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Improving forensic processes performance: A Lean Six Sigma approach

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ABSTRACT

Quality practices in forensic science are often in tension with providing timely results. When the Costa Rican Department of Forensic Sciences ballistics unit achieved accreditation under ISO/IEC 17020:2012 in 2018, the unit started experiencing slower turnaround times. With a view to expediting the resolution of forensic examination processes, the unit undertook a Lean Six Sigma project with a five-phase problem-solving methodology. The unit began to use data and process tools to transform its current state. The completion of all phases showed that two main aspects were preventing the laboratory from fulfilling the customers' expectations: standardization and constraints. This project took 6 months and improvements were seen through the reduction of the number of pending cases with a backlog of more than 3 months by 97% and the turnaround time from 4 months to 1 month. Through this project, leadership identified an effective methodology, creating a positive impact on customers' expectations.

1. Introduction

The Costa Rican Department of Forensic Sciences ballistics unit had already established a quality management system, in order to provide customers credible results; however, the ballistics unit needed to demonstrate reliability and technical competence, so accreditation became a goal as recommended by the National Academy of Forensic Science in the United States. The ANSI National Accreditation Board granted accreditation in September 2018. Accreditation signified that the Department was able to offer clients reliable, and valid results, with transparent and objective examinations. That said, accreditation also had the undesirable effect of an increase in turnaround time, therefore preventing optimized production.

At the time, the Department of Forensic Science, specifically the ballistics unit, was dealing with an increase in the amount of evidence received for examination because there was a rise in complex crimes involving firearms (homicides, organized crime, and assaults). In 2014, the number of items of evidence received for examination was 5753. In 2018, the laboratory received 8769 items of evidence. By 2018, the ballistics unit had an 8-month turnaround time, an increase in 4 months since 2014. In the past, the conventional solution had been to ask for new positions to increase the number of examiners. However, the organization, and the country of Costa Rica itself, were experiencing a challenging economic situation where a "strategy" of continually asking for more human resources was not feasible. Resources were decreasing and optimization of resources was crucial.

The backlog within the ballistics unit needed to be addressed with a different strategy. In a forensic laboratory, timely results add value by providing critical information while the investigation is active while results provided in an untimely manner may add little investigative value. For example, reporting identified hits using an automated firearms identification system may be critical to solving violent crimes and stopping violent offenders before they can reoffend [1]. As such, the unit needed to increase efficiencies in processing and eliminate unnecessary activities. For the Department of Forensic Sciences, this was the key to understanding that Lean Six Sigma, with its well proven benefits, was the required methodology to improve performance. When applied rigorously, Lean Six Sigma can have a positive impact on productivity, cost, time delivery and quality [2] and integrate customers' needs in the development of the product [3].

In "Six Sigma" everything starts with the customer [4]. Improving the value-added activities by reducing variation is a central tenet because variation adds time delays, more costs and less quality onto what had already been produced (devolutions

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Table 1
Data obtained from the application of Lean Six Sigma tools for the seven steps of the process.

Steps	Time (minutes)
Reception	61
Opening and describing evidence	597
Examination	67
Filling forms	30
Comparison	1125
Reporting	700
Return of the evidence to the storage	40

from peer review are an example in the forensic field).

"Lean" means eliminating non-value-added time activities and reducing costs while improving quality and eliminating wait time [4]. "Lean" necessitates the identification of speed and time traps causing delays. The Lean Six Sigma approach includes Six Sigma methodology focused on process variability reduction and standardization, with Lean manufacturing that prioritizes process simplification and waste reduction [5].

The Lean Six Sigma problem-solving is structured and rigorous [5], underpinned by improvement tools and a process consisting of five phases, referred to as the Define-Measure-Analyze-Improve-Control (DMAIC).

Particular tools assisted in measuring the state of the problem, finding and analyzing the root causes, improving the process [6], and finally sustaining the improvement, which was only possible with management engagement [4].

In the end, the key lesson is not to get lost in the statistical weeds or the improvement tools. Although the improvement process and tools are incredibly powerful, the most powerful element is the culture [4].

Many organizations considering implementing Lean Six Sigma may be wondering if it would actually lead to improvements and if it would, whether barriers exist that affect its successful implementation, such as the receptivity of the staff, the complexity of the adoption process, the evidence of innovation sharing, and resistance to change [7].

It is important to understand that culture is a big reason for the success of any project and every leader needs to be clear that every organizational system has its own natural "immune system" [8]. Despite the proven benefits of Lean Six Sigma methodology, people are afraid of transitions and this must be managed in order to ensure the project is a success. Management is not just about finding a better strategy to overcome problems for being more competitive or efficient, or worrying about finances, it also about helping people through transitions. The first task is to convince people to leave their current state [8]. Excellence is about seven parts commitment and three parts strategy [8] and most efforts succeed or fail based on execution; few fail for the lack of a good strategy [4].

