AN APPLICATION OF VALUE STREAM MAPPING TO IMPROVE A PURCHASE ORDER PROCESS

Phasinee Chuensunk*, Piyawan Puttibarncharoensri and Yenrudee Tantisiriphaiboon
Assumption University of Thailand

ABSTRACT

This research is about an electricity generating company whose long lead time in its procurement process for spare parts after breakdowns caused internal customer complaints. The focus firm, Allied Generating Company (AGCo), is in a sensitive industry, that of supplying electricity to provincial and national grids in Thailand. Therefore, the procurement problem is a threat to the nation's economy as well as to the reputation of the AGCo firm. To solve this embarrassing problem, this research applied the Value Stream Mapping (VSM) Lean methodology to identify and remove 'wastes' so as to reduce lead time delays and improve the procurement process.It was found that the problem originated in the Procurement Department's purchase order process. Historical data for a one-year period found that the actual lead time was 26% higher than the standard set time. Of the three bidding methods by which suppliers could tender their bids, the Written Bidding method had the highest number of purchase order delays, 54% of its 151 bids. The average actual processing time of this method was 50.5 days, compared with the set standard of 15 days. The major cause of delays was communication waste in confirming specifications and conditions, and seeking bids from too many suppliers.

Work plans were redesigned to eliminate this waste and improve the purchase order process, thus achieving the standard time. Continuous performance monitoring was also begun, with KPI standards.

Keywords: *Value stream mapping, Purchase order process, Electricity generating company*

บทคัดย่อ

บทความนี้เป็นกรณีศึกษาของบริษัทผู้ผลิตกระแสไฟฟ้า ซึ่งประสบปัญหาในการจัดหาอุปกรณ์เพื่อใช้ในการซ่อมแซม ซึ่งมีระยะเวลานาน ทำให้หน่วยงานภายในไม่พึงพอใจ บริษัทที่ทำการศึกษานี้อยู่ในอุตสาหกรรมที่มีความอ่อนไหว เนื่องจากต้องป้อนกระแสไฟฟ้าให้แก่จังหวัดและภูมิภาคต่าง ๆ ทั่วประเทศไทย ดังนั้นปัญหาในการจัดหาอุปกรณ์ซ่อมแซม จะส่งผลกระทบต่อเศรษฐกิจของประเทศ รวมทั้งชื่อเสียงของบริษัท เพื่อแก้ปัญหานี้จึงมีการนำหลัก Value stream mapping มาใช้เพื่อบ่งชี้และกำจัดของเสียเพื่อลดความล่าช้าและปรับปรุงกระบวนการจัดหา ซึ่งนักวิจัยพบว่าปัญหาเกิดจากกระบวนการสั่งซื้อของแผนกจัดหา จากข้อมูลย้อนหลัง 1 ปี พบว่าระยะเวลาสั่งซื้อนานกว่ามาตรฐานอยู่

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26% จากวิธีเสนอราคา 3 วิธี ซึ่งพบว่าวิธีเสนอราคาแบบลายลักษณ์อักษร มีจำนวนคำสั่งซื้อล่าช้าสูงสุดอยู่ที่ 54% จากการเสนอราคา 151 ครั้ง ระยะเวลาเฉลี่ยในการดำเนินการคือ 50.5 วัน เปรียบเทียบกับเวลามาตรฐานที่กำหนดไว้อยู่ที่ 15 วัน สาเหตุหลักของความล่าช้าเกิดจากการสื่อสารเพื่อยืนยันข้อกำหนดและเงื่อนไข การจัดหาผู้เสนอราคาหลาย ๆ ราย ดังนั้นจึงมีการออกแบบแผนงานใหม่ เพื่อกำจัดของเสีย และปรับปรุงกระบวนการสั่งซื้อ ทำให้สามารถทำได้ตามเวลามาตรฐานที่ตั้งไว้ โดยได้ริเริ่มให้มีการตรวจสอบผลการดำเนินงานอย่างต่อเนื่อง พร้อมทั้งมีตัวบ่งชี้มาตรฐานอีกด้วย

