

Improving a Dialysis Center Construction Project: A Lean Perspective

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Abstract — *Due to the necessity of the construction of new facilities for healthcare, the Lean tools are applied in a construction project. Specifically, in the construction of a new facilities for a dialysis center, to reduce waste and time to deliver the facilities as soon as possible. The project is based in one of the activities of the many activities the project has, the installation of the acoustic tile.*

Key Terms — *Construction Project, Lean, Project Management, Reducing Time, Waste.*

INTRODUCTION

Due to Hurricane Maria, many services have been affected throughout the island of Puerto Rico. As a result, the construction industry faces one of the greatest challenges in history. Being the ones responsible of rebuilding the necessary infrastructure, both temporary and permanent in order to provide the necessary services and be able to move the economy.

One of the affected services are the healthcare services. In this case, the research will focus in the dialysis services in Puerto Rico. Many of the dialysis centers that provide services to the public were affected by the fury of the winds and rains associated with the Hurricane Maria. Essential services in Puerto Rico were available three to five days after the hurricane lashed if the infrastructure where the services was provided was not affected. In the particular example that I bring to you in this research project, the dialysis center was begun to be built before the hurricane Maria, and by the end of September a substantial completion was presented. But the fury of the Mother Nature caused that the project was destroyed. The plan was for the center to be in operations and provide services to a growing population of patients by the month of November.

In November 2017, the infrastructure for this center were again started, but in this occasion, it

presents a particular and more important detail: Time. Time plays a more important role in the new construction process. For this reason, the lean methodology was an important tool to improve the construction process, applying its tools to the different tasks and process, to eliminate waste and reduce the production times. Using the tools provided by the lean methodology, we can contribute to the project, reducing the completion and delivery time. In this way, we can make possible that these essential services be available to all patients who need it.

PROBLEM STATEMENT

Due to the oath of the hurricane Maria through Puerto Rico, the dialysis centers in the east area of the island were affected. Around four centers from Carolina to Fajardo had to cease operations because the infrastructure was affected. Only two were kept open and operational to offer services to the patients, but at great distance from their homes, just Carolina and Humacao remain operational.

In the case of the Carolina center, it can only serve twenty-eight patients at a time, for this reason, a new center was under construction to provide capacity to forty-eight patients. But all plans were down due fury of the hurricane Maria, this center suffered substantial damages to the infrastructure. In order to provide services to the patients in an effective manner, it is proposed to rebuild this center and open it as soon as possible and support the operations of the operating center and satisfy the needs of the patients. The operational center, are working in extended hours, including weekends to meet the demand of services.

The dialysis procedure is a very delicate and rigorous one. It serves to eliminate certain toxins that patients cannot eliminate on their own because their kidneys are affected. Depending on the case of the

patient is the time in which should be performed and there may extreme cases that is necessary to perform it daily. This is the cause that arises the need to be able to operate the center as soon as possible.

RESEARCH DESCRIPTION

This research seeks to reduce the time in performing the activity of acoustical tile installation. The reducing time, will help the project overall because this activity is in the critical path of the project schedule. Several tools of Lean methodology will be applied to achieve the objective of reducing time without sacrifice quality.

RESEARCH OBJECTIVES

The objective of this research is to reduce time by ten days by applying the tools provided in the Lean methodology. The actual projected time for this activity is seven teen days.

Also, in the experiment of applying concepts of Lean in this activity, will help the workers and the managers to understand the concepts, so in a future can be implemented in other activities or future projects.

RESEARCH CONTRIBUTION

The research project seeks to contribute to the construction industry by applying some of the Lean tools available, and how we can apply and adapt it to the activities of a construction project.

Also, I want everyone in the construction industry know more about Lean and the powerful tools it has available and how we can used it to reduce time and make more affordable products and results.

LITERATURE REVIEW

During the early 20th century there was a growing demand for product and services that was needed at that time. As time went by, and new technology were discovered, there was a need to improve and increase productions, shorten times and be able to deliver the products on time. The different

industries were trying their different methods to be able to meet that demands and be able to increase their productions. But, it was not until Henry Ford introduce the production lines when more orderly methods were discovered in order to increase the production. Then, the creators of Toyota studied, improve and add new methods and tools to productions lines of Ford and create what they called the Toyota Production System. This production system is what we called today the “just-in-time” production [1]. This was the base and beginnings of Lean manufacturing.

