A DMAIC project to improve warranty billing’s operations: a case study in a Portuguese car dealer

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Abstract
This article describes and analyzes how a big Portuguese car dealer group successfully used all the stages of a Six-Sigma DMAIC (Define, Measure, Analyze, Improve, Control) project to improve the warranty billing process (paid by Car Brands). It shows that the project allowed car dealers managers to understand that financial metrics in use did not control compliance standards for Car Brands, in warranty services, or assure a good cash-flow for the car dealers. Necessary changes and new metrics (% time compliance to do the service and bill it, % time compliance reception, % time to find a defective part in an audit) generated time benefits and consequently a more controlled cash flow. These new metrics may be common to any car dealer with warranty services.

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Peer-review under responsibility of SciKA - Association for Promotion and Dissemination of Scientific Knowledge

Keywords: Project; DMAIC; car dealer; warranty; metrics; improvement; time compliance.

1. Introduction
The Six Sigma and its DMAIC (Define, Measure, Analyze, Improve, Control) methodology is seen as the last generation of improvement approaches, adding concepts, methods, tools and removing limitations identified in

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previous ones. It builds on insights from the quality engineering field, incorporating ideas from total quality management and Taguchi’s off line quality control.

Studied for some years with an essential focus on the different tools used and on its results, the DMAIC approach is a structured improvement procedure. Some evidence on the benefits of its implementation, on the conditions of its success and on its difficulties have been produced in the industrial sector, but not only. This article contributes to the body of knowledge on DMAIC from the perspective of a service sector: the billing of car warranties services. Through a case study which covers five car dealers representing eight car Brands, this article will attempt to answer to the following questions:

1. To what extent did the (financial) metrics in use indicate control of the billing process?
2. To what extent the implementation of a DMAIC project managed to improve the after sales warranties billing process and help meet clients’ and business’ requirements?

2. Background

Although companies have always been looking for ways to improve bottom line results, starting with Taylor in the beginning of XXth century, this has never been as critical as nowadays in times of financial difficulties evolving to the use of lean and six-sigma management approaches more recently. According to the isixsigma.com site, “six sigma is a disciplined, data-driven approach and methodology to eliminate defects in any process.” It consists in putting in practice the focus on DMAIC to create significant improvements using any of the available tools and has evolved into a comprehensive approach for improving business performance. It includes the following key elements: clear focus on the customers’ needs (what is value for the costumer), focus on improving business processes often through the reduction of inherent variation, use of performance metrics, a clearly defined role of the process improvement specialist, use of data-driven and highly structured problem solving methodologies, and ultimately the generation of tangible business value. Besides its structure and focus on metrics, the use of DMAIC is similar in function but more comprehensive as its predecessors in manufacturing problem solving, such as Plan-Do-Check-Act. In the theory of organizational routines, DMAIC is a metaroutine: a routine for changing established routines.

Since Motorola launched Six Sigma in 1987 and Jack Welch’s commitment in General Electric, Six Sigma has become a well-established methodology in the manufacturing sector with thousands of other companies having implemented it. Meanwhile, also services providers have adopted Six Sigma to continuously improve their processes, especially in the health sector and in the financial services. This methodology has also been applied in nonprofit organizations.

There is a fairly large and growing body of evidence associated with the benefits of implementing Six Sigma. In a literature review on this matter, Kwak and Anbari list the following ones for the industry: increase in benefits and savings, reduction in process defect levels, reduction of depot maintenance inspection time, reduction of turnaround time at repair shops, reduction of cycle time, increase of quality and productivity. Motorola, the inventor of the Six Sigma methodology, estimated that over the twenty years deploying Six Sigma, it has documented savings of $20 billion. At the service level the following benefits are outlined: accuracy improvement of cash allocation and of reporting, reduction of bank charges, minimization of documentary defects and variation in performance collection, increase of automatic payments. Bank of America claimed benefits of $2 billion and increased customer delight by 25% in less than three years with its Six Sigma initiatives.

