and Ingle (2019). A current shift in literature is focused on the application of

LSS principles in Telecom manufacturing include Andersson *et al.* (2014) and in the repair industry (Li *et al*., 2020).

In the first one, the authors Deithorn and Kovach (2018) studied a oil and gas exploration company with goal reducing the time-to-invoice to meet the corporate guideline of 30 days or less, on average. With the help of the team and with their brainstorming, solutions were sought for the problems raised. It was implementing a job package cover sheet and a technician workbook, training the employees who work in the billing process on these new tools/methods, and instituting control plans for both solutions, the time-to invoice decreased by approximately 50 percent.

In first case study related to the services sector the LSS was applied in a mouse cage sanitation with the purpose of reducing the time to sanitize mouse cages by implementing countermeasures to reduce causes of waste within this process (Kovach & Dash (2019)). The steps followed to solve the problem included mapping the current process for sanitizing mouse cage towers, creating a measurement system to collect cage sanitation process cycle time data, establishing a baseline measurement for the current process performance, evaluating the process using failure modes and effects analysis (FMEA), prioritizing causes to determine the root cause(s) of waste in the process, brainstorming and prioritizing ideas for countermeasures to address each root cause, implementing selected countermeasure(s) for each root cause, collecting data to measure the performance of the new process after full implementation, and finally, comparing baseline and new process performances to determine the degree of improvement achieved through the project.

In the health sector with the challenge of providing services in an efficient manner to prevent patient no-shows and encourage the continuation of medical care, in other words demonstrate how one nonprofit health care clinic can use the Lean Six Sigma methodology to help them further improve the efficiency of their clinic visit process. In this case example not all available Lean Six Sigma tools were used, however it demonstrates how to use Lean oriented process analysis methods within the Lean Six Sigma approach to define, measure, analyze, improve and control (DMAIC) when working in environments with limited data available (Kovach & Ingle, 2019).

In the case study carried out in a telecommunications company, the challenge was to understand whether Lean Six Sigma could improve flexibility, robustness, cost efficiency and agility at the same time in operational terms (Andersson et al., 2014). Throughout the project, the DMAIC (Define, Measure, Analyze, Improve, Control) tool was employed, encompassing five key phases. In the

Define phase, simulations were used to identify cost-effective improvements for at least five business objectives. The Measure phase utilized brainstorming, affinity diagrams, and team discussions to pinpoint potential root causes and establish measurement criteria. In the Analyze phase, these factors were scrutinized to identify areas requiring attention. The Improvement phase, informed by staff interviews, resulted in significant enhancements to the work environment. Finally, in the Control phase, team building initiatives were introduced, including biannual training sessions and stand-up meetings between shifts, to reinforce shared values and foster team spirit.

As mentioned earlier, the Lean Six Sigma methodology was implemented in the repair processes in the electronic maintenance sector because the company was concerned about the repair cycle time. With the help of Pareto analysis, they realized that there were 3 operations that negatively affected repair time, which was reinforced in the measurement and analysis phase through detailed process study and data analysis. Subsequently, a Failure Mode Effect Analysis (FMEA) was carried out to assess the risk priority of each proposed solution, using the available data. With the implementation of the proposals, the cycle time was reduced from 120 to 39 days on average (Li *et al.,* 2020).

2.5.Considerations on the literature review

The exhaustive analysis of the literature carried out for this thesis strongly supports the adoption of a combined methodology, integrating Lean Six Sigma with Action Research, as the most promising approach to achieving the overall goal of improving processes in the repair market.

Considering that this is an in-company project, it is necessary to have a methodology that combines the practical and the theoretical, hence the literary research on AR. The remaining techniques have been used in private sector manufacturing and service organizations for several years to improve efficiency.

To conduct this research work, two methodologies will be used, the AR methodology, and LSS. As previously mentioned, the AR works when associated with another methodology, once it acts as an outside agent that acts as a facilitator of an action and reflection within an organization, thus acting as an outside helper of the client system (Coughlan & Coghlan, 2002). Thus, this methodology offers a paradigm to combine theory with practice and thus provides an approach to bridge the gap between the two. Since not all questions of interest to managers and operations management researchers can be answered by surveys, case studies or participant observation.

To combine with the Action research methodology, Lean Six Sigma was chosen, because Lean thinking by itself does not seek to control a process in statistical form, and the Six Sigma approach alone cannot dramatically improve process speed, nor decrease capital investment, hence the interest in merging the benefits of these approaches (Bhuiyan & Baghel, 2005).

In Figure 2 is the summary table for all case studies, with information regarding key objective, main concepts, application area, key results, limitations, and further research.

	Key objective	Main concepts	Aplication area	Key results
		Action Research		
Marques (2020)	Process improvement	Dashboards, Scheduling, Indicators, Data visualization	After sale service	- Reduction in the number of pending cases and of printed processes - Cycle time reduction by 3.3 days
		Lean		
Ahmed (2010)	Process improvement	Quality; productivity; continuous improvement; Lean; customer value; waste	Mobile service operator in Egypt	- Cycle times decreased by 50% - Costs reduction by 20%.
Bagum et al. (2021)	Reduce the waiting time and reduce bottlenecks	Service time; VSM; Simulation.	Health care	- Reduced the waiting time from 376.05 minutes to 231.6 minutes - Total process time from 419 minutes to 276 minutes
R Siva et al. (2017)		Process improvement, cycle time reduction, Lean Methodology	Maintenance service in an aviation company	- Cycle Time (CT) decreased from 2,5 day to 2,2 hours
		Lean Six Sigma		
Deithorn and Kovach (2018)	Reduce the time-to-invoice	DMAIC; process improvement; service operations	Subsea oil and gas industry	- Reducing the time-to-invoice from 66.57 to 30.11 days
Kovach & Dash (2019)	Reduce Mouse Cage Sanitation Time	FMEA, Cycle Time Reduction, DMAIC	Cage Sanitation	- Cycle time was reduced from 94 minutes to 59 minutes - Technicians had more time to complete other tasks.
Kovach & Ingle (2019)	Reduce the cycle time (RCT)	Lean Six Sigma, process improvement	Nonprofit Community Clinic	- Cycle time was reduced by 22% - Increasing the clinic's patient visits by 27%
Andersson et al., (2014)	Process improvement	Six Sigma, Lean	Telecom manufacturing	- Products in the process were reduced by 50 units - More visibility of problems in the system
LI et al.(2020)	Reduce the cycle time (RCT)	Lean Six Sigma, Process Improvement, Repair Cycle Time	Electronics maintenance facility	- Reduction in repair cycle time by 39 days.

Figure 2- Summary table of the case studies used in the literature review

CHAPTER III

Methodology

The methodology chapter of this thesis project focuses on the implementation of Lean Six Sigma and Action Research in the company's after-sales services market. This chapter describes the framework and approach used to answer the research questions and achieve the study's objectives. The chapter begins with an overview of the action research methods and the stages of the study. The integration of Lean Six Sigma and Action Research provides a comprehensive and practical approach to improving after-sales service processes.

3.1. Action Research

Action Research (AR), according to Lewin (1997), embodies a cyclical process comprising preparatory phases and three fundamental activities (Figure 3). The preliminary stage is dedicated to discerning the overarching purpose and rationalizing the quest for action and inquiry.

Central to this methodology is the core activity of planning, entailing the formulation of a comprehensive blueprint and a definitive choice for the initial stride. Subsequently, execution becomes pivotal as the inaugural step is undertaken. Finally, the phase of fact-finding comes to the forefront, encompassing a meticulous evaluation of the initial action. This evaluation not only dissects the outcomes but also serves as the bedrock for course correction in subsequent steps.

At the heart of this approach is the importance of learning. This forms the basis of progression to subsequent cycles and systemic improvements in the configuration, management and evaluation of operations. This iterative learning and advancement through action assumes the role of an operations manager as an internal researcher. This role enables collaborative engagement with suppliers, customers and academics, as articulated by Coughlan and Coghlan (2002). As Figure 3 shows, the cyclical process continues as the project moves from one cycle to the next. The evaluation at the end of one cycle informs the next and, in certain cycles, certain metrics can be intensified and emphasized over others. In the realm of action research, data emanates from active involvement within the cycles of action. These cycles, where data collection constitutes an intervention, are the source of insights (Coghlan and Brannick (2014) cited in Coughlan & Coghlan, 2002). As posited by Coghlan and Brannick

(2014), the observations made during these action cycles concurrently serve as data collection and knowledge generation mechanisms for both researchers and participants.

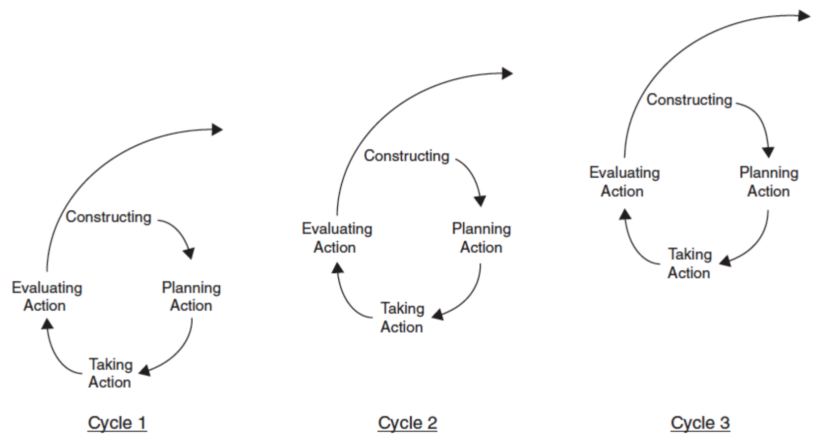


Figure 3- Action Research cycles

Throughout the project, keeping a diary ended up working as a mechanism for developing reflection skills. They wrote down all their observations and experiences in a diary and, over time, it became easy to distinguish between different experiences and ways of dealing with them. Writing in a diary made it easier to reflect on their experiences, to see how they think about them and helps them to anticipate future experiences before they undertake them (Raelin, 1999). Keeping a diary regularly imposes discipline and allows you to capture the experience of key events close to the moment they occur and before the passage of time alters your perception of them. It is a systematic and regular record of events, dates, and people, and it also turns out to be an analytical tool in which data can be examined and analyzed.

3.2. Case Study Steps

Here, it will be describing the DMAIC tool originally coming from the Six Sigma methodology consists of 5 phases, illustrated in Figure 4, that will be done to achieve the answer for the two research questions.

Define	Measure	Analyze	Improve	Control
Project charts - Problem & Mission statement Project Plans High-level process mapping: - SIPOC diagrams	Process Mapping -Swim-line diagrams Data: - Data types - Data collection plans Measurement systems - Alternative MSA method Baseline measurements	Process Analysis - Process failure mode & effects analysis (PFMEA)	Identifying potencial solutions - Brainstorming Prioritizing & selecting solutions -Prioritization Matrix	Control plans Closing the project

Figure 4- DMAIC steps and the tools used in the case study

3.1.1. Phase I- Define

According to Wiesenfelder (2011), "At the end of the Define phase, the team should have completed a project charter, a high-level process map that will allow data to be gathered in the Measure phase". To have high-level process map of the process can be use the SIPOC (Suppliers, Inputs, Process, Outputs, Customers) framework and the creation of a project charter to comprehensively understand the existing processes and lay the foundation for the next phases (SIX SIGMA DAILY, 2017). The project charter is a graphical representation that provides an overview of the scope, objectives, timelines, and responsibilities of the project. In this context, a project charter will be developed to represent the milestones, tasks and key personnel involved in the thesis project (Ruecker & Radzikowska, 2008).

3.1.2. Phase II- Measure

According to Stern (2016), "The main purpose of the Measure Phase is to establish a clear as-is picture of where the existing process is today and to make sure the tools used to measure the activity are reliable and valid".

During the Measure phase of the thesis project, several tools are used to map the process in detail and ensure a thorough understanding of its operation. Foremost among these tools is the flowchart, a visual representation that graphically outlines the sequence of activities, decision points and interactions within the process. This technique makes it possible to identify potential bottlenecks, redundancies, and areas where efficiencies can be achieved (Tague, 2005). These flowcharts were then tested through discussions with individuals or groups of individuals in the company to check the validity of the observation and hypothesis.

A multi-faceted approach will be used to gather comprehensive data, centered on a series of interviews with both operational staff and key members of the management team. These interviews will provide qualitative insights into the process, uncovering tacit knowledge, pain points and operational challenges that may not be apparent through other means. This qualitative data will be supplemented with quantitative data from Excel files provided by the company, etc. These files will contain records of the total cycle time and number of inquiries/complaints for various process instances, adding a quantifiable dimension to the process evaluation. To ensure the viability of the data collected, the strategy of repeated measures will be adopted. The process has been audited through direct observation, the process performance measurements recorded manually can be compared with the measurements generated by the process that are stored in the database (Kovach J. , 2019), some members of the CAT team and the stores repeated the processes so that as many cases as possible could be observed. In addition, the validation of the collected data is supported using the mystery shopper approach. This approach involves using simulated customers or auditors to interact with the process as external observers. This provides an unbiased assessment and cross-references the collected data with real-world observations (Jacob & Biard, 2018).

Incorporating these amalgamated methodologies and tools into the Measure phase will provide a comprehensive and multi-dimensional understanding of the process. This understanding, enriched by qualitative insights, quantitative data, and validation measures, will lay the foundation for evidence-based analysis and effective decision making as the project progresses through subsequent phases.

3.1.3. Phase III- Analyse

The Analyse phase of the thesis project will employ tools to delve into process failures and their underlying causes. In addition to analysing data from the excel database exported from SAP, Process Failure Mode and Effects Analysis (PFMEA) was also carried out.

Furthermore, the PFMEA method will be instrumental in comprehensively assessing potential failure modes within the process. PFMEA allows the identification critical sources of waste, their effect(s) on the process, their potential cause(s), and whether there were any process controls in use that would alert those working in the process that waste had occurred. In PFMEA the following is considered for each potential failure: i) Severity: Severity of the impact of the failure event. It is rated on a scale of 1 to 10. A high score is given to events with a high impact on the Total Cycle Time, while a low score is given to events with a low impact; ii) Occurrence: The probability that the failure event will occur, taking into account the prevention control; iii) Detection: how likely it is that the cause of the failure or the failure mode will be detected; v) Priority of Action: Assessment of the need to reduce the risk. An event with a high AP requires immediate attention, while events with lower APs are less risky (AIAG & VDA FMEA Handbook, 2022)

Analyse phase will facilitate a deep-rooted understanding of process failures and their root causes. This multifaceted approach empowers the project to uncover intricacies, prioritize improvements, and pave the way for informed decision-making in the subsequent stages. All this work was carried out with the management team and the after-sales support line.

3.1.4. Phase IV- Improve

After identifying the main problems that affect Total Cycle Time it is necessary to talk to the team and collect feedback on what could be possible solutions to the problems encountered and, from among the various options, to understand the most viable and structure action plans for their implementation.

During this stage, the strategy of brainstorming emerges as a potent approach, effectively involving cross-functional teams in a collaborative and systematic exploration of potential solutions. By harnessing the collective intellectual capacity and creative prowess of participants, brainstorming generates an array of potential remedies meticulously tailored to address the identified issue (Ahmad *et al.,* 2022). To translate this reservoir of ideas into a methodically structured trajectory, the affinity diagram assumes a pivotal role. This indispensable instrument adeptly categorizes interrelated concepts, thereby elucidating latent patterns and intricate interconnections that might otherwise evade notice (Tague, 2005). This visually orchestrated arrangement serves not only to expedite the decision-making process but also to stimulate synergistic thinking among team constituents. However, the journey toward amelioration encompasses more than the mere accumulation of conceptual constructs; it necessitates the meticulous selection of the most feasible avenues. The prioritization matrix, a strategic instrument, systematically assesses each proposed solution against pre-established criteria encompassing feasibility, projected impact, and alignment with overarching project objectives. Through the meticulous quantification and comparative analysis of these facets, the matrix aptly steers the course of selection, spotlighting solutions poised of strategical values of the company (Bernardo Renzi & Agner, 2023). Ultimately, the fusion of brainstorming, affinity diagrams, and the prioritization matrix coalesces into an integral trinity within the Improve phase, effectively harnessing the forces of creativity, organizational structure, and strategic cogency to herald the advent of transformative enhancements.

3.1.5. Phase V- Control

In the context of this thesis, the control phase emerges as a paramount juncture where the foundation of a control plan takes shape. This plan will stand as a comprehensive framework, encompassing all pertinent performance metrics essential for the vigilant monitoring and management of the process. Anchored by the wealth of insights garnered through the preceding phases, the Control phase ensures the strides made during the Improve phase are not just ephemeral gains, but enduring enhancements. By diligently tracking the defined performance metrics, the control plan facilitates the real-time evaluation of progress against predetermined benchmarks, fostering a continuous loop of feedback and refinement. This phase ultimately serves as the linchpin that transforms the theoretical constructs of process optimization into a tangible and sustainable reality, setting the stage for the consistent realization of improved outcomes.

CHAPTER IV

Research development

This chapter will begin with a brief contextualisation of the company and the after-sales team, then the implementation of action research in the definition of the project's objective and the various cycles of action research using the implementation of the DMAIC methodology.

4.1. Case study presentation

NOS is a telecommunications and entertainment company that currently employs around 4,000 people. It offers a range of services, from television, mobile and fixed network, cinema, consultancy and, more recently, alarms. Given that NOS sells mobile equipment from a wide variety of brands, it needs to provide its customers with a repair service during the warranty period, and even afterwards, to ensure that the customer receives a personalised service.

