

VALUE STREAM MAPPING (VSM) IN CONSTRUCTION AND  
MANUFACTURING INDUSTRY: A STRUCTURED LITERATURE REVIEW AND  
COMPARATIVE ANALYSIS

A Thesis

by

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## ABSTRACT

For the past few years, almost every sector of the manufacturing and service industries has applied some form of lean methodology. Likewise, lean-based tools have been applied to simple and complex construction projects. Value stream mapping (VSM) as a lean tool for manufacturing is used as a basic graphical tool that aims to describe production processes and to identify and reduce types of waste. In its current state, VSM is not being implemented as successfully in construction as it is in manufacturing due to fundamental differences between manufacturing and construction. This paper's methodology uses a structured literature review to summarize the current state of VSM application in both construction and manufacturing. A comparative analysis identifies the differences and similarities of the identified applications of VSM between the manufacturing and construction industries. Resulting analogies from this analysis will enable the adaptation of VSM for use in the construction industry and provide a theoretical framework of the applications of VSM in construction for further research.

## DEDICATION

To my beloved family, committee board, Alex, and friends, thank you for all of your support along the way.

## ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. José L. Fernández-Solís and my committee members: Dr. Sarel Lavy and Dr. Rodney Hill, for their guidance and support throughout the course of this research.

Thanks also go to my friends and the department faculty and staff for making my time at Texas A&M University a great and memorable experience.

Finally, thanks to my beloved parents and my grandparents for their encouragement and unconditional support that helped me go through my master's program.

## NOMENCLATURE

### *Definitions*

- **Lean manufacturing:** a production practice that regards the consumption of resources for any objective other than the making of worth for the end client to be inefficient, and in this way, an objective for elimination (Liker, 2004).
- **Value Stream:** the arrangement of activities needed to design, produce, and convey a product or service to a client; incorporates material flow and information flow (Womack & Jones, 2002).
- **Value Stream Mapping (VSM):** a lean-management method that aims to bring a product or service from productive beginning to the end customer by analyzing the current state and designing a future state for the series of events (Rother, Shock, Womack & Jones, 2003).
- **Value Stream Mapping Tools (VALSAT):** seven tools : process activity mapping; supply chain responsiveness matrix; product variety funnel; quality filter mapping; forester effect mapping; decision point analysis; overall structure maps (Hines & Rich, 1997).
- **MUDA:** derived from a Japanese word signifying "vanity; futility; absence of movement; pointlessness; waste; wastage; inefficiency"; a key concept in the Toyota Production System as one of three types of deviation from ideal distribution of resources ( Emiliani, Stec, Lawrence & Stodder , 2007).
- **Takt Time:** originated from the German word Taktzeit, sets the pace for industrial manufacturing lines with the goal that cycle times can be coordinated to client interest rate (Liker, 2004).

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## CHAPTER I

### INTRODUCTION

#### **1.1 Background**

The construction industry has been criticized and compared to manufacturing by governmental publications and society for low production efficiency, low quality, natural resources waste and the high rate of work accidents during the production process and operating performance. In order to improve quality and efficiency, and reduce waste, Lean Thinking philosophy has been imported to the construction industry since the 1970s (Fontanini, Milano, Fujimoto, Lintz, Gachet-Barbosa & Jacintho, 2013). Some successful experiences in implementing lean construction have been achieved: Conte and Gransberg (2001), for example, examined the principles used in applying lean construction by over 20 construction companies in Brazil.

Value stream mapping (VSM) originated in the Toyota Production System. VSM's functions are to both analyze and design the flow of material and information required to bring a product or service to the end-consumer (Rother et al, 2003). VSM was used in factories that use visual work processes in order to find waste created during their operations. VSM improves work strategies by developing a deeper understanding of the work flows through entire systems, establishing a strategic direction for making improvements, and delivering value to end users (Martin & Osterling, 2013).

According to Pasqualini and Zawislak (2005), since 1993 the philosophy of lean production and the principles of VSM have been applied to construction; however, the

application of VSM in construction has focused only on specific areas, and with no acceptable application. An in-depth literature review shows that previous studies on the application of VSM in construction have focused on only macro-processes such as supply chain (Arbulu, Tommelein, Walsh, & Hershauer, 2003) or project delivery (Mastroianni & Abdelhamid 2003), or on single operations such as components manufacturing (Alves, Tommelein & Ballard, 2005) or masonry works (Pasqualini & Zawislak, 2005). The application of VSM in construction has been very limited when compared to other industries. Manufacturing, on the other hand, has reported significant flow improvements for their organizations by applying VSM.