Besides the benefits of DMAIC, some academic research has tried to determine which elements make it effective or not. For leading organizations, the adoption of Six Sigma positively impacted organizational performance primarily through the efficiency with which employees (but not assets) were deployed. But other key elements are essential: management involvement and organization commitment, encouragement and acceptance of cultural change, continuous education and training, integration of other principles and characteristics of TQM (Total Quality Management), Human Resources Function, Lean Production, ISO 9001. However, some obstacles are pointed out that may weaken the effectiveness of the projects. In the heavy industry, especially in developing countries, statistical insight is not very common and systematic approaches are often neglected.

Six Sigma has still little expression in large Portuguese companies. In the service area, and in particular for billing services, we found the application of DMAIC to the billing process at a Portuguese metrology laboratory –
ISQ\textsuperscript{16}. In this case, improvements were proposed but no results of their implementation were outlined since this phase of the project was not analyzed. The other DMAIC case study in a car dealer importer\textsuperscript{17} dealt with the beginning of the warranty process, when car owners are called to the workshop. In this case, the recorded data were not being used at their best, becoming more visible with an excel sheet. Also, financial incentives were created to obtain results.

In face with very little existing research (in general and in Portugal in particular) this article aims to contribute to DMAIC case studies, reflecting on its implementation, in particular in car dealers and even more specifically in its after sales warranties billing process.

3. Methodology of the case study

The second author of the study worked as a consultant of the company. The study took place in five workshops of an important Portuguese company with five decades of existence that represented eight car Brands, in three buildings. The workforce included sixty people: one director, one consultant process manager (the author), three after sales managers, ten clerks, five receptionists and forty mechanics.

The after sales’ workshops provide three kinds of services: the repairing of breakdowns, the preventive maintenance and the solving of manufacturing defects for cars within their warranties period (that we will call simply as warranties in further text). The latter services are billed to car Brands, at the distance of a computer click.

The investigation methodology goes through each and all of the DMAIC steps, carried out by the second author of this article, as a consultant of the car dealer. We Defined the problem of the enterprise learning about current/existing ways to control the billing process, the used metrics and the standards to be met (before the intervention). We clarified and defined Value for the Car Brands and after two months of a preliminary study of the process, people and their roles, the software and procedures, we transformed the comprehension of this Value into new metrics and standards capable of measuring the process compliance with them, in real time and with all data recorded. We Measured the current state (baseline of the project) with these new metrics. We Analyzed the root causes for deviation from standard and proposed Improvements which were implemented and finally Controlled.

4. Define

4.1. State of the situation and metrics before the intervention

The billing process under this investigation starts when the company initiates the “contract” with the owner of the car who authorizes the Car dealer to do the warranty service. It ends when the car dealer receives money for this service by the Car brand. The contract is the legal and technical documentation that keeps track of the process, and is part of evidence, should a Car Brand visit (and audit) a car dealer. The steps for a warranty service, considering here the Brand as the final client (which will pay for the service) are: to do the service itself (that can include substituting spare parts or not), to bill the service (computer wise) to the Brand, to receive the payment from the Brand. Billing is made on a confidence basis between the authorized repairer (car dealer) and the Brand. It takes place every day. At some point, every year or more, a technician of the Brand (an Auditor) visits the car dealer to check for evidences. This moment is called an Audit. For each service the Brand paid for before, Auditors check for evidences in documents (like the owner’s signature or the mechanic’s report, for example) and look for the substituted defective parts that should be stored in an exclusive and closed store room. Some Brands have a checklist of up to thirty evidences to check. Other brands are not so specific and formal.