INTRODUCTION

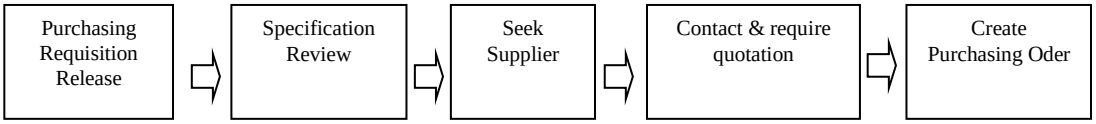
Allied Generating Company (AGCo: this and the full name are pseudonyms) was established in 2011 through company merges. The core business generates and supplies electricity to target customers, through its four plants in Thailand. AGCo's main function is to generate energy for the provincial and national electricity supply grids. The firm's Procurement Department meets internal requirements, such as the purchase of spare parts and the calibration of machinery. The business strategy of AGCo is to maintain production reliability. Any problems in the procurement process, especially delays, will directly affect production and supply. A common occurrence is machine breakdown, risking a production shortage and high recovery cost, opportunity loss, with low reliability from the customer's perception.

Nowadays, successful companies place great emphasis on their supply chain management skills, measured by effective and efficient flows of goods and services. This includes the movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption. Procurement is an important part, in acquiring goods and services in terms of quality, quantity, time, and location (Van Weele, 2010). Especially important is timely availability of what is needed.

'Lean' methodologies improve the flow of good and service based on the systematic identification and elimination of 'waste' activities. Value Stream Mapping (VSM) is a Lean methodology which identifies all action, both value-added and non-value-added waste. It leads to process improvement, emphasizing the values which customers expect (Womack & Jones, 1996).

The procurement process in AGCo starts when an internal customer sends a requirement for a part or service to the procurement department, who then send the requirement to a selected supplier, who finally delivers the part or service to the internal customer.

Figure 1: Purchase Order Process



Source: AGCo

The purchase order process begins when one of the company's internal customers produces and releases a purchasing requisition (PR) on the intranet system. Then a

purchasing officer reads the PR to review its specification and related conditions, as identified in the firm's terms of reference (TOR), so that suppliers can be selected who are able to meet these requirements and their price bids requested. For a satisfactory bid, the purchasing officer created a purchase order (PO). The PO processing lead time is from when the PR is released to the intranet, until a PO is finally issued to the supplier.

AGCo has four bidding methods, depending on price, urgency, or special conditions, as shown below in Table 1. This includes the standard PO process time.

Table 1: Procurement Method

Procurement Method	Budget (baht per issue)	Number of Supplier	Standard PO Processing Time (Days)
Price Negotiation	0 - 100,000	At least 1 supplier	**≤ 15**
Written Bidding	100,000 – 3,000,000	At least 2 suppliers	**≤ 15**
Invited Bidding	> 3,000,000	At least 3 Suppliers	**≤ 45**
Special - Urgent or exceptional condition	Not specific	Not specific	**≤ 30**

Source: AGCo

The historical data review shows that in 593 cases, 26% exceeded the standard time,

Therefore, the main research objectives are to:
Identify waste in the current process through Value Stream Mapping.
Identify the root causes of the delays.
Propose a new improved procurement process.

REVIEW OF RELATED LITERATURE

A reviewing of the literature for an improvement technique found several, including DMAIC and Business Process Improvement (BPI). However, the Lean methodology was deemed the most appropriate to deal with the firms' problem.

Lean Concept

'Lean' originated in Ford's manufacturing system of mass production (Imai,1986) to not only enhance productivity but also enhance quality, through eliminating 'waste' (Monden,1993). Furthermore, the Lean approach uses continuous improvement that focuses on quality, process, customer service and profitability. It helps to enhance speed and reduce cost by streamlining processes, while maintaining high quality (Shah & Ward, 2003), reducing delivery lead time, and thus improving customer satisfaction (Cusumano & Kentaro, 1998). This methodology can eliminate non-value added activities (waste) and raise value-added activities through workers' skills and good equipment (Gaskins & Holly, 2004).

According to Womack & Jones (2003), Lean activity has five principles;
(a) Define Value from the customer perspective.
(b) Identify the Value Streams to understand customer values.

(c) Achieve Flow to create a value stream map and product flow.
(d) Establish Pull system in production, to customer requirements.
(e) Seek Perfection by applied Continuous Improvement and Evaluation.