The goal of Lean Manufacturing is to reduce waste and is a continuous improvement philosophy. But to improve something you need to understand the process and the problem. In order to do so, you need to get data of the current progress, mostly the data is available, or you need to measure it. Once you get the data, you analyze it. But in the construction industry is another story.

The culture of this industry is to build something, and the only data available is the time schedules and the budget. There is no data about production. In order to get this data, you need to go to the field and measure this data.

The construction industry lack of a measurement culture because many variables are involved in the daily basis of the project [1]. Even when the activities are the same, for example masonry, through the different projects the difficulty changes. Therefore, many variables are involved in the production, so we will get different productions rates. Some examples of these variables are, the difficult of the site where the employees are going to work, manpower, the weather conditions, the pay, employee’s skills, and so on.

Lean philosophy tools are helpful to be applied in the construction industry and can be adapted to help in anyway [2]. Some of these tools are:

- Five Step Plan (5S) – a Japanese approach to improve operations organizing the work environment in order to facilitate the work.
- A3 Report – the report are helpful steps to find the root-cause of a problem.

- Five-Why Analysis – is a simple procedure to find the root cause of a problem.
- Plus-Delta Analysis – is a component in the learning process.
- First-Run Studies – a technique to construct new ideas on a pilot basis.
- Value Stream Mapping – main flow actions displayed in a map.

Other important tool in the process of improvement is the DMAIC. This tool is attributed to Six Sigma but is helpful to understand and to present in any improvement work.

METHODOLOGY

The methodology applied in this research project will be the define-measure-analyze-improve-control, DMAIC. This is methodology or model is perfect to present all the steps of the process. DMAIC stands for Define, Measure, Analyze, Improve and Control. (See Figure 1)

The Define phase is the stage in which the problem is stated, or the problem is presented. Also, is the stage where we define the goal of what we want to improve, the scope, and the objectives to accomplish on the resolution of the problem. Also, we need to identify the key persons or industries affected by the problem or the process of improvement. The time frame and the resources needed to accomplish the goal are define or identify in this stage.

The Measure phase is the phase where the data are collected, and the baseline is set. This collection may be measuring the current process or getting the data recollected in previous measurements.

The Analyze phase: in this phase the data are analyzed and seek for a root-cause relationship within the data to determine what is really happening in the process. Also, we make sure that all factors have been considered. We can analyze the possible steps or tools to be implemented in the process to improve it. The Parteto Chart and Root-Cause diagram are useful tools to determine the real problem and the areas that need to be impacted to get improved results.

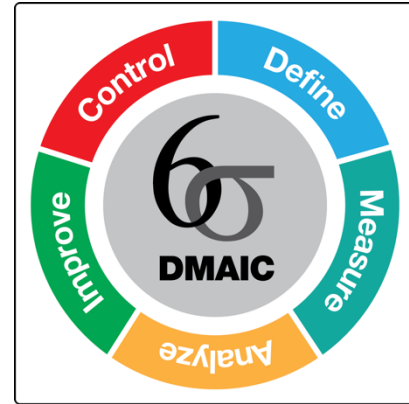


Figure 1
DMAIC Model

Improvement phase: Once all the data are analyzed and the root-cause are found, we can start to improve the system. In this phase the process is optimized though the use of different tools and pilot runs.

Control phase: In this phase the process is controlled and standardize to obtain the same results as the pilot runs, or the establish parameters. The continues monitoring of the process is very important in this point to control the process.

RESULTS AND DISCUSSION

The results and process discussion of this project, as mentioned before, is going to be presented in the DMAIC format to the benefit of everyone.

Define

The process of define involve different task in order to seek for a solution for the problem. Also, we have to make clear our goal to eliminate the problem and improve the process. In order to do so, we have to identify the internal resources available and seek for other resources that we need to accomplish this goal.