The mobile after-sales team is present in two NOS shops, one in Lisbon and the other in Porto. At the front-office of these shops, specialised technicians provide comprehensive services, from software updates to secure data transfers and support help, while at the back-office they receive and send all equipment that comes in for repair. Two authorised repairers, which the company refers to as "in-house repairers", are present in these two shops.

Within the after-sales team, customers can also clarify their doubts with the specialised team over the phone (with the support line team). As well as helping the customer, this team deals with all procedural irregularities in the shops, orders materials for the shops and helps the shopkeepers with any queries. The strategic management team deals with agreements with suppliers and repairers, manages the Technical Assistance Centers (CAT), the helpline teams and is involved in multidisciplinary NOS projects. Figure 5 summarises the information on the teams that manage the after-sales service strategically and operationally.

On contacting the company, it emerged that, given that there is no direct relationship between the investment made in the after-sales team and customer retention, this team does not have all the resources needed to make the operation more efficient. The company is very large and the shopkeepers who deal directly with customers deal with a lot of issues and after-sales matters end up not being a priority on the work orders.

	Generalist shops with after-sales service	**CAT (Technical Assistance Centre)**	**Help line**	**Management Team**
Dimensioning	70 stores	2 Stores		
Functions	• Mobile equipment and accessories sales • Insurance sales (new and used) • Repair deliveries • Exchanges and returns mobile	• Insurance sales (new and used) • **Transfer of contents** • **Configurations** • **User support** • Repair deliveries • **Home repair** • Exchanges and returns mobile	• Clarify the questions of the shops about the after-sales processes • Monitoring incorrectly created and/or incomplete in-store guides • Clarify customer questions on any after-sales issue	• Team management • Indicators • Contact with manufacturers and repairers

Figure 5- Description of the teams involved in the project with their dimensions and functions

4.2. Action research

The process of carrying out the action research included continuous evaluation and reflection. Evaluations were carried out twice a week in order to assess the final outcome of the project's main actions, while post-cycle reviews feed into subsequent cycles.

Throughout the project, the lessons learnt from each cycle meant that the project's objective, although always focused on process improvement, changed focus twice. Initially, the aim was to standardize the process and after checking that the research objective had been met, the focus was changed to reducing the cycle time of the entire operation. In this second phase of the project, based on the data analysis carried out, the company felt it was pertinent to focus the analysis only on the processes open in the shop, so phase three of the learning cycles began, with the aim of reducing the cycle time in the workshops.

4.3. Standardization of process

As a first step of the application of DMAIC in the identification of the problem, the company through feedback from employees who identified that there could be procedural differences between the various CATs (lack of standardization). However, by mapping the processes using VISIO, in collaboration with the teams of the various CATs, it was found that there were no significant differences between locations, which meant that this problem no longer made sense, shifting the focus to a new problem (this phase was called phase 1- standardization in Figure 6).

4.4. Reducing cycle time

In the second phase of the project, knowing that the processes were the same between locations, the company wanted to focus its attention on ensuring that the processes were as efficient as possible, so the most appropriate metric would be to measure the Total Cycle Time (TCT) of the repair process.

To begin investigating the repair check-in and check-out process, the entire process was mapped out using VISIO (Appendix A). Since the process mapping had already been carried out in the first phase of the project, the challenge in this phase was to check that the previous mapping was complete and to add the SAP transactions to the flowchart in order to combine the information from Excel and VISIO into a comprehensive view. Since these transactions are used internally by the company, it was useful to create a glossary of SAP nomenclature (Appendix B).

During the process mapping exercise, it became apparent that some of the issues that were causing CAT to spend more time at check-in were irregular situations that originated in the shops. To understand whether this problem was relevant, it was necessary to analyse the data in terms of volumes and total repair cycle time.

The results of this measurement process were audited in terms of their accuracy using two approaches: secret shopper and repeated measures. The first, with a sample size of 1 (n=1), the equipment was from Apple and went for external repair (because there is no in-house repairer), the equipment was delivered to CAT and it was possible to observe the messages received by the customer when the equipment was delivered, when the quote was approved by the customer and the message received when the equipment was already repaired. The aim of this analysis was to check that the times recorded in SAP corresponded to what had happened. All the messages observed corresponded to the information available in SAP, which indicates that the data can be reliable. On the other hand, repeated measures were used to compare the record in SAP with observations of the process of all transactions in SAP on different days and with different sample sizes. Two service centres and three shops were audited to observe the process and the exact time the transactions took place (Appendix C).

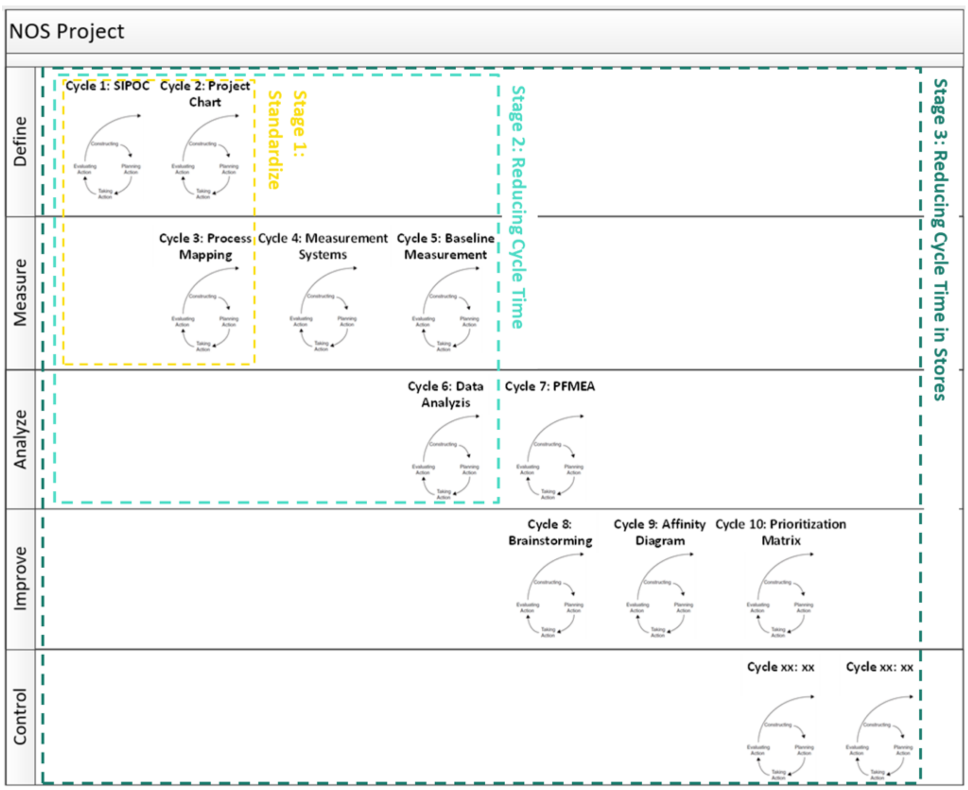
In order to assess the basic performance of the current process of compiling meeting minutes, data was collected from the metrics stored in the shared After-Sales-Service folder for the 12 months (Oct.2021-Sept.2022). This period was chosen in order to have an annual analysis and to see if there are annual trends that could affect the TCT. During this twelve-month period, 1,026 repair cases were generated. Considering that the scope of the project is limited to mobile equipment and repair cases processed by the República and Boavista CATs, excluding the Madeira and Alverca CATs, and excluding all open notes in which repair quotes were not accepted by the customer, the project is restricted to 6,624 repair cases (Appendix D). This project only covers the Lisbon and Porto Technical Assistance Centres because, during the course of the project, the Alverca volume was completely transferred to the other two and there was no point in changing the process if it would no longer exist later.

Based on a preliminary analysis, the total cycle time depends on three main variables: the channel in which the equipment is delivered for repair, whether it is carried out in shops or at CATs, the location of the repairer and the brand of the device (Appendix E).

1. Channel: Repair processes opened in-store take an average of 10.44 calendar days (weekends are included in the calculation) to close, while those opened at the CAT take an average of 6.43 calendar days.
2. Repairer location: Internal repairs take an average of 6.83 calendar days, and external repairs take an average of 12.61 calendar days.
3. Brand: Bearing in mind that in the process mapping it was identified that Apple equipment (Apple equipment was considered to correspond to new and reconditioned Apple equipment that is repaired by different repairers) required longer processing due to the active security systems, when analysing the figures, it can be seen that the repair of Apple equipment has an average TAT of 13.50 calendar days and the other brands 8.03 calendar days on average.

The data was analysed by month to identify seasonal trends, but no trend was identified. On the basis of this diagnosis, and after communicating with the company, it was important to reflect on the relevance of the project, and what changes had occurred since the project began, and it was concluded that, due to changes in the repair model and new contracts with repairers (changes due to another internal project), it would be advantageous to concentrate the project's efforts solely on the processes related to the shores.

According to the DMAIC process, the next phase would be to analyse. However, due to this change in the project scope, it was agreed with the company that the goal of the project would be to focus on the repair processes initiated in the shops only. Throughout the project there were several interactions with the company that led to a change in the project objective, this topic will explore this issue, the Figure 6 illustrates the different cycles of action research that took place throughout the project in each of the DMAIC phases.



The next topic will describe the use of DMAIC with the objective of "reducing cycle time in shops".

Figure 6- Diagram of the action research cycles throughout the project with the identification of each phase

4.5. Reducing cycle time in shops

4.5.1. Define

The scope of the project is now focused on the shops, and for this reason the problem and the mission statement are adapted to the new objective of the project.

Problem statement: "NOS's mobile phone repair cycle time for "normal repairs" in stores has averaged 10.44 days over the last one year (1/6/2022-31/9/2022), resulting in less time for technicians to complete other value activities."

Mission statement: "Reduce NOS's average mobile phone repair cycle time for "normal repairs" in stores to 10 days or less, resulting in more time for technicians to complete other value activities."

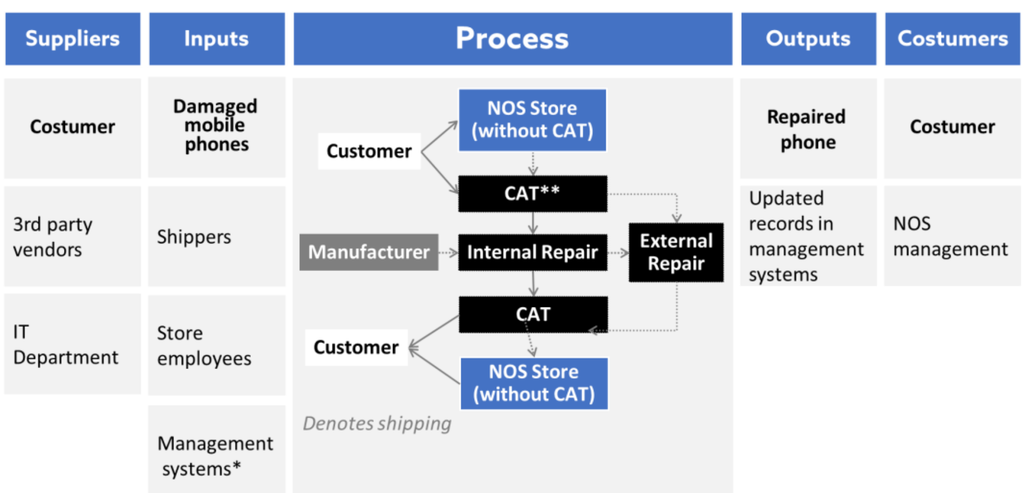
Because the mission of this project specified the goal of reducing the repair process time. The iterative use of the DMAIC approach in this project helps to illustrate the practical realities of conducting process improvement projects. That is, to effectively meet the objectives of process improvement projects, it is often necessary to systematically repeat or iterate through the problem-solving process. In addition, the project plan outlined steps to guide how the project was to be conducted. The steps included: 1) mapping the process of opening repair cases in shops, dispatching, receiving, and delivering repaired equipment to the shop; 2) audit the current measurement system to collect in-store process cycle time data; 3) evaluating the process by using failure modes and effects analysis (FMEA); 4) prioritizing causes to determine the root cause(s) of waste in the process; 5) brainstorming and prioritizing ideas for countermeasures to address each root cause; 6) implementing selected countermeasure(s) for each root cause; 7) collecting data to measure the performance of the new process after it has been fully implemented; and 8) comparing baseline and new process performances to determine the degree of improvement achieved through the project.

4.5.2. Measure phase

A. <u>Process mapping</u>

In order to better understand the mobile phone repair process, the objective of the process was identified, as well as the inputs and outputs, which it documented in SIPOC (a supplier, inputs, process, outputs and customers). As shown in Figure 7, the high-level process steps listed in the SIPOC diagram indicate that the first contact with the repair process occurs when the customer enters the damaged equipment to the store or CAT employees, in the first scenario the equipment is dispatched to the CAT, this triage process is done by the CAT team called repairer check-out, at the end of the repair the CAT team does the repairer check-in, and if the equipment has been received in the store it is still checked-out and sent to the store. The cycle time of the process is measured by the NOS management team by extracting data from SAP, where all processes are recorded.

Given the new scope of the project, it was important to return to the shop and be close to the shopkeepers to complete the previous VISIOS with the new inputs. In order to understand the process in detail, the processes in operation were observed and the workers who work in the shops and at CAT were interviewed.



Notes: (*) UNI, Portal 360 & SAP (**) CAT – Technical Assistance Center

Figure 7-High-level view of the billing process.

The general process starts with the customer going to the shop, where the employee will ask the customer for their details and the reason for going to the shop. The employee will check the condition of the equipment to see if it needs to be repaired. If the equipment does not need to be repaired, the shop assistant must close the process in the software as solved or not solved, depending on what the customer tells him. If the equipment needs to be repaired, it should be checked whether the customer has insurance or not, and if the equipment is insured, the employee should check whether the customer has proof of payment of the insurance excess. It is also the company's policy to lend the customer a replacement mobile phone with the same features as the customer's phone. To proceed with this loan, the employee must interview the customer and, if the customer wishes to subscribe to this service, he/she will receive a similar or inferior device.

Once the repair orders have been created, it is necessary to determine which equipment is under warranty. If it is, and there is no damage, the warranty repair process will begin. If the unit is out of warranty, or if the unit is within warranty but has physical damage such as a broken display, moisture stains or damage to the charger socket, the unit will be sent for repair without warranty.

In both processes, if the type of problem presented by the equipment is included in the "Physical Damage Repair Process", the employee will have to inform the customer of the fixed price. In order to proceed, the customer must first accept the fixed price and then both the customer and the agent will sign the repair order to complete the front office part of the process. However, if the device being repaired is an iPhone, the agent will need to check that the security system is active and, if it is, inform the customer that they will need to deactivate it in order to proceed with the repair, as the

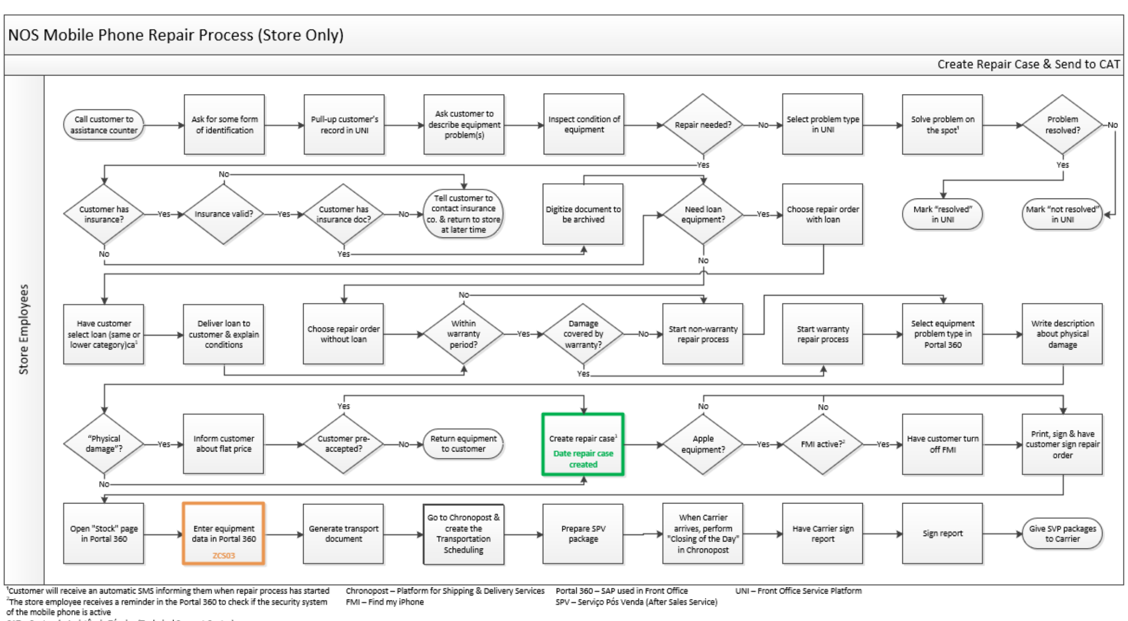


Figure 8- Detailed view of the billing process (the process of opening the repair note).

manufacturer does not allow technical intervention on their devices when the security mechanism is active (Figure 8).