Waste

Waste consists of activities that do not add value. Ohno (1988) states that waste in production adds cost without adding value. Seven types of waste are (Hicks, 207):

1. Overproduction; more than required, leading to excess inventory.
2. Idle time by machine operator, due to poor coordination activities.
3. Transportation in materials movement.
4. Extra processing is extra activities, such as re-work, overproduction, storage.
5. Excess inventory.
6. Unnecessary motion of machine and people.
7. Defects is finished goods.

Value Stream mapping (VSM)

A value stream consists of all activities, value added and non-value added, required in a flow process through suppliers, production, and distribution.

Value stream mapping is a Lean concept. It maps, as a one page diagram, product flow of materials and information, and shows their linkage (Rother & Shook, 1998). These maps identify process waste and help to elicit improvements, which reduce lead time and enhances productivity and competitiveness.

Rother & Shook (1998) listed the steps of value stream mapping

(a) Select a product family to map the process of one product.
(b) Map the current state by gathering data from the actual process.
(c)Then create a current map to identify material and information flows in each step.
(d) Identify and analyze wastes (non-value added activities).
(e) Make a future state map: a road map for improvement.

Process mapping uses icons to represent activity in process. The production process of a material flow is drawn from left to right. Show the shipping state and record important information of each process step and cycle time, change over time, number of people, available time, and customer demands. Show the amount inventory, finished goods and work in process, the time line that shows lead times throughout, and value added time.

Cause and Effect Diagram

A cause-and-effect diagram is also called an Ishikawa diagram or fishbone diagram. It identifies the possible causes of the problems as part of a problem solving process (Ishikawa, 1990). This diagram was created in the interviews, for use after brainstorming the ideas generated. It identifies the ideas in four categories:

Man: Anyone involved in the process
Methods: Operating the process, and its specific requirements such as policies, procedures, regulations.
Machines: Any equipment, tools, etc. required.
Materials: Raw materials used to produce the finished goods or service.

RESEARCH METHODOLOGY

The first step is data collection; second, is data analysis. Third, is a current-state map of the existing process via VSM. Fourth, is Gap finding, to identify the gap revealed by data analysis and identify the problem's root causes. Fifth, is a future-state map. Sixth, is a work and implementation plan.

Data Collection

The data is gathered from documents, observations, and interviews. Historical documents of purchase orders and the procurement process for 12 months from May 2015 until April 2016. The researcher observed the steps and operating methods of the Purchasing Order (PO) process, in the procurement department, intended to identify waste that causes delays. The researcher interviewed all four purchasing officers, to understand current operations and delay problems.

Data Analysis

From the historical data of purchase orders, the PO processing time was calculated. This processing time is the lead time after a PR is released into the intranet system until a PO is created and sent for confirmation. The Table below is an example.

Table 2: Example to Calculate PO Processing Time

PO No.	Sent PO for Approval	PR Release date	PO Processing time	
			Solution	Days
111	6/5/2015	20/4/2015	(6/5/2015) - (20/4/2015)	16
112	8/5/2015	7/4/2015	(8/5/2015) - (07/4/2015)	31
113	15/5/2015	13/2/2015	(15/5/2015) - (13/2/2015)	91
114	26/5/2015	15/5/2015	(26/5/2015) - (15/5/2015)	11
115	26/5/2015	19/5/2015	(26/5/2015) - (19/5/2015)	7

Source: Author

After calculating the PO processing times, the differences in the four bidding methods revealed that the Written Bidding method had the highest delays, at 54% (the others being 38%, 24% and 14%). Its standard time was 15 days. Its highest PO processing time over standard time was 276 days, and the lowest was 16 days. From the expanded data of four strata of delays, the highest proportion of delays (50%) was experienced in the stratum of 16- 30 days, so to make this research manageable this stratum alone will be examined (the three others were 26%, 8% and 16%).

Current State Map

This step is to draw the current state of the PO process (written bidding method) via VSM, showing all activities in the whole process so as to find waste and non-value added activities.

The component of this current map are:

(a) Physical flow, which is the flow of the PO. It shows sub processes and data from observation and interviews.

(b) Information flow, which is information, data and communication which controls physical flow.

(c) Value-added time, which is time for value-added activities, including sub-processes.

