NOVA IMS Information Management School

MDSAA

Master Degree Program in

Data Science and Advanced Analytics

Impact of Automation and Visualization on a Toyota's European process

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Internship Report

presented as partial requirement for obtaining the Master Degree Program in Data Science and Advanced Analytics

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IMPACT OF AUTOMATION AND VISUALIZATION ON A TOYOTA'S EUROPEAN PROCESS

by

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Internship report presented as partial requirement for obtaining the Master's degree in Advanced Analytics, with a Specialization in Data Science

Supervisor / Co Supervisor: *prof Doutor Flávio Luis Portas Pinheiro*

July 2023

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledge the Rules of Conduct and Code of Honor from the NOVA Information Management School.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all the members of the Campaign Team of Toyota Motor Europe for their support and cooperation throughout my internship in Brussels. I am extremely grateful to my manager, Geert Mattheus, and my senior manager, Zsolt Gersey, for their leadership example and for the trust they placed in me since the very beginning. Additionally, I could not have undertaken this journey at Toyota without the help of my mentors, Julia Portao and Shambhuraj Sawant. They were always patient with me and guided me throughout the entirety of this project.

I would like to extend my sincere thanks to all the Toyota National Marketing & Sales Companies (NMSCs) that I had the pleasure of working with. Without their careful feedback and collaboration, the development of this project would not have been possible.

Lastly, I would like to mention my supervisor from Nova IMS, Flávio Pinheiro, for his thoughtful assistance and responsiveness. The advice provided proved to be essential for the writing of a more professional and competent academic dissertation.

ABSTRACT

This dissertation focuses on implementing automation and visualization in a Toyota's European process that ensures compliance and customer safety across Europe. The Campaign Team within Toyota Motor Europe (TME) plays a crucial role in this Request process. Given its significance to the company, it is vital to automate and optimize this process and create visualization tools to enhance effective monitoring and informed decision-making.

By incorporating the Toyota Business Process (TBP) framework, we defined thirteen steps for completing this project. We analyzed existing pain points in the Request process, set clear goals, proposed a To-Be process, and involved all stakeholders in tool development. To enhance efficiency, we relied on some concepts from the Toyota Production System (TPS), including *Nemawashi*, *Genchi Genbutsu*, and *Poka-yoke*.

As a result, we significantly reduced manual work performed by the Campaign Team every time a new request is issued. Additionally, we provided all National Marketing & Sales Companies (NMSCs) with a visual overview of the Request process. Other benefits were also implemented in this project, such as job standardization, information centralization, and enhanced communication between stakeholders and the Campaign Team. Overall, this dissertation presents a methodology that can be replicated for enhancing other Toyota's European processes.

KEYWORDS

Process Automation; Power Apps, Data Visualization.

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LIST OF ABBREVIATIONS AND ACRONYMS

BPM	Business Process Management
CEA	Customer Excellence Award
CQ	Customer Quality
DB	Database
KPIs	Key Performance Indicators
NMSC	National Marketing & Sales Company
PBI	Power BI
PDCA	Plan-Do-Check-Act
PIC	Person in Charge
QF	Quality Function
RPA	Robotic Process Automation
TBP	Toyota Business Practice
TME	Toyota Motor Europe
TMC	Toyota Motor Corporation
TPS	Toyota Production System

1. INTRODUCTION

The term “automation” refers to using software and technology to execute tasks or processes with minimal human involvement. While this concept is not new, advancements in fields like data science, machine learning, and artificial intelligence force us to consistently re-evaluate its impact (Van der Aalst et al., 2018). IBM makes a clear distinction between basic and process automation. Basic automation involves automating simple and repetitive tasks to minimize manual effort, such as extracting data, report generation, data processing, or email sending. Robotic process automation (RPA) serves as a prime example of basic automation. On the other hand, process automation is where a process is studied and redesigned to enhance efficiency, productivity, and cost reduction. This can be achieved through process mining, workflow automation, or Business Process Management (BPM). The utilization of these automated machines allows for the efficient and convenient completion of critical tasks that are either time-consuming or beyond human capabilities (Singh & Namekar, 2020). Nevertheless, Chui et al. (2016) stressed the importance of collaborative efforts between humans and machines, highlighting the need for individuals to acquire new skills in order to thrive in today’s rapidly changing work environment. Moreover, the concept of “data visualization” can be described as the process of presenting information and data in a visual format to aid understanding, enable effective monitoring, and enhance decision-making (Few, 2007). In other words, data visualizations turn datasets into visual representations that are more easily comprehensible for the human brain (Islam & Jin, 2019). Additionally, the choice of different data visualization techniques significantly impacts the effectiveness of dashboards in revealing insights (Guachi, 2018). Therefore, by selecting the appropriate data visualization techniques and by customizing them to better fit the end-users, it becomes simpler to identify patterns in data, recognize clusters, and detect outliers that are not obvious using non-graphical forms of presentation (Hilda et al., 2016).

This dissertation aims to explore the successful integration of automation and visualization in a car-manufacturing company such as Toyota to support a specific European process called Request process. Toyota Motor Europe (TME) is responsible for developing, manufacturing, and selling Toyota vehicles in Europe while overseeing 30 National Marketing & Sales Companies (NMSC). One of their most important commitments is to ensure maximum safety for their customers, which is partially secured by the Campaign Team inside the Quality Department. The Campaign Team is responsible for preparing, implementing, and monitoring campaigns in Europe to ensure compliance with regulations and customer safety. Given their significant responsibility, it is vital for the Request process to be automated and highly efficient to prevent the sale of defective vehicles. Additionally, the monitoring of 30 NMSCs can be extremely challenging and exhaustive, which is why the use of visualization can be a key factor. Having real-time visualizations and the ability to share interactive insights with all the stakeholders would greatly enhance the monitoring of the teams involved and facilitate informed decision-making within the Campaign Team.

To automate and visualize this Toyota’s European process, a project was executed during a 6-month period. In order to ensure that maximum safety and quality were always achieved, the Request process was thoroughly analyzed and dissected, and the four main pain points were identified. Next, a target was set on tackling the limitations found, and a To-Be process was proposed. After the initial development of the tool, feedback was gathered on improving its efficiency, and possibilities for

improvement were tested and implemented. The tool consists of a SharePoint site that centralizes all the needed information in one place, and that uses Power Apps to automate the unskilled manual work that still existed in the Campaign Team's daily work. Additionally, two Power BI reports were designed to quickly monitor all the teams involved and easily show the needed data to make important and informed decisions. Before implementing this tool, the User Guidelines were written, and tool trials and staff training took place to ensure everything worked efficiently. During the monitoring of the tool, we identified the limitations and the next possible steps. Finally, the back-end process was carefully documented to help tackle future problems that may occur.

The remaining of the document is structured into four chapters. Chapter 2 provides an overview of literature related to automation and visualization of business processes. In Chapter 3, the framework used for the project's development will be specified. Chapter 4 explains all thirteen steps of the project in order of occurrence. Lastly, Chapter 5 concludes the dissertation with final remarks, relevant considerations for the next steps, and the main limitations faced while developing this project.

2. LITERATURE REVIEW

In this chapter, we will cover some important considerations that we should be aware of before developing this project. These considerations are, of course, supported by previous studies on the same topics we are facing now. To facilitate its comprehension, we will divide this segment into two parts: one focusing on the automation aspect, and one aimed at the visualization capabilities.

2.1. AUTOMATION OF BUSINESS PROCESSES

First of all, let us explore the automation of business processes. By automating routine and repetitive tasks, you are able to improve efficiency, reduce errors, and improve customer satisfaction (Mishra, Devi, and Narayanan, 2019b). Moreover, Robotic Process Automation (RPA) plays a central role in this automation of processes. Pramod (2021) notes that RPA is a rapidly growing technology that has the potential to transform a wide range of industries, leading to cost savings and improved accuracy. Moreover, Moreira, Mamede, and Santos (2023) explored the various applications of RPA in different industries, such as finance, healthcare, and manufacturing. With that, the authors verified some of RPA's biggest benefits, such as its flexibility, scalability, and integration with existing IT systems.

However, automation also presents some limitations. Wewerka and Reichert (2021) state that the two major challenges are the need for specialized technical skills and the potential for future job displacement. Thus, the authors emphasize the importance of careful planning and implementation of automation initiatives and ongoing monitoring and evaluation to ensure their effectiveness. One additional limitation companies face is the lack of a culture of continuous learning and improvement supported by strong leadership and communication. Mishra, Devi, and Narayanan emphasize the importance of continuously redesigning processes for successful automation, noting that businesses should carefully evaluate their existing processes to identify their main pain points where optimization and improvement may be lacking. Furthermore, Mishra, Devi, and Narayanan (2019b) state that successfully implementing automation in the BPM industry requires a culture of innovation, collaboration, and continuous improvement. Finally, Micheler, Goh, and Lohse (2016) state that businesses with a culture of continuous improvement and openness to new technologies are more likely to implement automation successfully. They also point out that new technologies raise additional constraints, such as equipment costs and workers' training. Nevertheless, they strongly defend the idea that these challenges can be addressed through careful planning, stakeholder engagement, and a commitment to ensure skilled employees at all times.

As mentioned in the last paragraph, it is crucial to understand that people are also critical factors for successful automation. It is essential to highlight this and understand that the biggest limitations we face are not the technology itself but the mindset and skills of those who use it. Mishra, Devi, and Narayanan (2019a) defend that there should be a holistic approach between technology, people, and processes. Companies should never forget the role of humans in implementing successful automation, meaning that investments need to be made in developing their employees. Only this way will they be able to achieve their strategic goals and stay competitive in the rapidly changing marketplace that exists nowadays.

In addition to what was already discussed, Pramod (2021) advises not to forget the importance of developing ethical guidelines for the use of RPA to ensure that it is utilized in a responsible and

sustainable manner. The author adds that the exponential technological advance with which we are experimenting can lead to unethical scenarios. When building systems that automate business processes, it is vital that we do not forget that we are the ones responsible for the systems we develop, meaning that automation should always be implemented in a way that respects everyone involved. Martín-Navarro, Sancho, and Berro (2021) state that companies must always tackle data security and privacy challenges. These risks need to be carefully considered in order to minimize their potential drawbacks.

To conclude this point, we should also consider the impact of RPA on the industry. Knowing that this topic is in continuous development and expansion, there is also a need for further research on how automation can impact job creation and how human-robot collaboration can lead to optimal business outcomes (Pramod, 2021).

2.2. VISUALIZATION OF BUSINESS PROCESSES

Secondly, let us discuss the visualization of business processes. Few (2007) states that data visualization has a significant impact on reducing cognitive load, aiding understanding, and allowing users to process large amounts of data more effectively than they would with textual or numerical data alone. To better understand how data visualization impacts decision-making, Park, Bekemeier, and Schulzt (2021) identified 29 studies related to public health. After its analysis, they understood that data visualization helps to understand complex data better, identify patterns and trends, and communicate findings to others. While focusing on the context of big data, Tahiri (2020) also notes that data visualization plays a critical role in making data more accessible and understandable to users. To sum up, as data continues to grow in complexity and volume, effective visualization techniques are becoming increasingly important, and we can easily understand that this topic can have several positive implications in many different industries.

Moreover, the power of interactivity between the users and the visuals should be explored. Tahiri (2020) states that data visualization helps to reveal patterns and trends in data, but that the possibility of discovering deeper patterns and gaining richer insights comes with interactive data visualization tools. Strecker (2012) considers interactive visualization one of the key developments in data visualization at the time, along with the increasing availability of open-source visualization tools and the growing use of visualization in social media and other online platforms. Thus, building interactive data visualization tools can lead to a deeper understanding of the data by the end user, as well as an easier way to gain powerful intuitions and insights from the data displayed.