## **1.2 Objectives**

This paper has two objectives: to develop an in-depth understanding of the application of VSM in construction and manufacturing industries, respectively, by using the Structured Literature Review, and to analyze and compare VSM's similarities and differences within both industries.

## **1.3 Delimitations of the Study**

The scope of the research is delimited to an in-depth literature review of previous studies on value stream mapping and especially the application of VSM in the construction and manufacturing industries. The literature search is limited to research written in English. Some valuable research may be excluded, due to being created in other languages.

## CHAPTER II

### METHODOLOGY

#### **2.1 Introduction**

Bernstein and Fink (1998) defined a literature review as: "A precise, unequivocal, and reproducible configuration for recognizing, assessing, and deciphering the current group of recorded writing". The analysis of literature helps researchers create a focused background in a field of interest. The literature review maps two sets of documents: first, they abridge existing research by distinguishing examples, topics, and issues. Second, literature reviews serve to distinguish the reasonable substance of the field and may add to theory improvement. The diversity of literature sources within the management disciplines has resulted in a growing need for a systematic methodology to map the territory of its associated theories and models. Compared with either a traditional or narrative review, a structured literature review is a more rigid, well-defined, and scientifically accepted method to review the literature by building on the method's criteria to identify, rate and synthesize all the literature in a particular research field. This paper concentrates on VSM and its application in the construction and manufacturing industries. In spite of being successfully applied in the manufacturing industry, VSM's application in construction still has not fully been utilized (Arbulu et al, 2003) . In order to build a theoretical framework, a comprehensive literature review is appropriate for understanding VSM in construction. The summary of previous research on the application of VSM will provide a larger picture of current research and

a clear link from manufacturing to construction, thus developing a deeper understanding of how VSM may be leveraged in construction.

## **2.2 Database and Keywords**

The databases used for the literature search include: Google Scholar, ASCE Library, Web of Knowledge, Construction Journal, Science Direct, and ProQuest Dissertations. In addition to the databases, the following books were used as references: “*The Toyota Way*”, written by Liker (2004), introduces lean principles and addresses VSM as a useful lean approach that can be applied across numerous industries. *Value Stream Mapping-How to Visualize Work and Align Leadership for Organizational Transformation*”, written by Martin and Osterling (2013), systematically introduces the definition of VSM and its application as a tool.

After determining the main databases, the next step is using keywords to refine the scope of the search for literature. A preliminary search of VSM yielded over 20,000 papers, and in order to narrow the scope, a set of keywords based on the main research question was used. For example, the following keywords proved useful: VALSAT, VSM in the construction, the application of VSM in the construction industry, application of VSM in the manufacturing industry. After using different combinations of keywords, the resulting list was narrowed down to more than 1000 papers for “VALSAT”, 107 papers with the topic of “value stream mapping in the construction”, 10 papers for “the application of value stream mapping in the construction industry”, and 15 papers with the study of “application of value stream mapping in the manufacturing industry”. The criteria for choosing the final analyzed literature focus on the research problem (related

to the application of value stream mapping in the construction and manufacturing industries), aims, research design and methodology, objectives, findings, and conclusions. Eventually, 18 separate works were selected as the final analyzed literature related to the research question. After identifying relevant studies, the papers, citations, and data were added into RefWorks, a web-based research management, writing and collaboration tool. It helps researchers easily gather, manage, store, and share all types of information by importing references from text files, online databases, and other sources, as well as generating citations and bibliographies. In order to further analyze the literature, a Literature Selection Table was created. This table lists any papers relevant to the research and documents the reason for their selection. Table 1 shows a sample of the relevant literature papers.

