AERO REPAIRS DOCUMENTATION CYCLE TIME REDUCTION BY LEAN APPLICATION

David A. Negron Rivera
Master of Engineering in Manufacturing Engineering
Edgar Torres, Ph.D.
Industrial Engineering Department
Polytechnic University of Puerto Rico

Abstract *— In our daily life and world, with a diversity of industries and services, from health to manufacturing, all kind of products; many of them care apply Lean concepts or tools to perform important improvements to their service or products. Value Stream Map (VSM) is one of the lean tools than can help to reduce the problem discussed on this article "cycle time reduction. One of the major opportunities of Aero Consulting Company (X) is that the average cycle time of each project is around 280 days. The main goal of this project is to evaluate the current state and develop a future state VSM to reduce the cycle time by 40%. Currently delivery of each project consists of at least three milestones, named as: Early-Milestone (EM), Mid-Milestone (MM), and Final Milestone (FM). Each of these milestones has several delays, once the action items have been implemented the new cycle time will be reduced to 123 calendar days. This represent to an overall cycle time reduction of 56%.*

Key Terms *— Cycle time, Lean, Manufacturing, VSM.*

INTRODUCTION

In our daily life and world, with a diversity of industries and services, from health to manufacturing, all kind of products; many of them care apply Lean concepts or tools to perform important improvements to their service or products.

One of the common tools used is the Value Stream Map (VSM), which is a technique of a visual representation of the material and information flow that uses symbols known as "Lean Language". This tool basically is a methodology to identify, prioritize, and improving processes through standardization and waste elimination.

After analyzing both, the problem and the different Lean tools we can choose the VSM as the best way to tackle our problem.

PROBLEM STATEMENT

Aero Consulting Company (X). provides Engineering analysis for the aerospace industry, which includes the creation of repair manuals for different aerospace engine parts. As part of the new goals established by the company, they want to increase the repair manuals in order to make the company more profitable. Per customer feedback they have took the decision to re-evaluate the established process. During the evaluation of the current process it was found that the average time to deliver one single project is 280 calendar days and an average process time of 61 days. This results in a high waste and/or cost ratio. In order to improve the established process, using VSM tool they will be able to identify value added and waste on the process. The expectation is to reduce cycle time, improve quality of the product and reduce operational and customer costs.

- **Research Description:** Using Lean tools they will be able to determine or confirm where the elements of trouble, and which are the non-value are added that could lead to waste in the process. This project will be focusing on eliminate the defects that could cause waste and therefore increasing the cycle time and most important affecting the quality of the product delivered to the customer.
- **Research Objectives:** Use VSM tool to re-define the process in such way that the cycle time will be reduced to an average of 180-200 days therefore increasing the quality and reducing operational and customer costs.

- **Research Contributions:** With the lean tool implementation and as a result of this research development, the company will see contributions such as: reduction of cycle time in 40% – 45% by the identification and subsequent the elimination of the waste or non-value added to the process. As results this will lead to a lower cycle time for each project, reducing operational cost allowing the company to increase the sales and the amounts of delivery projects. These contributions will help the company to gain customer loyalty and have the best position against their competitors when the customer decides which will be the best company to work their parts.

LITERATURE REVIEW

In this section, the discussion will go further on what actually is Lean Manufacturing; the deferent tools used, and more information about the tool that will be used in the develop for this research project. According with the Lean Enterprise Institute [1], the core idea is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources.

Here are some of the most important tools used on the Lean world; what does it means and how these tools may help in a company:

- **5S:** provide organization using the following terminology: sort, set in order, shine, standardize, and sustain. Basically, provides total organization to work areas by eliminating waste. i.e. wasting time looking for a specific tool.
- **Bottleneck Analysis:** improves manufacturing process by the identification of the weakest link.
- **Continuous Flow:** on companies that are defined as work-in-progress, identify and eliminates waste to ensure no buffers between steps. i.e. transport, delivery, inventory.
- **Kaizen (Continuous Improvement):** this tool needs the work of all the employees in order to achieve the improvements established.
- **Kanban (Pull System):** this eliminates the need of physical inventories using signal cards to indicate when goods are needed.
- **PDCA:** is an effective way to implement improvements using the following terminology: plan, do, check, and act.
- **Root Cause Analysis:** is a problem solving tool focusing on the identification real issue or problem using the methodology of the 5why's. This can allows the implementation of corrective actions to the problem.
- **Standardized Work:** is the way that most important procedures are documented for best practices. This eliminates waste by always using the best practices.
- **Value Stream Mapping:** this tool is used to visually map a production or work process. This expose waste on the current process helping into the implementation of improvements for a future state.