In the Audit, should any evidence to be submitted fail, the car dealer has to return the money already received for that service from the Brand. In this case study the company billed an average of 720 000 Euros a year. So, the company is interested in avoiding giving any money back (we will call money cuts in the subsequent text). Normally, every month, in a global view of the accounting service, an average of 60 000 Euros were billed to the Car Brands. Yet this amount was not all received monthly. Preliminary measures taken of the last year and a half showed that a total of 180 000 Euros of done/billed services were missing. The car dealer had been compelled to make a loan to face cash flow expenses. So there are basically two problems for the Car dealer: potential money cuts in an Audit and a growing and significant negative cash flow.
Before the intervention, the process was controlled, by 5 financial metrics, on a monthly basis: 1) how much money was in progress (measured upon labor and parts recorded as already used in that service), 2) how much money was billed (total), 3) how much money was received (total), 4) how much money was lost in brand audits (none as this point, because no Audits had happened yet), 5) the difference between the total amount billed in a certain month with what had been respectively received from this “billed” month: a total losses/gains metric (although losses or gains were registered for each service, what was checked was the total balance). These losses/gains happened because of a disagreement of the Brand with the content of some of the bills (the brand might have paid less or little more than what had been billed). An example of this situation could be the car dealer billing a service for 100 Euros but the Brand paying only 95 Euros, due to the Brands’ medium price of the spare part (different). On the contrary, because of a so called “handling rate”, the car dealer could receive 100 Euros from a Brand, although only 90 Euros were billed. The total balance of these losses/gains did not alarm for losses since there was not a significant difference between total losses and gains (although some bills had significant losses).

Every year, the Car Dealer approved a Budget for the following year. The set standards of the financial metrics in place (Table 1) were controlled on a monthly basis.

Table 1. Current (BEFORE the intervention) Formula, Standards and state of compliance to Standard.

| Metrics (BEFORE the intervention) | Formula                        | Standard (BEFORE)  | Compliance to Standard |
|----------------------------------|--------------------------------|--------------------|------------------------|
| $ in progress                    | $ Total money in progress       | No standard        | -----                  |
| $ billed                         | $ Total money billed           | Within budget      | Yes                    |
| $ received                       | $ Total money received         | Within budget      | No                     |
| $ lost in audit                  | Total money loss in Audit      | 0                  | No data                |
| Total $ losses/gains             | Losses/gains                   | Within budget      | Yes                    |

Money in progress was not systematically assessed although time for the service to be done always exceeded 30 days and money received was always under the budget forecast.

4.2. Understanding Value for Brands and establishing new metrics

To become an Authorized repairer, a car dealer had to sign a long term contract with the Brand that established the conditions in which warranty services should occur, including the existence of well trained mechanics, adequate facilities and equipment, well defined mechanical procedures, and time compliance.

Between the eight Car Brands represented by the company under study, only one had a clear list of all items to be checked in a warranties’ audit. Other brands were not so specific. Yet all car brands looked for evidences from the car dealer and wanted: every service to be done at the right time (section 4.2.1.) to be done right (section 4.2.2.), with the availability of evidences in the billed information and of the existing substituted parts (section 4.2.3.). Our goal was to traduce Value for the Brands into new metrics, measure the company’s performance on these metrics, find the causes of non compliance and propose process improvements, which would address the company’s problem of potential money cuts in an Audit and a growing and significant negative cash flow.

4.2.1. Metrics to measure if each service was done in the right time and Standard

In terms of time, the Brands value the time elapsed between the starting of the process with the client’s signature on the contract and the time when the contracted service is billed to the Brand (computer wise). Although, as we found out, the right time varied from Brand to Brand, it was always desirable to be under 15 days. We proposed 8 days as a Standard to have time compliance to do the service. Although the Company recorded in its software dates of staring of each service and of its billing, for services in progress (not billed yet), it did not calculate in a systematic way the time elapsed between the date of measurement and the date the contract started. Therefore it was not possible to know if services were becoming out of standard. It was a matter of introducing a new simple digital information treatment (value of the difference between the starting of the service and the date of measurement).
### 4.2.2. Metric to measure if each service was done right and Standards

The Brands did not have a way to measure if each service was done right (except in an Audit). After studying a sample of the bills whose services had not been paid or partially paid for, we found out that bad or insufficient information had been written down in the bills. To measure the quality of the billing content two indirect metrics of the service done right were assigned: a) the time between the billing of services and the respective payment (if there was a delay, it meant bills were not correct), b) bills paid partially (with significant loss) (if there was a significant loss it meant bills’ content was not correct).

### 4.2.3. Evidences of billed information in loco and of substituted parts

In addition to the aspects characterized above, which are observed by the brands for each service at a computer distance (through digital means), audits happen occasionally to observe in loco evidences of the already paid services. This can result in money cuts over what has already been paid. We transformed the initial absolute metric (how much money lost in Audit) in a relative one (% of money audited within compliance/audited money). The standard is having no money cut, that is to say 100 % of compliance. For the Audit metrics, no audit had yet taken place, therefore no information existed and success measurement would only be observable in future audits.