**Table 1. Sample of Literature Selection (see Appendix A for total list)**

Survey of all literatures on the topic VSM		Applicable to research			Reason	Notes		
Item	Paper topic	Authors	Journal/citation of the publication	Year			YES	NO
1	The seven value stream mapping tools	Hines, P., & Rich, N	International Journal of Operations & Production Management	1997	x		An introduction of value stream mapping tools	vsm
2	An evaluation of the value stream mapping tool	Lasa, I. S., Laburu, C. O., & de, C. V	Business Process Management Journal	2008		x	using the value stream mapping to redesign the production system	manufacturing
3	The application of value stream mapping to lean engineering	Pavnaskar, S. J., & Gershenson, J. K.	2004 ASME Design Engineering Technical Conferences and Computers and Information in Engineering Conference	2004		x	value stream mapping in the engineering process	
4	Value stream mapping: A study about the problems and challenges found in the literature from the past 15 years about application of lean tools.	Dai Forno, A. J., Pereira, F. A., Forcellini, F. A., & Kipper, L. M.	International Journal of Advanced Manufacturing Technology	2014		x	overview of application of vsm in different industries and its problems	vsm
5	Sustainable value stream mapping (sus-VSM) in different manufacturing system configurations: Application case studies.	Brown, A., Amundson, J., & Badurdeen, F.	Journal of Cleaner Production	2014	x		introduction about the sus-vsm	manufacturing
6	Concrete slab value stream mapping of brazilian residential buildings - A lean construction study case.	Fontanini, P. S. P., Milano, C. d. S., Fujimoto, A., Lintz, R. C. C., Gachet-Barbosa, L., Jacintho, A. E. P. G. A., et al.	4th International Conference on Manufacturing Science and Engineering	2013	x		vsm in the construction	construction
7	Production process improvement based on value stream mapping for CY company.	Longhan, Z., Hong, L., & Shiwei, X.	6th International Conference on Information Management, Innovation Management and Industrial Engineering (ICIII)	2013		x	vsm in the manufacturing but only cited few times	manufacturing
8	Adaptation of the value stream optimization approach to collaborative company networks in the construction industry.	Matt, D. T., Krause, D., & Rauch, R.	8th CIRP International Conference on Intelligent Computation in Manufacturing Engineering	2013	x		this paper describes in detail a methodology to design an integrated and customized value stream map for construction industries requirement	construction
9	The challenge: the impetus for change to lean project delivery	Remo Mastroianni1 and Tariq Abdelhamid2	Group for Lean Construction	2003	x		vsm in project delivery	construction

### **2.3 Analyze the Literature and Reference Matrix**

Table 2 is a reference matrix that overviews, organizes and summarizes the readings. The matrix includes general information, keywords, aims, research methods, summary of research results, and useful references. When relevant references were identified, they were also added to the matrix.

### **2.4 Group the Literature and Findings from the Extant Studies**

The objective of doing a literature review is to synthesize the literature into an integrated review. Tables 3-5 organize the literature into bibliography, themes, and keywords. According to the analysis of current literature, VSM is grouped into three different categories: VSM principles and tools; VSM in construction; VSM in the manufacturing industry. VSM in construction mainly focuses on: macro-processes, construction support processes and the construction process. VSM in the manufacturing industry focuses on: production process and supply chain. Tables 3-5 show the literature maps.



Table 2. Sample of the Reference Matrix (see Appendix B for total reference Matrix)

