

## LEAN PRINCIPLES APPLIED TO PROJECT MANAGEMENT

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## 1 Abstract

Lean Project Management is a rapidly growing area of interests as many organizations focus on improving the efficiency of their operations. They stand to gain great benefits by adopting and adjusting their culture to support lean thinking. Analyzing and eliminating non-value added processes from the project life cycle has accelerated time to completion and has generated cost savings that flow directly to the bottom line.

This project report summarizes the literature about this topic, compares the implementation of lean principles in the project management area in two major manufacturing companies, Sulzer Pumps and Novellus Systems Inc. along with the results of lean implementation.

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## 2. Introduction

Lean management has been around for decades in production area; however, organizations have recently realized the application of lean principles and techniques in the rest of the organization i.e., in software development, project management, sales, finance etc. "Lean refers to a general way of thinking and practices that emphasize less of everything – less processes, fewer people, lesser time, lower costs etc. When looked in depth of lean techniques, we realize that it can significantly improve our ability to deliver projects on time and within budget.

The main driving force behind lean is to eliminate waste. Muda, as it is called in Japanese, is "any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren't actually needed" (Womack and Jones 2003, 15). Lean principles can be used in project management areas in a number of ways, for example, to reduce non-value added processes from the project life cycle, increase speed, reduce documentation and hence less paper work and much more.

Though lean principles and techniques emerged in the manufacturing world, its use in other parts of the organization especially in the project management area has been recently recognized. Companies are adopting these practices with a significant advantage over their competition.

## 3. Literature Review

## 3.1 What is "Lean?"

"Lean", also known as "lean manufacturing", or "lean production", is a principle derived from the Toyota production system (TPS), Henry Ford and other predecessors. The goal is to maximize customer value through a perfect value creation process and eliminate waste.

Although lean is original used only in manufacturing, it is now a popular principle which could be applied in all kinds of business and organization. By lean thinking, organizations will specify what customer wants and focus on the key process that could create those values. In the management level, lean thinking changes the focus from optimizing spectate technologies, assets, and vertical department to optimizing the flow of products and services through entire value stream (Lean Enterprise Institute, 2009). Allows customers pull value from enterprise so they are able to respond to changing customer desires with very fast throughput times. The lean principles could be summarized as five steps below:

- 1. Value: Organization has to correctly specify the value by asking what the customer actually wants.
- 2. Value stream: Organization identifies the value stream by asking if each step in the value stream really create value.
- 3. Flow: Organization needs to make the remaining value-creating steps for a specific flow continuously, which could shorten the entire throughput times
- 4. Pull: Let the customer pull value from the enterprise, so that the value streams would became a rapid-response system
- 5. Kaizen: Organization would never achieve lean unless it implements kaizen, continuously improvement in the whole value stream (Jones, 2003).



Figure 1. Principles of lean

Lean construction is a comprehensive adoption of lean manufacturing, coined firstly by Lauri Koskela and his International Group for Lean Construction in 1993. Construction, software engineering, product development, moving making etc. and all kinds of work-order systems are project-based production system. Lean project management is focus on these project-based production systems and objective on more value with less waste in project context. The main differences between traditional project management and lean project management could be concluded as: definition of phases, the relationship between phases and the participants in each phase (Ballard & Howel, Lean Projec Management, 2003).

## 3.2 Historical background

Back to 1450s, Venetian introduces floating assembly line for boats of standard designs moving through standard station, which is the first time people thinking about rigorous process in manufacturing (Lean Enterprise Institute, 2009). In the next 450 years, manufactures mainly focused on the individual technologies instead of the process. Until 1913, Henry Ford create what he called flow production, which took all parts of manufacturing system –people, machines, tooling, and products- and arrange them in a continuous system for manufacturing the Model T automobile (Strategos-International, 2009). He is the first person integrate the entire production process. By standardizing the production process, Ford made mass-producing possible. The decreasing of the cost revolutionary changes the car from a luxury machine to a general-purpose tool. This makes him become incredibly successful and rich; However, Forb's system is not perfect. The problem is the system could not provide the variety for the customer needs.