Table 3: Average Value Added Time of Current State

Sub process	Value-Added Time (Minutes)
Review TOR	20
Seek Supplier	49
Contact Supplier & Request Quotation	18
Receive Quotation & Check	8
Create Purchase Order	16
Total	**111**

Source: Author

(d) Lead time is processing time, consisting of value-added time and waste time. Lead times are collected by reviewing the timeline of purchase orders, actual time over standard time.
All this is recorded in tabular format. Then the researcher calculates lead times of the whole process and sub processes, as shown in the Table below.

Table 4: Summary of Lead Times of Current State

Sub process	Total Lead Time (days)	Calculation	Average Lead Time (Days)
PR Release	**151**	151 days / 151 issues	**1**
Review TOR	**528**	528 days / 151 issues	**3.5**
Seeking Supplier	**1,903**	1,903 days / 151 issues	**12.6**
Contact Supplier & Request Quotation	**5,028**	5,028 days / 151 issues	**33.3**
Receive Quotation & Check	**15**	15 days / 151 issues	**0.1**
Create PO	**0**	0 days / 151 issues	**0**
Total	**7,625**	7,625 days / 151 issues	**50.5**

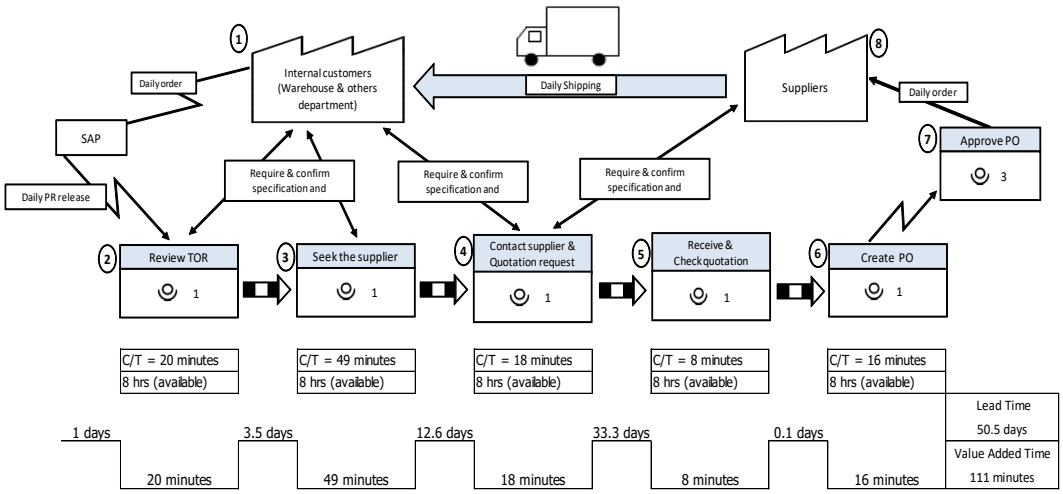
Source: Author

PO processing time is 50.5 days or 72,720 minutes of which value-added time is only 111 minutes (0.15%). A low figure means that too much time is waste, non-value added activity.

It is necessary to describe and examine the following four sub-processes.
1.Contact a supplier, and request a quotation. This has the highest average lead time of 33.3 days and operating time of 18 minutes. Two waste activities are Waiting for a Quotation from a supplier – who are sometime late. More waste is in the Communication for Request, and for Confirm the Specification & Condition of the customer's requirement – when the TOR specification is inadequate.

The next VSM map shows how all the accumulated data is displayed.

Figure 2: Value Stream Mapping



Source: Author
*1 day = 1440 minutes or 24 hours

2.Seek a Supplier. This: has an average lead time 12.6 days, and operating time of 49 minutes. The waste activity is due to the purchasing officer taking too long in seeking a supplier, because there are so many types of information data, such as name card and historical purchase data in two systems. Another waste activity is more communication needed to request and confirm the TOR specification and condition, because of TOR inadequacy to qualify which suppliers are able to meet the requirement.
Extra communication activity between the purchasing officer and internal customer is a sub-process waste because the TOR scope and specification in TOR unclear.

The wastes in the sub-processes of PO are shown in table 5.