No	Title	Bibliograph	key words researched	Aims	Research Methodology	Summary of results	Useful references
1	The seven value stream mapping tools	Hines, P., & Rich, N	Value Stream Mapping	The motivation behind this paper is to develop a typology to take into consideration a compelling utilization of sub-sets of the complete suite of tool and help researchers or professionals to distinguish waste in individual value streams and, hence, locate a proper course to removal, or possibly decrease, of this waste.	grounded theory	Describes a toolkit consisting of seven tools : 1. overproduction 2. waiting 3. transport 4.inappropriate processing 5 unnecessary inventory 6. unnecessary motion and 7 defects. The article discusses problems with existing tools for analyzing value streams. The main problem identified was that each of these tools was too limited in scope and did not integrate well with one another in order to provide a comprehensive view of the value stream. The seven tools presented in the article were specifically designed to eliminate this problem. The first tool, process activity mapping, aids in developing solutions to reduce waste. The second tool, supply chain response matrix, aids in identifying the activities constraining the process so that these activities can be targeted for improvement. The third tool, production variety funnel, is similar to IVAT analysis and helps one understand how products are produced. The fourth tool, quality filter mapping, aids in identifying where quality problems occur. The fifth tool, demand amplification mapping, aids in analyzing the increase in demand variability as one travels up the supply chain. The sixth tool, decision point analysis, aid in identifying “ the point in the supply chain where actual demand pull gives way to forecast-driven push”. The seventh tool, physical structure, aids in developing a high-level understanding of the supply chain.	Womack, J. and Jones, D., "From lean production to the lean enterprise", Harvard Business Review, March-April 1994, pp. 93-103.
2	Concrete slab value stream mapping of Brazilian residential buildings: a lean construction case study	Patricia Stella Pucharelli Fomnani, Caroline de Souza Milano, Aparecido Fujimoto, etc.	Value Stream Mapping Construction	This paper presents the value stream mapping could improve the production and environmental performance	Case Study	This paper presented the application of VSM and the preliminary sustainable analyses too. The execution of research started with the diagnosis of lean and sustainable concepts selected, and an analysis initial of the value stream mapping applicability in the concrete slab processes. In the first step, three visits were carried out at the residential works, aiming to detect and to observe the waste inherent in construction processes. In a second step, the authors analyzed the company. In the third step, the search consisted in the implementation of semi-structured interviews with the engineer responsible for the work and other work employees. In the sequence, it was chosen a standardized process for value stream mapping of current state (concrete slab process). As a result, through the analysis of the mapping performed, it was possible to identify waste that could be prevented and then it was proposed a future state for the flow that resulted in a better performance of the process making it more lean and sustainable. This paper gave a case example of how VSM contributes to making decisions about the flow represented making it logical and simplified, the production process, addressing lean techniques and concept as a whole.	J.P. Womack: <i>the challenge of value stream management</i> . Lean Enterprise Institute value stream management conference. Dearborn, 2000 M.Rother: <i>Crossroads: which way will you turn on the road to lean?</i> In: LIKER, J.K. (Editor) > Becoming lean: inside stories of U.S. Manufacturers. Portland, Oregon, USA : Productivity press, 1997
3	Development of Lean Model for House Construction Using Value Stream Mapping	Haitao Yu; Tarry Tweed; Mohamed AL-Hussen and Reza Nasserri	Value stream mapping Construction	Using VSM to improve the constructive process	Case Study	Lean construction has recently attracted considerable attention in the home building industry. Lengthy delivery time and significant waste in the construction process have caused many home builders	Alves, T.C.L., Tommelen, ID., and Ballard, G.(2005). "Value stream mapping for make-to-order products in a job shop environment."

**Table 3. Literature Map of VSM Principles and Tools**

VSM PRINCIPLES AND TOOLS		
<i>NO</i>	<i>THEME</i>	<i>KEY WORDS</i>
1	Martin, K., & Osterling, M. (2013). Value stream mapping: how to visualize work and align leadership for organizational transformation.	How to visualize work and align leadership for organizational transformation
2	Rother, M., & Shook, J. (2003). <i>Learning to see: value stream mapping to add value and eliminate muda</i>	Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA
3	Hines, P., & Rich, N. (1997). The seven value stream mapping tools	Contingency planning, Cross-functional integration, Process layout, Supply-chain management, Value analysis, Waste disposal

**Table 4. A Literature Map of VSM in Construction**

VALUE STREAM MAPPING IN CONSTRUCTION		
<i>NO</i>	<i>THEME</i>	<i>KEY WORDS</i>
1	Fernanda Pasqualin and Paulo Antônio Zawislak. (2005). Value Stream Mapping in Construction: A Case Study in a Brazilian Construction Company	Value stream mapping, Systemic implementation
2	Sergio Rosenbaum; Mauricio Toledo, ; and Vicente González. (2013). Improving Environmental and Production Performance in Construction Projects Using Value Stream Mapping: Case Study	Management; Process control
3	Patricia Stella Pucharelli Fontanini; Caroline de Souza Milano; Aparecido Fujimoto; Rosa Cristina Cecche Lintz; Luisa Andréia Gachei-Barbosa; Ana Elisabete P. G. A. Jacintho; Lia Lorena Pimentel. (2013). Concrete Slab Value Stream Mapping of Brazilian Residential Buildings - A Lean Construction Study Case	Lean construction, Value stream mapping, Concrete slabs, Lean tools
4	Haitao Yu; Tarry Tweed; Mohamed Al-Hussein; and Reza Nasser. (2009). Development of Lean Model for House Construction Using Value Stream Mapping	Buildings, residential; Housing; Lean construction; Production management; Construction