In Table 1 is presented a brief of a project charter for this project. The problem statement is stated as the improvement of the process of installation of acoustical tiles at the Carolina Dialysis Center in order to shorten times in the project delivery. As a main goal is to reduce by 10 days or 60% of the actual project time.

Table 1
Project Charter

Project Charter
Problem Statement: Improve the process of installation of acoustical tiles at the Carolina Dialysis Center in order to shorten times in the project delivery.
Goal: Reduce time by 10 days or 60% of the actual projected time.

As presented in Table 1, the problem statement is to improve the process of installation of acoustical tiles at this project in order to shorten times in the project delivery. To understand the process of installation we have to define the value stream for this activity. See Figure 2.

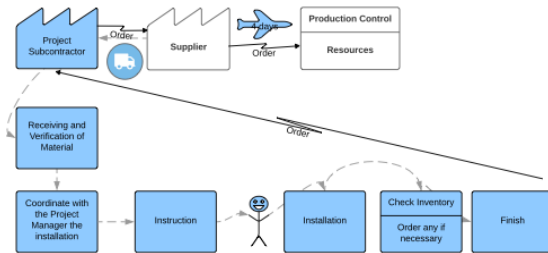


Figure 2
Value Stream Map

In the creation of this value stream mapping we can see that there are some activities within the principal activity that represent so much waste. This value stream mapping helps us understand the process involved in the installation of acoustical tiles, so we can know where start improving the process.

For instance, the persons responsible for the process improvement of this activity are the supplier, subcontractor, including his employees and supervisors, and the Project Manager. These persons need to be in this process to succeed in the improvement proposed.

Other external factors were not considered in this project, for example: change of orders, rework due to the owner or inspector, etc.

Measurement

For the measurement phase we need to understand the current process to make the

measurements of production or productivity of the current crew for the installation of the acoustical tiles.

The crew start with the office area installing acoustical tiles, so I retrieve data in this part of the activity. See Figure 3.

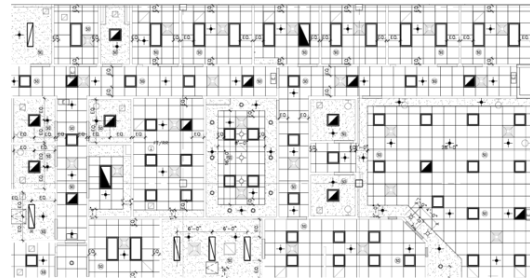


Figure 3
Reflected Ceiling Drawing of Office Area

Table 2
Areas for Productivity Calculation

Area Description	Area Square Ft
Room 1	120
Room 2	120
Room 3	110
Room 4	110
Room 5	120
Room 6	80
Room 8	75
Hall 1	450
Hall 2	102
Hall 3	118
Room 7	800
Hall 4	35
Room 9	260
Room 11	128
Room 12	216
Room 13	60
Room 14	51
Room 15	120

In Table 2, the areas of the office section are presented in terms of square foot. In this area were assigned a crew of 4 workers for the installation of acoustical tiles. The production of this crew is presented in Table 3.

Table 3
Production at Office Area

Area Description	Area Square Ft	Work Hours per day	Rate
Room 1	120	1.5	80
Room 2	120	1.5	80
Room 3	110	1.5	73.3
Room 4	110	1.5	73.3
Room 5	120	1.5	80
Room 6	80	1	80
Room 8	75	1	75
Hall 1	450	6	75
Hall 2	102	1.5	68
Hall 3	118	1.5	78.7
Room 7	800	10	80
Hall 4	35	1	35
Room 9	260	3.5	74.3
Room 11	128	1.5	85.3
Room 12	216	2.5	86.4
Room 13	60	1	60
Room 14	51	1	51
Room 15	120	1	120
Total	3075	40	76.9

Table 3 presents the production in terms of square foot worked by hours per day. If the worked hours are less than eight hours, the activity in this area is concluded that same day. Therefore, if they worked than eight hours it will include another extra day to conclude this area.

The arithmetic average rate of this crew is 75.29. If we obtain the average rate in square foot by worked hours we get a result of 76.9.