For the spare parts, which needed to be evidenced in a possible Audit, we proposed a new metric: % of spare parts which were found in less than 1 minute time.

### 4.2.4. New metrics and standards

In above sections, we searched for metrics that could allow the control of the billing process (and potential losses for the company/Car dealer in line with the Values given by Brands to the warranty service). In Table 2, we summarize theses metrics, transformed in money or time and expressed in percentage of compliance (compared to the standard), instead of in amount of money (to be compared to budget). The “standard” is the ideal time or money to have the process under control.

| Metrics (AFTER)                             | Formula                                                                 | Compliance to standard (%) | Standard     |
|---------------------------------------------|-------------------------------------------------------------------------|----------------------------|--------------|
| Time to do the service and bill it          | Difference between date of billing and date of contract with owner      | Nr. services in standard / Total Nº services | <8 days      |
| Time compliance for each bill to be paid    | Difference between date of payment and date of the bill                 | Nr. services in standard / Total Nº services | <60 days     |
| Money loss compliance for each service paid for | Difference between money received and money billed (only when lost) | Nr. services in standard / Total Nº services | < 10%        |
| Money loss compliance in an audit           | Ratio between money confirmed to comply to audit and total money being audited | $ audit in compliance/ Total $ audited | 100%         |
| Time compliance to find a substituted defective part | Time to find a part                                                 | Parts found in standard time/ Total parts to be found | < 1 minute  |

### 5. Measure

Although Six Sigma is generally identified with complex statistics use, in our case, measurements of performance with the new metrics were made through simple histograms of four classes (Table 3) and results exposed to the people in the company. Each of these classes of the histogram goes progressively, from left to right, to a bigger and bigger deviation from standard.

The first class is the standard. The second is the process at the limit of compliance. The third class is out of compliance, but shortly, it may be reworked. The fourth class is most probably not re-workable, thus having to be assumed as a definitive loss. Measurements included all the bills (not a sample). We extracted data to an excel sheet and treated differences between dates or money (billed and paid for). We measured how many bills were waiting to be paid for more than 90 days. If that time overcame 60 days (the proposed standard), it meant that the Brand was
not satisfied with the information billed. We also measured how many bills had already been paid for, but only the ones with losses. If the brand paid much less than had been billed for, this was an internal evidence of a defect in billing. We proposed 10% loss as a standard to have losses under control (Table 3).

Normally, in the Measure stage of the DMAIC methodology, statistic training sessions are delivered to the people involved. As these histograms were easy to understand, these training sessions were not necessary.

Classes out of control are the ones we used to study the root-causes. As it is possible to see in Table 3, measurements show that all the new metrics were far from meeting the standards.

Table 3. Histogram classes for the three first metrics and measurements to standard for current state.

| Metrics registered on excel/ Classes       | Standard  | Compliance to Standard (%) | Under control | Reworkable | Scrap |
|-------------------------------------------|-----------|----------------------------|---------------|------------|-------|
| Time to do the service and bill it        | < 8 days  | 20                         | 8 to 15 days  | 16 to 30 days | > 30 days |
| Time compliance for bills to be paid for  | < 60 days | 20                         | 60 to 90 days | 91 to 180 days | > 180 days |
| Money loss compliance for each service paid for | <10%       | 60                         | 11 to 15%     | 16 to 20%   | >20%   |
| Money loss compliance in an audit         | No data   |                            |               |            |       |
| Time compliance to find a substituted defective part | 0           |                            |               |            |       |

6. Analyze

We walked the process through back and forth, endless times, in each work station, evolving people in DMAIC, questioning them, using the 5 Whys technique, showing the state of measurements in relation to the established standards, observing and listening. We gathered past and current data, measured with the proposed metrics and confronted with the proposed standards. The possible causes and solutions were discussed with every one as people turned themselves available. We used the Ishikawa fish-bone to resume root-causes: metrics, method, people, machine, material and environment.