Nevertheless, there are also some challenges when designing and building visuals. Walney, et al. (2019) raised some of the challenges that exist in the handoff process for data visualizations. They argued that different levels of expertise between workers can lead to misunderstandings and miscommunications that ultimately affect the quality of the final product. Additionally, the design of visuals often involves a high level of iteration and experimentation, which can be challenging for both designers and end users. The authors also defend that these challenges can be mitigated if a clear and effective communication channel exists between all team members involved and if an effort is made to understand each other's roles and perspectives. This way, they will have a precise understanding of the goals and objectives of the final product. Furthermore, Strecker (2012) argues that it is vital that the visualizations are accurate and unbiased. One major challenge we face when building data visualization tools is ensuring that the data shown is reliable and transparent at all

times. The author also states the necessity of engaging audiences to promote understanding of complex data. Before building any visuals, we need to make sure that the final audience understands their necessity and their positive implications.

To conclude, it is crucial to choose the right visualization techniques and customize the visual elements. Mauricio (2018) utilized different data visualization techniques, such as bar charts, heat maps, and scatterplots, to visualize survey results and found that the use of these different techniques had a significant impact on the effectiveness of the dashboard in revealing insights and facilitating decision-making. The author also highlights the importance of considering the specific context and objectives of a data visualization project when selecting the right visualization techniques. However, Viégas and Wattenberg (2018) suggest a more artistic approach over traditional data visualization techniques. They believe that while traditional data visualization techniques can be effective for conveying information, they often fail to capture the richness and complexity of the data that is being visualized. The authors suggest artistic data techniques as a way to help transmit the emotional and subjective aspects of data that more traditional approaches may overlook. Examples of these artistic elements are the "Wind Map", a project that visualizes real-time wind data as a delicate, animated map, and the "History Flow", a visualization of the evolution of Wikipedia pages over time that uses color and shape to transmit the contributions of different users. Moreover, Vazquez-Ingelmo, Garcia-Penalvo, and Theron (2019) reviewed a total of 87 studies on information dashboards and concluded that the possibility of customizing a certain dashboard to meet the specific needs and preferences of the different end users can improve usability and effectiveness, particularly in contexts where users have different needs and levels of expertise. The authors explain that this leads to a tradeoff between flexibility and simplicity, where you want to customize as much as possible without losing the clarity and validity of the visuals. Still on the customization topic, Kintz, Kochanowski, and Koetter (2017) discuss the importance of dashboards to monitor real-time data on key performance indicators (KPIs). They then introduce their model-driven approach to creating customized dashboards. The way this works is that a model of the dashboard is created that captures the user's requirements, such as the KPIs they want to monitor and the visualizations they prefer. The model is then used to generate a personalized dashboard that meets the user's specific needs. By testing this approach with a logistics company, the authors reported that customized dashboards were successfully implemented while still being easy to use. Hence, it is imperative that the right visual elements are chosen, always considering the end user’s needs and the main purpose and objective of the data visualization design.

Overall, careful planning is essential for automation and visualization projects. Robotic Process Automation (RPA) offers efficiency benefits, but skill requirements and job displacement must be addressed. A culture of continuous learning is also crucial, and ethical guidelines cannot be overlooked. Data visualization aids in more informed decision-making, but effective communication among all parties involved poses a challenge. By considering these factors, businesses can achieve their goals more effectively and remain competitive. We will take these aspects into consideration during the development and implementation of our project.

3. DEVELOPMENT FRAMEWORK

To accomplish this project, we followed an already established framework and modified its steps to better address the issue at hand. The framework is called Toyota Business Practice (TBP) and consists of a problem-solving methodology that is used by Toyota and its suppliers. TBP is based on the "plan-do-check-act" (PDCA) cycle, a way to continuously improve their business processes. This also allows them to easily identify the problems and solve them in a structured and systematic way. Figure 1 shows the steps of the TBP framework.

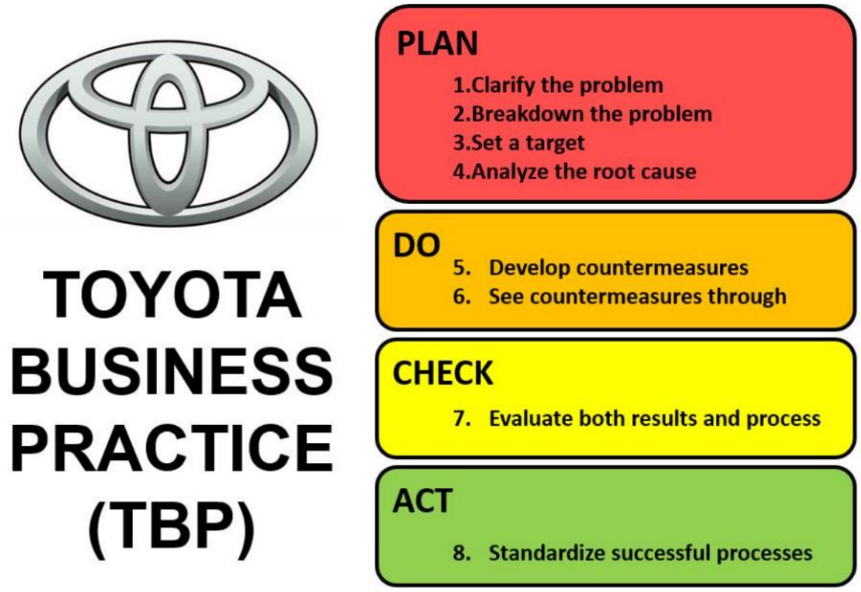

Figure 1 - Steps of the Toyota Business Practice Framework

To have a better understanding of this methodology, the steps are explained below in more detail:

1. Clarify the problem: The first step is to define the problem in a clear and understandable way. This also includes gathering information from the relevant parties to identify the root causes of the problem.

2. Breakdown the problem: Analyze the problem in more detail to have a deeper understanding of what the main pain points and bottlenecks are. It helps to break down the problem into smaller parts and identify which parts are in more need of improvement.

3. Set a target: The team sets a specific target to overcome the problem at hand. This target needs to be measurable and achievable, and it should be aligned with everyone involved in the process.

4. Analyze the root cause: The team conducts a thorough analysis of the root cause of the problem. For this, the process flow should be analyzed along with all the necessary data. The Five Whys and the Fishbone diagram are examples of tools that can be used here to identify the underlying causes of the problem we are facing.

5. Develop countermeasures: In this step, we start developing potential solutions to address the problem we identified. The team must brainstorm, test, and evaluate different countermeasures until the best possible solution is reached.

6. See countermeasures through: Once the best countermeasure is identified, the team implements it in a pilot test environment. The results are monitored closely and adjusted accordingly to ensure the efficiency of the process.

7. Evaluate both results and process: After the countermeasure is implemented and the problem has been solved, it is time for the team to evaluate the results and the process itself. This includes evaluating its effectiveness and identifying any limitations and areas for future improvement.

8. Standardize successful processes: Lastly, the team documents and standardizes the improved process to ensure that it can be replicated in the future. These procedures must be very clear, and the employees need to be trained accordingly.

Overall, the TBP framework is designed to be iterative, meaning that the team can go through these steps multiple times until the problem is fully solved. By following this methodology, Toyota and its suppliers are able to continuously improve their business processes and efficiency while reducing costs and waste.

However, to better fit the problem we wanted to tackle in this study and the constraints of time, we made a few changes to the standard TBP framework. Even though it still followed the "plan-do-check-act" cycle, we grouped several procedures and included some additional steps that we believed to be essential for the current project. The thirteen updated steps, which can be seen in Figure 2, are described next.

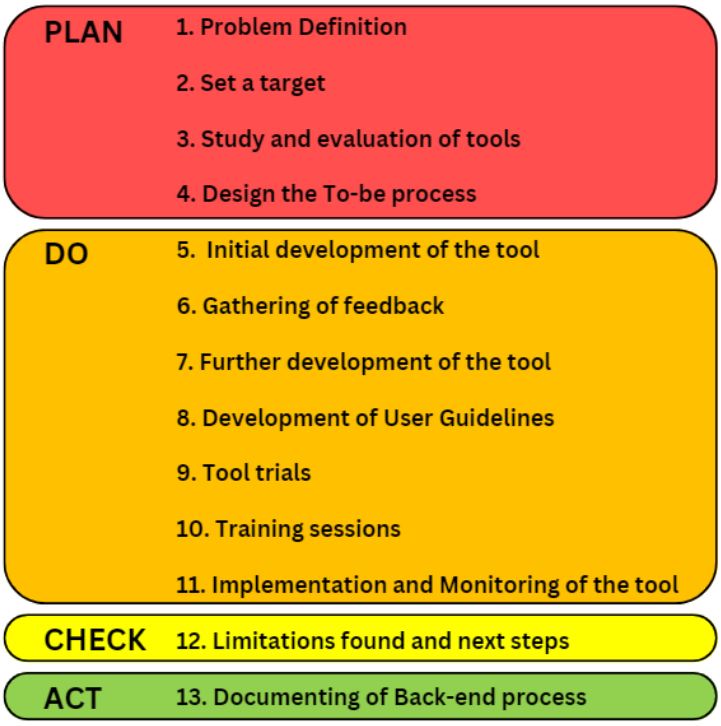

Figure 2 - Steps of the project

In the "plan" section, we started with the problem definition. We not only clarified the problem but also broke it down into several parts. With this, the main pain points were clearly exposed and identified. Next, we established the main goals we wanted to achieve to fix the pain points. The targets were precise and realistic. Later, we evaluated and compared different programs and tools to decide the best way to tackle the problem. Finally, a To-Be process was designed and presented to the team members, aiming to propose a redesigned process that would improve efficiency.

Moving to the "do" section, we started by developing countermeasures to address the identified bottlenecks. We started developing the tool and gathered more in-depth feedback from all the teams involved. The NMSCs' requirements were cautiously structured and organized. Using the collected requirements, we fine-tuned the tool and expanded its capabilities. We implemented everything in a way that minimized future errors. User Guidelines were written in a clear and simple manner to facilitate understanding of the tool. Tool trials were conducted with a sample of participants in a way that as much as possible resembled the real-life environment. Next, training sessions were held to ensure everyone knew how to use the tool correctly. Finally, the rollout of the tool took place. At the same time, we closely monitored its effectiveness and success, and adjustments were made when necessary.

In the "check" section, we identified existing limitations and provided guidance on future improvements.

To conclude, in the "act" section, successful processes were standardized. All the Back-end procedures were carefully documented to ensure that workers could understand them and replicate them in the future.

Now that we have outlined the thirteen steps, we can proceed to the next chapter of the dissertation, where a more elaborate explanation of each step will be provided.

4. PROJECT DEVELOPMENT

This chapter focuses on clarifying each step of the PDCA methodology that was applied to complete this project. All the significant decisions and implementations made are described in detail.

4.1. PROBLEM DEFINITION

To start with, it was important to get to know the Request process in more detail. For this, a flowchart was designed with all the existing steps and all the people involved, as can be seen in Figure 3. Note that the main points of the process were flagged and numbered, in red, and will be explained below.