Analyze

Table 3, the productivity in the installation of acoustical tiles in the office area give us much information about the activity itself and the workers.

The average performance of these workers in approximate 76 tiles per hour. In the construction industry, this is a low productivity performance. This is just the productivity of the installation activity. Other tasks in this activity are not represented in the table like, the purchase order, receiving, planning,

and the instructions time. For this, we can make reference to Figure 2 to understand the complete process.

Everything starts with the order that the subcontractor make to the supplier. The supplier makes the order to the industry that products these tiles. Depending in the production, availability of products in stock, it can take from four days to two weeks, depending in the shipping method. If the shipment is needed rush, you can request express delivery by air in three or four days. Regular shipment is by ship and can take two to three weeks longer. Once the supplier receives the materials, it takes two to three days to be delivery to the project.

These delivery items can be controlled by making the orders on time and we can concentrate in the installation activity itself.

The coordination of the execution of this activity must be made with the Project Manager or the person in charge of the project. The execution of the activity will depend in the master schedule of the project. If everything is okay and the previous activities are completed, it can take one day to start the installation.

Once the activity has started, it is observed that the tiles that are going to be installed at the sides, corner or when the walls had no regular shapes, its takes longer to install because the workers needs to fabricate shapes to fit in the areas with the available material. The installation of this irregular acoustical tiles takes another step in the process that is the fabrication of the tile. In the fabrication of these tiles we can see defects, overproduction, shortage in material due to the waste generated in the fabrication, waiting by the worker that is installing the tiles, because of the fabrication process.

To determine the type of waste we draw a cause and effect diagram or fishbone diagram that is illustrated in the Figure 4.

As we analyze the activity we can state some waste that we can eliminate to improve the process. The waste can be identified by its type. For example, in this cause and effect diagram presented in Figure 4, we identified five classifications of wastes:

methods, materials, management, people and tools. Each one has his reasons for the classification.

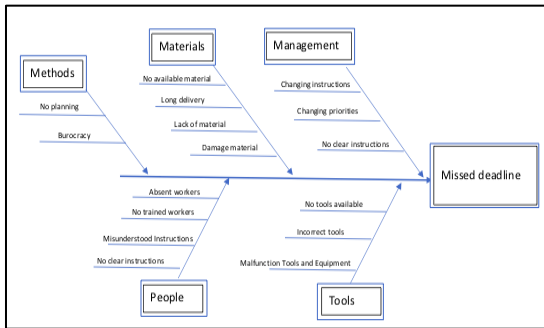


Figure 2
Cause and Effect Diagram

The methods bullets represent the issues of no planning and the bureaucracy that represent to get permission or simple instructions.

In the materials, there are more issues than the other classifications. The issue of no availability of material, the long deliveries of material, lack of material available, and the damage of the material by the handling or the quality control at the manufacturing company.

The Management takes an important role in the missing deadline. The management is the one with the authority to make changes and control the project. But the authority also gives the power to change instructions all the time, and this mean that we can miss the deadline for the changing instructions. Also changing priorities and giving no clear instructions will represent a big problem that will produce unfinished work and rework, mobilization and demobilization.

The People or workers, also give us the most variable factors of missing the deadline. The workers can be absent to a day of work on purpose, by illness or for personal reasons. Some of them aren't trained or are no skilled in the activities. For this and with the unclear instructions, the instructions could be misunderstood.

At last, but not less important are the tools. It can happen for many reasons, that when the workers are going to start the activity and there are no tools available or the one available are no the correct ones. By the use and by time some of these tools can be damage or malfunctioning.

Also, I wanted to know how the worker of these crews spent the time of the shift for this activity. By observation, I obtained the data represented in Table 4.

Table 4
Time Spent in a Shift

	Time (hr)	Percentage in the shift
Direct work	4	50
Waiting	1	13
Traveling	0.39	5
Instructions	0.31	4
Tools/Materials	0.30	4
Early quits / Late starts	1	13
Personal breaks	1	13

These data can be used to obtain a Pareto chart. The Pareto chart is presented in Figure 5.