During the World War II, the market in Japan needed small quantities of cars to be produced in many varieties. For this reason, in 1930s, Japanese engineers Kiichiro Toyoda and Taiichi Ohno reviewed Ford's mass-producing principle, and invented Toyota Production System (TPS) which made it possible to provide both continuous system for manufacturing and variety of products (Lean Enterprise Institute, 2009). The action and goal through the TPS is as the table below

Action	Goal		
Producing right-sizing machines for the actual volume	Low cost		
needed			
Introducing self-monitoring machines	High quality		
Lining the machines up in process sequence, pioneering			
quick setups so each machine could make small volumes	High variety		
of many part numbers			
Having each process step notify the previous step of its	Rapid throughput times		
current needs for material	to meet customer needs		

Table 1. Toyota's action and Goal in TPS

By applying this system, Toyota changed from individual machines and their utilization to the flow of the product through the total process (Lean Enterprise Institute, 2009).

The term of "lean" was first coined by John Krafcik, who is a quality engineer in Toyota, in his article "Triumph of the lean Production System" based on his master thesis research on Japanese manufacturing industry in 1988. His research was continued by a research team studying the international automobile industry. The team first coined the phrase "lean production" and thoroughly described in the book

"The Machine That Change the World" (1990) by Jim Womack, Daniel Jones, and Daniel Roos (WikiPedia, 2011). In Womack & Jones' most recent book, "Leaning Thinking: Banish waste and create wealth in your corporation", distilled these lean principles even further to five steps: value, value stream, flow, pull and Kaizen.

The next milestone of lean is when Lauri Koskela and his International Group for Lean Construction coined the term "Lean Construction", which adapts lean manufacturing principles and practices to the construction industry in 1993 (Koskela, Application of the New Producton Philosophy to construction, 1992). Construction is one among many types of project-based production system, and Lean Construction aims to manage and improve construction process with minimum cost and maximum value by considering customer needs (Koskela & Howell, The Underlying Theory of Project Management is Obsolete, 2002).

Today, Toyota had become the largest automaker in the world. Their success is heavily relying on the success of implementing lean principles into their production. Leaders and managers now apply lean thinking in different areas such as logistics, distribution, engineering management, construction and maintenance. "Lean project management", which also known as "Lean Project Delivery System (LDPS)", differs from traditional project management not only in the goals, purpose, but also in the structure and its phases, the relationship between phases and the participants in each phase. Lean thinking, which objective on deliver the project with maximizing value and minimizing waste can now be seeing throughout all different types of engineering management all over the world (Ballard & Howel, Lean Projec Management, 2003).

## 3.3 Why "Lean" in Project management?

After the success of Toyota, academics and professionals started to discuss "Lean Concept in PM' in nineties. On the other hand, deficiencies in classical PM approach also triggered professionals and academics to find new solutions to PM environment problems. Since then, Lean PM has attracted more interest, widely spirited and accepted in many countries. (Bertelsen, 2004). For instance, Ballard and Howell believe that Lean Construction will take the place of traditional project and construction management. Lean construction attracts interest in many countries such as US, UK, Denmark, Finland, Australia, Brazil, Chile, Peru, Singapore, Indonesia, Ecuador, and Colombia.

Deficiencies in classical project management approach can be summarized as follows:

- Classical project management tools do not recover uncertainty issues, but as the scope of projects increase, the uncertainty increases.
- Relationships between activities are assumed to be sequential. But in real life applications, there are many interdependencies between actions which make this assumption unrealistic.
- Activity boundaries are not as rigid as they are assumed to be. In real life, downstream activities can start before upstream activities are totally finished.
- Control mechanisms ensure outcomes, but do not let process improvements.

In contrast, Lean PM has advantages as avoidance of duplications, lower cost, reduced risk, right balanced of performance and quality, and high level of commitment and motivation (Gabriel, 1997).Reduction in variability is also an important dimension of Lean philosophy. Variability in project environment is considered as source of low performance. Workforce management practices of lean management have the potential to improve project performance (Thomas, Horman, Lemes de Souza, & Zavrski, 2002).Differences between lean and non-lean project management are summarized in Table 2.