Conclusions of the analysis for non compliance led us to identify bad method as one of the main causes. There was absence of control (bad method) of the scheduling and of requested parts, absence of documentation control, and absence of parts control (to be stored in warehouse). We observed that 34% services registered “in progress”, either awaited a spare part, or, if the spare part had already arrived, the service had not been scheduled with the client. In relation to the information to fill in the bills, out of the 200 returned invoices to be reworked/corrected, we found out that the information available to bill was not always correct or sufficient (for example lack of a code or incorrect series number of the car). No one controlled what was written in the documents, for example, what had been diagnosed and what had been done. The reason that could explain “bad information” was that the current “service order” form which accompanied the service had an unclear design and very little space for the mechanics to write down the diagnosis and explain the job done. On the other hand, the billing clerk would usually talk with the mechanics and get the essential information orally. In relation to the substituted parts, to be in the storeroom, they had to be returned to the parts’ balcony. Every time a new part for a warranty service was given to a mechanic to substitute the defective one, the parts’ clerk made a card with its identification and kept it besides the computer screen among other papers and only when the substituted defective part would be put there, he would search for the respective card and store the substituted defective part.

If an audit would occur, the greater probability was that people would start looking everywhere for the parts to be evidenced only some days before the parts audit’s date. It was assumed that they should be in the store and easy to find. However there was no control method of this aspect.

Another root cause was the lack of motivation of people. People were not motivated to control or improve the warranties process or potential problems. People performance was evaluated upon their punctuality and presence at work. Some people, like the warranty clerk, were assessed with productivity measures (value billed per month). People were therefore punctual, present and maybe productive but the process had still a potential problem and significant money losses. Another founded root cause was related to the bad use of the machines: the mechanics did not fill in and/or print the results of the diagnosis processed by a computerized system. The origin of the situation
lied in the lack of training of the mechanics in the use of these machines. In addition, some services were refused because they were not correctly billed in the software. Training was needed for warranties clerks and mechanics.

Finally as we could observe in most workstations the environment was not the best: information and office material were not always available or not available on time. Processes could be more efficient if more organized.

7. Improve

The Results presented AFTER (Table 4) come from data extracted seven months after the introduction of the improvements. The AFTER metrics revealed services and bills that could not be recovered and had to be assumed as losses. These were integrated in these results and constitute part of the reason for some improvement. Yet significant operational improvements made (and new metrics) allowed an easier way to work and control the process. Since audits did occur during the IMPROVE step, it was possible to measure results for money and time compliance to find a part, both in an Audit (last two metrics).

Table 4. Improved Metrics, current and after results.

| Metrics (AFTER)                                             | % BEFORE IMPROVEMENT | % AFTER IMPROVEMENT |
|-------------------------------------------------------------|-----------------------|---------------------|
| Time to do the service and bill it                         | 20%                   | 80%                 |
| Time compliance to be paid for each bill                   | 20%                   | 75%                 |
| Money loss compliance for each service paid for           | 60%                   | 80%                 |
| Money loss compliance in an audit                          | No data               | 95%                 |
| Time compliance to find a substituted defective part       | 0%                    | 95%                 |

These results were due to several improvements made tackling all the identified root causes for the problems. Instead of the information being dispersed between all people or workstations, the use of a Google excel sheet (Table 5) allowed the control of time compliance of the scheduling and of the requested parts in a fluid manner. This sheet had to be filled in 9 columns: the first 6 columns were the data needed to make an order to the parts’ supplier, the seventh column had the name of who ordered the part, and the eighth column, the workstation to which the part was to be addressed, the last column related to the control of the arrival of the part. Reception, workshop and parts clerks could read and write in this sheet, in real time. After the part was pulled, the line of the spreadsheet was deleted, so all lines on the spreadsheet represented parts requested in progress. If there were too many lines, this meant that too many parts had been ordered and not pulled yet. This way it was possible to have a visual control of the parts and scheduling (if the destination of the part would be the reception, scheduling would be the next action to take place, by the reception clerk).

BEFORE improvement, control of parts and scheduling was made when the “contract” started, stretching the time for service in progress. At this moment, the contract time would only start when the service started. Time compliance became easier.