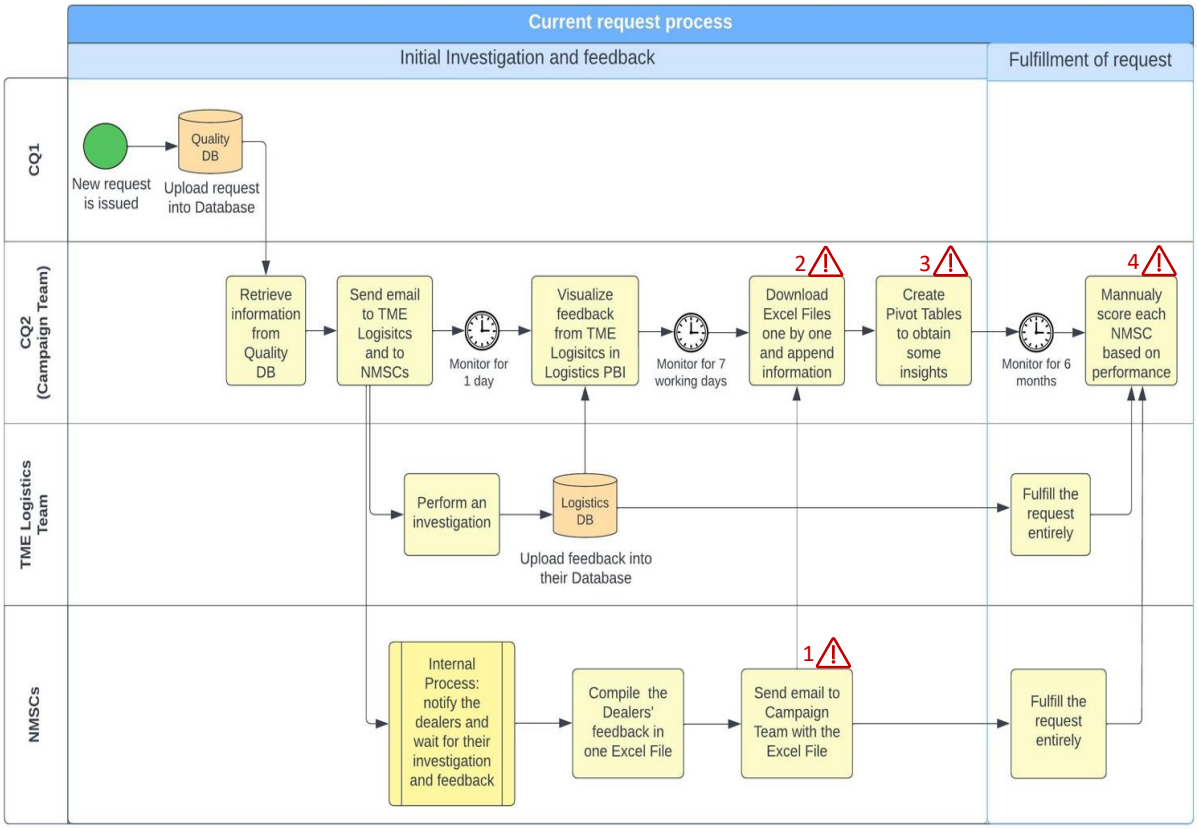

Figure 3 – Flowchart of the current request process

This process starts whenever a new request that affects European vehicles is issued. The new request is decided by Customer Quality 1 (CQ1), and they are the ones uploading this new information into their database (Quality DB). Once it is stored there, the Campaign Team (name given to CQ2) needs to retrieve that information. This is possible because each new request has a unique request ID. Next, an email notification is sent to all 30 NMSCs and to the TME Logistics Team. In this email, alongside all the necessary steps and needed information, a request is made to everyone involved for them to perform an investigation on specific vehicles and provide feedback back to the Campaign Team with the status of those vehicles. There are four possible statuses (status 1 to 4), plus an additional option of unknown (if the vehicle cannot be seen in the system). These statuses will later

impact how the requests will be fulfilled. After this email, we have a split between TME Logistics and all the NMSCs.

Regarding the first ones, which are under TME responsibility, they perform the investigation themselves on the vehicles and upload their status directly into their database (Logistics DB). This database is linked to a pre-existing Power BI visualization (Logistics PBI). This upload of the feedback occurs one day after the request was announced, and from that point on, the status of the vehicles investigated by the Logistics Team can easily be seen and monitored by the Campaign Team. Note that this Logistics PBI is refreshed once a day, overnight, meaning that the updated information can only be seen the day after it was inputted.

As for the NMSCs, they first need to go through an internal process to know the status of the vehicles from all the Dealers of their country. In other words, NMSCs need to notify their dealer network, and the Dealers must perform the investigation and provide the feedback back to the NMSCs. Some of these internal processes are automated with the help of an internal system, while others are 100% manually performed. This is why their effectiveness and complexity vary a lot from one NMSC to another. At the end of this internal process, all the feedback is combined into one Excel file, and one email is sent to the Campaign Team containing that information. All these emails with the Excel files should be provided by each NMSC within one week after the announcement of that request. During this time, it is the Campaign Team's responsibility to monitor these feedbacks and guarantee that all the investigations are properly performed by all the NMSCs.

Once all the information from the NMSCs reaches the Campaign Team, all the Excel files need to be manually downloaded and compiled into one master file. Here, a pivot table is developed by the person in charge (PIC) to obtain some insights from the general overview of that request. These insights include whether the NMSCs are complying with the investigation or not, if the status was received within the expected time, etc.

Finally, both TME Logistics and the NSMCs need to fulfill these requests. All the vehicles with status 1 need to be fulfilled by TME Logistics, all the vehicles with status 2 or 3 need to be fulfilled by the NMSCs, and the vehicles with status 4 are liberated from any fulfillment. Because each request expires six months after it is issued, it needs to be entirely fulfilled before reaching that deadline. Similar to above, it is the Campaign Team's responsibility to monitor these actions. At the end of the process, depending on how well they perform, a score is given to each NMSC. This grading is done manually by the PIC, and the scores are attributed to the NMSCs at the end of each year in what is called the Customer Excellence Award (CEA). This CEA evaluation takes into consideration if the status of the vehicles were provided on time and if the NMSC truly fulfilled that request. With this final step, the Request process is concluded.

After mapping the process, it became easier to detect and identify the main bottlenecks and pain points that existed in the current Request process and that are flagged in Figure 3. Below, the main limitations found are listed:

1. Abundant email traffic: Firstly, since all 30 NMSCs send an email back to the Campaign Team, it is easy to understand that the information is scattered across this mailbox, and it becomes difficult to

organize it and find information easily. Furthermore, this raises some storage capacity in the Campaign Team's mailbox, which leads to the need to delete some emails or spend money upgrading the storage capacity.

2. Time-consuming monitoring: Secondly, the follow-up and monitoring of all the emails is also time-consuming. This action is performed by the PIC from the Campaign Team, and they need to chase the NMSCs down and ensure that all of them provide the status of the vehicles on time and in the right format. This last part is very important since, without a standardized way to provide feedback, each NMSC does it as they see fit. In the end, this will make the job of compiling all of the Excel files together a challenging and very time-consuming task.

3. No standard format to visualize the process: Thirdly, there is no consistent way to visualize the overview of this entire process. This summary is the PIC's responsibility, and since it varies from one request to another, each one does this overview in their own manner. Normally, this is achieved by creating a pivot table with some filters applied, and the status of the vehicles from each NMSC is shown in the form of a table. However, there is no clear visualization tool that can easily show this overview in an obvious and effortless way.

4. Very challenging to evaluate the NMSCs: Finally, it is a very challenging and time-consuming task to evaluate the NMSCs every time a request expires. Please remember that the Customer Excellence Award (CEA) is where each NMSC receives a score based on how well they performed during the year. Here, we take into consideration if the feedback of the requests issued that year were provided on time and if the NMSC truly fulfilled that request (it can happen that they provided the feedback on time but, at the end of the request, only a percentage of the vehicles were fulfilled). This evaluation requires scoring each NMSC individually based on the feedback received. On top of that, the information about the fulfillment of the requests is stored in a different database (Fulfillment DB), which makes the process of getting the data and double-checking the fulfillment a lot more exhaustive and manual.

4.2. SET A TARGET

After identifying those four areas of concern, it became crucial to establish clear and achievable targets. These targets were designed to address and overcome the limitations mentioned earlier. It is worth mentioning that, since the objective was to study the impact of automation and visualization in this particular Toyota's European process, all the goals were categorized under these two main topics. You can see this division in Figure 4.

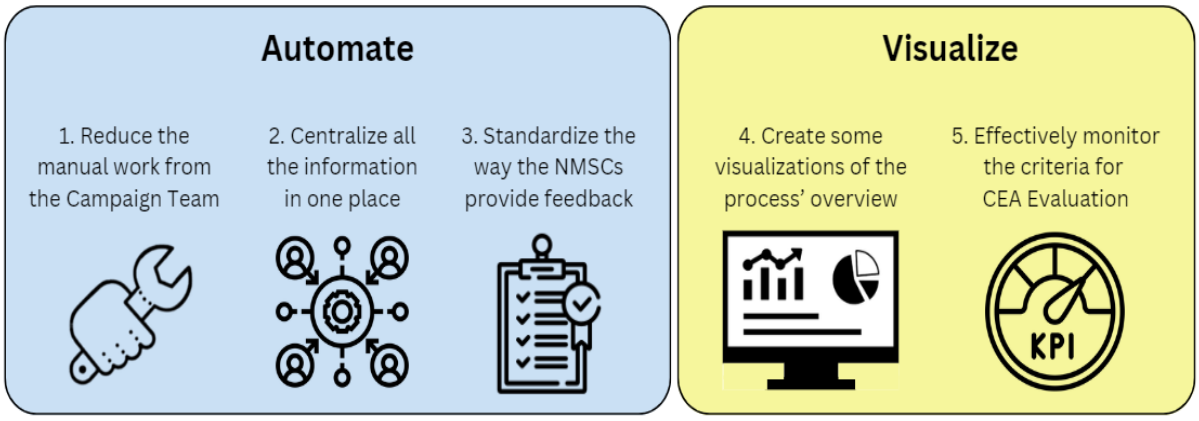

Figure 4 - The five objectives of the project

Inside the Automation pillar of the dissertation, we set three targets, as described next.

1. Reduce the manual work from the Campaign Team: The first objective was to reduce as much as possible the manual work performed by the PIC from the Campaign Team. As we wanted to automate and optimize the Request process, it was important that all the repetitive manual activities were replaced by queries and power flows that the machine triggered and performed by itself. Activities like compiling all the feedbacks together, one by one, or even monitoring the emails during 7 working days were great examples of actions that should have been automated in the future. However, it was impossible to completely eliminate the manual work that existed, as some decision-based activities still needed to be performed by someone from the Campaign Team whenever a new request arrived. Nevertheless, we made every effort to minimize these critical manual activities as much as possible, enabling the members of the Campaign Team to dedicate more of their time to developing other Kaizen projects. These projects revolve around the Japanese concept that means continuous improvement.

2. Centralize all the information in one place: The second objective was to centralize all the information related to this PDC process in one place. We realized that the needed information was scattered across the Campaign Team's mailbox, making it sometimes difficult to find and search for. Additionally, this posed potential storage limitations, as the emails took up space in the mailbox. Considering these circumstances, we decided that the future process should overcome this limitation by bringing together all the required information and data in one place. This means that all the files, emails, and visualizations should be stored in a unique place, accessible by all the necessary employees. This would certainly reduce the email traffic that existed.

3. Standardize the way the NMSCs provide feedback: Thirdly, we aimed to standardize the way the different NMSCs provided feedback of the request. Each country had been doing this in its own way, which posed additional challenges for the Campaign Team in compiling and understanding all the information. The goal was to create a standardized template that would be used by all the NMSCs in the future. It was crucial to ensure that all the involved countries were strictly following this protocol. Even if a single NMSC failed to comply, it would result in incomplete feedback for that request.

As for the visualization aspect, two main objectives were defined and are explained below.

4. Create some visualizations of the process' overview: The fourth objective was to create some helpful visualizations that helped to keep track of the overview of the process. This dashboard should address the needs of the NMSCs, the Campaign Team, and even the Quality Function itself. It should be a place that can quickly and effortlessly provide the NMSCs with important insights as to what their status is regarding each request. This visualization should also facilitate the Campaign Team day-to-day activities and enable fast access to data that can support the decision-making of the PIC on each request. Ideally, these visualizations would join information that already exists in other visualization reports and show all the important and necessary data in one place. Having all these systems combined would facilitate a lot in getting this wanted overview of the Request process.