# Table 1: Lean PM versus Non-lean PM (Ballard & Howell, Competing ConstructionManagement Paradigms, 2004)

Lean Project	Non-lean project			
Focus is on product system	Focus is on transaction and contract			
Transformation, flow and value goals	Transformation goal			
In decision making, downstream and	Decisions are made in order			
upstream players are involved				
Concurrent engineering	Product and process designs are made in			
	order			
In design phase, product life cycle stages	Design phase does not cover all product			
are considered	life cycle stages			
Activities are carried out at last possible	Activities are carried as soon as possible			
moment				
Efforts have been made to reduce lead	Split organization link with the market			
times	and take what the market offers			
Learning is included in project, firm, and	Learning occurs irregularly			
supply-chain management				
Stakeholders interests are in agreement	Stakeholders interests are not in			
	agreement			
Buffers are absorbing variability	Buffers are locally optimized			

## 3.4 How is it used in Project Management?

The problems in PM root from theory. PM practitioners try to apply production management theory and applications in project management environment. Mass production management approaches do not fit the current requirement of project management. They are too simple to solve and to manage big in size, complex projects. (Howell & Koskela, 2000).

Lean applications, basically, aim to decrease non-value adding activities within the PM process. It is more customers oriented. In order to eliminate non value adding activities, the negative flow of work is tried to be reduced, and the positive flow is encouraged. Controlling processes are more proactive that aim to "make things happen" instead of "monitoring results". The outcomes of lean PM can be summarized as;

- Reduction in cycle times
- Increase in throughput
- Simplification of process, elimination of waste, and increased reliability.

(Shenjun, Lieyun, & Hanbin, 2010)

As lean philosophy is originated from manufacturing industry, using the same tools directly in PM environment is very difficult if it is not impossible. The following table shows the differences between manufacturing and PM in application of lean approach (Ballard & Howell, Competing Construction Management Paradigms, 2004).

	Manufacturing	PM
Supply chain	Well defined operations	Flexible Operations based on
	Make or buy decisions are	resources and cost
	made at the beginning	
Workforce	Stable wage policy and	Varying wages depending on skill
	higher employment ecurity	and experience Lower
		employment security
Quality	Process control Elimination	Product conformance like safety
	of rework	requirement, environmental
		consideration conformance to
		regulations

#### Table 2: Differences among Manufacturing and PM

Construction industry is a pioneer in Lean PM. Here, some examples of lean PM applications form construction industry.

- Flow variability is an important issue in construction industry. In manufacturing environment, small lot sizes, product scheduling techniques, multi-functional layout are important tools to cope with demand fluctuations. In construction industry, last planners are the people who are responsible for flow variability. These people have to find the roots causes of variability and take prevention actions.
- Process variability is also critical in both manufacturing and construction industries. In manufacturing industry, visual tools and poka-yoke solutions are developed to prevent process variability. In construction industry, quality is depending on conformance to specifications. Fail-safe actions are common implications on preventive actions to ensure first-time quality.
- In manufacturing industry, 5S (sort, straighten, standardize, shine, sustain) is the way to eliminate waste. 5S provides a transparent environment in construction which makes work flow more visible and creates awareness. (Salem, Solomon, Genaidy, & Minkarah, 2006)

## 3.5 What kinds of industries use lean management as a part of PM?

Lean project management is highly accepted in many different industries. Some of these industries can be named as follows:

- Manufacturing
- Property Development
- Construction
- Education
- Transportation/Shipping
- Engineering/Consulting
- Hospitality
- Healthcare
- Finance
- Printing/Publishing
- Not for Profit
- Government (www.leanprojectmanager.com)

## 4. Lean Management in Sulzer Pumps:

Sulzer Pumps U.S. Incorporated is a pump manufacturing company that is based out of Portland, Oregon. The manufacturing facility is located in the industrial district of Portland, with a corporate headquarters in downtown Portland. They manufacture pumps for all different kinds of purposes. The primary purpose of the pumps that are manufacturing out of the Portland facility is for crude oil pipelines, crude oil drilling, and nuclear power facilities.

Lean management has been used for a long time in the machine shop of the facility, but was recently implemented in the office departments in March of 2009. All the different departments have been starting to use lean management, with the project management department leading the way. Lean practices have been a way for the different departments to effectively communicate, and work together to cut the amount of time, and money spent on a project that comes through company.