Lean Six Sigma is a method production agencies commonly use to proper structuring of processes [9] which leads to improved efficiency and quality [10], but what does Lean Six Sigma have to do with a business management strategy in forensic science? Although there are many differences with industrial applications, Lean is a management strategy that is applicable to all organizations because it is chiefly concerned with improving processes [2]. Forensic science laboratories comprise a series of processes that need to be accomplished in order to deliver a product and provide value to the customer. In addition, forensic laboratories, often government entities, need to be efficient with funding provided through taxes from citizens, the ultimate customer.

2. Methods

The Department of Forensic Sciences serves a population of 5 million by meeting an annual demand of 40,000 examinations with a staff of 220 technical and administrative personnel. Ballistics is divided in two sections: one conducts comparisons and the other conducts examinations of caliber size, firearm functionality, and serial number restoration.

Structured and comprehensive training is a critical success factor of any LSS Project [11]. West Virginia University imparted the skills to the project manager to conduct a Lean Six Sigma project through training and certification. During the LSS project, the ballistics unit employed DMAIC steps and used them for identifying waste (muda) and overburden (muri).

The first step during the 'Define' phase was to write a project charter. Determining the team and the project are one of the most discussed topics in LSS deployment [4]. Selecting appropriate members for the team and identifying strengths and weaknesses in team members was important, as well as evaluating the project with the biggest potential impact. Also, the project had to be aligned with the strategic goals of the organization and with quality improvement efforts, to receive the institutional support to succeed [12]. Finally, the project charter included a basic financial analysis to calculate the investment to be made, the budget available and the support of the management in using that budget.

Once the 'Define' phase was completed, the team moved forward to the 'Measure' phase, but not before the presentation of the results of this phase called "tollgate". The "tollgate" confirms that the phase has successfully completed and must be done for all 5 phases.

In this second phase, the team gathered data using five different tools. The team used *"Voice of the Customer"* to understand customer dissatisfaction; *process mapping* for understanding and documenting processes; *SIPOC (suppliers, inputs, process, outputs and customers) Maps* to identify all elements of the project; *Standard Work Combination Sheet* (SWCS) for documenting the steps of the process and measuring the manual time, automatic time, walking time, waiting time; the *Value Stream Map* for documenting activities from when the process begins (submission of the evidence) to ends (return of the evidence) and *Five Valuable Times*: lead time (total time from beginning to end), cycle time (time between initiation and completion of a process), takt time (rate at which a finished product needs to be completed in order to meet customer demand) and value added and non-value added time. All these tools were used for understanding the current state and defining the future state so the LSS project could be implemented and sustained.

The third phase "Analyze", took place once the problems that contributed the most to the process were identified. In this phase, the team was empowered to work out solutions by brainstorming. They also used *level load charts* (level loading is a balancing of all activities of the process to the takt time) and *Pareto analysis* (prioritization tool that allows to effect change on 20% of the biggest issues to get an 80% gain) to visualize and identify solutions to the problems.

As a result of the evaluations conducted in the 'Analysis' phase, a series of improvements were executed in the fourth phase, "Improve". The changes were focused on standardization of the process and the reduction of the non-value-added activities and constraints.

The aim of the 'Control Phase' was to monitor performance of the improvements that were implemented in the ballistics unit. The following tools were used: huddles for feedback and any issues that needed to be immediately corrected. Production boards for showing current status, listing information relevant to goals and