When talking about waste it is necessary to say that there are various interpretations regarding the waste, however most of them lead to the same results. Let's talk about the how the most commonly used the Toyota Production System (TPS) define waste and their different types of waste. Jerry Kilpatrick on his paper Lean Principles [2] states that according to Taiichi Ohno (co-developer of the TPS) that the following eight wastes account for up to 95% of all cost in non-Lean manufacturing environments. Here are the eight wastes:

- **Overproduction:** produce more than the customer demands. The best lean tool for this is a pull system.
- **Waiting:** this concept involves waiting for materials, tools, equipment, etc.
- **Transportation:** this is when you have raw material that is shipped for a vendor to a receiving location, then processed to move into a warehouse and finally transported to the assembly line. Instead the material should be delivered direct to the point of use.

- **Non-value added processing:** most commonly known as; re-working, deburring, and inspecting. This can be solved with a Value Stream Mapping.
- **Excess Inventory:** this is basically overproduction; this can impact the cash flows and uses valuable floor space.
- **Defects:** production defects and services errors.
- **Excess Motion:** this can be caused by poor workflow, poor layout, housekeeping, and undocumented work methods. This waste can be identified with a Value Stream Mapping.
- **Underutilized People:** underutilization of mental, creative, and physical skills and abilities in non-lean companies.

By identifying wastes and applying the correct Lean tool we can traduce this effort on improvements to our processes. There could be two types of improvements; the first one is Operational which includes: Lead Time reduction, productivity increase, working-in-process inventory reduction, quality improve, space utilization reduction, etc. The second is Administrative which include: reduction in order errors, customer are no places on hold, paperwork reduction, staff can handle larger number of orders with the same amount of office, allows the company to focus their efforts on the customer needs, turnover reduction, etc.

METHODOLOGY

One of the major opportunities of Aero Consulting Company (X) is that the average cycle time of each project is around 280 days.

The main goal of this project is to evaluate the current state and develop a future state VSM to reduce the cycle time by 40%.

As established on Figure 1. team has created a flow map for this project in order to achieve the established goal.

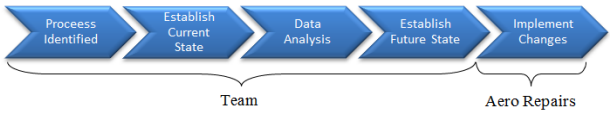

Figure 1
Project Flow Map

A. Establish Current State: Currently delivery of each project consists of at least three milestones, named as: Early-Milestone (EM), Mid-Milestone (MM), and Final Milestone (FM).

1. ***EM***: customer meeting where it is discussed the objectives for each project.
2. ***MM***: customer meeting to provide project status and the technical repair is discussed.
3. ***FM***: customer final meeting where all technical documents (product) are delivered to the customer as established on EM.

Current process state is presented on Figure 2.

B. Data Analysis:

1. *Data Acquisition:* In order to acquire the data of each project step, Aero Repair use two important tools to capture all data. The first one is the Quality Process Errors (QPE), where all defect found in the project due the established process is documented. The second one is the Project Deliverable Inspection Tool (PDIT), where all defects found to the deliverables during an internal inspection.

C. Data Analysis:

1. *Data Acquisition:* In order to acquire the data of each project step, Aero Repair use two important tools to capture all data. The first one is the Quality Process Errors (QPE), where all defect found in the project due the established process is documented. The second one is the Project Deliverable Inspection Tool (PDIT), where all defects found to the deliverables during an internal inspection.

Figure 2. Repair Development Current Process State

D. Identify Time-waste activities:

1. Given the data provided the QPE and PDIT it will be identified all possible time-waste activities that could lead to the cycle time reduction.
2. Once the process steps have been identified the amount of time for each step should be recorded.
3. Value added activity is defined as the work coming through the process that furthers the unit to its completion. This has three criteria. First, the customer wants it done. Second, the process step furthers to its completion. Third, the step is done correctly from the first time.

E. Establish Future State

Given the current process state, the team has identify 34 delays where the process can be improved in order to reduce the cycle time.

RESULTS AND DISCUSSION

Here in this section we will discuss all the findings and how were addressed in order to reduce the cycle time.

As a first step, lets define each delay and how it will be addressed in order to reduce the cycle time, as shown on Table 1. Table 2 and you will see the actual cycle time of each delay and the new reduced cycle time.

Once all action items have been implemented cycle time will be reduce, as shown on Figure 3. We need to establish that all these action items will be closed and worked with the customer.