Depending on the shop, when the equipment is dispatched, the person responsible for the closure has to do three important things. Firstly, he or she must access the 360 portal and enter the equipment's details so that the equipment is in transit internally; secondly, he or she must create the shipping repair cases and the transport order on the Chronopost website; and finally, he or she must prepare the shipping package with the green box and white seals to guarantee the security of the equipment. When the courier arrives, the employee must sign the delivery repair cases and hand over

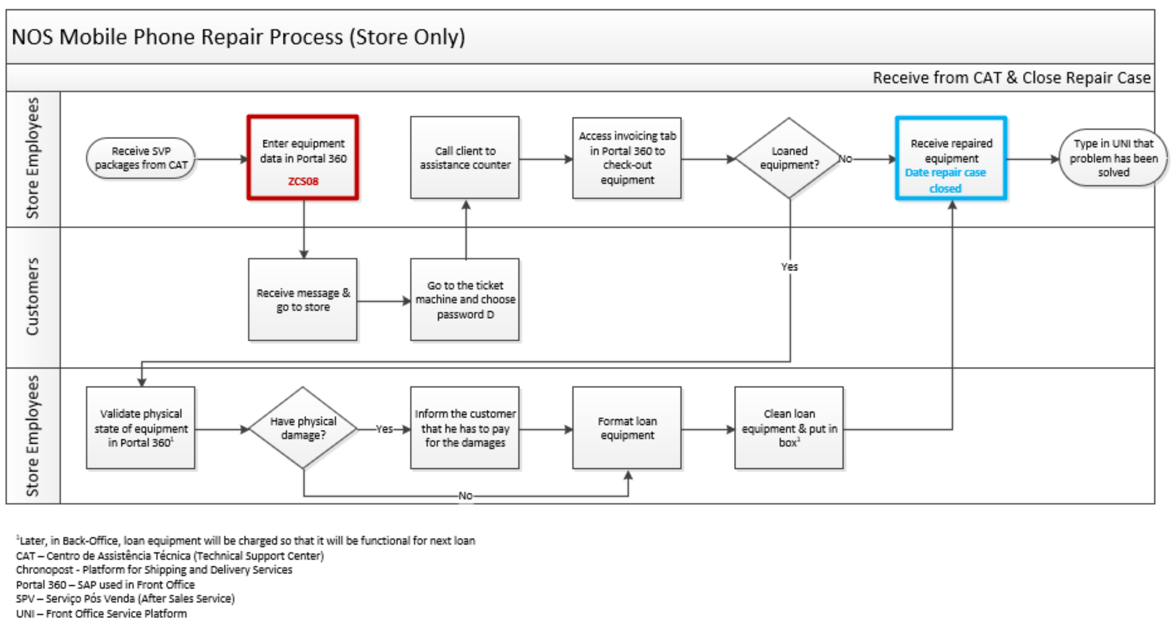


Figure 9- Detailed view of the billing process (the process of closing the repair note).

the box containing the equipment (Figure 9).

B. <u>Measurement Systems</u>

The after-sales team draws up monthly reports that are shared with the repairers to control the repair times that are carried out using outsourcing. These reports have as base information an Excel file taken from SAP. This excel has information such as the repair case number, the date of opening of the repair note, the sending from the shop to the CAT and its check-in at the CAT, the sending of the equipment for external repair and its reception after repair and finally the sending of the repaired equipment back to the shop and its check-in at the shop.

In the scope of this thesis, it will be considering the Customer's TAT in calendar days since the fact that the shops are open every day of the month allows the customer to pick up the equipment not only on working days but also at the weekend.

As indicated in red in the previous flowcharts, the data required to calculate the cycle time is automatically recorded in SAP using the various transactions (Figure 11) that act as time stamps (1) the date the customer delivers the equipment (2) the date when the repaired equipment is in the available for pick-up (i.e., the time it takes for the customer to pick up his equipment).

The outputs of this measurement process were audited in terms of their accuracy using Repeated measures. This tool was used to compared SAP log versus process observations of all transactions in SAP on different days and with different sample sizes (Figure 10). The visit to the shop made it possible not only to check that all the dates and times recorded in SAP corresponded to what was observed in the shop, but also to strengthen the bonds between the shopkeepers and the management team, so that the shopkeepers realised the importance of their work for the after-sales service.

Action	Transation	Description
Customer drop-off	Repair case created	Customer drop-off (CAT and Store)
Send to CAT	ZCS03	Sending unrepaired equipment from the shop to the CAT (only Store)
Check-in CAT	ZCS04	Receipt of unrepaired equipment at the CAT from the shop (only CAT)
Send to store	ZCS07	Sending repaired equipment from the CAT to the store (only CAT)
Arrive at store	ZCS08	Receipt of unrepaired equipment at the store from the CAT (only store)
Customer pick-up	Repair case closed	The customer is notified that the equipment has been repaired and goes to the same place where he took the equipment during the first interaction

Action/Code	Cases Obs.
Repair case created	4
ZCS03	3
ZCS04	28
ZCS08	30
Repair case closed	4
Total	**69**

Figure 10- Number of repeated measures per process

Figure 11- Description of each transaction in SAP with the corresponding action

C. Baseline Measurements

To assess the baseline performance of the current process for compiling meeting minutes, data was collected from the metrics stored in the shared After-Sales-Service folder for the 3 months (Jun.2022-Aug.2022) the initial months of the project, before there are any changes to the project and to be a period comparable to the three control months of the following year. During this three-month period, 2,936 repair cases were generated, bearing in mind that the scope of the project is limited to the mobile equipment part, however there are repair cases that are cancelled for various reasons, from rejected quotes to undetected anomalies, and bearing in mind that the scope of the project relates to shops, the number of cases analyzed is 1,224, representing only 41.69% of all repair cases created during the analysis period.

The repair cycle time is then calculated by subtracting the time the equipment enters the shop and the time it is available for collection.

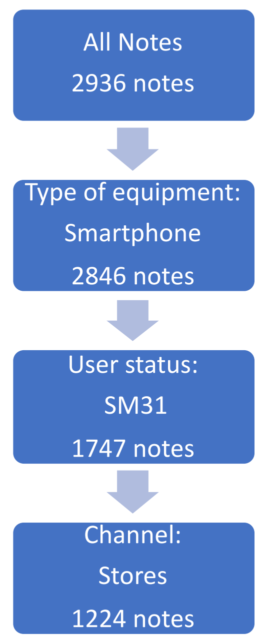


Figure 12- Filters used to arrive at the baseline and their respective note numbers.

4.5.3. Analyze phase

In the analysis phase, the focus shifts from simply measuring and documenting data to delving deeper into the underlying factors that contribute to the issues at hand. Through the combined use of data analysis and FMEA, the analysis phase enables teams to gain a comprehensive understanding of the root causes of the problem and lays the foundation for developing solutions in subsequent DMAIC phases.

A. Data analysis

Considering the analysis carried out in phase 2 of the project, it is possible to see that there is no seasonal trend to consider. And as mentioned earlier, this new phase of the project is only targeting notes opened in-store. According to this more restricted data set, the total length of the repair cycle is 10.90 calendar days on average. In order to understand which sub-processes, take the longest in the operation (Figure 13), as you might expect the longest sub-process is repair, but what surprised the company is that on average it takes 4.19 calendar days from the time the customer delivers the equipment until it is ready for repair. Considering this worrying figure, the company realised that the initial part of the process not only has some inefficiencies but also contributes to a high TCT.

The TCT of the process and each sub-process was analysed by month, by type of shop (whether it was a high street shop or a shopping centre) and by district, and no significant differences could be

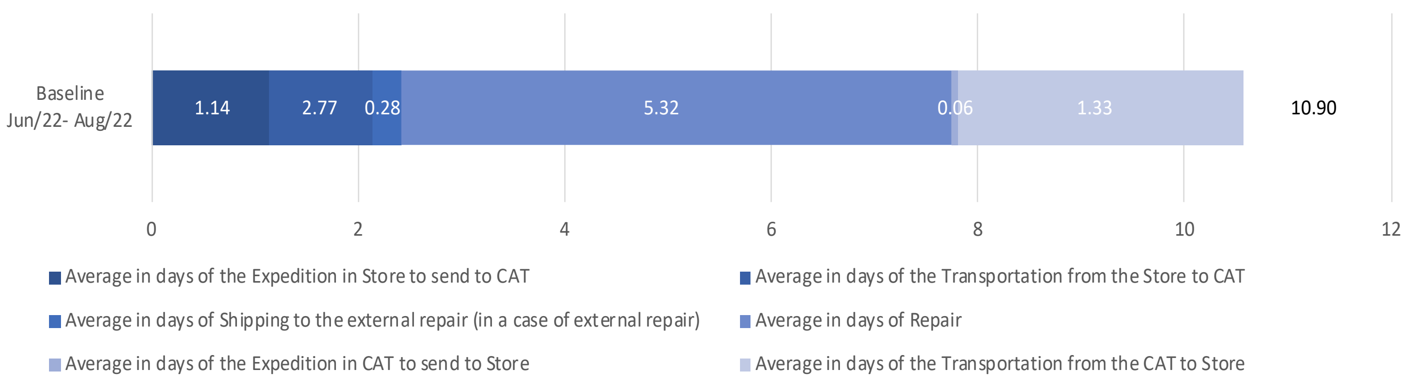


Figure 13-Analysis of repair sub-processes

identified.

D. <u>Process analysis</u>

After validating the available data in this phase, a quantitative analysis is done to find trends or errors and a qualitative analysis through the implementation of process failure modes and effects analysis (PFMEA). In this investigation, PFMEA was used to identifying and prioritizing sources of waste in this process. The description with all the steps of the process can be found in Appendix F. From this analysis, it was possible to identify the causes that affect the TCT in each of the sub-processes identified earlier in the Data Analysis:

Expedition in Store to send to CAT (From point 1 to 21 in Figure 14) - When opening the repair note, the customer's lack of knowledge about their equipment can result in inadequate descriptions of the problem, leading the retailer to fill in incomplete or incorrect information in Portal 360. At this early stage in the process, the TCT can be delayed, as incorrect equipment can result in notes being opened when they weren't needed (Point 1 to 6). Retailers' lack of knowledge of NOS' internal processes means that, when opening the process, they forget to ask the customer about insurance cover, which can lead to an increase in back-office work because it is a bureaucratic process, due to the documentation and the need to validate the insurance with the insurer (Points 7 to 10). While the customer is still in front of them, the shopkeeper should give a description of the reason for the breakdown so that the repairer doesn't waste time trying to find out what's wrong with the equipment. This description is important so that there is a record of the physical state of the equipment (scratches, dents, etc.) (Point 14 to 18). In addition to insurance, shopkeepers, because they don't have all the tools and knowledge about the devices, forget that Apple devices require security mode to be disabled, which once again delays repair time and increases back-office work (points 20 and 21).

Transportation from the Store to the CAT (From point 22 to 27 in Figure 14) - At the time of dispatch, the line team that deals with irregularities generated in the store and that every day analyzes the number of bills that are pending in the store helped to understand why stores take so long after the customer delivers the item. equipment to repair and effectively deliver to the CAT, essentially, retailers need to carry out transport documentation, as well as keep a stock of packaging materials always available.

Transportation from the CAT to Store (From point 27 to 33 in Figure 14)- Once the equipment has been repaired, the total cycle time is no longer so affected by the final processes. However, if the equipment is not entered correctly in Portal 360, the customer will not receive the message that the equipment is ready to be picked up, which can lead to a perception on the part of the customer that the repair has taken longer (Points 28 and 29).

Since the sub-processes of Shipping to the external repair, the Repair, and the Expedition from the CAT to Store are not carried out by NOS store employees, they have not been considered in this analysis.

Figure 14 shows the causes of the failure, identifies who from the company provided the information, in pink they were the shop support line leader, in green they were the store employee and in blue the shop team manager.

	Process Step:	Failure Effects (FE)	S	Failure Mode (FM)	Failure Cause (FC)	Current Prevention Control (PC) of FC	O	Current Detection Controls (DC) of FM	D	AP
1.	Ask customer to describe equipment problem(s)	Select wrong equipment problem type in Portal 360	6	Problem(s) not adequately described by customer	Limited customer knowledge about how to describe problem(s)	None	10	None	10	H
2.	Ask customer to describe equipment problem(s)	Do not select all applicable equipment problem types in Portal 360	7	All problems not identified	Customer does not describe all problems	None	10	None	10	H
3.	Inspect condition of equipment	Equipment not sent to CAT (adds unnecessiarly to cycle time)	8	Do not proceed with repair case when it should have been created	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
4.	Inspect condition of equipment	Equipment sent to CAT (adds unnecessiarly to cycle time)	8	Proceed with repair case when it not should have been created	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
5.	Inspect condition of equipment	Do not select all applicable equipment problem types in Portal 360	6	Only physical damage seen - other damage not seen	Detailed diagnostics not performed	None	10	None	10	H

6.	Inspect condition of equipment	Do not select all applicable equipment problem types in Portal 360	6	Not all phyical damage seen	Detailed diagnostics not performed	None	10	None	10	H
7.	Customer has insurance?	Time spent on settling the repair note type	7	Process as not having insurance when customer does have insurance	Limited customer knowledge about the insurance processes	None	10	None	10	H
8.	Insurance valid?	CAT cannot process further (must wait until the insurance is valid)	7	Franchise is not paid	Limited customer knowledge about the insurance processes	None	10	None	10	H
9.	Insurance valid?	CAT cannot process further (must wait until the insurance is valid)	7	The client was not informed that he had to pay the franchise to activate the insurance	Lack of supports for/training about after-sales process	None	10	None	10	H
10.	Customer has insurance doc?	CAT cannot process further (must wait until the insurance document)	7	The equipment is sent to CAT without the claim document	Lack of supports for/training about after-sales process	None	10	None	10	H
11.	Have customer select loan (same or lower category)	Customer does not receive loan and leave the store with the equipment to repair	4	Store does not have equipment for loan	Lack of supports for/training about after-sales process	None	10	None	10	H
12.	Have customer select loan (same or lower category)	Customer does not receive loan	4	Store does not have equipment for loan	Lack of supports for/training about after-sales process	None	10	None	10	H
13.	Have customer select loan (same or lower category)	Customer receives loan of higher category	1	Store does the equipment category for loan	Lack of supports for/training about after-sales process	None	10	None	10	L
14.	Select equipment problem type in Portal 360	Equipment sent for wrong type of repair	7	Select wrong equipment problem type in Portal 360	Problem(s) not adequately described by customer	None	10	None	10	H
15.	Select equipment problem type in Portal 360	Equipment sent for partial repair only	6	Do not select all applicable equipment problem types in Portal 360	Problem(s) not adequately described by customer	None	10	None	10	H
16.	Select equipment problem type in Portal 360	Equipment sent for partial repair only	6	Do not select all applicable equipment problem types in Portal 360	Only physical damage seen - other damage not seen	None	10	None	10	H
17.	Select equipment problem type in Portal 360	Equipment sent for only partial repair	6	Do not select all applicable equipment problem types in Portal 360	Not all phyical damage seen	None	10	None	10	H
18.	Write description about physical damage	Not clear who is responsible for damage (customer, company, or tranporter)	4	Description of the physical state is incomplete	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
19.	Create repair case	Time spent trying to repair equipment that shouldn't be/doesn't need to be repaired	8	Create repair case when it should not have been created	Select wrong equipment problem type in Portal 360	None	10	None	10	H
20.	Active FMI?	Cannot repair until customer deactivates FMI (adds unnecessarly to cycle time)	8	Status of FMI not checked	Know they will wait for customer to deactivate - not enough time taken/available to do this (due to pressure to sell)	Automatic system reminder when creating repair case to check phone security system	9	None	10	H
21.	Active FMI?	Cannot repair until customer deactivates FMI (adds unnecessarly to cycle time)	8	Status of FMI not checked	Do not have same access to Apple platforms as after-sales team	Automatic system reminder when creating repair case to check phone security system	9	None	10	H
22.	Generate transport document	Equipment not sent to CAT (adds unnecessarly to cycle time)	8	Forget to generate transport document	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	6	H
23.	Generate transport document	Equipment not sent to CAT (adds unnecessarly to cycle time)	8	Forget to generate transport document	Lack of supports for/training about after-sales process	None	10	None	6	H
24.	Go to Chronopost & create the Transportation Scheduling	Equipment not sent to CAT (adds unnecessarly to cycle time)	8	Forget to enter shipping data in Chronopost	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	6	H

25.	Go to Chronopost & create the Transportation Scheduling	Equipment not sent to CAT (adds unnecessiarly to cycle time)	8	Forget to enter shipping data in Chronopost	Lack of supports for/training about after-sales process	None	10	None	6	H
26.	Prepare SPV package	Equipment not sent to CAT (adds unnecessiarly to cycle time)	8	Lack of expedition material stock (green boxes)	Lack of supports for/training about after-sales process (to ask for more stock)	None	10	None	6	H
27.	Prepare SPV package	Equipment not sent to CAT (adds unnecessiarly to cycle time)	8	Lack of expedition material stock (green boxes)	No inventory management for shipping equipment	None	10	None	6	H
28.	Enter equipment data in Portal 360 (ZCS08)	Customer not notified equipment ready for pick-up in store	6	Forget to enter data	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
29.	Enter equipment data in Portal 360 (ZCS08)	Customer not notified equipment ready for pick-up in store	6	Forget to enter data	Lack of supports for/training about after-sales process	None	10	None	10	H
30.	Validate physical state of equipment in Portal 360	Financial loss	4	Damage to loaner equipment not charged to customer (not in swim-lane)	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
31.	Validate physical state of equipment in Portal 360	Financial loss	4	Damage to loaner equipment not charged to customer (not in swim-lane)	Lack of supports for/training about after-sales process	None	10	None	10	H
32.	Format loan equipment	Liable for privacy breach	4	Customer's information stored on equipment later loaned to another customer	Not enough time taken/available to do this (due to pressure to sell)	None	10	None	10	H
33.	Format loan equipment	Liable for privacy breach	4	Customer's information stored on equipment later loaned to another customer	Lack of supports for/training about after-sales process	None	10	None	10	H

Figure 14- Process Failure Modes and Effects Analysis (PFMEA) of each process identified in the flowchart

4.5.4. Improve phase

Once the root causes of the process have been identified, the next stage is to brainstorm ideas on how to resolve them. Conversational interviews were held with management staff, with the support line team and it was essential to visit the shops, talk to the employees and understand what their pain is and what solutions might work best. In this way, employees feel listened to and an integral part of the team. These interviews were planned in advance so that the questions were aligned with the audience.