**Table 4. Continued**

<i>NO</i>		<i>THEME</i>	<i>KEY WORDS</i>
5	D.T. Matta,b, D. Krausea, R. Raucha.( 2013). Adaptation of the value stream optimization approach to collaborative company networks in the construction industry	Macro-process	Value stream mapping design, Collaborative networks
6	Remo Mastroianni; Tariq Abdelhamid. (2005). The Challenge : The Impetus for Change to Lean Project Delivery	Macro-process	Lean Construction, Implementation, Organizational Change, Value Stream Mapping, Logistics Planning, Visual Management, 5S, Last Planner System
7	Patricia S.P. Fontanini; Flavio A. Picchi.( 2004). Value Stream Macro Mapping- A Case Study of Aluminum Windows for Construction Supply Chain	Construction support process	Supply chain, Macro Mapping, Value Stream Mapping, Lean Thinking, Aluminum Supply Chain
8	Thais da C. L. Alves; Iris D. Tommelein; Glenn Ballard.( 2005). Value Stream Mapping for Make-To-Order Products in A Job Shop Environment	Construction support process	Value Stream Mapping, HVAC sheet metal fittings, Make-to-order, Job shop, Lean Production, Lean Construction
9	Roberto Arbulu; Iris Tommelein; Kenneth Walsh; James Hershauer.( 2002). Value stream analysis of a re-engineered construction supply chain	Construction support process	Construction performance, Lean project delivery system, Production management, Re-engineering construction, Supply chain management, Value stream mapping, waste

**Table 5. A Literature Map of VSM in Manufacture**

VSM IN MANUFACTURING		
NO	THEME	KEY WORDS
1	Production process	Value stream mapping, Simulation
2	Production process	Current state value stream mapping (CVSM), Future state value stream mapping (FVSM), Value added time
3	Production process	Dynamic value stream maps, Complex systems, Value stream mapping
4	Supply chain	Automotive industry; Lean supply chain management; Value stream mapping
6	Supply chain	Edible oils, Waste minimization, Supply chain management, Value chain, India
7	Supply chain	Sustainable Manufacturing, Supply Chain Assessment, Value Stream Mapping, Sus-VSM, SC Sus-VSM

## CHAPTER III

### LITERATURE REVIEW




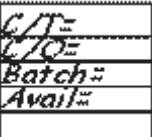

This chapter summarizes the literature based upon three categories: VSM principles and tools, VSM in construction and VSM in the manufacturing industry.

#### **3.1 Value Stream Mapping Principles and Tools**

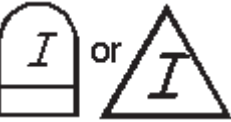
##### *3.1.1 Value Stream Mapping Principles*

VSM originates from Toyota's material and information flow diagrams and was designed to help Toyota's suppliers learn the Toyota Production System (Rother et al. 2003). Rother's study and ten years' of experience in operating VSM in various industries have demonstrated that VSM is more than just a tool. VSM was not limited only to identifying waste in a system, but could also be used to analyze and aid in designing processes, tracing material flow, and documenting information flow of a given product or product family. VSM uses symbols to represent a clear and visual process from the customer's requirement to the final accomplishment. The following tables show the symbols of VSM:








**Table 6. VSM Process Symbols (Strategos. (2007). Value Stream Mapping Symbols & Icons. Retrieved from: [http://www.strategosinc.com/vsm\\_symbols.htm](http://www.strategosinc.com/vsm_symbols.htm))**

Symbol	Meaning
	Customer/Supplier Icon: represents the Supplier when in the upper left, customer when in the upper right, the usual end point for material
	Dedicated Process flow Icon: a process, operation, machine or department, through which material flows. Represents one department with a continuous, internal fixed flow
	Shared Process Icon: a process, operation, department or work center that other value stream families share
	Data Box Icon: it goes under other icons that have significant information/data required for analyzing and observing the system
	Work Cell Icon: indicates that multiple processes are integrated in a manufacturing work cell

**Table 7. VSM Material Symbols (Strategos. (2007). Value Stream Mapping Symbols & Icons. Retrieved from: [http://www.strategosinc.com/vsm\\_symbols.htm](http://www.strategosinc.com/vsm_symbols.htm))**

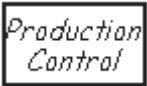
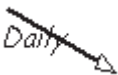