5. Effectively monitor the criteria for CEA evaluation: Finally, and throughout this entire process, it was important to effectively monitor all the KPI criteria involved in the CEA evaluation in a fair and transparent way. In fact, this evaluation shared at the end of each year could raise some questions and doubts about its fairness since the data that supported it needed to be retrieved again for past requests and reviewed. Therefore, one objective of this project was to store the necessary data and information in the tool that could be used to support all the scores attributed to each NMSC. The evaluation should be as clear and transparent as possible in order to build trust between the Campaign Team and the NMSCs, as this will be an important step towards a better way of conducting business with them and gaining their respect.

4.3. STUDY AND EVALUATION OF TOOLS

After clearly specifying the targets, it was time to investigate how those objectives could be achieved. We needed to decide which software, programs, or tools to use to our advantage that could more easily allow us to accomplish the five main goals.

To start with, we focused on how we could reduce the manual work that existed throughout the process. We started by exploring the possibilities of using Power Apps. These low-code development platforms, developed by Microsoft, offer several ways to reduce manual tasks. Firstly, it allows the automation of repetitive tasks and processes, saving time and reducing errors. Secondly, it simplifies data collection and management by creating intuitive forms and mobile apps. Thirdly, Power Apps integrates with existing systems, ensuring data consistency and reducing the manual transfer of information. Fourthly, its mobile accessibility enables field workers to collect data and perform tasks wherever they are, reducing paperwork and location restrictions. Lastly, Power Apps can be combined with Power Automate to automate complex workflows and processes, such as notifications, approvals, email reminders, etc. By utilizing Power Apps, organizations can enhance accuracy, efficiency, and productivity while minimizing manual work and associated challenges. Therefore, we decided that the integration with Power Apps, especially Power Automate flows, would be ideal for the project at hand.

Then, we looked into ways to centralize all the information in one place. We did some investigation of possible ways to achieve this, as well as studied the way the NMSCs and the Campaign Team already communicated and interacted with one another. In fact, if the NMSCs were already familiar

with a specific tool or interface, it meant that they were probably more comfortable with it and had more expertise in it as well. As the Request process involves all the European NMSCs and is mainly directed at them, it was imperative that all of them knew how to properly use the tool we were going to develop and felt comfortable around it. Bearing this in mind, our initial decision was to opt for a SharePoint site as the centralized location of the Request process. A SharePoint site shared between NMSCs and the Campaign Team already existed, but it was extremely outdated and eventually fell out of use. Nevertheless, SharePoint sites are interfaces that all the NMSCs are used to having in their daily activities, as they are a powerful way Microsoft made available to store, organize, exchange, and retrieve information online. A SharePoint site also allows for a targeted view of the information, as it helps you restrict specific libraries or even pages for certain users. This allowed us to restrict the information for the Campaign Team's use only, the information that could be shared with all the NMSCS, and the information that visitors could access.

Furthermore, research was conducted about ways to standardize and store the data. We realized that both Excel files and SharePoint lists were great candidates to be incorporated into the tool, but both of them had some limitations and restrictions. On one hand, SharePoint lists are ideal for scenarios where you need a structured and consistent data model, when collaboration and real-time updates by multiple users are essential, when data needs to be accessible from various devices and locations, and when you require version history and audit trails for data changes. However, SharePoint lists suffer from the issue of information overload and are known for having a view limit of five thousand items. On the other hand, Excel files are ideal when you need flexibility in data organization and analysis, when advanced calculations, formulas, or macros are required, when data analysis, reporting, and charting are a primary focus, and when the data volume is not enormous. Overall, both SharePoint lists and Excel files have their strengths and can be used together in complementary ways to meet different data management needs. The choice depends on the specific requirements of the project and organization. Since this project focused a lot on reporting and charting while having great flexibility, we opted for Excel files as a way to standardize and store the data. Moreover, since the volume of data was not huge, we could use Excel files to achieve our objective. Note that, if SharePoint lists were chosen, we would have had the possibility of having different views with nice filtering options, but we would not have been able to see all the records on the SharePoint site.

Regarding the visualizations that were lacking in this process, we wanted to define a way to visualize the process' overview and monitor the KPIs used for CEA evaluation. For this, we decided to develop a Power BI report since it was a tool that NMSCs and the Campaign Team were already using in their daily lives. In fact, Power BI offers several significant advantages as a business intelligence and data visualization tool. First, it enables users to create visually appealing and interactive reports, making complex data more understandable and facilitating data analysis. Second, Power BI provides intuitive tools for data exploration, allowing users to slice, filter, and drill down into data to uncover insights. Another advantage is its extensive data integration and connectivity capabilities, allowing users to connect to various data sources and combine data for a comprehensive view. Real-time data monitoring is also supported, enabling users to track KPIs and make timely decisions based on up-to-date information. Additionally, Power BI promotes collaboration, allowing users to share reports and datasets with colleagues for teamwork and feedback. Lastly, scalability and flexibility are also key advantages of Power BI, as it can handle large data volumes and be deployed on-premises or in the cloud. To conclude, Power BI empowers organizations to transform data into actionable insights,

enabling data-driven decision-making and high levels of collaboration. With this valuable tool for data analysis and visualization, all the Excel files can be connected to Power BI, as well as other already existing databases used by the organization.

4.4. Design the To-Be Process

At this point in the project, it was imperative to design and propose the To-Be process. This new process aimed to improve efficiency for both the Campaign Team and the NMSCs by reducing or eliminating the existing pain points of the current Request process. For that, some steps were introduced or modified, and the main differences are numbered and represented in Figure 5, in blue.

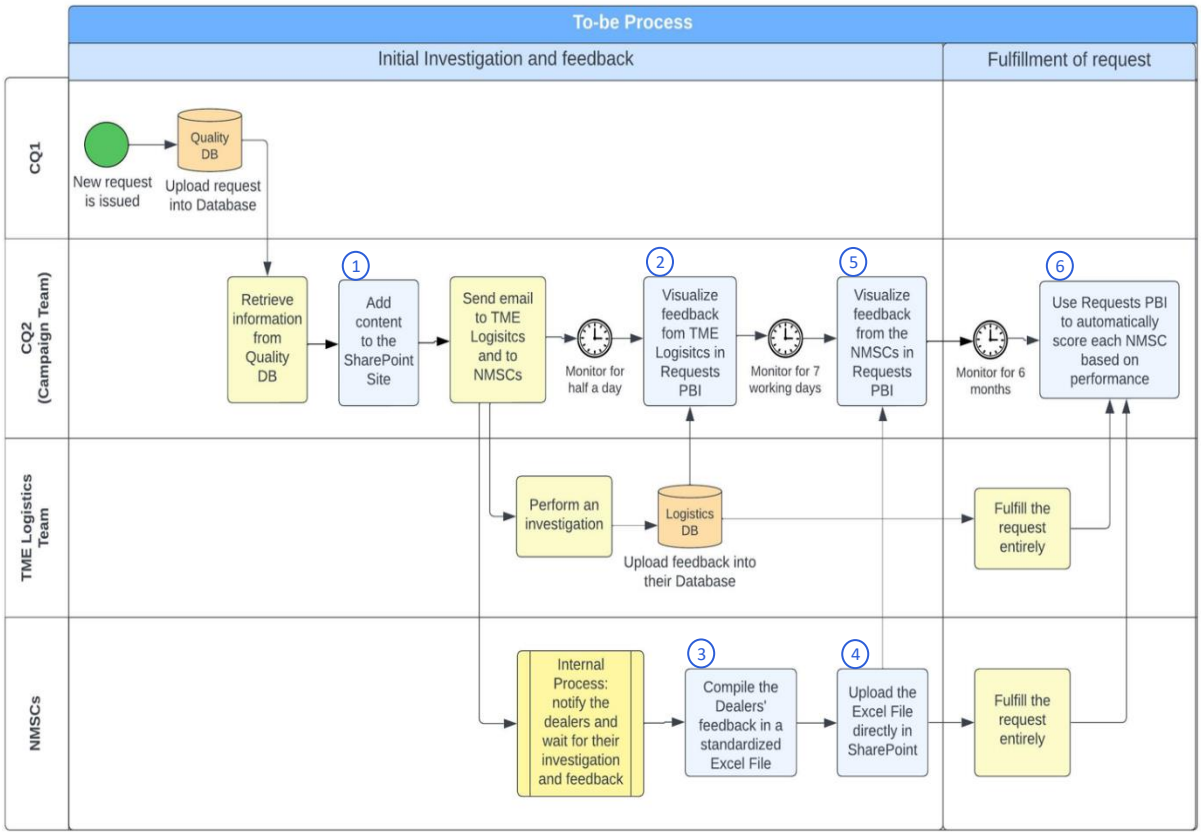

Figure 5 - Flowchart of the To-Be request process

There are some key differences between the current and the To-Be Request process, as explained below.

1. First, the Campaign Team needs to perform some additional actions before sending the email notification with the new request. These activities aim to maintain the SharePoint site and make sure that there is a place where all the NMSCs can upload their feedback. When the email is issued, it includes a link that redirects the NMSCs to the SharePoint site developed, as well as the steps they need to take to successfully go through the To-Be process.

2. As for TME Logistics, they follow a similar set of activities as in the current process. However, we reduced the monitoring time of the Campaign Team as we wanted to see the feedback of the request

as soon as possible and create better and faster communication between the Campaign Team and TME Logistics. Regarding the visualization of this feedback, we linked the Logistics DB to the new Power BI that we created for this process, the Requests PBI. This new PBI, used by everyone involved in this activity, centralizes all the useful visualizations in one place.

3. As for the NMSCs' scope, we introduced one of the main changes to the process. After the internal process of notifying the Dealers' network and receiving the status of their vehicles, the feedback is compiled in a standardized way. This means that all the NMSCs have an Excel file that follows the same structure and format, reducing the inconsistencies and discrepancies that exist in the feedback received by the Campaign Team.

4. Furthermore, these Excel files are not sent by email but uploaded directly in SharePoint in the correct folder (the NMSCs just need to follow the link provided in the email notification). This modification is essential to reduce the email traffic that exists throughout this process, as all of the emails with feedback from the NMSCs to the Campaign Team will be prevented.

5. After uploading the feedback to SharePoint, all the feedback is compiled into one master Excel file with the help of Power Query. This master Excel file is updated several times throughout the day and is linked to the Requests PBI. This means that, whenever new information is appended to the master Excel file, it also shows up in the visualizations created. This way, both the Campaign Team and the NMSCs can easily monitor how they are performing so far. They can identify which NMSCs are complying with the request and which ones should be notified and reminded of.

6. Lastly, after monitoring for a maximum of 6 months, all the requests need to be fulfilled. Note that this monitoring by the Campaign Team is done just by looking at the Requests PBI, which centralizes all the important information together. A very key change in this last part of the process is that the Requests PBI now has all the necessary data to automatically score all the NMSCs for the CEA evaluation. This is achieved because all the necessary KPIs are shown in these visuals. Even though this evaluation is only provided to the NMSCs at the end of each year, it is the most time-consuming task that the Campaign Team needs to perform. In fact, it can take an entire week to get all that historical data on the requests and review the NMSCs' performance one by one before sharing the final results. By having the Requests PBI always updated, this problem is quickly avoided.

4.5. INITIAL DEVELOPMENT OF THE TOOL

Our tool can be divided into two main sections: the SharePoint site and the Power BI Visuals, both of which are covered next. As for the SharePoint site, its main purpose was to centralize all the information and data related to the Request process in one place. Moreover, the objective was that this site could be used by everyone involved. In this sense, we decided to split the SharePoint site into three different tabs, as shown in Figure 6 and listed below.