Table 5: Waste Activities in the Purchase Order Process

Sub Process	Average Lead Time (days)	Waste Activities
Review TOR	3.5	- Communication activity to request and confirm specification and condition between purchasing officer and internal customer
Seek the supplier	12.6	- Communication activity to request and confirm specification and condition between purchasing officer and internal customer - Seeking supplier from multiple sources
Contact supplier and request quotation	33.3	- Communication activity to request and confirm specification and condition between purchasing officer, internal customer and supplier - Waiting quotation from supplier.
Receive and check quotation	0.1	-

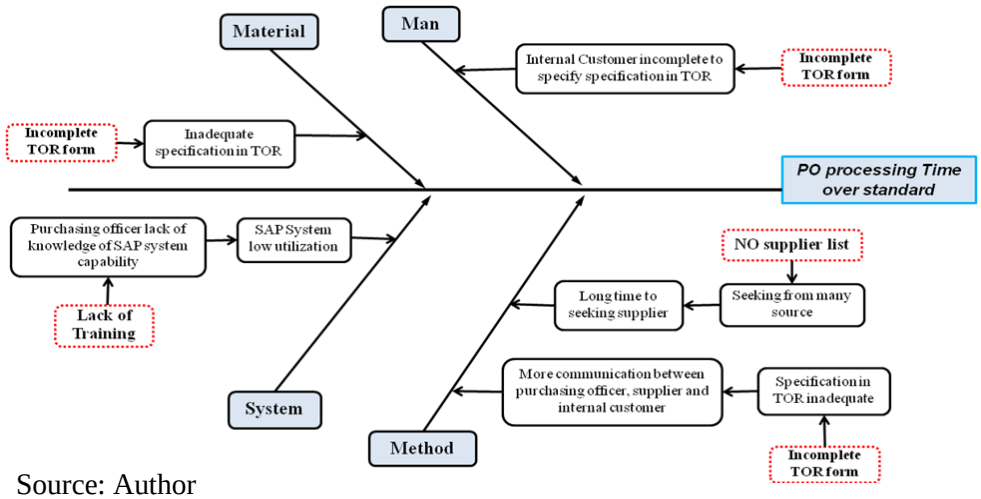
Source: Author

Cause & Effect Diagram

This step aims to identify the root causes of PO processing time over standard time. It formulates a cause and effect diagram, with historical data, plus observation and interview data. The diagram is shown below, in Figure 3.

These root causes are allocated to four categories: Man, Material, Method and System. The root causes are incomplete TOR forms, no proper list of suppliers, and purchasing officers' lack of training in the computer (SAP) system.

Figure 3: Cause and Effect Diagram of PO Processing Time over Standard Time



Source: Author

Future State Map

A proposed new model of the PO process, which eliminates the identified non-value added activities (wastes) in the PO process Written Bidding method. Details will be shown later in the Results section.

Work Plan and Implementation

This improvement plan consists of the following:

(a) Revise the TOR form to determine which details of Specification and Condition that the internal customer must include.

(b) Train Staff and Implement the new module in the SAP computer system to reduce time in seeking suppliers. The system has two modules:

A Purchasing Information record of material and relevant suppliers;

A Sort List of the suppliers and material for unusual condition and time.

(c) Set KPIs to measure and monitor monthly performance of purchasing officers.

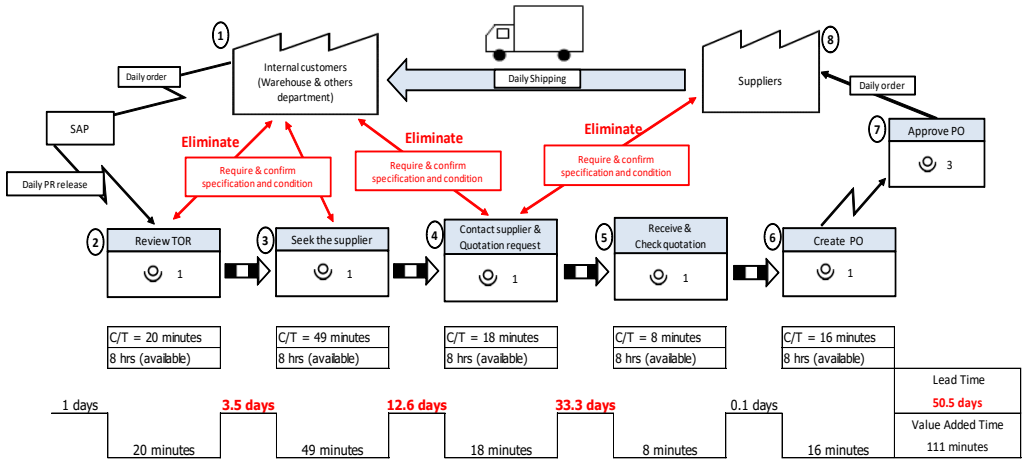
PRESENTATION AND DISCUSSION OF RESULTS

This section shows a future-improved-stage map and three work plans.