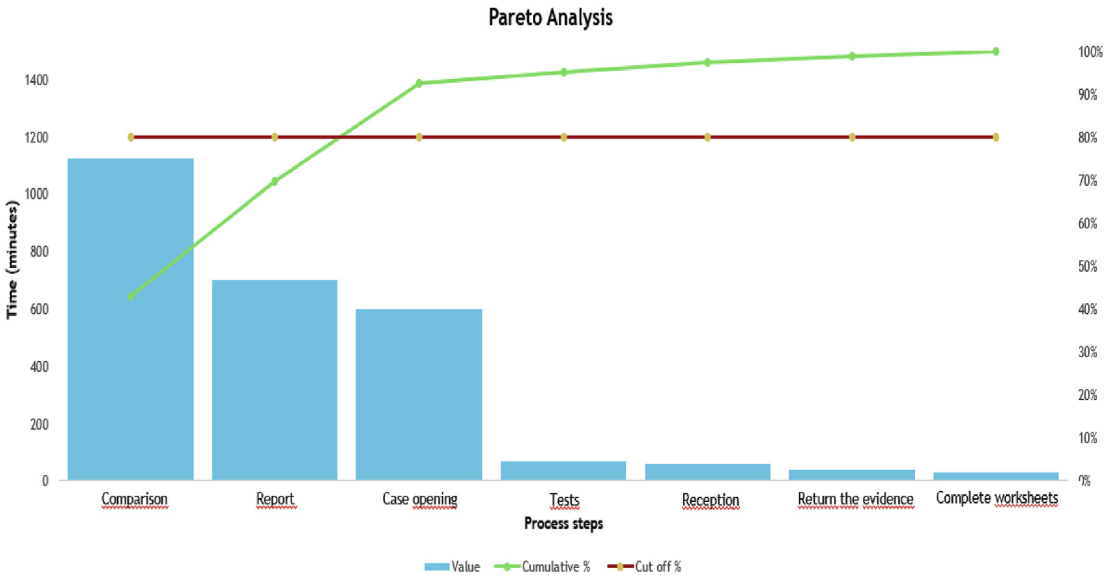

Fig. 1. Pareto Analysis used to prioritize efforts in the limited number of processes producing the significant overall effect.

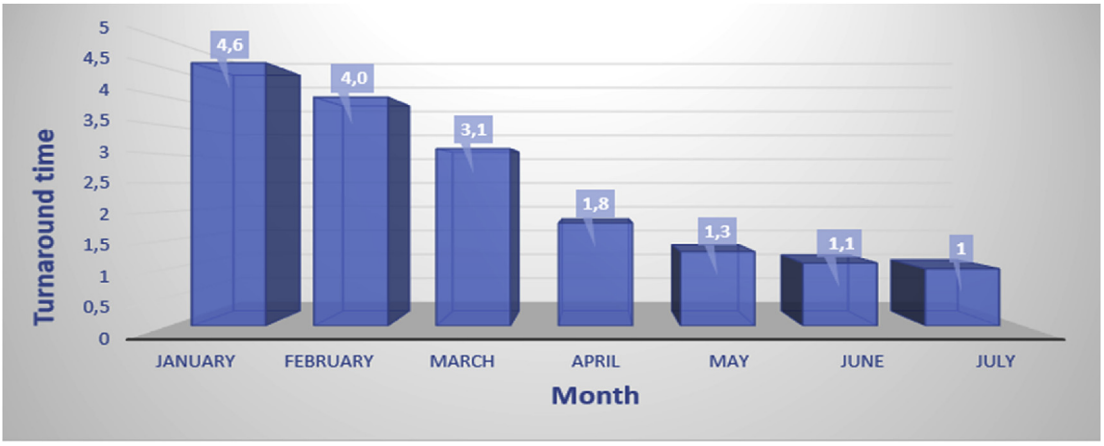

Fig. 2. Turnaround time in Ballistics Unit before and after Lean Six Sigma implementation.

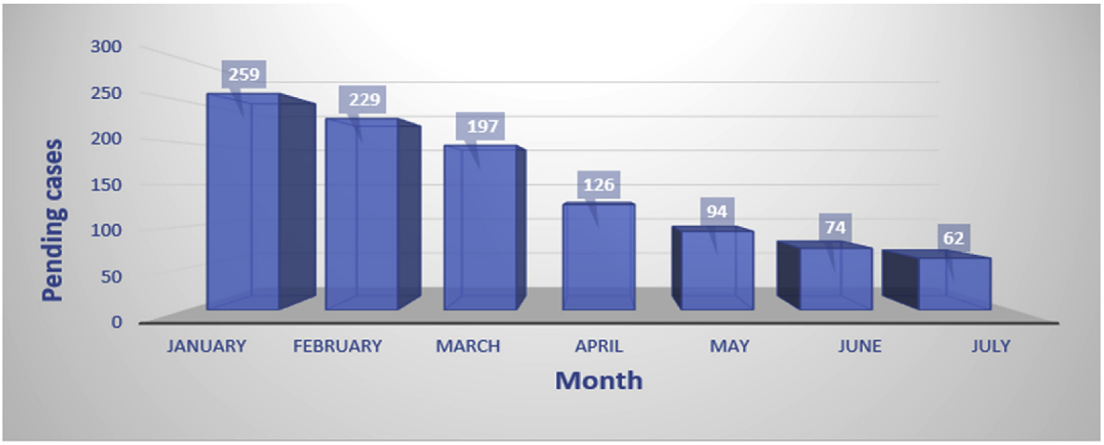

Fig. 3. Pending cases in Ballistics Unit before and after Lean Six Sigma implementation.

work in progress, serving as a visual control. Huddles and production boards were used to promote teamwork. Finally, to measure the impact of the changes the backlog, turnaround time and lead time were used as reference values.

3. Results

The team decided on an implementation period of 6 months, which is the recommended time for a successful Lean Six Sigma project.

Applying the *Voice of the Customer* in the project led the team to know the expectations customers had and their unhappiness with the turnaround time. With this in mind, the team established a target goal of an 8% reduction in the amount of pending cases with a backlog of more than three months by June 28, 2019.