Figure 6 – Tabs of the new SharePoint Site

1. NMSC Feedback Drop-off: The NMSCs will use this library to upload their feedback for each request. In order to facilitate navigation through this library, there is a folder for each year, which has a folder for each request, and inside that folder is a folder for each NMSC. This way, it is easier to track down the needed information and upload the feedback for each request in the correct place. The folders also allow for better control over who adds and edits each file in SharePoint since each NMSC can only make changes to documents inside folders under their name.

Furthermore, the Excel files uploaded here follow the standardized template. This template is crucial for this part of the process for two main reasons. First, it allows for a more consistent and uniform way for all NMSCs to provide feedback. Second, by following the same template, it was possible to develop a Power Query in Excel that automatically appends all the feedback information to one master Excel file. This eliminates the need for manually downloading and appending all the files one by one. Thus, this standardization reduces a lot of the manual work of the Campaign Team.

The standardized template has 13 columns. Table 1 describes each column and provides an example record. The first 8 columns have information about the vehicle, while the following 4 columns focus on the feedback from the request's investigation. Please be reminded that there are only 4 possible statuses, plus the additional option of unknown (if they cannot see the vehicle in the system). A single cross (X) should be placed in the correct column, providing the exact status for each vehicle.

Column name	Column description	Example of a record
Item	Index of the vehicle in the request list	1145
Request ID	Unique identifier of the request	RE22-002
Vehicle ID (ordered)	Unique identifier of the vehicle (when it was ordered)	JHY7463
Vehicle ID (produced)	Unique identifier of the vehicle (when it was produced by the manufacturing plant)	QTR7781
Model Name	Name of the model of the vehicle	Model 3
Produced Date	Date when the vehicle was produced	02-07-22
NMSC Code	Unique code that identifies the NMSC	910
NMSC Name	Name associated to the NMSC code	NMSC 1
Status 1	Include a cross (X) if the investigation on this vehicle returned Status equal to 1 (it needs to be fulfilled by the TME Logistics)	
Status 2	Include a cross (X) if the investigation on this vehicle returned Status equal to 2 (it needs to be fulfilled by the NMSC)	X
Status 3	Include a cross (X) if the investigation on this vehicle returned Status equal to 3 (it needs to be fulfilled by the NMSC)	
Status 4	Include a cross (X) if the investigation on this vehicle returned Status equal to 4 (it is liberated from any fulfillment)	
Status Unknown	Include a cross (X) if the vehicle cannot be seen in the system	

Table 1 - Standardized template with an example record

2. Campaign Team Scope: This library includes all the documents that can only be accessed by the Campaign Team. They are the ones storing and maintaining these files. Figure 7 shows the 4 main files stored in this tab.

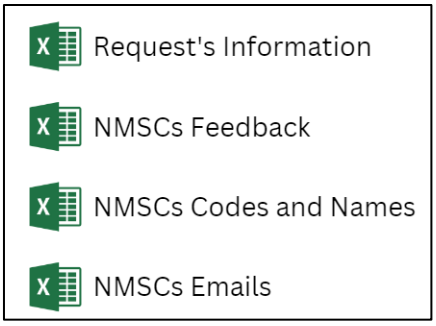

Figure 7 - Excel files stored in Campaign Team Scope

First, we have a list of all the requests, along with additional information for each one. This Excel file is named "Request's Information" and includes historical data from all the past requests with information about the issue date, end date, brief description of the request, number of affected vehicles, etc. Second, this library stores the master Excel file that compiles and stores all the feedback from the NMSCs. It is named "NMSCs Feedback", and it is one of the most important files since it is the one feeding the visuals of the Requests PBI. Third, we have the file "NMSCs Codes and Names". This is a static table with all the codes of the NMSCs, along with the correct labeling. Since we have requests being issued by Europe and others by Japan, it is vital that both these codes and names are standardized and remain the same. Basically, we have unique labeling for each NMSC, avoiding having the same country spelled differently (e.g., for requests from Japan, we have "Holland" as a country name, and for requests from Europe, we have it as "Netherlands"). Lastly, we have information about the emails stored in the "NMSCs Emails" file. This file is important because it has an updated list of everyone responsible for the Request process for each NMSC. This way, we know who to contact if we need to clarify something along the way.

Overall, these files are important to guarantee the veracity of the data we have, and we store them in this library to ensure that no NMSC can modify them or that we lose any important information.

3. Home Page – Power BI: Finally, a third and final tab was created to include the Power BI reports. As we wanted to centralize all the information in one place, it was crucial that all the visualizations created could also be seen on the SharePoint site. Moreover, the User Guidelines on how to use the tool should also be included in this tab, ensuring all the involved users know how to use the tool properly and efficiently to better fit their needs.

As for the Power BI report, our initial development focused on deciding which tables and which information should appear in this report. We tried to include all the necessary information to have a fast understanding of how the process is flowing and where the main bottlenecks are. It should be easy to grasp how each NMSC is performing, meaning what their feedback is and how many vehicles are still missing proper feedback. Therefore, a percentage of correct feedback provided was attributed to each NMSC at all times. Likewise, the same system was developed to monitor each request. We should be able to quickly understand the number of statuses of each request, along with

the percentage of proper feedback provided so far for that request. This way, all the NMSCs and the TME Logistics can be easily monitored by the Campaign Team with the use of these tables.

Moreover, additional information about each request was clearly shown in the report as well. This enables a better understanding of which request we are dealing with, especially when we have multiple requests that are similar to each other. Besides, we added a panel with multiple filters and slicers, so we can easily navigate to the information we want in a fast and effortless way.

Furthermore, we wanted to be able to track all the KPIs involved in this process (such as the timestamp of when the feedback was uploaded, if it was completed or not, if the request was later entirely fulfilled, etc.). For this, we developed a table where all the KPIs are visible and where each NMSC is scored based on their performance. With all this information, the evaluation of the NMSCs shared at the end of the year can be done automatically with this report, which will have all the data supporting each score provided.

Finally, in order to enhance its capabilities, we linked these Power BI reports with some other databases that already existed in the company and that supported this Request process (such as the Logistics DB). This way, instead of manually adding that information to the tool, it is reflected there automatically.

4.6. GATHERING OF FEEDBACK

For gathering the feedback, we relied heavily on the concept of Toyota Production Systems (TPS), which you can see in Figure 8. The Toyota Production System was developed between the 1950s and the 1960s, and it was crucial for Toyota's early success. TPS aims to reduce costs, eliminate waste, and improve efficiency. For this, it focuses on two main principles: the "*Just-in-time*" and "*Jidoka*".

The first one consists of producing only what is really required, when it is required, and in the amount required. Waste can result in excess inventory, unnecessary processing steps, and defective products, which can eventually have an effect on how the business is managed. The vehicles should be efficiently constructed in the smallest amount of time in order to fulfill a customer request as promptly as possible. And that is what "*Just-in-time*" aims to achieve.

The second one, "*Jidoka*", means "automation with a human touch". This principle requires that systems be built and improved by hand until they are truly reliable and safe. Only then can the *"Jidoka"* mechanism be incorporated into actual production lines. The process of improving both human skills and technologies is the essence of Toyota's *"Jidoka"*.

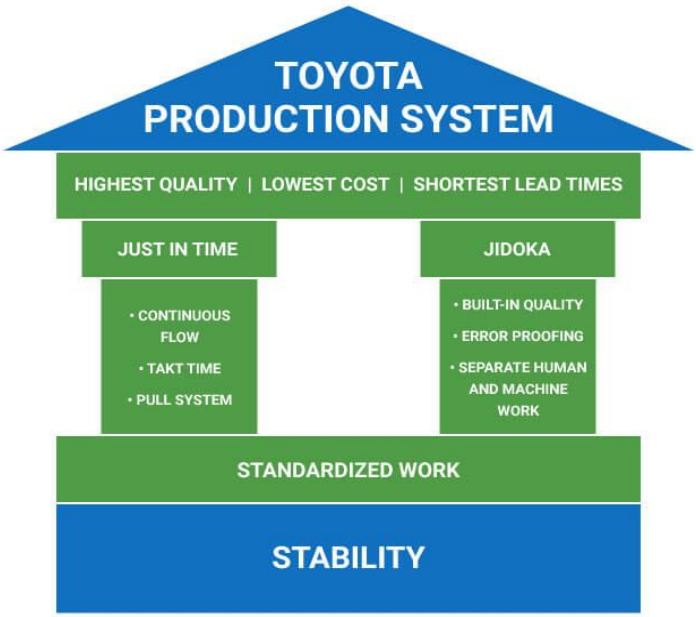

Figure 8 – Principles of the Toyota Production System

Furthermore, inside the Toyota Production System, a lot of concepts are used, such as *Nemawashi* and *Genchi Genbutsu*. These two concepts are explained below, as they were extremely important for this project.

Nemawashi is a Japanese term that refers to the process of gaining consensus among all stakeholders in a decision-making process. It consists of collecting feedback from all involved parties and using the input received to build support for a particular decision. By involving all stakeholders in the decision-making process, Toyota ensures that all perspectives are taken into consideration and that the decision is more likely to be positive and successful.

Another important concept in TPS is *Genchi Genbutsu*, which means "go and see for yourself." This concept emphasizes the importance of firsthand observation and better understanding the processes and problems that may exist. Toyota encourages its employees to go to the source and observe these situations directly rather than relying on second-hand information or assumptions, which can lead to missing or inaccurate information.

Consequently, both concepts were included in this part of the project. For the countries where it was possible to perform *Genchi Genbutsu*, we opted for this approach. For the ones this contact was not really feasible (financially and time-wise), we scheduled online *Nemawashi* meetings with everyone involved in the Request process for that specific country.

In the end, we managed to make 3 *Genchi Genbutsu* (to Germany, France, and Belgium) and 17 online *Nemawashi* meetings, this way covering all the NMSCs involved. In all these reunions, we explained in more detail the Kaizen project at hand: the main pain points of the current process, the target we want to achieve, and the proposed process to reduce or even eliminate those identified pain points. Afterwards, we asked for their support, answered their questions, and gathered all their feedback and additional requirements. The main goal was for them to clearly understand why we were doing this automation and visualization, why it was important and beneficial for them, and what could be added and improved to better help them in their operations.

It is important to highlight the huge difference we felt between these two approaches. In the *Nemawashi* meetings, since they followed an online format, it was obviously more difficult to connect with the audience and captivate them. Even though we had some great feedback during these meetings, the outcome of the *Genchi Genbutsu* encounters was far more beneficial for us. The possibility of meeting in person and explaining the project in a more personal way generated more helpful and valuable results. Not only did we discuss what could be improved in the tool to enhance its possibilities, but we also focused on what could be revised in the Request process from their side (all the pain points that they experience throughout this process, the problems they face with their internal process of interacting with the dealers, and where the communication between them and TME could be improved in the future).

With respect to the collected feedback, all the requirements were compiled together in one table and labeled accordingly. There were two main differences between them: the ones concerning this specific Kaizen project and the ones focusing on the general Request process. Even though the requirements for the general Request process were important, we solely focused on those related to the tool we were developing. Moreover, a second split was made for these requirements, separating the ones that were feasible and achievable (having in mind the constraints of resources and time) from the ones that were not. Table 2 illustrates the most important requirements gathered in the meetings and their respective labels.