As we can see from Figure 4 and 5, the cycle time of more than 50% of the delays has been reduced by more than 70%. The biggest impact will be at delays 9, 18, 21, and 28. These four delays are the most impacted in term of cycle time reduction. Comparing actual cycle time vs future cycle time we can see that all delays now are not greater than 80 %.

Table 1
Delays Identified and Action Items

Delay	Delay Description	Action Item	
		Consulting Company (CC)	Customer
1	From assignment until Repair Manual Creator (RMC) until RMC star working the task.	Project Management (PM) Create detailed schedule at assignment and provide task deadlines and budget to RMC. Modify process to gather Customer Management concurrence if new task assignment.	
2	Until Part Family Contact (PFC) Task initiation review	This meeting is optional based on task complexity. Low complexity is not required. Modify process to set this meeting immediately after Task assignment no later than 2 day after assignment.	Increase priority of PFC to assist this meeting
3	PFC input to start working task after initiation review		Increase priority of PFL to assist this meeting
4	EM exit inspection	FIFO inspection, additional inspector certification. PM to plan future inspection workload	
5	Export Control inspection to the EM presentation	Have this presentation inspected at CC	
6	PFC review the EM presentation		Explore the possibility to allow AR equivalent technical person (Inspector) to perform this role
7	EM presentation meeting wait time	Use detailed schedule developed at task initiation to schedule EM meeting one week after assignment.	Determine methods to allow full team support in EM meetings. Allocate common days for EM meeting
8	Time from EM to Meeting Minutes creation and submittal	Modify procedure to require submittal time of maximum of 3 hrs after EM meeting	
9	Waiting response from Team on EM Meeting Minutes action items		Require Team to come prepared at EM meeting and bring any issues to whole team for resolution.
10	Export Control graphics		Repair writing program conversion to occur only one time at the end of workflow
11	Time takes Customer to create graphics including rework		Complete the repair in MSWord format up to after Team approval. Repair Writing Program conversion to occur only one time at the end of workflow
12	Structural assessment evaluation of the proposed repair		Resource management. Outsource AR Structures. Utilize other person to aid as an approver check
13	Export Control MM package review	Perform the Export Control review at AR	
14	MM Exit Inspection	FIFO inspection. Additional Exit inspector certification. Project management to plan future inspection workload	
15	PFC review prior to MM		Explore the possibility to allow AR equivalent technical person (Inspector) to perform this role
16	Pending availability of PFC/Validation for MM	Use detailed schedule developed at task initiation to schedule MM meeting as soon as possible. Standardize key possible roadblocks	
17	Time from MM to Review Customer input	Modify procedure to set review incorporation time to 4 hrs after MM	
18	Inputs to close MM AI	Assign accountabilities for open action items to disciplines. Establish escalation process guidelines to get answers needed to close actions	
19	Prelim Material Process Program (MPP)		Assign accountabilities. Propose closure of MPP updates after repair delivered (approved). Remove from delivery workflow
20	FM Exit Inspection	FIFO inspection. Additional Exit inspector certification. Project management to plan future inspection workload	
21	PFC review prior FM	Kaizen to submit to MPE prior to PFC review. Certify CC equivalent (Inspectors) to perform this role	
22	Style guide review	Create templates and store in database	
23	Pending availability of PFC/Validation for FM		Create a new process where a pool of task ready for review is created, instead of allocating it by date
24	Time from FM to Review Database input	Modify procedure to set FM incorporation time to 4 hrs after FM	
25	Input to close FM AI		Assign accountabilities. Pareto of delays per discipline. Establish escalation process guidelines to get answers needed to close actions
26	Export Control Final Package review	AR will be certified as Export Control expert, so this review could be perform at AR	
27	Final Package validation exit inspection	FIFO inspection. Additional Exit inspector certification. Project management to plan future inspection workload	
28	PFC review		Kaizen, customer resource allocation
29	Final delivery Export Control review	AR will be certified as Export Control expert, so this review could be perform at AR	
30	Material Contact Validation	Consider Program plan out of repair development workflow. Propose closure of MPP updates after repair delivered (approved). Remove from delivery workflow	
31	Complete Package Export Control review	AR will be certified as Export Control expert, so this review could be perform at CC	
32	Request Final Validation 2 Exit Inspection	FIFO inspection. Additional Exit inspector certification. Project management to plan future inspection workload	
33	Customer/PFC Final review	Customer Action Item: Kaizen, customer resource allocation	

A % reduction was obtained and as shown on Figure 5, % reduction are within control limits. However, we should note that there is a frequency of delays above the mean; fewer delays are below the mean. For future improvements the four % reduction near the LCL could be investigated in order to determine why of that tendency. There is a slightly difference between the mean % of reduction and the overall cycle time reduction %, this is because there are some delays that are performed in parallel.