When lean principals were first implemented in the project management department it was used as a way of eliminating waste. New printers were put in the office areas to help the process of cutting back on paper waste, and a cleanup of all office space, and cubicle space was performed. This was the beginning of lean principals using the 5S principals, also known as the best practices methods. These S's stand for 1) Sort 2) Set in order 3) Shine 4) Standardize 5) Sustain. These practices were implemented in the work space to conserve space, and make management more effective.

For the project management department of the company, most of the lean practices is being applied for documentation purposes. The project management team uses lean practices to find quicker and more effective ways to process documentation throughout the life of the project. Most of the documents to process are drawings and other technical data of the pumps that are being manufactured.

When lean principals first entered in the pm department, it was taught as a way of cleaning up the work space, and creating a well more organized work space. Different policies were made up to limit the number of different items that could be placed on a co-workers desk, and even the size of the object that could be found on the co-workers desk. As mentioned before this was a part of the best practice principals. Eventually the Kaizen method was applied to Sulzer lean principals. This method is a Japanese word meaning "Change for the better". This was a way to start the steps for sustainable continuous improvement.

Sulzer lean is a six step process that exemplifies an action oriented philosophy adopted throughout the Sulzer organization based on Sulzer employees living on the core values, with the objective of creating value for customers and stakeholders, by

eliminating all waste, and is anchored in an organizational desire and ability for continuous improvement. The first three steps for Sulzer lean is essentially fluff that describes why Sulzer Pumps should use lean principals, and the last 3 steps describe how lean principals will benefit Sulzer Pumps. The following figure below exemplifies what the 6 steps are for Suzler lean.



## Value Creation:

The fourth step is the start of the more important steps that explain how Sulzer and its partners will benefit from using Sulzer lean principals. Value creation is about creating growth for the company, profitability, asset productivity, and environmental impact.

#### Growth

- Improving customer satisfaction makes repeat customers
- LEAN frees up capacity, without significant capex or investment
- Competitive costs, results in market share gains

#### Profitability

- Removal of waste and unnecessary costs
- Reduction of errors at interfaces also reduces costs

#### Asset productivity

- Getting more output per invested CHF. e.g. increase of sales per square meter by 20% to 50%
- Increased speed \_ reduction of working capital

#### Environment

• Reduction of energy consumption and transportation

The immediate beneficiaries of value creation are the customer, the employees, and the investors.

#### **Eliminate Waste:**

Waste elimination is about eliminating the obvious waste, make visible and reduce necessary waste, and optimize added value. This means to eliminate the physical waste that takes up space, and hinders the environment, and the time waste that extends the life of the project. Waste elimination is a very important step to continuous improvement which is the final step in Sulzer lean.

#### To eliminate waste, waste needs to be visible

- Take measures
- Use visual management
- Question status quo and existing processes

#### The 7 forms of waste

- Overproduction
- Waiting
- Unnecessary transport
- Unnecessary coworker motion
- Defects
- Overprocessing / incorrect processing
- Excess inventory

#### Customer have to benefit from our waste reduction

• Easier to do business with us: Better service and

#### responsiveness

- Better quality
- Increased delivery speed
- Cost reductions

By evaluating the negative impact of waste on process or cycle time Sulzer Pumps was able to eliminate 5 days off of the cycle time it takes to bring the order from the sales department to the project management department. Sulzer was able to cut down the amount of time on each step that was taken, without eliminating the steps themselves.

#### **Continuous Improvement:**

Continuous improvement is about using the combination of all the steps in Sulzer lean principals, and organizing it all to keep track of efficiency of project management. Part of the continuous improvement is creating a value stream map that puts the process of the management of the project into steps that are easily measured. By taking measurements of each step in the VSM the project management team can pinpoint where the problems are in the process, and take corrective action. The project management team would need to keep track of each project and determine where in the VSM is the project is having problems of lateness on.

#### Identify and prioritize problems

• Challenge status quo. There is no such thing like a perfect

#### process

- Make problems visible
- Define ambitions

#### Improve step-by-step

- Learn how to solve problems effectively (Plan-Do-Check-Act)
- Gain confidence by realizing successes quickly

#### **Trial and error**

- Take action early
- It is acceptable to make mistakes. Learn from them.
- Perseverance and endurance is required Stabilize improvements
- Formalize improvements so that they can be sustained
- Document the "Before" and "After"

#### Measure and follow-up

- Define measures as detailed as necessary to track progress
- Make metrics understandable/ transparent to all people affected
- Have frequent reviews and identify new problems

Since October of 2010 Sulzer has been taking measurements of the front end of every project that has been going through the Portland facility. Since taking these measurements the project management team has been able to find out where there are certain problems for lateness, in the VSM. These problems of lateness are discussed in weekly KPI meetings. There are also lean teams that are created within the project management department to help determine solutions to the problems of lateness. The following figure shown below shows the VSM process for the front end of receiving a project from the sales department. This also shows the form that each project manager has to fill out to help improve problems of lateness.