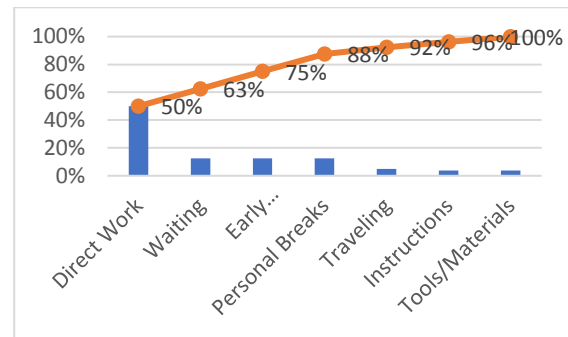


Figure 3
Pareto Chart

The pareto chart presented in Figure 5 can give us important information for the actions that we need to make for the improvement process. Just 50% of the time of the shifts are applied to direct work. The rest of the time are wasted in the different other activities within the acoustical tile installation. The 80/20 rule will have a great effect in the improving process. The rule tells us that if we attack at least the 20 percent of the events or activities that have the mayor effects in the waste of time we are going to improve the 80% of the process.

Improve

In the improvement stage we have to ask some questions yet to improve the system. The first lean

tool that we used in the improvement process is the 5S. This tool stands for: Sort, set in order, shine, standardize, and sustain. See Figure 6. This is just the first step for the improvement process.



Figure 4
5S

For the activity that we are trying to improve, installation of acoustical tiles, first we sort the tools necessities for the activity. These crews and the supervisor were instructed that only the necessary tools for the job can be on hand in the areas of work. Because the crew is always moving from one area to another, a table with wheels has been set. In this table all the necessary tools are sort for finding what the crew are looking for.

All these tools are set in order by one person of the crew and this person are in charge to maintain the tools in order and giving the tool to the worker of the crew that requested it. Also, the worker in charge will check the tools and maintain in perfect conditions or discarding and requesting a new one if one is damage. All crew members have to follow the directions of the worker in charge to maintain and standardize this procedure.

The use of this procedure is the first time for this job and is new for the workers. By following this procedure, we can make a habit for other projects and maintaining the tools and the workplace in order.

This process will improve the time for direct work and also will impact the tools and materials/ time waste. The direct work will increase the time because the workers will have the necessary tools available and on hand. This mean that the productivity will increase, or the crew members will install more acoustical tiles in less time. In the tools

and materials, the time will decrease because the worker in charge of the tools, knowing the activity of the day, will have all the necessary tools for the job. Also, all the tools will be in conditions and may not have problems or malfunctions.

Other problem that we have in the installation of acoustical tiles in the direct work is the installation of the tiles near the walls and with irregular shapes. In these cases, the worker has to get measures of this spaces to cut the tile to fit in the space. This part takes almost the big part of the time of the direct work. To improve this, one person of the crew is assigned to take the measurement of this tiles and giving this data to one worker that will be assigned to prepare these tiles. The job of this worker will be only to fabricate these tiles with the measurements given to him. This will improve the time of installation because the workers will have all the material on hand and will impact the time wasted in waiting.

The process of improvement includes a training session for the workers and supervisor in the lean philosophy and the tools. Also, the training will include specific instructions on how the process will run. The instructions are the same ones explained before to improve the direct work and it include the times that are necessary to comply with the process of improvement. The times will include the time of entry, the process to check in to work, time of break, time for instructions, time of work, and the checkout time. The most important is that a new time is introduce for planning the other day but will only apply to the supervisor.

When we set this tools in actions we measure the new times and productivity of the crew for visualize the improvement. Only that this time will be in the area of dialysis. It is a bigger area, but the rates that are the ones I will compare are supposed to decrease. Table 5 present these data.