Future Stage Map of the Purchase Order Process

This is a VSM road map for improvements to eliminate waste and by eliminating the identified root causes, so that the PO processing time achieve standard time. The VSM map is shown below in Figure 4.

Figure 4: Value Stream Mapping for Eliminate Wastes



Source: Author
* 1 day = 1440 minute or 24 hours

Figure 4 shows two waste activities which need to be eliminated. First eliminate communication activity that is waste of three sub process in PO process. And second eliminate seeking supplier from multiple sources activity which is waste of seeking supplier process. Then lead time reductions in sub processes are eliminated wastes.

The following Table shows the effect of these eliminations.

Table 6: Estimate Lead Time and Value Added Time after Eliminate Waste

Sub process	Waste	Current Stage		Future Stage	
		Lead Time	Value Added Time	Value Added Time	Lead Time
		Minute	Minute	Minute	Minute
PR Release	-	1,440	-	-	1,440
Review TOR	Communication activity	5,040	20	20	20
Seek the supplier	-Communication activity -Seeking supplier from multiple sources	18,144	49	49	49
Contact supplier and request quotation	-Communication activity -Waiting quotation activity*	47,952	18	18	7,200
Receive and check quotation	-	144	8	8	144
Create PO	-	-	16	16	-
Total		72,720	111	111	8,853

Source: Author

In Table 6, shows that the PO lead time reduces from 72,720 minute to 8,853 minutes. This is because the sub-process times have reduced.
The expected improved lead times are shown in Table 7, below.

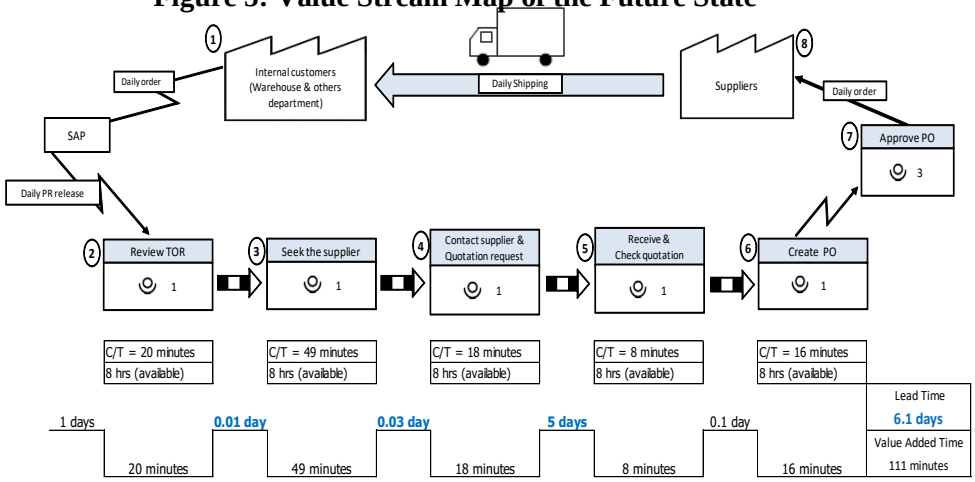
Table 7: Summary Expect Lead Time and Value Added Time of Future State

Sub process	Future Stage					
	Lead Time			Value Added Time		
	Minute	Calculate to day	Days	Minute	Calculate %	%
PR Release	1,440	1,440minutes / 1,440 minutes	1	-	-	-
Review TOR	20	20 minutes / 1,440 minutes	0.01	20	20 minutes / 20 minutes	100%
Seek the supplier	49	49 minutes / 1,440 minutes	0.03	49	49 minutes / 49 minutes	100%
Contact supplier and request quotation	7,200	7,200 minutes / 1,440 minutes	5	18	18 minutes / 7,200 minutes	0.25%
Receive and check quotation	144	144 minutes / 1,440 minutes	0.10	8	8 minutes / 144 minutes	5.56%
Create PO	-	-	-	16	16 minutes / 16 minutes	100%
Total	**8,853**	7,488 minutes / 1,440 minutes	**6.1**	**111**	111 minutes / 8,853 minutes	**1.26%**

Source: Author
* 1 day = 1,440 minutes

Therefore, is possible now to create a VSM map of the future improved state by applying expect lead time and value added time after waste elimination. This future map is in Figure 5, below.