With the ideas for possible solutions found, it was necessary to use an affinity diagram to categorize the ideas generated in an organized way. In Figure 15, the solutions found are divided into three main areas: 1) Training, 2) Software development, 3) Procedural changes.

Training all employees on the company's processes is critical to the success of the organization, even if some processes are not performed daily by all employees. By knowing the after-sales processes, employees become more aware of the impact of their actions, which can lead to greater collaboration and teamwork, as well as a more comprehensive understanding of each department's role in realizing the company's goals. Among the various ways of delivering the training in this project, the following made sense:

1. **E-learning:** E-learning training has several benefits, from flexibility that does not require travelling or imposing schedules, low costs, and quick access to updated and interactive content.
2. **Video Classroom:** Similar to the e-learning format, the video classroom allows the company to keep travel costs at zero, since the content is just a click away, however, video classes generally do not have interactive features and are more passive.
3. **On-site training:** the most efficient of all, as team managers are present in person and ensure greater awareness of the topic.

In the measure phase, when processes were mapped and brainstorming interviews were conducted, employees made various suggestions to make it easier to enter equipment data, the process of dispatching after-sales equipment and visualizing the equipment's journey within the process.

4. **Application to take a photo of the physical state of the equipment:** when the equipment arrived at the shop, before it was sent for repair, the shopkeeper would take a photo of the physical state of the equipment to capture all the physical damage and this photo would be attached to the process opening sheet.
5. **Checklist on Portal 360 to categorize anomalies:** since it is difficult for the shopkeeper to know all the possible anomalies that the equipment may have, this checklist would allow the shopkeeper to quickly check the equipment and prevent it from going in for repair when it doesn't need to and at the same time leave more information for the repairer.
6. **Data would be filled in automatically when entering the IMEI:** the after-sales support team and CAT team leaders spend part of their time regularizing errors that shopkeepers make by not filling in the equipment model fields correctly, the system would make the process much easier by automatically recognizing the IMEI.
7. **Notification in Portal 360 in case of insurance:** Similarly, to idea 6, in case of insurance, Portal 360 can recognize IMEI's that have insurance.
8. **Developments in Chronopost for the after-sales shipping:** the shipping process for equipment to be repaired and already repaired is different from other shipping processes in the company, such as orders, and by standardizing the process with the distributor it would be easier for employees not to make mistakes.
9. **Track and Trace:** With the development of a track and trace application, the customer would know where their equipment was, and the support team would be quicker to intervene when it was needed.

Based on the observations made by the workers in the shops and CATs, it is important for them to teach customers how to work with their equipment so that they learn how to update the phone's software and how to keep their personal information safe, when privacy is an increasingly important issue due to data protection and as a company NOS needs defense mechanisms in order to prevent non-compliance with the law. In this sense, and in order not to hold tenants responsible, the following possible solutions have emerged:

10. **Card with FMI info:** due to the issue of iPhones not being repaired with the security mechanism active, this card would be given to customers so that, using basic step-by-step instructions on how to deactivate the FMI.
11. **QR code with FMI info:** similar to solution 10, this solution has the same purpose, to teach the customer how to deactivate the FMI but this time by providing a QR code.
12. **Redirect to the site:** within the same scope as the last two solutions found, this one would not use material resources to be carried out; in this case, the shopkeeper would direct the customer to the NOS website, and the customer would access it to find out the step-by-step instructions on how to switch off the FMI, either using their equipment or the shopkeeper's computer.

Bearing in mind that shopkeepers deal with various issues with the customer, from invoicing, contracts and the sale of equipment and accessories, some ideas for solutions are presented to make it easier for the management team to ensure that the after-sales service process is not forgotten.

13. **Access to Global Service Exchange (GSX):** Giving all shop managers permission to access GSX, which is the platform that allows them to see if the FMI is active or deactivated, allows them to identify these cases, if the customer is still in the shop, they can help them deactivate the security system and in the worst case notify the helpline to contact the customer.
14. **Knowledge Management (KM):** To facilitate communication between the after-sales service management team and shopkeepers, an up-to-date knowledge base means that all processes are ready to be consulted. In this case, the Knowledge base is already used by the shopkeepers and already has some of the after-sales processes displayed, but many of them are out of date.
15. **Dashboard**: Bearing in mind that the operation depends a lot on the shopkeepers, the processes they open and the time it takes them to complete the dispatch process, the management team thought it would be a good idea to find metrics that could be sent to the shop managers monthly to sensitize them to after-sales issues.

Figure 15 shows an improvement proposal accompanied by numbers that correspond to each line of the PFMEA tool. These numbers are important for accurately identifying critical points and potential failures in the process in question. By including the numbers corresponding to each line of the PFMEA along with the improvement proposal, it is possible to have a clear view of the specific points of the process that are being addressed.

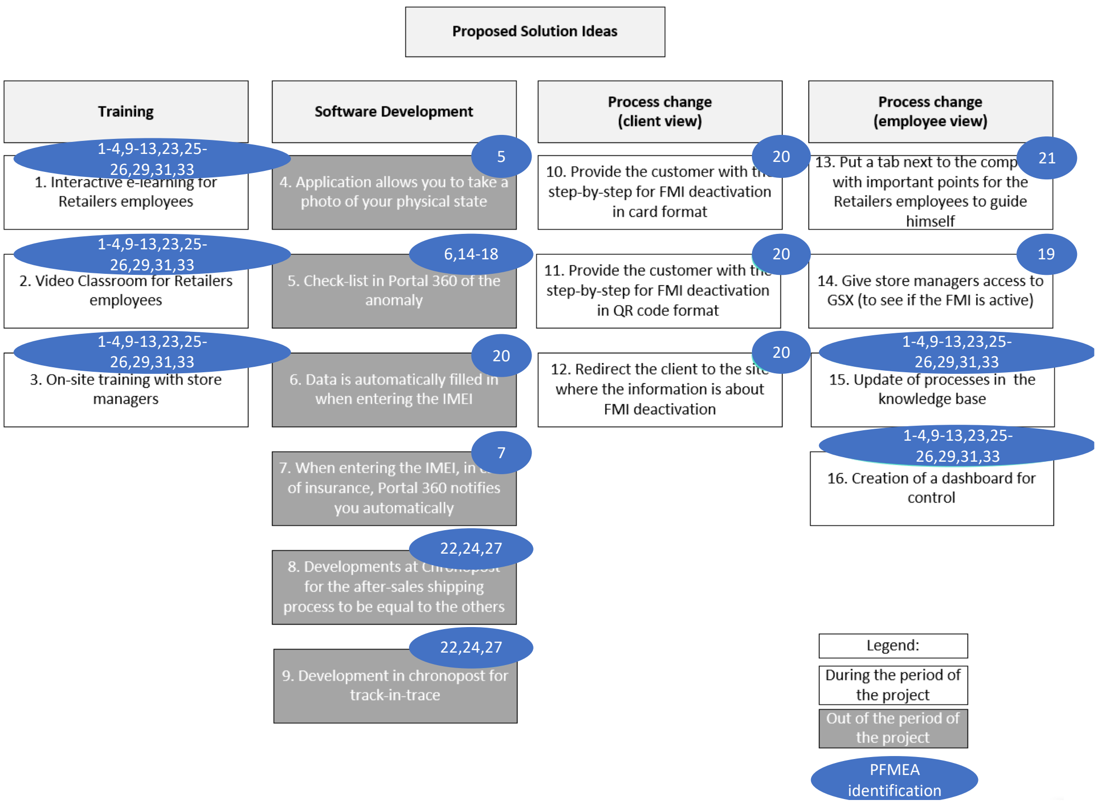


Figure 15- Affinity diagram

Before proceeding to implement all the ideas, it was necessary to evaluate them, with a twofold objective: firstly, to understand with the company whether the solutions were in line with its values and to choose those that didn't make sense to implement and those that were more important, and secondly, by presenting all these ideas, to show the company that there is still a lot that can be done to improve the operation (Figure 16). Therefore, the criteria chosen were:

- Sustainability performance: The company's ambition is to promote prosperity, create social, environmental, and economic change, achieve process optimization, and improve the capabilities of people and organizations. As such, a set of principles has been defined which form part of the sustainability policy. Given this company value, initiatives such as 10, 11 and 13 make no sense to implement.

- Value for Money: Given that the after-sales service does not give a financial return, it is difficult to justify to management that this solution needs to be implemented, depending on the strategy the executive committee has in mind. In this way, the options that require the most software development will not be prioritized, as is the case with software development (ideas 5 to 9).
- Low time requirements: The after-sales team is made up of only 3 people and the work is optimized, each person has their own tasks and the extra time they have is spent on new projects, so it's important to focus the team's work on relevant projects, which is why and taking into account the aforementioned obstacle, software development ideas would cause the team to spend a lot of time trying to justify the need for this investment to management and therefore consume the team's time.
- Not dependent on third parties: Bearing in mind the diversity of projects and daily tasks that all NOS operations staff carry out, one of the criteria for choosing the best solutions are those that are not dependent on people outside the after-sales service. Based on this criterion, the training programmers (ideas 1 to 3) turn out to have a weak point.
- Integrate issues outside the scopes: The solutions generated by employees working with the after-sales service have more value if they manage to incorporate more areas of the company.
  No loading required: Operations are in a constant state of need to adapt to customer demand, which is why information needs to be constantly updated and therefore someone is needed to update it; solutions in which the after-sales team doesn't need to spend a lot of time updating this information are preferred.

When evaluating all the solutions on the basis of the criteria presented above, was chosen the learning, video classroom and on-site training, updating Knowledge Management (KM) processes, redirecting customers directly to the website and the dashboard. Using the prioritization matrix, allows to see that anything that required printing paper and putting it in the shops would not be implemented for sustainability reasons. And all the software developments cannot be implemented during the thesis period but will be incorporated into other company projects.

Criteria	Solution Options															
	1. E-learning	2. Video Classroom	3. On-site training	4. Application	5. Check-list	6. Automatic fields	7. Automatic warnings	8. Chronopost Update	9. Track-in-trace	10. Card with FMI info	11. QR code with FMI info	12. Redirect to the site	13. Tab with the process	14. Access to GSX	15. Knowledge base	16. Dashboard
Sustainability performance	●	●	●	●	●	●	●	●	●	□	□	●	□	●	●	●
Value for money	●	●	●	□	□	□	□	□	□	○	○	●	○	□	●	●
Low time requirements	●	●	●	□	□	□	□	□	□	●	●	●	●	●	●	●
Not dependent on third parties	○	○	○	□	□	□	□	□	□	●	●	●	●	□	●	□
Integrate isues outside scopus	●	●	●	□	□	□	□	○	○	□	□	●	●	□	●	●
No loading required	○	○	○	●	●	●	●	●	●	○	○	○	○	●	○	□
Total	**42**	**42**	**42**	**22**	**22**	**22**	**22**	**24**	**24**	**25**	**25**	**48**	**34**	**30**	**48**	**38**

Legend:

● 9 ideia fulfills criteria

○ 3 ideia somewhat fulfills criteria

□ 1 ideia does not fulfills criteria

Figure 16- Prioritization Matrix

With the actions chosen, the next step was to outline the action plans and contact the teams that needed to be informed so that the solutions could be implemented.

To get the training up and running, the Academy team that is responsible for the audiovisual content made available to employees was contacted to see if it was possible to develop training on the most worrying issues within the after-sales service. In three brainstorming and idea-sharing meetings, it was considered that, given the size of NOS and the number of teams working directly with the academy, although it made sense for the training to be implemented as soon as possible, it could only happen in stages. Appendix G contains the final version of the training content manual.

It was then decided that it would be given in two modules, the first dealing with the opening of the file in the shops, with topics such as insurance, FMIs, loan situations and technical checks.

The training was also used to demystify some of the issues that repairers and service center assistants complained about:

- The recurring referral of customers to CATs, with promises that it would be repaired on the spot.
- The obligation to switch off the security system on iPhones.
- The advice to managers to use the GSX as a way of realizing whether the iPhone had the FMI active when the note was opened.

The training took place in e-learning format, and each topic was presented in isolation. First the training, then the importance of after-sales service, mobile screenings, deactivation of the FMI, loans, the conditions for opening a repair note, and the conclusion (Appendix H). Finally, to make sure that all the visualizations created by the store owners were valid, a mini test was inserted (Figure 17).

Figure 17- Mini test with the aim of assessing the shopkeepers' knowledge of the compulsory subject matter

As part of updating the processes in the knowledge center, the continuous improvement team of NOS, was contacted about the matter and its urgency and after seeing the suggested changes, they agreed that the matter was relevant, as outdated, and incorrect information can lead to errors in operations that impact the organization at various levels. All procedural changes were properly communicated both through training and in the knowledge base. The creation of the dashboard will be explained in the control phase, in greater detail.

Finally, Figure 18 describes each action plan, as well as a brief description and status. This includes the implementation date and, if it has not yet been implemented, whether it is in the company's plans to do so and when.

Action	Status
1.1 E-learning	Implemented on May'23
1.2 E-learning	Plan to be implemented in September'23
2. Video Classroom	Implemented on May'23
3. On-site training	Plan to be implemented in September'23
4. Application	On hold
5. Check-list	On hold
6. Automatic fields	On hold
7. Automatic warnings	On hold
8. Chronopost Update	On hold
9. Track-in-trace	On hold
10. Card with FMI info	Not approved
11. QR code with FMI info	Not approved
12. Redirect to the site	Implemented on May'23
13. Tab with the process	Not approved
14. Access to GSX	Implemented on May'23
15. Knowledge base	Implemented on May'23
16. Dashboard	On hold

Figure 18- Actions proposed to the company and their status (those implemented, those yet to be implemented, those on hold and those not approved).

4.5.5. Control phase

For the control phase, the months of June, July and August were considered because the training was implemented in May, as well as the changes to the knowledge base and the obligation to decommission the FMI. The Control phase takes center stage, meticulously designed to monitoring and control he work done in the stores with the repair case notes.

Team building was introduced to promote the sharing of values. Around 340 module one (about the note repair opening) trainings were viewed during the control period (June to August), so as not to overload tenants the second module (about the expedition process) of training will be launched in September and given that it is a compulsory training like the first module all tenants attended. In the future, the management team is considering continuing to provide training of this type for problems that come up through customers or that they identify on the dashboard.

The PFMEA analysis identified several steps in the repair process which, in addition to affecting the Total Cycle Time, also affected customer satisfaction and the number of calls made to the helpline. Bearing in mind that the company had data on some of these metrics, the ones to be monitored throughout the project were chosen with the aim of improving them.

The catalyst for the design of this control plan is a meticulously conceived dashboard, designed to monitor the process's most critical key performance indicators. These are total cycle time, the number of pieces of equipment wrongly entered the system, loan rates and the No-Fault-Found (NFF) rate. However, it should be noted that this dashboard is prepared to exclude the recently introduced Voice of the Customer (VOC) model from its calculations, in line with the change that took place in November 2022.

Figure 19 shows the draft of the dashboard presented to the company, which will put it into practice. On this page, is possible to see the total figures for the whole operation, however, the idea is that by filtering by shop you can see the volume for the shop in question, there are some indicators that it is not possible to individualize the information:

1. It identifies the total number of repairs per month, and it is possible to identify the volume relating to each shop.
2. Total Cycle time is calculated from the time the customer hands their equipment over to the shopkeeper for repair until the equipment is returned to the shop repaired.
3. The VOC indicator, when the customer leaves the shop, they receive a call from NOS asking them to rate their experience with NOS on a scale of 0 to 10. This indicator will not be used in the metrics followed in this project because the VOC model has undergone significant changes during the project period, which does not allow the values to be compared. This indicator can be associated with the shop where the equipment was delivered.
4. The NFF Rate corresponds to the number of pieces of equipment that come in for repair for some reason that the customer complains about and when they reach the repairer the anomaly is not detected, the formula for calculating this indicator is the number of pieces of equipment without a detected anomaly divided by the total number of repairs.
5. This indicator represents the number of pieces of equipment that have already been repaired and the shopkeeper, when checking in at the store, ends up doing this process incorrectly in Portal 360 (NOS' internal portal that works as a SAP front-end), it is possible to filter this information by store.
6. This graph represents the evolution of the volume of repairs, giving the management team a better view.
7. This graph allows the management team to see which 4 stores have an NFF rate of more than 50%, which means that more than half of the equipment didn't need to be repaired. When this

indicator was chosen, it was considered that it was more interesting to follow the stores with the highest volume in order do have a bigger impact.