Feedback Gathered from the NMSCs (14 Requirements)			
Index	**NMSCs Requirement**	**Within the scope of the project?**	**Is it feasible?**
1	Better assess how severe the requests are when issuing them. Some may be way more urgent than others and that is crucial to be known in order to prioritize some investigations on the vehicles.	N	-
2	Fairly choose which requests are going to be prioritized for the CEA evaluation.	N	-
3	Consider extending the deadline for the fulfillment of the request in extraordinary cases.	N	-
4	Have the possibility to see Dealer-level operations (investigation and fulfillments).	Y	N
5	Have the Power BI already showing past requests when it goes live.	Y	N
6	Connect the Power BI with other internal data sources from the NMSCs.	Y	N
7	Show a timestamp from when the Power BI was last updated.	Y	Y
8	Send an automatic email to the NMSCs that did not yet provided proper feedback.	Y	Y
9	Unify the names of the Excel Files so it is easier to search for them.	Y	Y
10	Link this new SharePoint site to the main SharePoint Page that some NMSCs already use.	Y	Y
11	Get the dealer's name where each vehicle is and obtain additional information about them (such as city, postal code, address, etc.). This way, the NMSCs know exactly who to contact to investigate about certain request in that vehicle.	Y	Y
12	Show the requests that were fulfilled by each NMSC after the initial investigation.	Y	Y
13	See all the Power BI reports useful for the request process in one place.	Y	Y
14	Manage access permissions to both the SharePoint site and the Power BI report.	Y	Y

Table 2 - NMSCs' Requirements and respective labels

By looking at Table 2, we can understand that the first 3 requirements do not fall within the scope of this project. This is due to the fact that the prioritization of some requests over others is something decided outside the Campaign Team scope. Moreover, the requests that will be used for the CEA evaluation are also chosen by other teams in the Quality Department. Finally, it is established that the requests only last for 6 months, and that is something the Campaign Team cannot change in the near future.

Regarding feasibility, the option of having past requests show up in the Power BI report when it goes live was considered not practical since it would involve a lot of manual work (note that all the feedback would need to be transformed into the new standardized template). Next, the possibility of seeing Dealer-level operations and connecting this Power BI report with other internal data sources from the NMSCs was also considered unattainable. The reason behind this decision is the fact that the internal processes followed by the NMSCs differ a lot from one another. It would be extremely demanding and troublesome to try to incorporate all the different Dealer-level operations and different systems in the report.

Overall, you can perceive that diverse requirements were raised by the different NMSCs. To further develop the tool, we focused on implementing the requirements numbered from 7 to 14.

4.7. FURTHER DEVELOPMENT OF THE TOOL

It was time to expand the tool's capabilities by implementing the NMSC's requirements. For that, we revised the access permissions of the SharePoint site to ensure that maximum control and security existed for all the files stored in each of the tabs (requirement 14). We explored the different kinds of groups that would use the SharePoint site and provided them with a specific level of access (which tabs they could see, and which modifications could be done in the folders). To facilitate access, the link to this new SharePoint was referenced on the home page of the other SharePoint page that some NMSCs were already using (requirement 10). Finally, to ease navigation through the folders, all the Excel files were unified and named accordingly (requirement 9). The files uploaded by the NMSCs should always follow the format "NMSC name | Request ID | Date of upload".

Regarding the Power BI reports, we were also challenged to include the dealers' names where each vehicle is located (requirement 11), as well as additional information about the dealer (such as city, postal code, address, etc.). This information is extremely useful for the NMSCs to know exactly who to contact to investigate certain requests in that vehicle, improving its efficiency and NMSC-Dealer communication. The problem here relied on where to get this data. In fact, an additional database that has the last known location of all the vehicles produced (Vehicle Location DB) needed to be linked to the Power BI. And since this information does not have any link to the Request ID, we cannot extract from it the location of the vehicles exclusively affected by a certain request. Therefore, we need to get the location of all the recently produced vehicles and link them to the Power BI by Vehicle ID. The biggest constraint here is how to limit this data: we cannot simply get the location of all the vehicles produced in the last few years, as this brings huge computational problems. After multiple considerations, we decided to limit this data to vehicles produced in the last 6 months, where the destination continent is "Europe", and where the last known location is a dealer. We then sorted production dates in a descending way (so we see recently produced vehicles first) and limited this data to 500 thousand rows. Even though this implementation still considerably slows down the refresh of the visuals (average of 5 more minutes per refresh), it adds enormous value to all the NMSC that use it, and that is why we decided to keep it this way.

Next, one of the requirements was that the visuals also include information about the fulfillment of the requests (requirement 12). This data also comes from a separate database from warranty (Warranty DB), which is an enormous source of historical information. Because of this, getting information from there means, once again, slowing down the refresh of the Power BI report. After considering this option, we decided that this information was not critical enough to be seen by the NMSCs, but it was needed for the Campaign Team in order to fairly score the NMSCs for the CEA evaluation. So, to solve this, we decided to develop a second Power BI report, linked to the main one, that would be used only by the Campaign Team. This way, we can better control which information is shared with whom while maintaining a faster refresh of the information the NMSCs see.

Furthermore, we added a timestamp to both reports to indicate when they were last updated (requirement 7). With this, it is easy to understand when it was the last time that the files and databases were fed into the visuals. Later, both of these reports were added to a Power BI App along with all the important Power BI reports that the Campaign Team was already using in their day-to-day job (requirement 13). A Power BI App is basically a way that Microsoft made available to share visual content that allows you to group reports together and decide which group of people sees

which reports. It is also a way to centralize all the information and visual content used by the Campaign Team in one place.

To sum up, we built two separate Power BI reports: one for everyone involved in the Request process, and a second one only for the Campaign Team. Figure 9 shows which information is being fed to each of the Power BI datasets and which Power BI reports are being shown. Basically, the first dataset gets all the necessary files from the SharePoint site, the information from the Logistics DB, and the name of the dealer where each recently produced vehicle is. All this information is shown in "Requests PBI (EU View)". Likewise, the second dataset gets information about the fulfillment of the requests and shows that information in "Requests PBI (Campaign Team View)". Note that this last report also gets all the information from the EU View, as they are linked through Direct Query (which allows you to retrieve the data directly from the data source in real time, enabling you to build visualizations over datasets without having to import them).

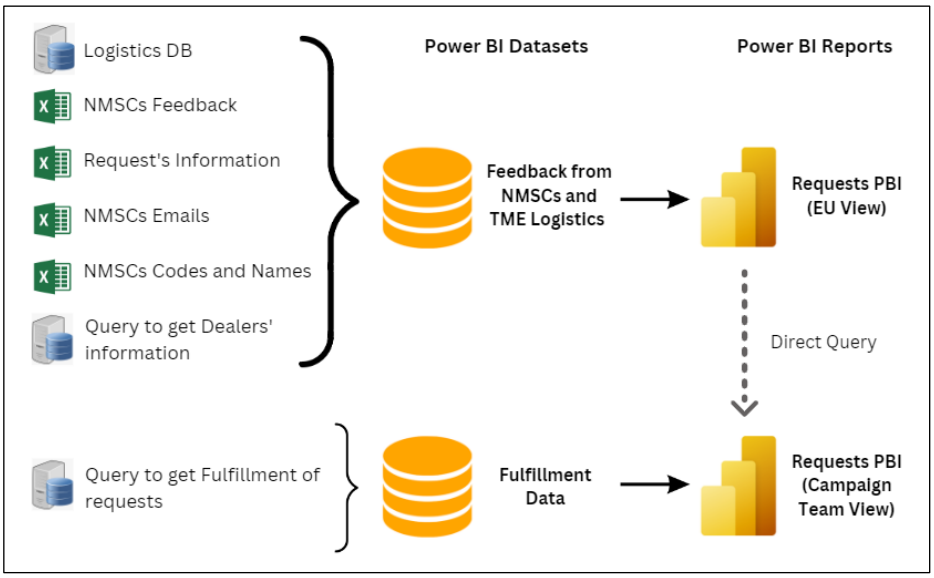

Figure 9 - Structure of the Power BI Architecture

After making these final modifications to the visuals, we finalized the structure of the Power BI reports. Both of them follow the same format, which is divided into four main parts. On the left side, we have the filter panel, where we can slice the visuals based on all kinds of attributes. Here, the timestamp that indicates when the report was last updated is shown. On top, we can see information about the selected request (such as a description, the issue date, the end date, the deadline to provide feedback, etc.). Below that, we have the flow of the vehicles, where we can easily perceive how much feedback was received for each status, and how many vehicles we are still missing feedback from. Finally, the remaining tables and bar charts enable us to monitor and understand how the process is flowing for each NMSC and for each request. Figures 10 and 11 illustrate what the reports look like.

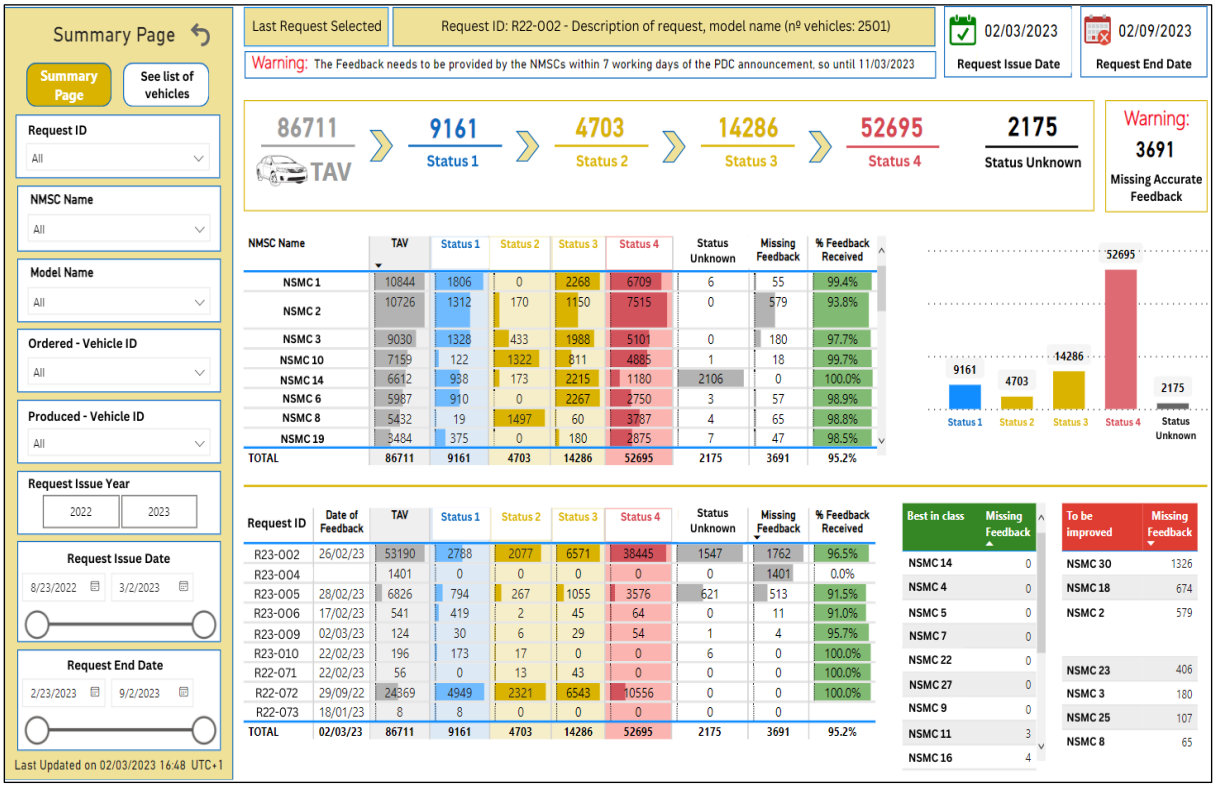

Figure 10 - Requests PBI (EU View)