Table 5
Production in the Dialysis Area

Area description	Area Sqrt ft	Work hrs	Rate
Space 1	432	4	108

Space 2	1662	16	104
Space 3	210	2	105
Room 15	139	1.3	107
Space 4	124	1.2	103
Room 16	67	0.75	89
Space 5	124	1.5	83
Space 6	343	3.5	98
Space 7	343	3.6	95
Space 8	124	1.1	113
Room 17	68	0.67	102
Space 9	124	1.4	89
Space 10	343	3.2	107
Space 11	124	1.1	113
Space 12	1896	18	105
Total	6123	59.32	103

In the improvement process data, we can see that the rate of production is impacted in favor of the productivity, increasing his number. In area by worked hours we obtain a rate number of 103 and by arithmetic average we obtain a rate number of 101. This mean an increment of 25% in productivity by the use of lean tools to improve the performance of the workers in the acoustical tile installation.

In the improvement process I obtained the data of the time spent by the workers when the improvement is in place and implemented. See Table 6.

Table 6
Time Spent in a Shift

	Time (hr)	Percentage
Direct work	7	88
Waiting	0.2	3
Traveling	0.05	1.6
Instructions	0.10	2.3
Tools/Materials	0.05	1.2
E quits/ L starts	0.10	2.3
Personal breaks	0.5	1.6

The direct work is also impacted by the implementation of the lean tools for improvement. As we can see we increase the direct work from 50 % of the time of shift to 88%. For this reason, the productivity is also increased.

Control

The data described in Tables 5 and Table 6 validate the improvement made in the previous stage. Introducing these lean tools like 5S improve our process of production, eliminating the waste of time and material and increasing the productivity of the workers. Table 5 can show us that the productivity is improved to an average of 103 tiles per hour, including the difficult ones that are the ones aside the walls and the one with irregular shapes.

In Table 6 is shown the improvement or impact in the time spent, minimizing the waste of time and dedicating more time to the direct work of the activity of acoustical tiles installation.

To maintain and continue improving the system it is proposed to use the A3 report with the process of 5S. This report will be presented, and once it is fill, will be used for information to improvement and discussed with the workers once a week for training purposes. An example of a A3 report is presented in Figure 7.

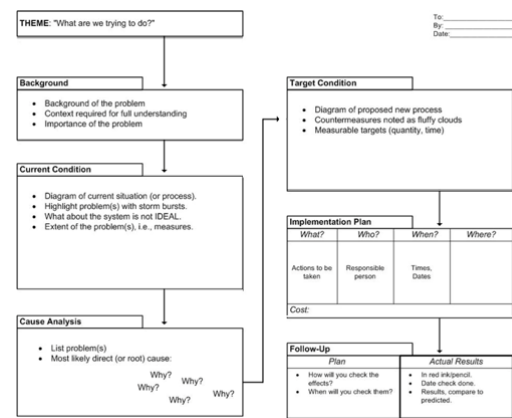


Figure 5
A3 Report

The report will be adapted to the 5S process stated in the improvement stage for the acoustical tiles installation.

This report will help us to understand better the process of improvement and to make a better performance of the work identifying the problems and root of causes.

Hopefully all these tools will help us all in the next projects for improving the productivity.

CONCLUSION

The implementation of lean tools in the construction industry is a very difficult job for anyone. The people from this industry are attached to their practices learned from the beginning and learning new process or the way they use to do the work would represent resistance. But is not impossible.

Not only the workers present resistance, also the engineers, project managers, up to the executives of the construction companies and owners. As once said the writer Robert Fisher “You cannot know the unknown by clinging the known”. To improve the system, you have to trust in the Lean philosophy and the person implementing it. Each one of them, you can get to it in different ways, by the interest or the priority of each group.

Once the tools are applied, like in the case presented in this project, you will see the improvement that will represent the minimizing of waste of time, material and more revenues for the company. There are a lot benefits of implementing these tools. In the case of this project, we could improve the process of installation of acoustical tiles by a 25% of productivity and incrementing the direct work of the shifts to an 88% of the time. In terms of days it will represent an improvement to by 5 days or one week setting the activity to 12 days. A continues improvement is needed to reach our goal of reducing the activity to 10 days.

On the other hand, these practices will help the construction industry to improve the old practices and get more cost-efficient operations. The tools also could be applied at the central offices or to other activities or process. From times of difficulty to times of prosperity the tools represent order, discipline, organization, and other to the practices of the company.

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