8. As with number 7, this graph allows us to identify the 4 stores with the highest percentage of equipment entering the system incorrectly. This indicator is calculated by dividing the number of cases entering incorrectly by the total volume.
9. This graph allows the team to visualize the evolution of the VOC.
10. This graph breaks down the Total Cycle Time by stage of the process, from the dispatch from the store to the center, the time it takes to create the guide and transport it to the repair center, the time it takes the center to send the equipment to the external repairer in the case of an external repair, the repair, the time it takes to return from the external repairer, the dispatch from the center to the store and finally the time it takes the center to send it back to the store.
11. This indicator doesn't correspond to any subject in the project but given that the dashboard will be used to monitor the work done by the stores, a graph representing the volumes of stores that don't ma

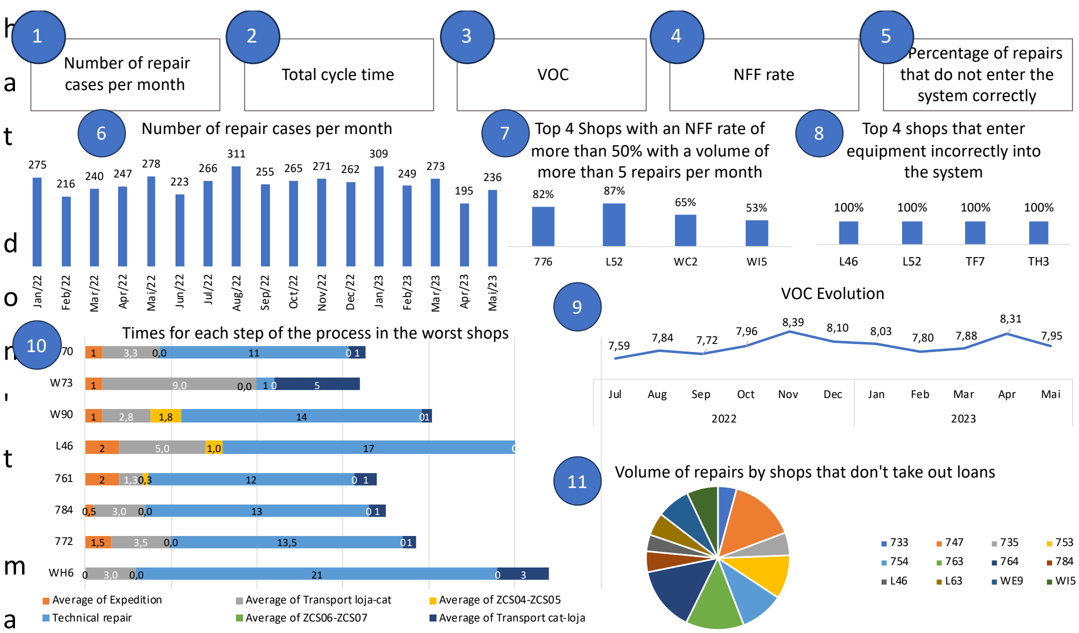


Figure 19- Draft of the dashboard to be implemented in order to monitor repair processes opened in the shop

ke loans to customers is included here.

4.6. Discussion of the results

One of the research questions is “"What" process improvements can be made to reduce the cycle time of the repair process?” and with this objective in mind, it makes sense that the main metric to be monitored in this project is Total Cycle Time. But as mentioned earlier, there are other metrics used by the company that make sense to measure. These range from the number of calls customers make to the helpline to ask for information about the status of the equipment's repair, to the number of calls from customers complaining because they don't agree with how long the repair is taking, percentage of equipment that does not present an anomaly to the repairer, number of equipment’s that were not correctly inserted in system and lastly the metric on which any change is only justified by the training and procedural changes made is the time it takes shopkeepers from opening the note to creating the guide.

A. <u>Total Cycle Time</u>

To determine the performance of the improved process, once the training of the first module, the updating of the processes in KM, and the procedural changes have been fully implemented, the data for the process time KPI from its opening in the store was analyzed over a period of three months (June - August 2023), which, as was done in the measure phase, will only take into account normal repairs (status SM31), relating to smartphones and those opened in the store. During this three-month period, 866 repairs were generated. As Figure 20 shows, 25% of the dataset has a TCT of 5 or fewer days, with 50% take 7 or fewer days, representing the median. Furthermore, 75% of the data demonstrate a TCT of 10 or fewer days, while 90% and 95% of the data set 14 or fewer days and 16 or fewer days, respectively. The highest value observed in the dataset reaches 36 days, with an average of 9.22 days

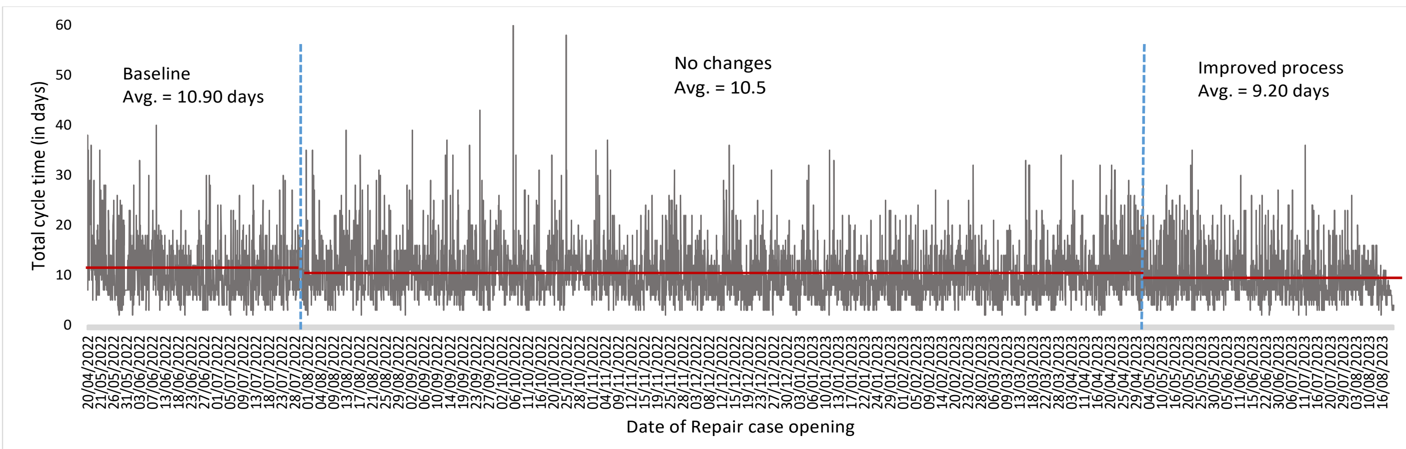


Figure 20- Performance of the repair process before and after implementation of improvements (solid lines represent sample means).

and a standard deviation of 5.88 days.

To gain a deeper insight into the reduction of repair cycle time, it is essential to break down the process into its constituent parts. The data presented in Figure 21 reveals two main factors that contributed to the reduction in total cycle time: Expetition times and Repair times. Surprisingly, the significant improvements in repair time can be attributed to the fact that the repairer has more information about the condition of the equipment, since awareness was raised among shopkeepers with training on the importance of giving a fuller description of the reason for the customer's complaint.

By focusing on reducing the time spent by store staff, both in terms of training and updating information, it is hoped that this will lead to a reduction in shipping inefficiencies. The results, shown in Figure 21, confirm this expectation. Shipping times have been reduced by 15 percent, which is irrefutable proof of the positive impact of this collaboration. Transposing the data from days to hours, the solutions implemented in the shop allow shopkeepers to save 1 hour and 18 minutes in the dispatch process for each repair, which on average, taking into account that there are 288 repairs in a month, represents approximately 374 hours that can be spent on more valuable tasks. These include dealing with front-office enquiries and/or tidying up the back-office space.

In addition to the reduction in time, there are other metrics that can be used to measure the

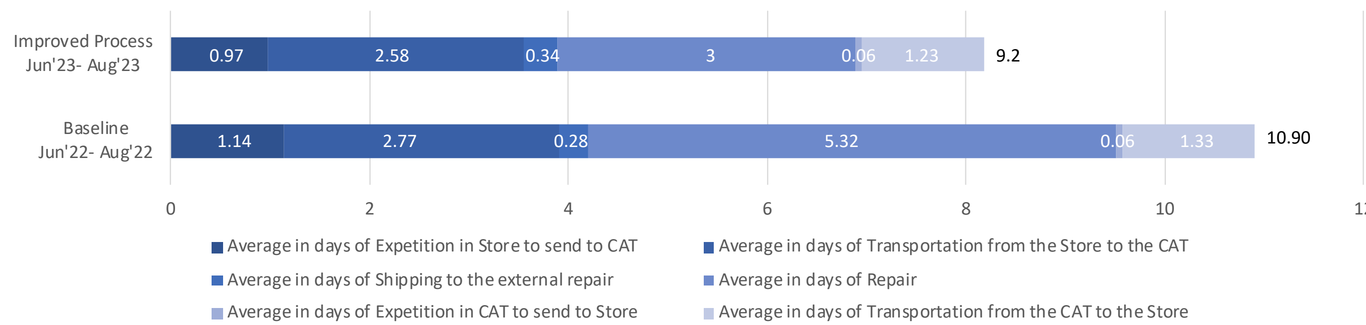


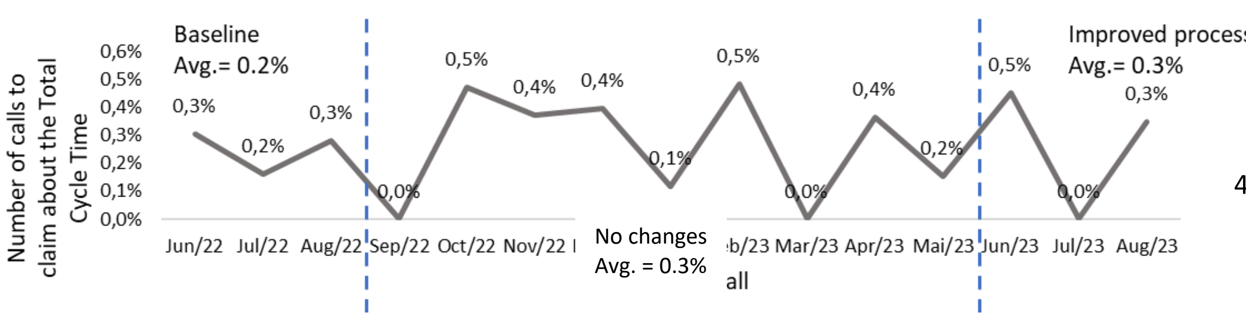
Figure 21-Performance of the repair process shared by the process parties before and after the implementation of improvements.

performance of tenants, such as the NFF rate and the percentage of equipment that has been incorrectly registered.

B. <u>Number of calls</u>

Efficient customer service is a vital part of any business, and one way to measure its effectiveness is to examine the ratio of customer calls to the number of repair requests. This ratio provides valuable insight into customer satisfaction and the need for improvement in repair processes. In this case, the ratio between calls and repairs was analysed, with a particular focus on complaints and information requests, to understand the dynamics of customer interaction in the context of total cycle time. Importantly, this ratio is examined in relation to the month in which repair notes were opened, allowing us to understand how many repairs prompted customers to call, either to voice complaints or to seek information.

When it comes to complaints about repair services, one would naturally expect this number to decrease as Total Cycle Time improves. However, it's important to consider the context. In the baseline period, the number of complaint calls was not particularly high, which means that even though



improvements have been made, major changes in this indicator may not be readily apparent. Figure 22 above illustrates the trend in complaint calls. Although there is an increase in the number of complaints by an average of around 0.1 percentage points, it is still possible to say that the company was already providing a reasonably satisfactory repair service.

Calls made to inquire about the status of repairs are another crucial aspect of customer interaction. It is notable that in both June 2022 and June 2023, the number of information-seeking calls was higher compared to other months. However, it is equally important to highlight that there has been a slight overall reduction in the number of such calls over time. Figure 23 above demonstrates the fluctuation in information-seeking calls, with a slight decrease observed over the analysis period. While the increase in

Figure 22-Number of total repairs resulting in a call to complain with repair time before and after improvement proposals are implemented

June can be attributed to seasonal factors or specific customer behaviors, the gradual reduction suggests an improvement in the transparency and communication of repair status information.

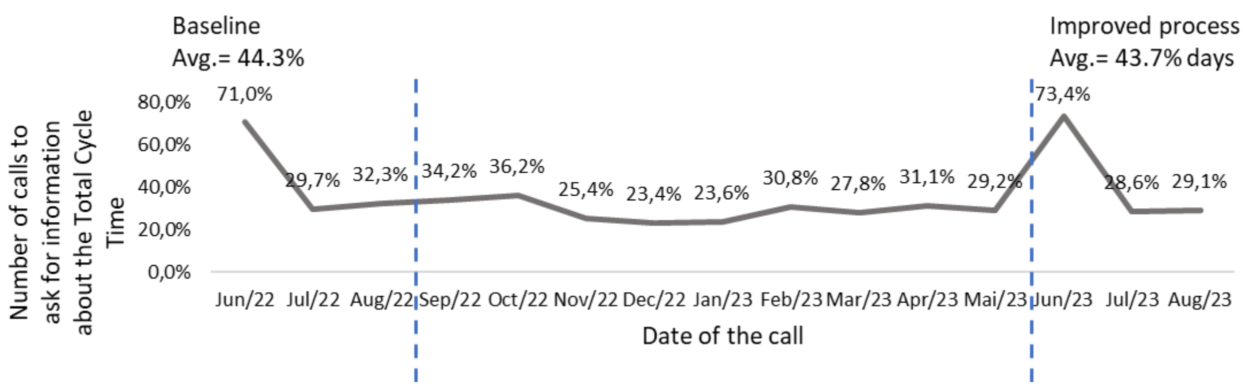


Figure 23- Number of total repairs that result in a call requesting repair time information before and after improvement proposals are implemented

C. <u>NFF Rate</u>

The NFF rate is a key performance indicator that quantifies the percentage of equipment sent in for repair where either no anomaly is detected, or the issue is resolved through a simple software update. It offers insights into the efficiency of repair services, as a high NFF rate can indicate unnecessary costs for the company and customer inconvenience.

To tackle the challenge of high NFF rates, the company implemented training programs aimed at equipping shopkeepers with the necessary skills to address customer issues efficiently. One of the training sessions revolved around conducting mobile checks on customers' equipment before initiating a repair note. The objective was to determine if the issue could be resolved in-store, saving the customer time and hassle when it's merely a matter of a software update.

Additionally, training emphasized the importance of thorough anomaly description in Portal 360, a crucial tool in the repair process. The intent behind this emphasis was to provide repairers with comprehensive information to understand and resolve anomalies effectively. The expectation was that this training would lead to a decrease in the NFF rate.

Figure 24, shown below, illustrates the evolution of the NFF rate over the control period, comparing it to the period after the implementation of training and process enhancements. As depicted in Figure 24, during the control period, the NFF rate was lower, having fallen by 1.03 percentage points. This reduction signifies a positive outcome, suggesting that the training on mobile checks and anomaly

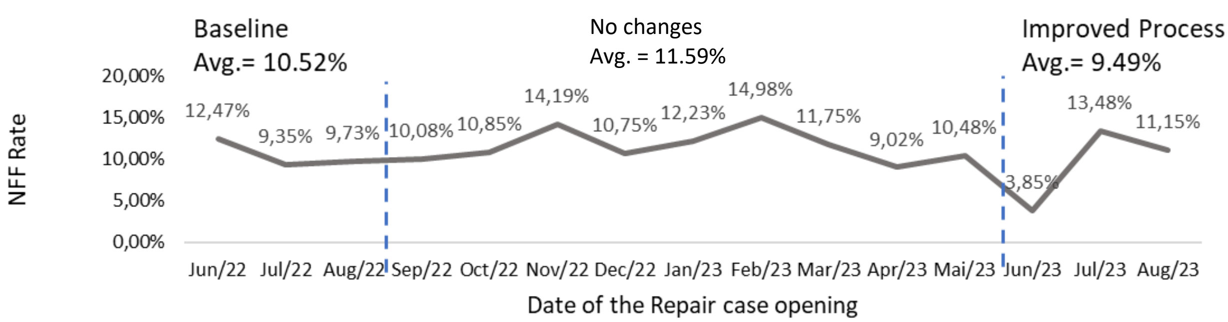


Figure 24- Number of repairs opened in the store that have no anomaly or that only had a software update performed before and after the improvement proposals were implement.

description in Portal 360 has had a noticeable impact on decreasing the NFF rate.

D. <u>ZCS08</u>

One of the most glaring inefficiencies identified in the shop-initiated processes related to equipment that had already been repaired but was incorrectly accepted by shopkeepers. This problem could be reduced if the second training module on receiving repaired equipment was implemented, but this has not yet been done. However, it was recognized that the opportunity for improvement could also lie in updating processes and raising awareness among shop managers.

To identify this inefficiency, it as used SAP, which plays a crucial role in keeping track of equipment as it enters and leaves the CAT/Shop/Repairer. Analyzing the data revealed that although it was possible to determine precisely when the equipment was delivered to the customer, one piece of the puzzle was missing - the check-in at the shop, represented by field ZCS08.

The missing information in the ZCS08 field indicated that shopkeepers had not made this entry correctly, leading to potential errors in the repair process. To quantify the scale of this problem, an indicator was calculated - the ratio between the number of notes without information in the ZCS08 field and the total volume of repairs. As Figure 25 shows, analyzing the data revealed a significant improvement in this indicator during the control period, compared to the baseline of the same period the previous year. Specifically, there was a notable drop of around 1.17 percentage points in this inefficiency. The greater accuracy of ZCS08's field entries means a significant step towards optimizing shop operations.