When the *process mapping* and the *Value Stream Map* tools were used, the team was able to see all the steps that involved before handing the final examination report to the customer. Once all the steps were known by the team, it was easier to understand the lack of standardization and analyze all of the activities that were being carried out. The most valuable data obtained from applying these tools were the lead time measure of 2620 min, a takt time of 60 min and the seven steps provide in Table 1.

For three processes: opening and describing evidence, comparison, and reporting, it was concluded that 85% of time was non-value added. By seeing this on the *Standard Work Combination Sheet,* examiners could graphically see the value added and non-valued added time.

However, this single Lean Six Sigma project was not able to work simultaneously with all aspects of the examination process; in 6 months, work teams were required to carry out a successful project and prioritize accordingly. Therefore, the *Pareto Analysis* (see Fig. 1) allowed teams to prioritize efforts in a limited number of process steps that could produce a significant overall effect. By focusing on 20% of the small problems (comparison and reporting processes) allowed the team to fix the 80% of the larger problem.

After these measurements, the problem statement was that the non-value-added time in the ballistics unit was attributed to 78% of lead time. Having requests of more than 6 months exceeded the Departments parameter of not having pending cases with more than 3-months.

As part of the solution, a brainstorming session was conducted. The team developed sixteen ideas in a short time. All ideas were heard and considered without judgment. Potential root causes were identified, organized, categorized, and voted on. The ideas with the most votes received further attention and were as follows: First, only one examiner was helping the other seven to open and describe the evidence. This was a time constraint on case processing and support from the entire team was needed. Second, the service request needed to be clearer in order to eliminate unnecessary work.

Third, case goals were not set, and peer review and verification of comparison results took the most time. This was confirmed with the *level load chart* tool.

Improvements ideas led to the following solutions:

- Standardization of the process to reduce variation in the tasks that were conducted by the seven examiners of the team.
- Eliminating the constraint of having only one examiner helping other examiners. By requiring the rest of the other section of the team (examinations of caliber size, firearm functionality and serial number restoration) to assist the comparison section with opening/describing evidence, examination, and form filling, the unit streamlined the process so the seven examiners from the comparison team only conducted comparisons and released reports.
- Implement the review of files on the first day of the month to reassign examinations that did not need a comparison (because of the lack of evidence to compare) to the serial number/functionality section.
- Rotating assignments for peer review and verification to eliminate long waiting times, because this was previously done only by one person.
- A production board was posted in a common area to list monthly goals. Huddle meetings were conducted every week to check goal accomplishments and propitiate team effort and support.

At the end of applying the 5 phases and rolling out the improvement process in a disciplined and structured way, the turnaround time went from 4.6 months to 1 month (see Fig. 2), the total amount of pending cases went from 259 to 62 cases (see Fig. 3), and the *lead time* went from 2620 to 1060 min.

Finally, from an economic point of view, based on the turnaround time, backlog, and costs per case [13], a savings per year of $72, 575 was achieved.

4. Discussion

Lean Six Sigma should be viewed and applied as a way of life that serves to constantly improve an organization's performance and financial position by translating sound strategy into effective operational execution [8]. Implementing Lean Six Sigma in the Department of Forensic Science helped to identify some key issues and trends that had been practiced for a long time, leading to the dissatisfaction of customers and inhibiting attainment of organizational goals. Some gains were made in the short-term. Others required further, ongoing analysis and improvement actions [14].

Results demonstrated the benefits of working under Lean Six Sigma methodology. The improvement of turnaround time was significant, and a collaborative team effort led to results by allowing people to criticize the existing processes, identify waste, overloads, and constraints, and to subsequently control these parameters. After the measure and analysis phases, the team was able to differentiate between the "vital few" and the "trivial many," allowing the unit to understand that decision making was sometimes carried out without data. With Lean Six Sigma, data and calculation replaced intuition.

A lack of standardization in some steps of the process, led to ballistics experts working in a discontinuous work process. The staff were doing what was requested, but not in the same way. The team understood that standardization set the basis for continuous improvement.

Finally, a constraint in the process was one examiner working for seven others. All of the experts needed so much assistance, that a single person could not maintain the flow necessary to satisfy the demands. As such, this limited the activities of opening and describing the evidence. Team efforts eliminated the overburden (*Muri*) and reallocated assistance from a unit with additional capacity.

5. Conclusions

This project allowed the unit to accomplish personnel engagement, eliminate waste and variation, and set the basis for continuous improvement and innovation.

Process improvements will follow when a Lean Six Sigma project has been developed in a methodical and disciplined way and the culture is managed to execute the changes and lead the

collaborators correctly through the transition. Crucially, it is about teamwork and celebrating achievements.

Lean Six Sigma projects can help forensic science laboratories identify opportunities for improvement, not only in the reliability of results, but also related to time and cost savings.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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