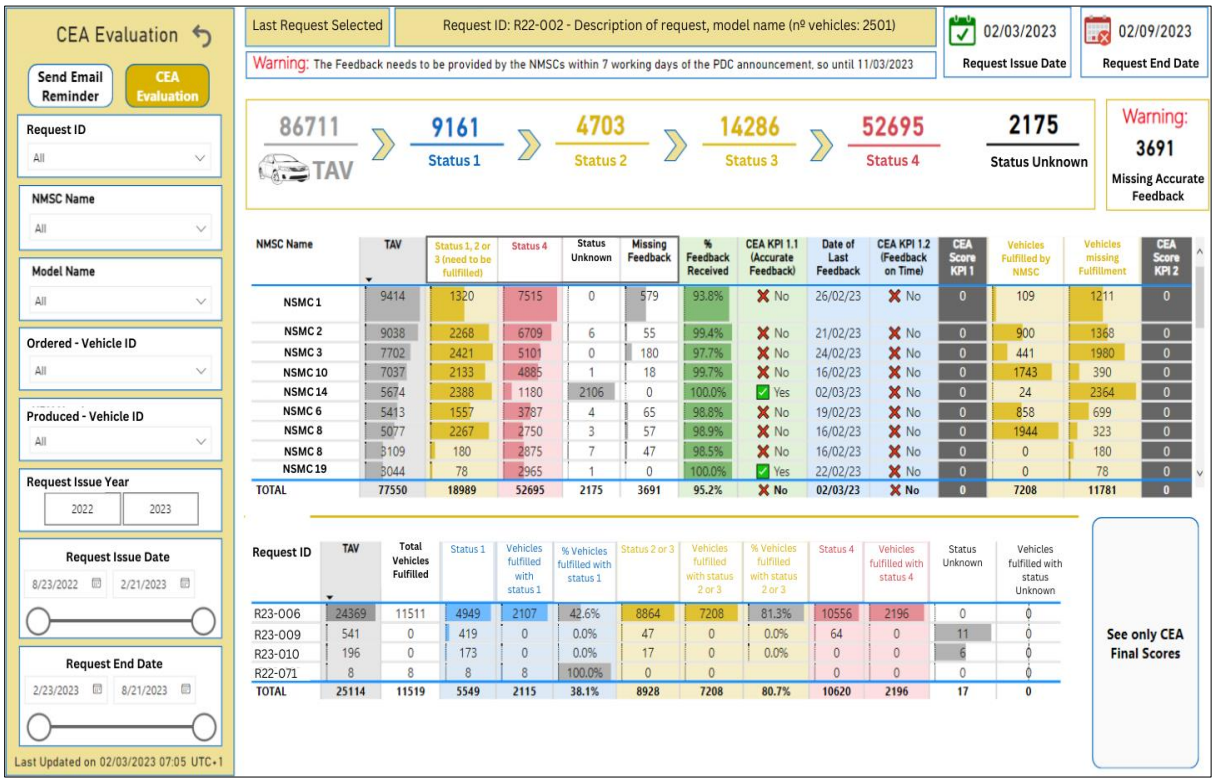

Figure 11 - Requests PBI (Campaign Team)

The last requirement (requirement 8) focused on developing a way to send automatic email reminders to the NMSCs that, after some days of the request announcement, did not provide proper feedback on the status of their vehicles. This requirement was achieved through a Power Automate Flow. This flow uses the visuals of the Requests PBI and links them with the emails we have from the NMSCs. If some NMSCs failed to provide proper feedback on time, the Campaign Team can send an email informing them of that delay with a simple click of a button. Other Power Automate flows were also developed throughout this process, mainly to trigger the online refresh of the Power BI datasets. Note that it is important to automate as much as possible the manual and time-consuming steps of the project, but it is also vital not to overdo this. The monitoring of all these flows is also time-consuming and requires some prior knowledge of how to do it. One question we need to take into consideration is this: in the future, will the monitoring of this flow be more time-consuming than the task that it is automating? So, even if there is not a thumb rule for this, it is important to implement as many Power Automate Flows as possible, but only if these flows can be easily monitored and adapted in the future (in case a problem occurs, in case the Request process changes, etc.).

Moreover, while further developing the tool, it was crucial to ensure that it was built in a way that all possible errors were avoided. For this, we relied on an additional concept used in the TPS called *Poka-yoke*. *Poka-yoke* means "mistake-proofing" or "error-proofing", and it is a process of designing products and processes in a way that makes errors or mistakes difficult or almost impossible to occur. This is accomplished by adding features to the product or process that prevent incorrect actions or that provide immediate feedback to the operator in case any error occurs. *Poka-yoke* can take many forms, such as simple visual aids that help operators ensure that the correct part is being used or more complex sensors that detect errors and automatically shut down a machine. By implementing *Poka-yoke* in its production processes, Toyota has been able to reduce defects and improve quality, which of course helps to improve customer trust and loyalty.

With that being said, we identified all the possible errors that could occur that might crash the system. These errors could be made by the Campaign Team, by the tools used, and mainly by the NMSCs. We realized that this latter one was our main problem, being that to ensure that the process of filling in the standardized feedback and uploading it to SharePoint was "error-proof" for all the NMSCs who did it. We needed to anticipate loads of different scenarios, such as:

a) What if the NMSCs do not follow this standardized template and add or remove columns?
b) What if two different feedbacks are provided for the same vehicle?
c) What if they use different codes and names for their country?
d) What if any unique identifier is missing or has duplicates?

To tackle this, we added additional steps to the Power Query responsible for compiling all the standardized feedback together in one master Excel file. These steps ensured we were getting the correct sheet of the Excel file, getting the needed columns from that sheet, removing any #N/A errors resulted from mistaken formulas, ignoring empty feedback, and removing any files that were returning an error in any of these steps. Even though it is possible to track down which file is returning an error to try to fix it, it is vital that these files, by default, are removed. This way we ensure that we do not crash the entire compilation of the feedback just because one of the files is wrongly filled in. Consequently, we managed to develop a more error-proof tool.

4.8. Development of User Guidelines

At this point, all the vital information on how to use the tool was summarized and written down in a document named User Guidelines. These User Guidelines were divided into 8 sections and can be seen in Figure 12.

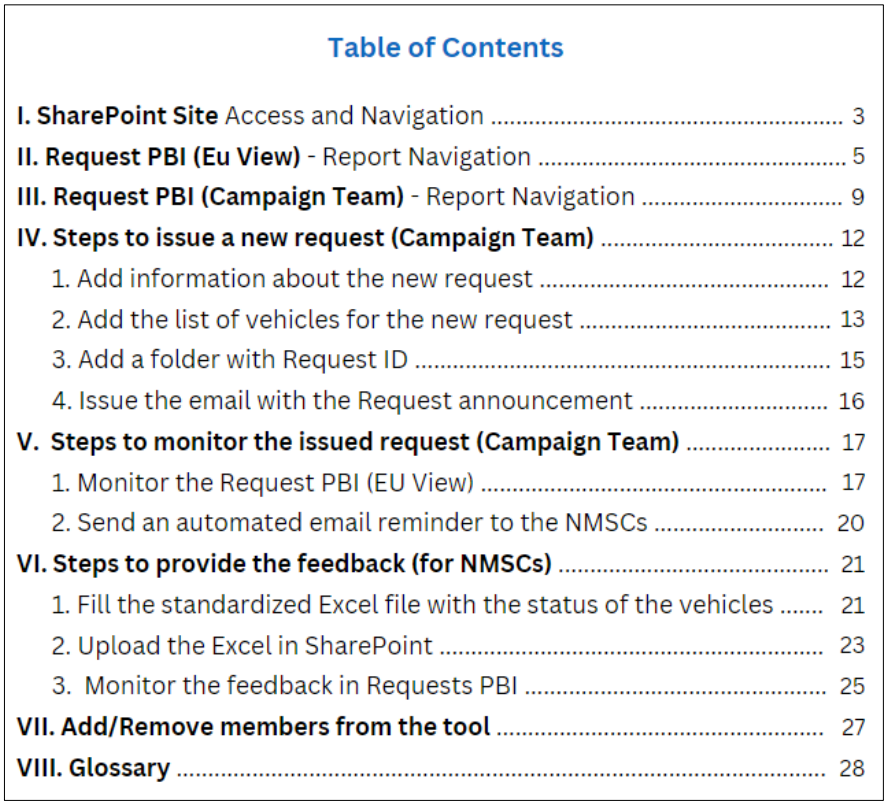

Table of Contents

Figure 12 - Table of Contents of the User Guidelines

To start with, we have SharePoint site Access and Navigation. In this section, the different SharePoint tabs were explained, as were the locations of the folders and documents to use during this process. It was also explained how to gain access to the necessary tabs and who to contact if something is not working as it should.

Then, both Power BI reports were described in more detail in sections II and III. The European View and the Campaign Team View were divided into parts, and all the visuals were broken down to help understand how to better use and sort each graphic. After carefully reading this section, both the NMSCs and the Campaign Team will be able to use these dashboards in a faster and more efficient way.

Next, the steps for the Campaign Team and the NMSCs to follow were listed in sections IV to VI. It starts with the four steps that should be performed by the Campaign Team every time before issuing a new request (these include adding the new request information to the SharePoint, adding the list of vehicles that are affected by that request, creating the folder where the NMSCs will upload their feedback, and sending the email notification to everyone involved). After receiving the email notification, the NMSCs need to fill the standardized Excel file with the correct status of the vehicles, upload the feedback in the correct location in the SharePoint site, and monitor that feedback. Finally, the Campaign Team should monitor the visuals in the “Requests PBI (EU View)” and trigger, if

necessary, the automatic email reminder for the NMSCs that are not complying with the Request process on time.

Lastly, all the necessary steps on how to add or remove people from the tool were recorded. It is important that the information shared in the SharePoint site is restricted and only people involved in this process should be allowed to see the data. Also, to add or remove permissions from other users, you need to be owner of the site, so only a limited number of people have that authority. At the end, the Glossary of all these sections was added.

4.9. TOOL TRIALS

After finalizing the guidelines, we used them for the tool trials. We first chose a sample of the NMSCs to include in this part of the project. The chosen sample needed to be representative of all the NMSCs, so we selected big countries and smaller ones, ones with effective internal systems and ones that rely a lot on manual work, ones that work alone, and others that are dependent on their neighboring countries. After analyzing these characteristics, a sample of six NMSCs was selected, and a meeting was scheduled.

Since we did not want to raise misunderstandings between the NMSCs and the already existing requests, we created two dummy requests (from 2030) to experiment with the tool in a controlled scenario. We were mainly interested in examining how the different NMSCs provided feedback on the investigation through the SharePoint site. For that, we issued these two dummy requests to the six NMSCs by email and gave them one week to provide the correct feedback in the right folder in SharePoint. To bring this exercise closer to a real-life scenario, we used real vehicles that were in transportation throughout Europe at that time, even though no request was issued for them. The NMSCs were also advised to monitor their internal processes and identify their main difficulties and troubles during the upload of their feedback. During that period, we were also closely monitoring the NMSCs and answering all their questions and doubts.

In the end, an evaluation form was sent to the participating NMSCs for them to evaluate the process and the steps they had to follow. Then, having examined these forms, we identified three main areas for improvement: the user guidelines were not as clear as they should be in certain steps, the time it took for the Power BI to refresh with the new information could be reduced, and the request description that appears in the Power BI report could be more complete. Regarding the User Guidelines, we rewrote some of them and added more pictures and remarks to facilitate their comprehension. Concerning the time it took to compile and refresh all the information into Power BI, we did everything we could to improve this. As explained above, in order to include additional information that proved to be very helpful for the NMSCs, the refresh time became a bit slower than before. Nevertheless, we strongly considered this trade-off necessary. Finally, regarding the request description, we opted to add more information to it (such as the model name, a more detailed description of the request, the number of units, etc.). This way, it is faster for the NMSCs to quickly identify which request they are working with, saving the time needed to double-check that information.

Overall, and even though the scenario was not real, these trials with dummy requests helped us make small adjustments to the tool and the User Guidelines before making them available to all the NMSCs.

4.10. TRAINING SESSIONS

The last step of the project before implementing the new process was to train everyone who would use the tool in their daily tasks. These include all the NMSCs and all the members of the Campaign Team as well, since they are the ones initiating this Request process every time a new request is issued.