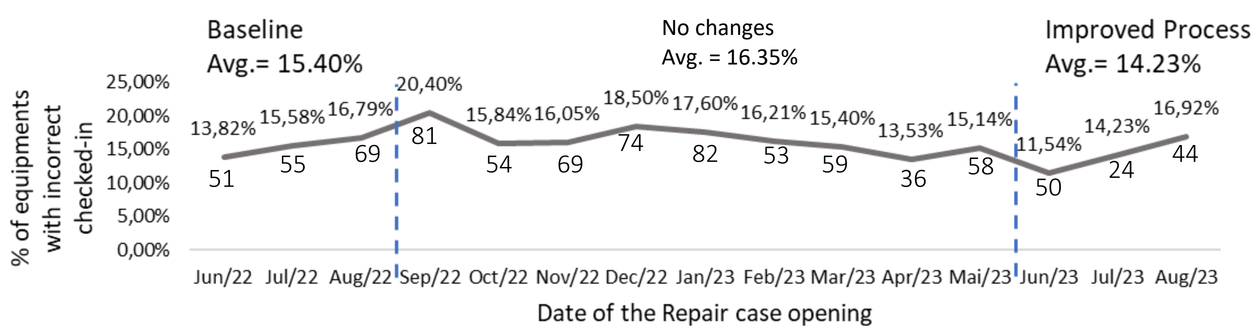


Figure 25- Number and percentage of equipment that, when repaired, arrives at the store incorrectly enters the 360 Portal before and after improvement proposals are implemented

By closely monitoring key performance indicators and implementing specific strategies, it was possible to reduce total cycle time, improve interactions with customers and reduce inefficiencies in open repair processes in shore. This data-driven approach will continue to be monitored by the management team in order to improve operational efficiency and customer satisfaction in the future.

As mentioned in the introduction, cycle time reduction can lead to improved customer satisfaction and retention, but at NOS the existing customer satisfaction surveys (VOC) are very general and no question in the survey asks directly about repair service, and given that it was changed during the project, it will not be considered as an indicator because there is no value before and after implementation.

Figure 26 summarizes the metrics analyzed to assess the project's performance and its impact on after-sales service operations.

	Metrics	Baseline *Jun22-Aug22*	Control Phase *Jun23- Aug23*
Times	Repair time from opening the note until you are in the shop repaired	10.90 days	9.20 days
	Shipping time in the store	1.14 days	0.97 days
Customer inbound calls	% of customers calling to enquire about repair status by repair volume	44.3%	43.7%
	% of customers who call to complain with the complaint time per volume of repairs	0.2%	0.3%
NFF Rate	Percentage of equipment that does not present an anomaly to the repairer	10.52%	9.49%
ZCS08	Number of equipments that were not correctly inserted in system	15.40%	14.23%

Figure 26- Project performance metrics before and after improvement proposals are implemented

CHAPTER V

Conclusions

This chapter presents the final results considerations from the project, the methodological conclusions, the contributions to the company, the limitations experienced over the course of the project, as well as some suggestions for future work.

5.1. Final considerations

In the context of NOS' operations, the main aim of this project was to improve processes in order to make the operation as efficient as possible. To improve the process, the existing historical data and all phases of the process were first analyzed. During the collaboration with the NOS employees and the data analysis, it was realized that the processes that required more detailed work were those that depended on the shopkeepers and, once the problems had been identified, it was analyzed which ones had the greatest impact on Total Cycle Time and then they were ranked. Once the points for improvement had been identified, a list of solutions was drawn up for the category of training, software development, changes to the process, for the client and for the shopkeeper. All these suggestions were aimed at gaining a greater competitive advantage by offering greater operational efficiency.

To this end, one of the training modules, the modification and updating of processes in the company's knowledge base and finally the creation of a dashboard was implemented during the project period.

To measure this impact, results were obtained on the total repair cycle time, the number of calls to complain about the repair time or request information, the number of devices that went in for repair and didn't need to be repaired and finally the number of devices that weren't introduced correctly in Portal 360. It was concluded that the results measured in the control phase were positive and that the repair process cycle was reduced by 15 per cent compared to the same period last year.

With regard to the partial objectives initially defined for this project, it can be seen that almost all of them have been met in full, since what was defined in the define phase was for the TCT to be reduced to less than 10 days for all cases, and in this case, only 75% of cases wait that long.

Finally, the two major questions that were defined to help fulfil the objectives were also answered during the course of the dissertation. The first, which asked “"What" is the composition of the cycle time of the current repair process?”, was answered by identifying the waste in the repair process flowchart and, in addition, by studying the times. The second question, which sought to find out “"What" process.

5.2. Methodological conclusions

As presented in the literature review of the after-sales service, reducing internal times as well as better utilization of assets has allowed the background work to be more productive and ultimately reduce costs.

This project demonstrated how structured approaches to process improvement, such as the Lean Six Sigma methodology, can support organizations in achieving further performance improvements. By using Lean-oriented process analysis tools/methods within the framework of the DMAIC approach, an after-sales was able to further reduce repair cycle time by importing the work of shopkeepers even when faced with a variety of issues that they deal with.

The defined structure of DMAIC, and the surrounding dynamics of action research, helped give direction to the investigation, in this case like the cases presented earlier in the literature review, not only the reduction of the process cycle, but also the involvement of the company's management in the shopkeepers' operations.

The set of iterative cycles meant that after each cycle something important was learnt that was used as a basis for the next cycle, in the second phase of the project it was learnt that there was no such thing as seasonal, and knowing this in the second phase it was possible to focus on data measurements for example. produces knowledge that can deepen understanding, improve practice, and extend theory.

5.3. Company contributions

This project has yielded significant contributions to the company's operations and the dynamics between the after-sales team and shop management. Prior to this initiative, it was evident that the after-sales team had limited influence over shop operations, resulting in challenges in maintaining control over shopkeepers and their repair processes, which accounted for a substantial portion of the company's workload. The complexity of shopkeepers' tasks made it difficult to provide them with dedicated after-sales training, even though it was deemed important by the academy. However, by establishing direct communication channels with retail shop managers and the Academy, a vital connection was forged between after-sales service and shopkeepers, bridging the previously existing gap.

Moreover, the project introduced crucial process changes, such as the mandatory deactivation of the FMI, granting shop managers access to GSX, and providing information on FMI deactivation on the website. These changes have relieved shopkeepers of excessive customer-related responsibilities, enhancing their confidence in handling repair processes, which was a previously overlooked aspect. The implementation of a dashboard has empowered the management team with an operational overview, enabling prompt problem resolution and efficient communication with shop managers. This not only lightens the workload of the line team but also streamlines communication, fostering a faster and more effective response to recurring issues. The company's commitment to these changes signifies a positive shift towards a more integrated and responsive approach, ultimately benefiting both customer satisfaction and operational efficiency.

5.4. Limitations and future research

During the realization of this project, some limitations were experienced that directly or indirectly influenced the course of the project and the results obtained. The main limitations include the dependence on the company for the improvement proposals to be implemented, the limitations of the software, changes in the team structure, the size of the organization and the diversity of issues that tenants deal with on a day-to-day basis. In addition, the management team made some changes during the project period that could influence the results, in the real context of the labor market circumstances change on a daily basis. In addition to the limitations mentioned above, access to data was often limited and so it was not possible to carry out further analyses.

In terms of future research, comparative studies should be considered to broaden the applicability of the results, carry out studies with a longer control period to capture long-term impacts, delve into effective change management in dynamic environments and explore innovative engagement and commitment strategies to overcome resistance to change. By addressing these areas, researchers can advance the understanding of the applicability and effectiveness of Action Research in diverse organizational contexts, ultimately improving its usefulness as a problem-solving approach.

CHAPTER VI

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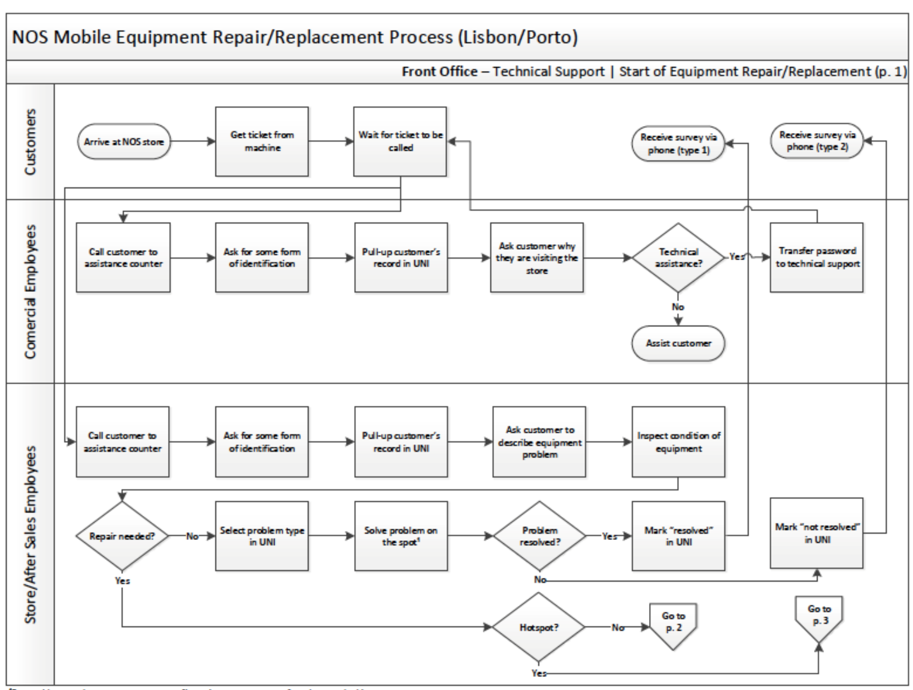
CHAPTER VII

Appendix

Appendix A- Process mapping in the “Reduce the cycle time”

The detailed mapping of the mobile equipment repair process contributed to a better understanding of the process and to visualizing the challenges faced that required further investigation.

The general process initiates with the customer arriving to the store to deliver their damaged equipment. After verifying that the equipment needs repair the front office employee will create a repair order with or without a loan equipment (this equipment is given to the client temporarily while their equipment is being repaired), and it is at this moment that the “creation repair case " (the moment from which the total cycle time starts counting). To continue the process, you need to identify where the equipment is, whether at the CAT or in the shop. If the equipment has been received at the CAT front office, is necessary to bring to the back office and place it on the corresponding shelf, and at the very moment the repair case is created, the "Work order created" also takes place, since the equipment is already with the technical assistance team and if it is a internal repair, it is ready for intervention (Figure 27 and Figure 28).



[1]For problems such as usage support, configurations, content transfer, phone unlocking, etc.
UNI – Front Office Service Platform

Figure 27- Detailed view of the billing process (Insurance verification and create repair order)

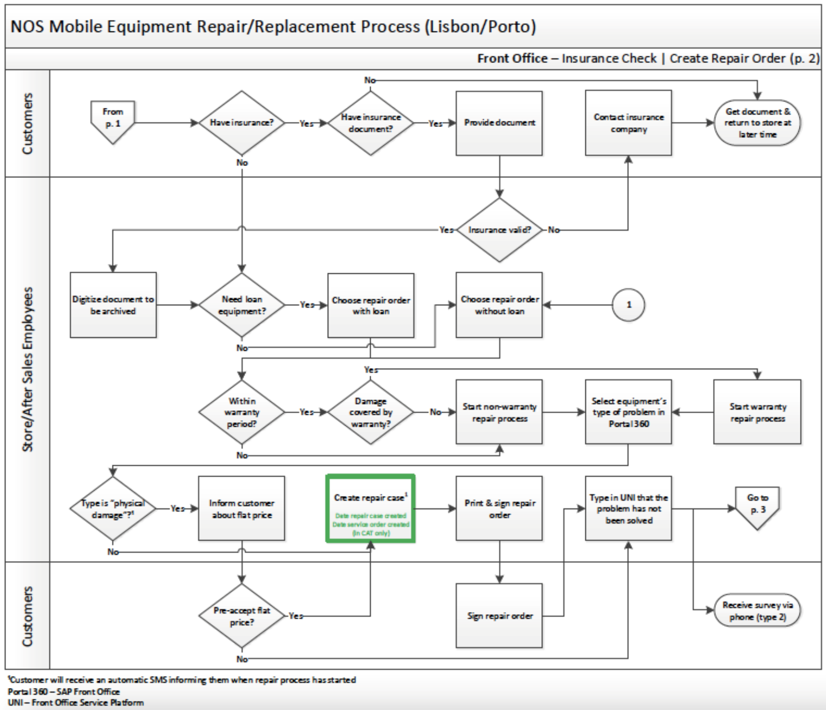


Figure 28- Detailed view of the billing process (Customer enters shop to pick up specialised service ticket)

Already if the equipment has been delivered in shop, it needs to be sent to the CAT by the carrier (DPD), through transaction ZCS03 in SAP, where it is received and its status checked, through transaction ZCS04 in SAP (Figure 29). The "Service order created" also takes place in this moment since the equipment is ready to be repaired.

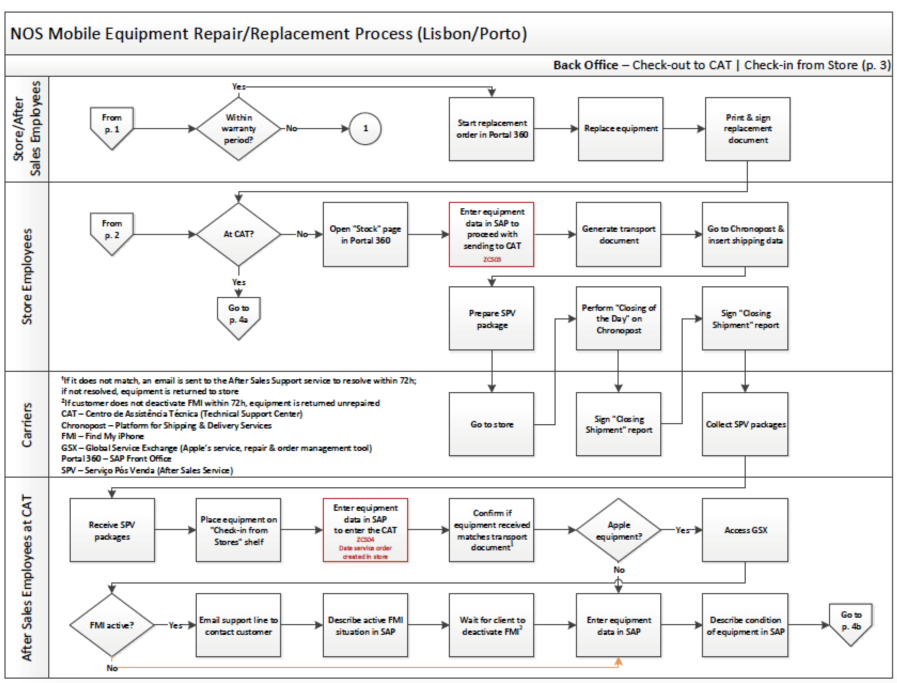


Figure 29- Detailed view of the billing process (*Check-out for repair)*

To start the repair process, it is essential to identify which equipment must go for external repair and which will follow the in-house repair process. Apple equipment is identified so that they cannot be sent for external repair (internal repairer cannot repair Apple devices, as it is mandatory to send them to the external repairer), beyond that, it is possible that the internal repairers identify that they are not able to carry out the repair, either because they do not have enough parts or they are repairing equipment and, in both cases, end up sending the equipment for external repair (in this situation, that equipment will also follow the process of check-out to external repairer) and all other equipment prescribes for internal repair. At this stage of the process, Apple stands out from other brands because it is necessary that the location system (Find my iPhone (FMI)) is turned off and in case it is active the process is in stand-by.

Apple and other equipment that do not qualify to be repaired internally, will then be sent for external repair, throughout the check-out process to the external repairer, through transaction ZCS05 in SAP (Figure 30).

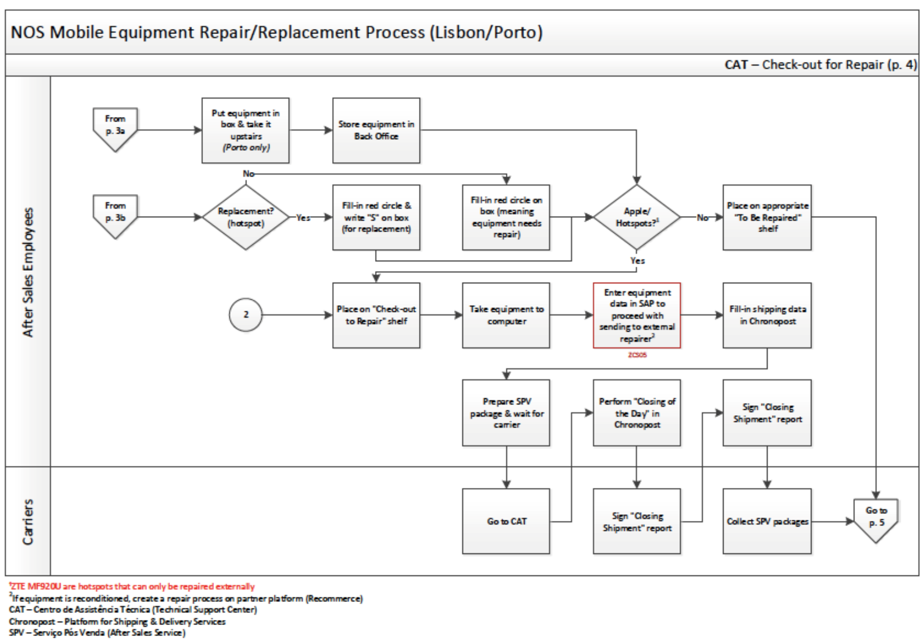


Figure 30- Detailed view of the repair process (*Check-out in store to CAT and check-in in CAT from the store)*

The repairers will then proceed to repair the equipment, according to the equipment's warranty status. Both internal and external repairers follow the same steps, so they are shown on the same track (Figure 31).