CONCLUSION

One of the main goals of this project was reduction on cycle time for a repair manual development by at least 40%. Current state establish a cycle time of 280 calendar days. Once the action items have been implemented the new cycle time will be reduced to 123 calendar days. This represent to an overall cycle time reduction of 56% .

Table 2
Cycle Time Reduction per Delay

Delay	*Actual Cycle Time (hrs)*	*Expected Cycle Time (hrs)*
D1	40	8
D2	40	16
D3	40	16
D4	160	8
D5	48	8
D6	40	24
D7	200	32
D8	16	3
D9	960	80
D10	48	0
D11	120	0
D12	424	80
D13	48	8
D14	160	8
D15	200	32
D16	120	32
D17	8	4
D18	1200	40
D19	240	0
D20	160	8
D21	960	32
D22	40	0
D23	120	32
D24	8	4
D25	360	40
D26	48	8
D27	160	8
D28	1280	32
D29	48	8
D30	32	0
D31	48	8
D32	160	8
D33	40	24

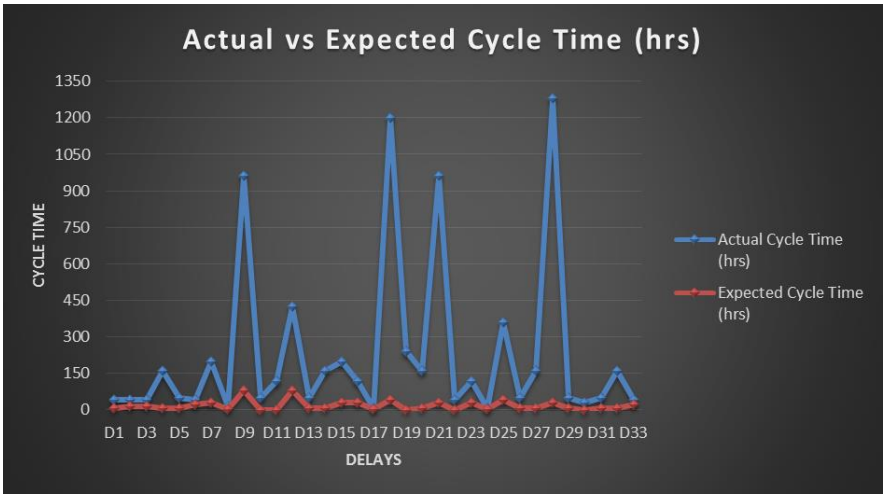

Figure 3
Actual vs Expected Cycle Tim

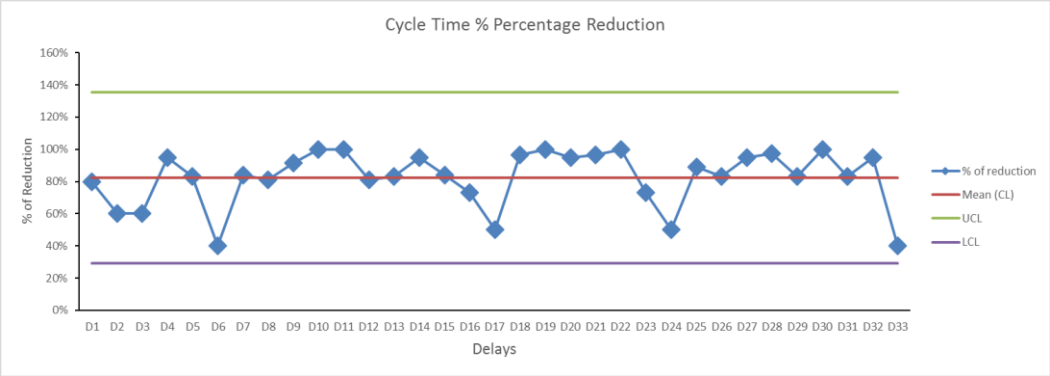

Figure 4
Cycle Time Percentage Reduction Control Chart

REFERENCES

[1] Lean Enterprise Institute (LEI), "What is Lean?", *Lean Enterprise Institute, INC.*, 2009. Retrieved on January 25, 2014 from: http://www.lean.org/.

[2] Kilpatrick J., "Lean Principles", *Utah: Manufacturing Extension Partnership*, 2003.