Figure 5: Value Stream Map of the Future State



Source: Author
* 1 day = 1440 minute or 24 hours

Figure 5 above shows the future state map of the PO process in the Written Bidding method. With no waste activities the lead time reduces to 6.1 days, which is well below the standard time of 15 days. Lead times in the sub obviously also reduce; Reviewing TOR is down to 0.01 day, Seeking Supplier is down to 0.03 day, and Contact supplier to request a bid is down to 5 days. A comparison between the old state and the new improved state is shown in Table 8, below.

Table 8: Time Comparisons between Current State and Future State

Sub process	Waste	Lead Time		% Value Added Time	
		Current State	Future State	Current State	Future State
		Days	Days	%	%
PR Release	-	1	1	-	-
Review TOR	Communication activity	3.5	0.01	0.40%	100%
Seek the supplier	-Communication activity -Seeking supplier from multiple sources	12.6	0.03	0.27%	100%
Contact supplier and request quotation	-Communication activity -Waiting quotation activity*	33.3	5	0.04%	0.25%
Receive and check quotation	-	0.1	0.10	5.56%	5.56%
Create PO	-	-	-	100%	100%
Total		**50.5**	**6.1**	**0.15%**	**1.26%**

Source: Author

Table 8 shows that after eliminating wastes in the current state, lead times of four sub processes greatly reduce, and thus the value-added proportion in three sub processes greatly increase.

Therefore, the AGCo firm should move into the action phase, to turn this from a map with numbers into reality. Improvement action plans are needed, to eliminate waste and restore the firm's reputation for on-time reliability. A Work Improvement plan is essential to achieve standard times. Table 9 is a summary of what is needed to tackle the root causes so as to achieve the desired results.

Table 9: Summary of Work Plans

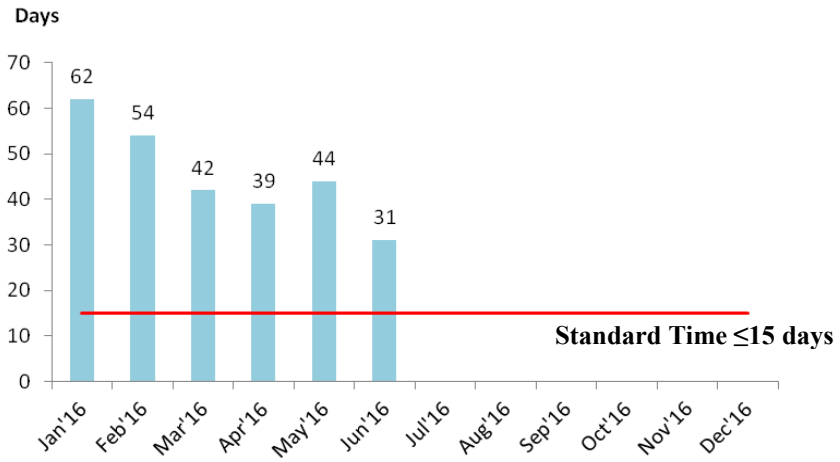
Root Cause	Work Plan	Expected Result
Incomplete TOR form	Revise TOR form	TOR form is completed to identify details for purchasing, and eliminate communication waste.
- No supplier list - Purchasing officer lack of training in SAP system	Training staff, and Implementation of new modules in SAP system - Purchasing Information record - Sort List	Increase utilization of technology for ease of working and short lead time.
-	Set KPIs to measure and monitoring performance	Control and maintain improvement

Source: Author

Before implementing the new system, the company should train the purchasing officers in how to operate it. They need to understand the capability of the modules and maximize utilization to achieve the expected process benefits, and help purchasing officers to be skillful workers.
The company should also set KPIs to measure and control the performance of purchasing officers and the procurement department. Suggested KPI details are given below.