Table 5. Sheet on Google docs to control parts and scheduling.

| Part code | How many | Part name | Brand | Order number | Order date | Person requesting | Workstation destiny of part | If part received yet |
|-----------|----------|-----------|-------|--------------|------------|---------------------|------------------------|---------------------|
| Gh5678    | 4        | Key       | xxx   | 564          | 5-8-10     | John                | Reception              | Yes                 |
| ..        | ..       | ..        | ..    | ..           | ..         | ..                  | ..                     | ..                  |

In relation to the storing of the substituted parts, the solution found consisted in storing the substituted parts by a numerical order (the number of the service order) as they would be asked for in an audit. Every part was stored with a label corresponding to the number of the service order. Parts were stored by blocks of large numbers, for example, from 800 to 899. All pieces of the services within these numbers were stored there and easy to find. We first eliminated a very big amount of parts that had been stored for too long. Also from then on, the cards (related to the new parts) were put in a specific box on the balcony so that everyone could see them. At the end of the day, the
parts’ clerk could control which defective parts had not been returned and why there were parts missing, if service was still in progress or already finished.

Concerning the initial form filled in by the mechanics, it was redesigned with two different clear spaces to fill in this important data (Fig. 1).

![Fig. 1. Before and After form.](image)

In relation to people, improvement consisted also in making processes more visual to the mechanics. People started to be more motivated because they were involved in the problem, knew, weekly, the initial state and the improvements. This information was given in each work station, by the Project manager.

Training was given, with inner resources, from colleagues and supervisors, to improve the use of machines, including in printing diagnosis and interventions. Finally the technique of the 5S was used in every clerk’s work station and updated information and material became available at the right time, every time.

8. Control

For all the metrics, and since compliance was expressed in percentage, people could easily visualize improvements. For example, in one location, and for one brand, time compliance improved from 24% to 64%, (in 7 months), so still there was improvement to be made to achieve 100%. Standards could, in the future, evolve and become tighter.

9. Discussion and Conclusions

Along the nine months of its implementation, the DMAIC approach took us to DEFINE compliance for Car Brands (the paying customer), study current metrics, improve them and set the standards to meet compliance, to
MEASURE non compliance, to ANALYSE root causes for non-compliance, to IMPROVE the problems deriving from the root causes, and then to CONTROL compliance.

This case study made clear that the company’s current metrics only attended financial budget concerns and were not able to establish where and why money was being lost or missing. Moreover, the “to budget” financial metrics in use did not attend the Car Brands values of an efficient billing service, nor helped having the cash flow under control. This article showed how the DMAIC approach, used consistently with all its stages, was powerful to define the problem and to find the locations and the causes of the inefficiencies. The Measure stage turned out to be of greatest importance to understand the reasons why the company was not meeting compliance standards. We put in evidence how the proposed metrics, expressed in percentages, allowed to seek for improvement of the billing process in a continuous cycle, thus turning the cash flow under tighter control and decreasing the loss of money, and in parallel accomplish Value for Car Brands.

Three out of the five proposed new metrics dealt with time. Consequently the main direct benefits for the Car Dealer consisted in time gains, more specifically in the cycle time confirming what the bibliographic review had already mentioned for other services. Consequently the company benefitted from a more tight cash flow control. The other two metrics Money compliance for each service received, Money compliance in an audit allowed direct measure of losses in money.

This study case shows that it is not always necessary, as Gupta and Srir already pointed out, to use a large quantity of statistics to find ways for improvement. Also there was no need to create new data since it was possible to use the already recorded ones. It is a matter of looking at these data and work with them in a way that sheds light on the metrics that accomplish Value for the Car Brands. So not much time was spent in the provision of data and statistical treatment nor was there a need for many hours of formal training in statistics. It was more important to spend time to define the problem, analyze the root causes and implement the solutions.

In a practical perspective, this investigation shows that it is important to align people’s performance evaluation with customer satisfaction standards. After the changes were implemented, the company asked the second author to make the same measurements in the rest of the car dealer workshops which revealed to have the same problems of noncompliance for Car Brands. So we believe that the proposed metrics are universal for the process under study.

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