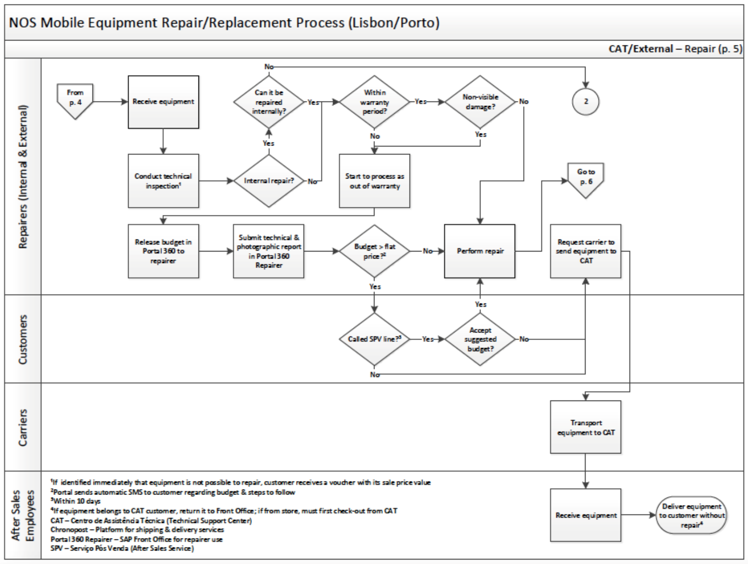


Figure 31- Detailed view of the billing process (*Repair (internal or external)*)

After the repair is completed, the equipment is sent back to CAT. At CAT, if the equipment was repaired externally, the employees receive the equipment, through transaction ZCS06 in SAP, which at the same time translates into “Date service order closed”, since the repair is finished. However, if it was repaired internally who "closes" the repair and submits the repair report is the internal repairer that is already in CAT (Figure 32).

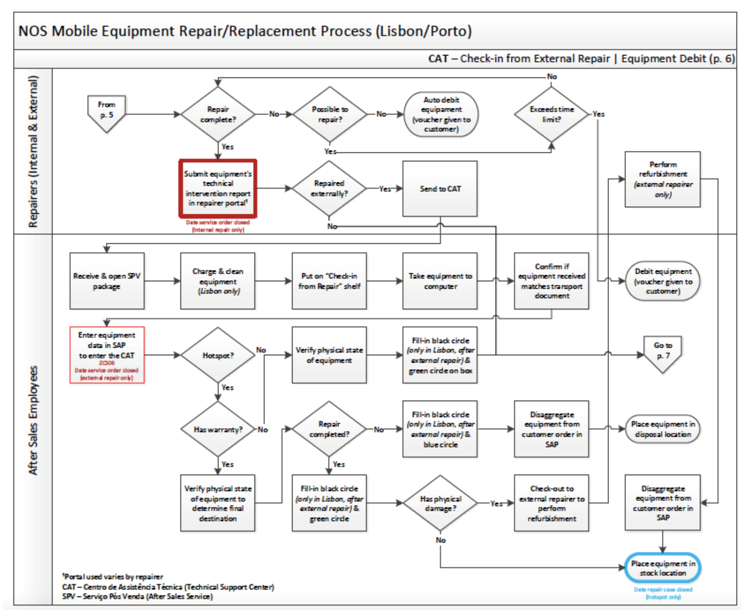


Figure 32- Detailed view of the billing process (*Repair process and CAT check-in of repaired equipment from the repairer (internal or external)*)

After the conclusion of repairs, all equipment received in stores is returned to the stores of origin, and so in these cases the equipment is shipped from CAT, through transaction ZCS07 in SAP. When it is received in the store, the team does it through transaction ZCS08 in SAP.

The process ends when the repaired equipment is picked up by the customer and regardless of the channel in which it is done the transaction is "Date repair case closed" (Figure 33).

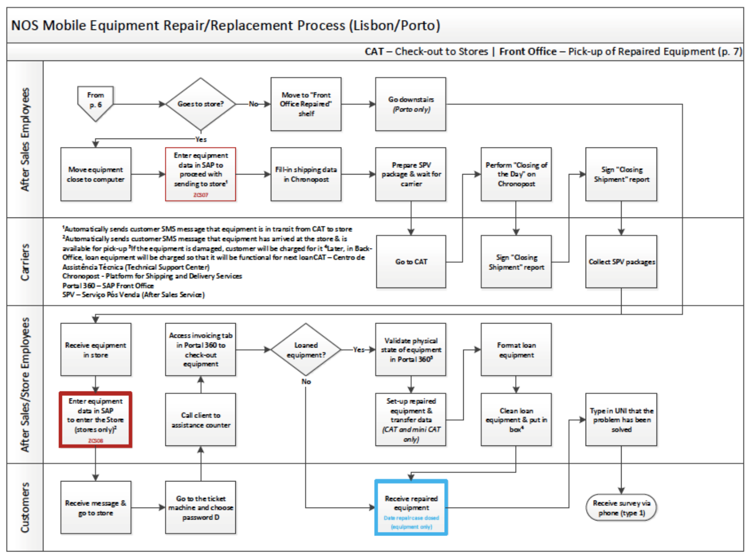


Figure 33- Detailed view of the billing process (Check-out of repaired equipment from to the shop and check-in of the shops)

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Appendix B- Transactions used in SAP and the corresponding action that triggers them

Action	Transation	Description
Customer drop-off	Repair case created	Customer drop-off (CAT and Store)
Send to CAT	ZCS03	Sending unrepaired equipment from the shop to the CAT (only Store)
Check-in CAT	ZCS04	Receipt of unrepaired equipment at the CAT from the shop (only CAT)
Beginning of the intervention	Service order created	In the case that the equipment was delivered by the customer in shop the intervention starts when enter in the CAT, in the case of CAT it starts in the moment that is delivered in front-office
Send to external repair	ZCS05	Sending repaired equipment from the CAT to the external repair (only CAT)
End of the intervention	Service order closed ZCS06	Whether it is an external or internal repair, this is the moment when the repair is finalised. In the case of external repair, the reception of repaired equipment at the CAT from the external repair
Send to store	ZCS07	Sending repaired equipment from the CAT to the store (only CAT)
Arrive at store	ZCS08	Receipt of unrepaired equipment at the store from the CAT (only store)
Customer pick-up	Repair case closed	The customer is notified that the equipment has been repaired and goes to the same place where he took the equipment during the first interaction

Figure 34- Description of each transaction in SAP with the corresponding action.

Appendix C- Number of repeated measures per process

	Cases Obs.	
Action/Code	**Store**	**CAT**
Repair case created	4	15
ZCS03 (store only)	3	
Service order created (ZCS04 – store only)	28	28
ZCS05 (external only)		22
Service order closed (internal)		23
Service order closed (ZCS06 – external)		20
ZCS07		19
ZCS08 (store only)	30	
Repair case closed	4	13
Total	**69**	**140**

Figure 35-Number of repeated measures per process.

Appendix D- Sample size based on filters used

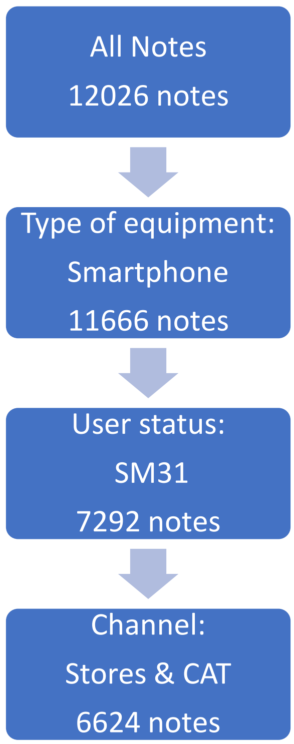

Figure 36-Filters used to arrive at the baseline and their respective note numbers.

Appendix E- Data analysis

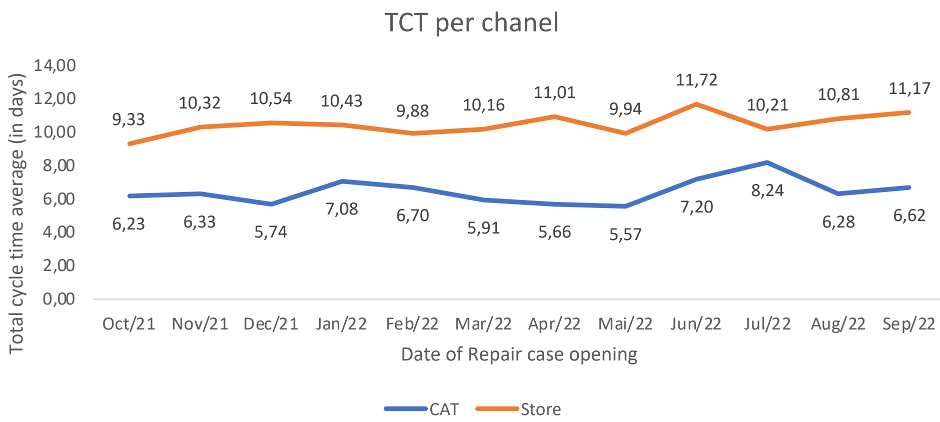

Figure 37-Evolution of the average Total Cycle Time over the months according to the input channel

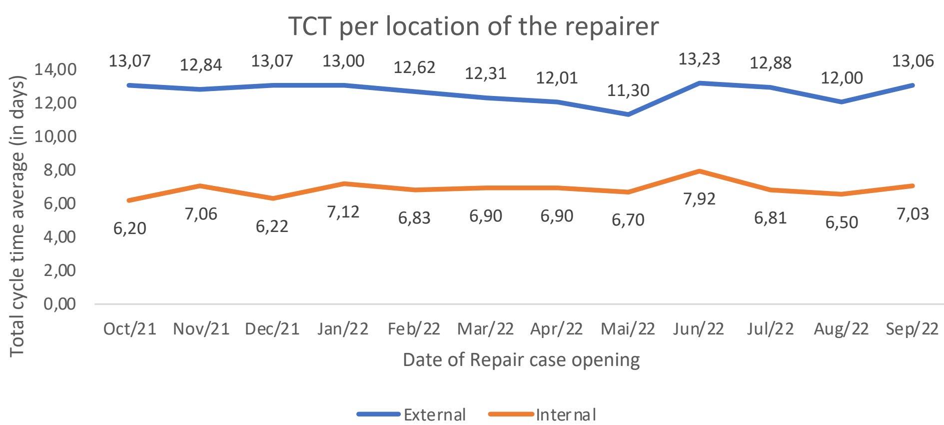

Figure 38- Evolution of the average Total Cycle Time over the months according to the location of the repairer

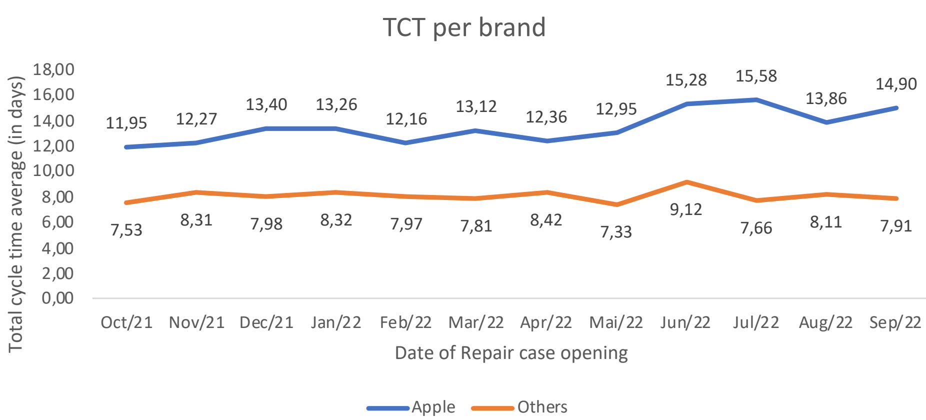

Figure 39- Evolution of the average Total Cycle Time over the months according to the brand

Appendix F- Description and presentation of the process analysis carried out using the FMEA tool

Process Step 1: “Ask customer to describe equipment problem(s)”

When the customer visits the shop to deliver his equipment to be repaired, the shopkeeper must typify the type of problem of the equipment in Portal 360, and in this step 1) the customer due to lack of knowledge about his equipment may explain himself badly and the problems are not identified in Portal 360, or 2) even if the customer describes the reason for the malfunction correctly, the shopkeeper may not describe them, which is reflected in incomplete information in Portal 360 that the repairer takes into account in his intervention .

Process Step 2: "Inspect condition of equipment”

When inspecting the condition of the equipment, the shopkeeper should make the breakdown, where he identifies if what the customer complains about are situations that he can solve on the spot, or if it will be necessary to resort to repair. As shown in Table 3, the lack of time available on the part of the shopkeeper to carry out a complete analysis of the equipment's condition triggers one of two situations: in the first scenario, the shopkeeper does not open the repair note when it is needed; in the second scenario, the opposite happens, the repair note is created when it is only a software update that does not require repair.

On the other hand, the lack of diagnosis of physical damage leads to the type of problem typified in Portal 360 being wrong later on, in this case, the equipment may have physical damage or damage by humidity, and by not being identified in this step of the process causes the process to be opened with warranty, when in fact it is not.

Process Step 3: "Customer has insurance?"

In this step of the process the shopkeeper asks the customer if the equipment they want to repair has insurance, the customer's lack of knowledge about their equipment, may cause them to reply that the equipment does not have insurance, when in fact it does, and the note is opened without insurance. Since any repair charge is covered by insurance, when the customer receives the quote and remembers that he has insurance after all, the situation needs to be regularized which translates into extra time for the process due to all the bureaucracy involved.

Process Step 4: "Insurance valid?"

In the Insurance verification, the lack of knowledge on the part of the customer and the shopkeepers about the insurance participation process leads to the bill being opened with insurance and with the situation regularized when it is not, which leads to the CAT team having to wait until the customer pays the deductible and the insurer accepts to proceed with sending the equipment for repair, translating into unnecessary waiting time.

Process Step 5: "Customer has insurance doc?"

In the case that the insurance is valid it is necessary that the loss document is attached to the equipment that follows to the CAT, the shopkeepers' lack of knowledge of this procedure means that when the CAT team receives the equipment it has to contact the customer and wait for the document to be sent so that the situation is regularised and the equipment is sent for repair .

Process Step 6: "Have customer select loan (same or lower category)"

When the customer wants to repair the equipment, the after sales service provides loaner equipment, and these are chosen based on the range of the customer's equipment. The shopkeeper has access to the range of the customer when he fills in Portal that the customer wants to borrow, and based on that must choose from the available stock in shop which to give to the customer, in case there are no equipment's of the same range as indicated the shopkeeper can lend the category below and not above,.

Process Step 7: "Select equipment problem type in Portal 360"

After verifying the equipment warranty, the shopkeeper must select the type of problem that the equipment has so that the CAT team and the repairer know the reason for the repair, in this step due to the wrong or incomplete choice of options by the customer, leads the shopkeeper to choose the wrong options in Portal 360, in this the equipment is sent to the repairer, who will only look at the identified anomalies. During the repair does not necessarily translate into added time to the total cycle time, however, the anomaly is not resolved, and the customer will return to the shop unsatisfied.

Process Step 8: "Write description about physical damage"

After selecting the type of malfunction, Portal 360 asks for a description of the physical state of the equipment, this is the step in which shopkeepers most make mistakes and which has more proportions in the shop, since the customer receives the repair document where the information about the state in which the equipment was delivered is available, the customer, on his turn, at the time of the budget or when picking up the repaired equipment at the final stages of repair, may allege that the equipment when delivered did not have those damages, and since the shopkeeper at the first contact did not describe those scratches or dents, the shop has no way to prove that the equipment was delivered like that.

Process Step 9: "Create repair case"

As a result of the faults incurred in the steps after the opening of the note, a repair note may be opened when in fact it is not necessary, which leads to time spent on the part of the repairer with this equipment that could be spending on other equipment that really needs repair.

Process Step 10: "Active FMI?"

If the equipment that is sent for repair is Apple, it is necessary to verify that the mobile phone's security system is not active, since iPhones are not repaired if the FMI is active. When the equipment is delivered, the customer should be informed of this procedure and if he is not able to do this deactivation by himself, the shopkeeper should help him to do it. However, the lack of time available to do this type of process often leads to this step being ignored and when this same equipment is received at the CAT, the team must contact the customer to turn it off by himself and wait for the customer to do it. Tenants when they open the repair note receive a reminder that they should turn off the security systems, however, even if they do not ignore this reminder tenants do not have access to Apple's platform that allows them to see if the mobile phone has the FMI active.

Process Step 11: "Generate transport document"

To start the request for shipment of the equipment to the CAT, the person in charge must access the Chronopost Portal to register a new shipment, in many cases considering that this process is different from the usual and that it requires more time to perform, the shopkeepers do not do it. Later, the support line controls these notes that were not dispatched and alerts the shop team of the process they must carry out and its importance. This failure causes equipment to be parked in the shop which contributes to the increase in Total Cycle Time.

Process Step 12: "Go to Chronopost & create the Transportation Scheduling"

Similar to the previous step, the creation of the transportation scheduling is a different procedure in aftermarket matters from those that shopkeepers are used to. So that the equipment is shipped from the shop to the CAT. In this way the equipment is not sent to the CAT until the situation is regularized with the help of the line.

Process Step 13: "Prepare SPV package"

Still on the process of shipping the equipment, the last step is to prepare green box and seal it with the white seals to ensure that the equipment is not damaged in the transportation to CAT. The back-office manager of the tenants' team must ensure that there is stock of these items, for two reasons, firstly because it is imperative that as soon as the customer enters his equipment for repair it is dispatched as soon as possible secondly because there is no inventory management of these dispatch products. Thus, due to lack of material the equipment is not dispatched and remains parked in the shop until conditions are met.