KPI to Monitor Continuous Improvement
(a) Average PO processing time
This KPI is to measure the performance of purchasing officers, for how many days they spend on PO processing, by measuring average PO processing time, monthly.

Figure 6: KPI to Monitor Average PO Processing Time



Source: AGCo

Figure 6 shows the monitoring KPI. It is a graph of the average PO processing time. The percentage of purchase orders in the Written Bidding method, for 12 months which achieved standard time was 46%. So, the KPI target to monitor performance after improvement is 15 days = 100%.

SUMMARY OF RESULTS AND ACTION

By using VSM to identify and tackle the root causes of delay, it is expected that AGCo's PO process will achieve the set standard time. This will mean that processing time will reduce from 50.5 days to 6.1 days. This is a very substantial reduction. The value-added time percentage will increase eight-fold, from 0.15% to 1.26%. A purchasing officer's average PO processing time will become less than 15 days. The number of purchase orders achieve standard time will increase from 46% to 100%.

The researcher created three work plans to achieve and embed the improvements
First was revise the TOR form by tightening the specifications and conditions, and to separate the purchase and requirement services.
Second, is a Training & Implementation plan, with a purchasing information record and sort list within the SAP computer system, which will create a supplier list that records supplier material details such as price and delivery lead time.
Third is a set of KPIs to measure and monitor the monthly performance of purchasing officers and the procurement department, for control and sustained improvement.

Limitations and Recommendations for Future Research
This research VSN methodology may not be applicable to all other firms or industries. The result of this study are expected, not actual, because there was insufficient time. Further research could focus on whether the actual implementation was successful, and whether there was continuous improvement over at least two years.

REFERENCES

Cusumano, M. A., & Nobeoka, K. (1998). *Thinking beyond lean: How multi-project management is transforming product development at Toyota and other companies.* New York: Free Press.

Dobler, D. W., & Burt D. N. (1996). *Purchasing and supply management.* New York: McGraw-Hill. 6th Edition.

Doshi, J. A., Kamdar, J. D., Jani, S. Y., & Chaudhary S. J. (2012). Root Cause Analysis using Ishikawa diagram for reducing radiator rejection. *International Journal of Engineering Research and Applications,* 2(6), 684-689.

Gaskins, T., & Holly, S. (2004). *Machining operations cycle time*. Retrieved from http://ocw.mit.edu/courses/engineering-systems-division/esd-60-lean-six-sigma-processes-summer-2004/lecture-notes/8_2maching_optime.pdf

Goldsby, T., & Martichenko, R. (2005). *Lean Six Sigma Logistics: Strategic Development to Operational Success.* Florida: J. Ross Publishing.

Harrington, H. (1991). *Business Process Improvement: The Break though Strategy for Total Quality, Productivity and Competitiveness.* New York: McGraw Hill.

Hicks, B. (2007). Lean information management: Understanding and eliminating waste. *International Journal of Information Management*, 27(4), 233-249.

Imai, M. (1986). Kaizen (Ky'zen), *the key to Japan's competitive success*. New York: Random House Business Division.

Ishikawa, K. (1990). *Introduction to quality control*. Londres: Chapman & Hall.

Monden, Y. (1993). *Toyota Production System,* Georgia: Industrial Engineering and Management Press. 2nd Edition.

Ohno, T. (1988). *Toyota Production System: Beyond Large-Scale Production , English translation ed*. Oregon: Productivity Press.

Rother, M., & Shook, J. (1999). *Learning to See*. Value stream mapping to add value and eliminate muda. Massachusetts: Lean Enterprise Institute.

Shah, R. (2003). Lean manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21(2), 129-149.

Summers, D. C. (2006). *Six sigma: Basic tools and techniques*. New Jersey: Pearson Prentice Hall.

Van Weele, A. J. (2010). *Purchasing and Supply Chain Management: Analysis, Planning and Practice*.London: Cengage. 5th Edition.

Womack, J. P., & Jones, D. T. (1996). *Lean Thinking: Banish Waste and Create Wealth in your Corporation*. New York: Simon & Schuster.

Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, Mitch. (2013). *Business Research Methods*. Mason, OH: Erin Joyner/South-Western. 9th Edition.