This figure shows sort of a critical path of the process of receiving the order in project management in Sulzer. These steps show the best finish time, the worst finish time, where each step comes from, and where they go, and who owns each step or is responsible for carrying out each step. At the bottom it shows symptoms to each step or what might cause the lateness in each step. This is meant to help the process of solving the symptoms.

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## Project Management VSM

Fig. 5: Project Management VSM for Sulzer Pumps US Inc.

#### How Lean has worked for Sulzer So Far:

Lean Principals have been implemented for just over 2 years now in project management at Sulzer Pumps. It is still very new to the company. It has been starting to show some benefits. The front end of each project has had time cut off of the receipt of order process. There is still much improvement to be had on using lean principals. Ultimately Sulzer hopes to have the lean management perfected in the process of order management in the next 5 years.

## **5** Lean Management Implementation in Other companies:

Apart from Sulzer Pumps, our team researched the implementation of lean management principles at Novellus Systems Inc. The company is one of the leading semiconductor equipment manufacturing companies supplying chemical vapor deposition (CVD), physical vapor deposition (PVD), electrochemical deposition (ECD), ultraviolet thermal processing (UVTP), and surface preparation equipment used in the manufacturing of semiconductors. Being an ISO 9001/14001 certified company, it has its engineering and manufacturing facilities in California and Oregon and has sales and service operations in 15 countries around the world to support a global customer base.

Novellus company goals are:

- Increase customer responsiveness
- Strengthen product portfolio
- Grow market share
- Improve financial model

Their goal was much the same as Toyota or GE who are using lean management in manufacturing, development, with suppliers etc. Novellus decided to lean a team based approach to eliminate waste. This in turn helped to adapt themselves to the industry's changing demands and yet stay competitive in a business environment in which manufacturing efficiency and short cycle time are crucial for survival.

Lean management was implemented throughout the company starting from manufacturing, engineering, finance, sales and finally in operations department. The implementation was done in three phases – Phase I in manufacturing, phase II in operations and phase III throughout the company. The company implemented all lean manufacturing tools and processes in manufacturing such as just-in-time, kaizen, 5S, Virtual Stream Mapping (VSM), POU storage, Poke Yoke, standardized work etc. The key objective was to reduce the cycle time and hence reduce bottlenecks involved in manufacturing and testing a customer's order. Implementing lean manufacturing denoted successful results which were then carried on by implementing in the rest of operations. Finally continuous improvement was put in place by incrementally improving the products, processes and services with the goal of reducing waste to improve functionality, customer service and product performance.

Phase II involved the implementation of lean management in the rest of the operations which includes sales, configuration management, procurement etc. Finally, the lean management was extended throughout the company including finance. Figures below denote implementation of lean in phases and the key objectives of implementing lean principles at Novellus.



Lean principles - Key objectives are...



Our research concentrated on the requirements of lean implementation in the business processes side of operations, lean approach that was used, and the success due to lean management throughout the company.

The main problem identified specially in operations was that the then business processes were not effective enough to reduce customer complaints apart from the need to optimize BOM creation, discharge, record keeping, and billing procedures. Thus the goal was to review all business processes to prevent internal discrepancy reports (IDR) occurrences, validate documented processes and update them to

reflect standardization. The idea was to extend lean across the entire operations value stream. Improving the processes was the key, leading the roadmap to lean. Thus the expected results included efficiency and effectiveness in meeting goals through:

- Standardized work (process-validation)
- Improve product quality (Reduced IDR)
- Reduce supplier defects/shortages
- Safer and simpler processes

Thus the lean management team tried to make Novellus processes more efficient by implementing Value Stream Mapping (either reducing or removing redundant and non required steps from the processes or by removing processes itself entirely). So the basic steps involved in Value Stream Mapping process are:

- 1. Selecting a job to be analyzed
- 2. Breaking the job down into a sequence of steps
- Identify potential hazards by categorizing into value added (VA)/non-value added (NVA)/ non value added but required. This would be done through brainstorming.
- 4. Determining preventive measures to overcome these hazards

Table below categorizes the processes involved in a job into VA/NVA/NVA but required:

Process Flow	Description	Value Added	Non-Value Added (NVA)	NVA but Required
Sales	 			
Scheduling/Planning	<ul> <li>Request line item 10 to be created</li> <li>-Create line 10</li> </ul>		Y Y	
Configuration Engg	-create tool specific order BOM -Notify Mfg & Master scheduling	Y		Y
Manufacturing				
Shipping				

Apart from Value Stream Mapping, Novellus also implemented other lean tools such as Kaizen, Poke Yoke, cross-training, visual controls, work balance etc. Further self assessment of tools and techniques were done to identify every employee's technical proficiency in order to close any proficiency gaps that may exist. The table below shows the self assessment form used:

Tool/Techniques	Need Knowledge (I)	Some Knowledge (2)	Average Knowledge (3)	Considerable Knowledge (4)	Expert Knowledge (5)
MacGregor's theory X and Y					
Ouchi's theory Z					
Herzberg's two-factor theory					
Myers-Briggs indicator					
Risk assessment techniques					
MBNQA criteria					
ISO 9000 criteria					
Process management					
Total quality management					
PERT charts					
Costs of quality					
Gantt charts					
Critical path method					
Quality philosophies					
Pareto charts					
Cause-effect diagrams					
Flowcharts					
Control charts					
Check sheets					
Concentration diagrams					
Histograms	<u> </u>				
Scatter diagrams					
PDCA technique	<u> </u>	<u> </u>	<u> </u>	<u> </u>	
Matrix diagrams		Q		Q	Q

SELF-ASSESSMENT OF TOOLS/TECHNIQUES KNOWLEDGE The intent of this self-assessment is to assist you and us in identifying your technical proficiency and in aiding you in developing your IDP for closing any proficiency gaps that may exist. It is our plans to offer courses in many of these tools and techniques by WebEx or via the Alcoa Quality Institute (AQI).

Thus lean was implemented by first committing to lean, mapping the current state, mapping the future states and finally implementing various lean tools mentioned earlier. Lean success was then measured against certain metrics such as Interactive Discrepancy reports (IDR) which directly measures customer satisfaction. The company aims at having an IDR score of zero ideally i.e., no customer complaints. However recent reports indicate a drastic decline in the IDR scores which might possibly lead to zero overtime. As per Novellus CEO, Novellus has used lean manufacturing and is becoming more leaner day by day as lean improves in its adjacent departments serving the overall company goals.

The table below shows the traditional way versus the lean way of performing business at Novellus:

Traditional	Lean		
Large stock of back-up materials	Materials pulled on just-in-time basis		
Dedicated worker	Flexible work force		
Minimal skills, hidden knowledge	Diverse, multi-skilled work force		
Long, uniform report runs	Progressive build (one report flow)		
Enormous inventory levels	Minimal inventories		
Isolated developmental efforts within	Cross-functional development efforts		
departments			
No formal collection and use of customer	Active cultivation of customer feedback		

feedback				
No solicitation of employee suggestions	Active	cultivation	of	employee
	suggestions			

By becoming lean, Novellus created a culture in which everyone is continuously improving process and production. It provided an integration of vision, culture and strategy to serve the customer with high quality. Focus was on making the product flow without interruption, a pull system that cascades back from customer demand by replenishing at short intervals and a culture with everyone striving continuously to improve.

## 6. Conclusion

Lean management was once a principal that was just considered for manufacturing, and has been implemented in all sorts of different industries. Virtually any industry that works on projects can utilize lean management to make the process of every project more efficient from beginning to end. Over time Sulzer which has been relatively new to using lean principals in project management will become just as efficient and see the benefits the way that a company like Novellus does.

For project management, most of the project process revolves around documentation. Lean management helps make the documentation process go quicker. It is used as a quicker process to get the documents from vendors, and engineering to getting them to the end user of the product. The end result of using lean management is always to make the end user happier and more willing for return business.

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