Process Step 14: “Enter equipment data in Portal 360 (ZCS08)”

The store operator, when checking in the repaired equipment at the shop, must make this entry through transaction ZCS08 on Portal 360. Due to unfamiliarity with the process and its consequences, the store operators make the entry of the equipment through another transaction. For the shopkeeper who does not know the after sales process there is no impact on the customer, but in fact this way the customer does not receive the message about the reception in the shop and the possibility of picking up his equipment. This problem does not translate into a direct increase in total cycle time, but from the customer's perspective the process took much longer.

Process Step 15: "Validate physical state of equipment in Portal 360”

In the case that there is damage to loan equipment, the shopkeeper should report it on the customer account so that the customer pays for the damage and the customer who uses it later has no reason to complain about it. The lack of knowledge of the process and time to do this detailed analysis leads to the equipment being in poor condition for use and the company is responsible for its costs.

Process Step 16: "Format loan equipment”

When the customer hands over the loan equipment, it is important that the shopkeeper erases his account and the available people data so that at the time the equipment serves its purpose again, the new customer does not have access to the previous customer's data. Once again, the shopkeepers' lack of knowledge and time to perform after-sales activities hampers their performance.

Appendix G- Content manual presented to the academy team (50 slides of content)

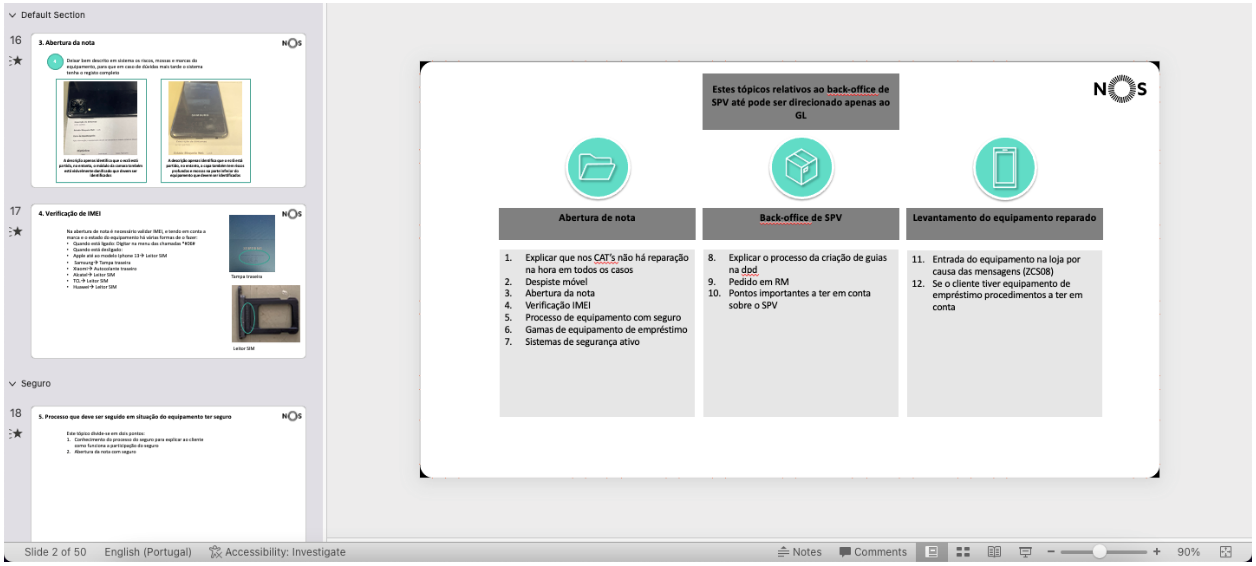

Figure 40- Examples of the slides sent to the academy team with the desired training content.

Appendix H- First training module

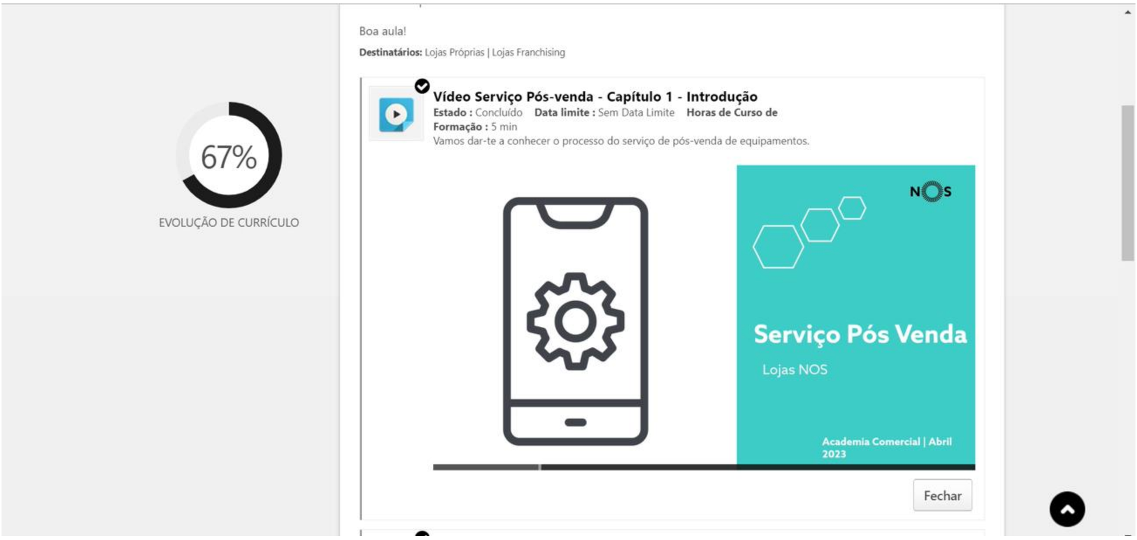

Figure 41- First e-learning lesson - Introduction

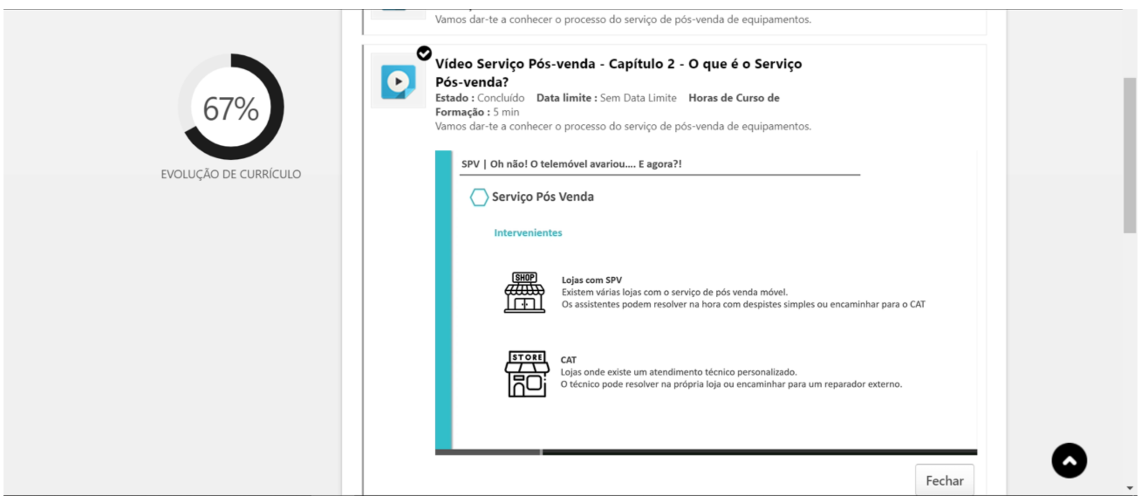

Figure 42- Second e-learning lesson - What is after-sales service?

Figure 43- Third e-learning lesson - Mobile screening

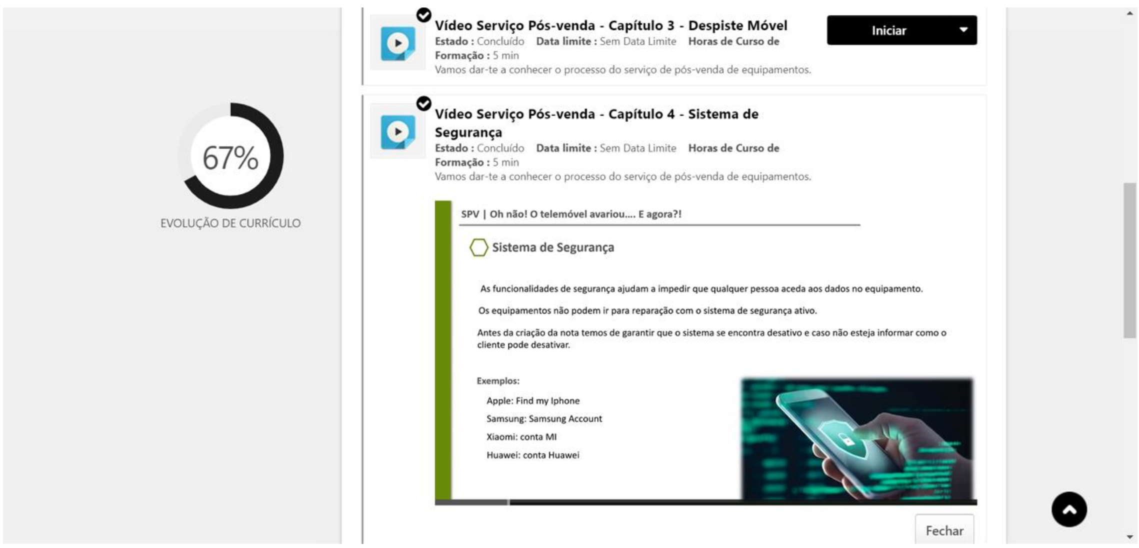

Figure 44- Fourth e-learning lesson - Security system- FMI

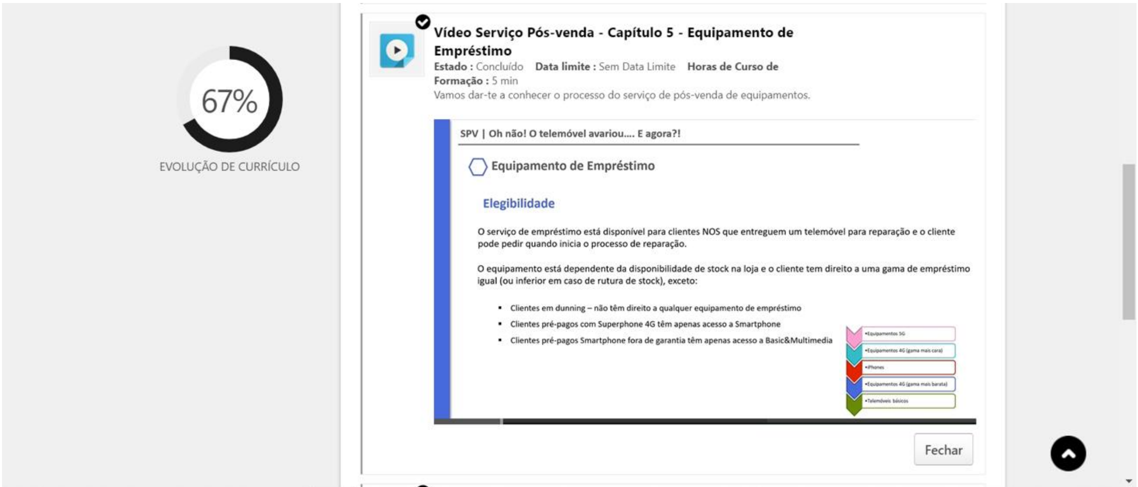

Figure 45-Fifth e-learning lesson - Loan equipment

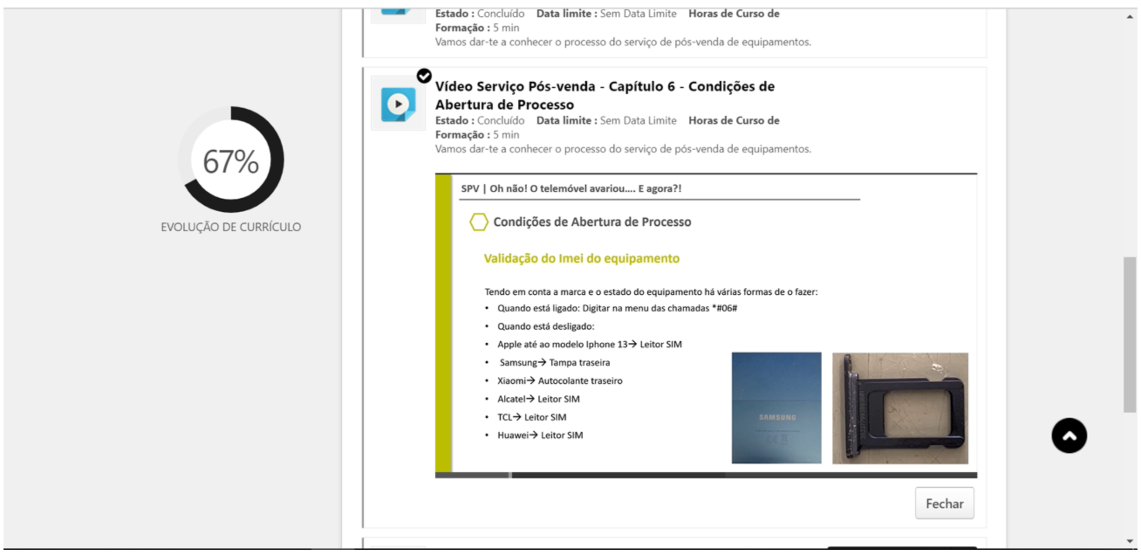

Figure 46- Sixth e-learning lesson - Conditions for opening a case

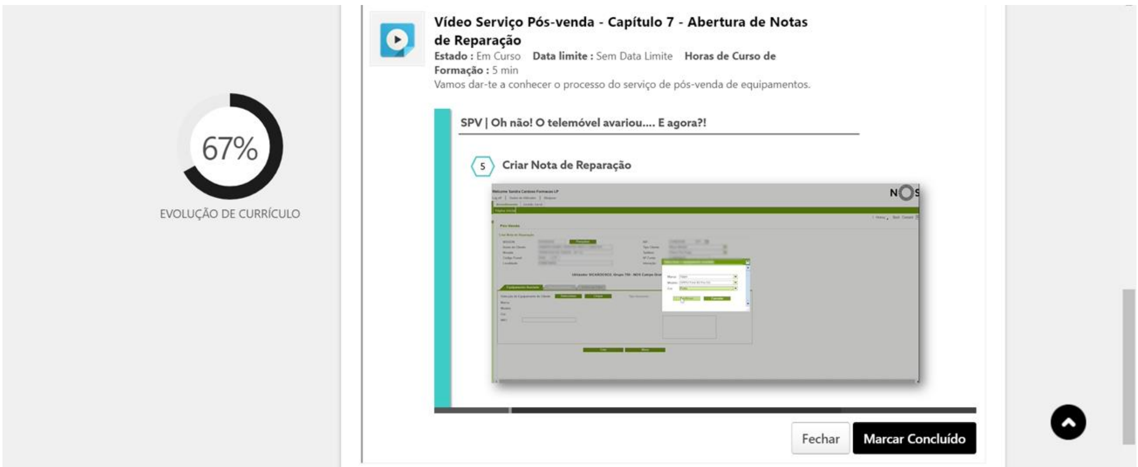

Figure 47- Seventh e-learning lesson - Opening repair notes

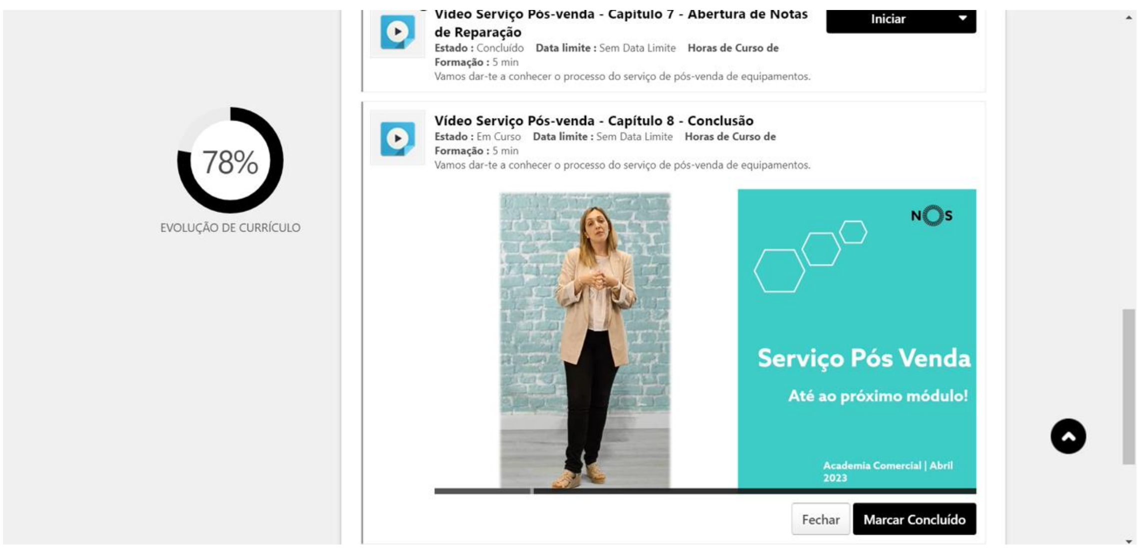

Figure 48- Eighth e-learning lesson - Conclusion