This time, we included all 30 NMSCs. We scheduled two separate meetings and asked for all the people involved to be present in one of these sessions. Here, we took a few steps back and started by explaining why we were doing all these modifications in the first place, what the main existing pain points were, and how this new process would help them overcome those limitations. It was important to start from the beginning to get their attention and their support once again. Next, we shared the User Guidelines and carefully explained step by step all the activities they needed to perform throughout the process. All the important exceptions and remarks were also taken into consideration so we could reduce as much as possible future errors that could occur. This training of the NMSCs was essential since they are the main protagonists in this process. If they are not correctly educated and well-informed, they will not know how to better use the tool for their own needs.

Finally, let us not forget the Campaign Team. They are the ones triggering this process for the NMSCs and also the ones that will analyze all the information at the end to evaluate the NMSCs according to their performance. Given the importance of the matter, two sessions were scheduled for in-person training. The goal of the first session was to outline the steps to follow at the beginning of the process to make sure that no errors existed that could later impact the NMSCs. The second session focused on how to use the Power BI visualizations correctly and efficiently to closely monitor all the parties involved and to help with decision-making.

At the end of these trainings, we were ready to finally implement this project in a real-world scenario, making this To-Be process the new way to proceed whenever a new request arrives.

4.11. IMPLEMENTATION AND MONITORING OF THE TOOL

After completing the training sessions, we proceeded with the final rollout of the tool. As soon as this new process went live, all the new requests were processed in this new way. The old process, where we first identified the pain points, became obsolete and outdated. It was important that everyone involved be aware of this change to avoid NMSCs still using with the old methodology. To achieve this, an email was sent to all the NMSCs and to all the members of the Campaign Team to let them know that, from that moment on, the newly proposed process was live.

This meant that all the new data fed to the tool from that point on was real and accurate data provided by the NMSCs. After the implementation and as soon as new requests started to be issued,

it was important to closely monitor the tool and how the NMSCs reacted to it in a real-world situation. Some small errors and mistakes were still happening during the first one or two weeks, so we contacted the NMSCs individually and informed them what should be done to avoid those faults. Instead of fixing the problems by ourselves, it was important that we, as the Campaign Team, taught the NMSCs how to properly do it and how to proceed in those different situations. It was easy to understand that the first two weeks of monitoring and thorough follow-up of the new requests proved to be crucial for the correct usability of the tool by all the NMSCs. After this period of dedicated monitoring, all the errors that were occurring were eliminated.

4.12. LIMITATIONS FOUND AND NEXT STEPS

After implementing and monitoring the tool, we gained an understanding of the primary limitations of this project and identified potential Kaizen ideas that could be applied in the future to overcome these limitations.

To start with, we understood that one of the biggest limitations we had was getting the names of the dealers where the vehicles were. Firstly, we were getting this data from a system that updates daily overnight. Ideally, this system should refresh 2 to 3 times a day, so we could have more reliable information about the exact location of the vehicles. Secondly, we were getting information from all the vehicles produced in the last 6 months. Preferably, there should be a way in the mainframe to connect the Vehicle IDs to the Request IDs, so we could fetch data only for the vehicles affected by the required requests. Thirdly, this query should be refreshed in a different Power BI file so it does not slow down the refresh of all the other files. Because this query is getting data from up to 500 thousand vehicles, it makes the refresh of the Requests PBI (EU View) much slower. This separation was not implemented because Direct Query has some limitations, as we are not able to merge this query with other tables or use VLOOKUP's formulas online in Power BI Service. This means that, even though the information was appearing in the Power BI Desktop, it was not being reflected in the online version once it was published. Thus, this is the main point of improvement time-wise, as it would make the Requests PBI (EU View) refresh much faster by only fetching online files from the SharePoint (no querying of the mainframe anymore).

Next, one important aspect of the tool's usability in the future is which data to store in SharePoint and where to archive this information before deleting it from the PBI reports. The idea here is that, for the CEA evaluation at the end of each year, we need data from requests issued during the last one to two years (as some requests are carried over from one year to another). With this in mind, if we are providing the scores of the CEA evaluation at the end of 2022, we should use all the necessary requests issued in 2022 and at the end of 2021. After that, we can remove from the tool all the requests from 2021. Whenever possible, it is important to remove unwanted requests from the tool to reduce the amount of data we are getting and to improve its performance. This is vital since Excel also has storage limitations. However, before deleting past requests from the tool, a strategy should be defined for how and where to store this historical data:

a) Should a copy be made to the Campaign Team Scope Library in SharePoint?
b) Could it be stored in the standard SharePoint used by Campaign Team members?
c) Should a new database be developed to archive this old data?

These are all factors that need to be considered in the future before starting to archive old information from the tool.

To conclude, we also need a premium license to run the Power Automate Desktop Flow which compiles all the feedback from the NMSCs together. This Flow is considered premium because, even though it is triggered as a Cloud Flow, one of the steps is to run a Desktop Flow. You can activate a 90-day free trial, but ideally, in the future, two people should have this license so they can have two similar flows running alternately on their computers. This way, the feedback from the NMSCs will be compiled around 6 times every day during Campaign Team work hours. Furthermore, this Flow can also be improved by preventing some of the warnings from appearing (such as file not synced, file opened in the background, run failed because file was not found, etc.).

4.13. Documenting of Back-end process

In the final step of the project, we needed to document the entirety of the backend process. This is vital for the continuity of the tool at hand. If a new person picks up this project without any prior knowledge of it, they should be able to understand what is happening in the background with the Power Queries, the Power BI visuals and measures, the Power Automate Flows, etc. All these components are working together to achieve the desired goal of the project, so all of them need to be carefully and meticulously described in this final document. The table of contents of the Back-end process can be seen in Figure 13.

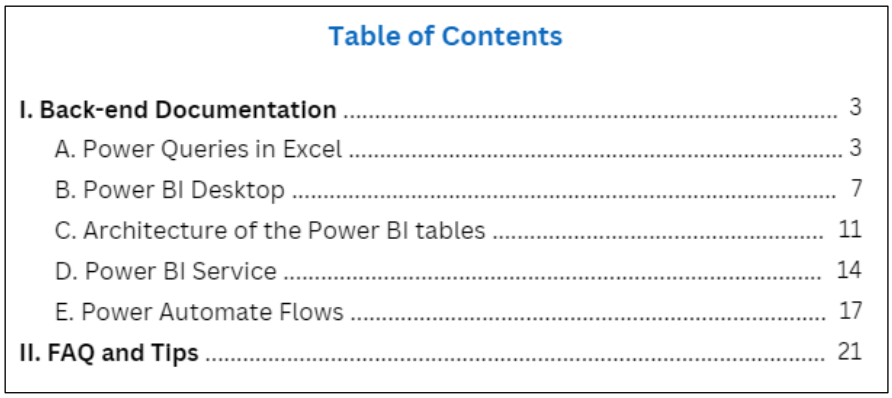

Figure 13 - Table of Contents of the Back-end Process

Since this documentation includes multiple Power Queries running on different Excel sheets, all the applied steps were described one by one in order to better explain the reasoning and logic behind the queries built. Hence, the reader will be able to easily identify which error is occurring and why, as well as which step should be modified or adjusted in the future to solve future problems and data inconsistencies. It is important for the new personnel to know which queries to review and who to contact for support in case an error occurs in a specific part of the flow of the Request process.

Because this documentation focused a lot on the more technical details of the process, it was important to conduct in-person meetings with the technical members of the Campaign Team. The steps were explained in a simple and straightforward way to make sure that the core message was retained. With this, we enabled an easier and smoother handover of the tool. For this project, five

different meetings were scheduled, focusing on five different modules of the Back-end process: Power Queries in Excel, Power BI Desktop, Architecture of the Power BI tables, Power BI Service, and Power Automate Flows. Next to these five modules, a final section was added with FAQs and Tips on how to use the tool more efficiently.

5. CONCLUSION

This dissertation aimed to study how automation and visualization could be implemented together to support a Toyota's European process. The results indicate that automation and visualization had an enormous positive impact on how the Request process was conducted. Regarding automation, unskilled manual tasks were replaced by Power Automate flows and Power Queries. In addition, the Request process was optimized with the design of a new and improved flow of information (where email traffic was greatly minimized). As for data visualization, the resulting Power BI reports represent a fast and efficient way to monitor the entire process and all the people involved, as well as an effective way to support decision-making and the scoring of the NMSCs for the CEA evaluation.

The approach we took intended to implement automation and visualization in the Request process while still maintaining the Toyota Business Practice framework. This framework is used as a guideline for every project carried out inside the company. By adapting it to this specific problem, we defined 13 steps to follow to ensure that this project was implemented in a skilled and effective way. We started by carefully analyzing the Request process and identifying its main pain points, which proved crucial for setting a clear goal for this project. Then, a To-Be process was proposed to overcome the identified limitations, which was vital to reducing the manual work of the initial process. From that point on, the tool was developed based on the input of everyone involved, and proper guidelines and training were carefully included before the final implementation. This was decisive in ensuring that everyone knew how to use the tool properly and accurately to better fit their needs. For the successful development of the tool, we relied on concepts from the Toyota Production System (TPS), such as *Nemawashi* (gathering consensus between all stakeholders), *Genchi Genbutsu* (go and see for yourself), and *Poka-yoke* (development of an error-proofing tool), which enabled us to maintain the Toyota identity throughout the entirety of the project. As a consequence, we managed to achieve important tangible and non-tangible benefits. As for non-tangible gains, we highlight job standardization, information centralization, and enhanced communication between NMSCs and the Campaign Team. Concerning tangible benefits, the automatic compilation of all the feedback in one master Excel file saves the PIC 5 to 6 hours of work per request. In addition, the automatic scoring of the NMSCs for the CEA evaluation reduces another 8 to 10 hours of work per request. As a result, we managed to reduce 13 to 16 work hours for the PIC every time a new request is issued.

Moreover, we identified some points for improvement to further enhance the capabilities of the tool developed. To speed up the refresh of the data in the reports, future work could be conducted on ways to limit the information and data we are querying from other databases. If unique keys existed between the different databases used for the Request process, it would be possible to easily select exactly the information we want to appear in the Power BI reports. This transformation would ensure that the data and information of the dealers where the vehicles are located could be fetched in a simple and much more efficient way. Ultimately, this would lead to a much faster refresh of the Power BI reports for both the Campaign Team and the NMSCs. Additionally, further research is needed by the Campaign Team to assess the best way to store the data of past and obsolete requests that are stored on the SharePoint site. Since we only want to see data for the past two years, it is important that all the unnecessary information be removed from the tool to prevent it from slowing down and reaching maximum storage capacity. There are several possibilities to tackle this problem, such as copying the Excel files that contain past information to the Campaign Team Scope Library,

moving that information to a different SharePoint, or even developing a new database that could in the future archive this information automatically. These are all factors that need to be considered by the Campaign Team before deciding how to archive old information from the tool.

Overall, this project explored some of the innumerable capabilities of basic and process automation and how their combination with data visualization can revolutionize how a process is conducted and monitored. In doing so, this dissertation also exposed some of the incredible applications of Power Apps in facilitating our daily repetitive tasks, such as creating Power Automate flows and developing Power Queries. Above all, this project developed a valuable and significant tool that reduced and even eliminated a lot of the pain points that were initially identified in the Request process and that were troublesome for the Campaign Team. From the moment this tool was implemented, it has been used daily by the Campaign Team and all the NMSCs involved across Europe to monitor the new requests being issued. Even though this project focused specifically on the Request process, it helped raise awareness about how automation and data visualization can truly make a difference in the effectiveness of a business process. In fact, the methodology presented in this dissertation can be replicated for enhancing other Toyota's European processes. That is why the Campaign Team is now developing new Power BI reports to better monitor, visualize, and understand other processes that they are responsible for.

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