Symbol	Meaning
	Inventory Icons: show inventory between two processes

**Table 7. Continued**







Symbol	Meaning
	<p>Shipments Icon: represents movement of raw materials from suppliers to the receiving dock/s of the factory. Or, the movement of finished goods from the shipping dock/s of the factory to the customers</p>
	<p>Push Arrow Icon: represents the “pushing” of material from one process to the next process</p>
	<p>Supermarket Icon: an inventory “supermarket” (kanban stockpoint)</p>
	<p>Material Pull Icon: supermarkets connect to downstream processes with this "Pull" icon that indicates physical removal</p>
	<p>FIFO Lane Icon: First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input.</p>
	<p>Safety Stock Icon: represents an inventory “hedge” (or safety stock) against problems such as downtime, to protect the system against sudden fluctuations in customer orders or system failures</p>
	<p>External Shipment Icon: shipments from suppliers or to customers using external transport</p>





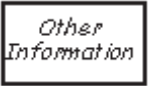

**Table 8. VSM Information Symbols (Strategos. (2007). Value Stream Mapping Symbols & Icons. Retrieved from: [http://www.strategosinc.com/vsm\\_symbols.htm](http://www.strategosinc.com/vsm_symbols.htm))**

Symbol	Meaning
	<p>Production Control Icon: represents a central production scheduling or control department, person or operation</p>
	<p>Manual Info Icon: A straight, thin arrow shows general flow of information from memos, reports, or conversation. Frequency and other notes may be relevant</p>
	<p>Electronic Info Icon: represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network). You may indicate the frequency of information/data interchange, the type of media used, ex. fax, phone, etc. and the type of data exchanged</p>
	<p>Production Kanban Icon: triggers production of a predefined number of parts. Signals a supplying process to provide parts to a downstream process</p>
	<p>Withdrawal Kanban Icon: represents a card or device that instructs a material handler to transfer parts from a supermarket to the receiving process. The material handler (or operator) goes to the supermarket and withdraws the necessary items.</p>
	<p>Signal Kanban Icon: used whenever the on-hand inventory levels in the supermarket between two processes drops to a trigger or minimum point. It is also referred as “one-per-batch” kanban.</p>

**Table 8. Continued**

Symbol	Meaning
	<p>Kanban Post Icon: a location where kanban signals reside for pickup. Often used with two-card systems to exchange withdrawal and production kanban.</p>
	<p>Sequenced Pull Icon: represents a pull system that gives instruction to subassembly processes to produce a predetermined type and quantity of product, typically one unit, without using a supermarket</p>
	<p>Load Leveling Icon: a tool to batch kanbans in order to level the production volume and mix over a period of time</p>
	<p>MRP/ERP Icon: scheduling using MRP/ERP or other centralized system</p>
	<p>Go See Icon: gathering of information through visual means</p>
	<p>Verbal Information Icon: represents verbal or personal information flow</p>

**Table 9. VSM General Symbols (Strategos. (2007). Value Stream Mapping Symbols & Icons. Retrieved from: [http://www.strategosinc.com/vsm\\_symbols.htm](http://www.strategosinc.com/vsm_symbols.htm))**

Symbol	Meaning
	Kaizen Burst Icon: used to highlight improvement needs and plan kaizen workshops at specific processes that are critical to achieving the Future State Map of the value stream.
	Operator Icon: represents an operator. Shows the number of operators required to process the VSM family at a particular workstation
	Other Icon : other useful or potentially useful information
	Timeline Icon: shows value added times (Cycle Times) and nonvalue added (wait) times. Use this to calculate Lead Time and Total Cycle Time.

There are five basic steps for applying VSM in various industries. The first step is to define the product family and then draw a current state map of the product. After identifying the non-value added and value added processes, the team brainstorms and combines lean concepts with the value added to construct a future state map. The final step is to implement an action plan with a detailed process map, and a yearly value stream plan that could achieve the future state.

### 3.1.2 Benefits of Value Stream Mapping

“*Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA*” written by Rother et al. (2003) and “*Value Stream Mapping: How to Visualize Work Flow and Align People for Organizational Transformation*” written by Martin and Osterling (2013) present the following benefits of Value Stream Mapping:

#### (1) Provides a holistic view of the entire flow

By mapping the value stream, a better understanding of the whole process can be achieved. The act of connecting separate parts into a more holistic system helps the team to identify both the necessary and unnecessary functions, allowing the latter to be either removed or changed for better process flow. VSM also helps to discover any potential information problems that are not easily identified within the product system. Visualizing non-visible works such as information exchanges are important in understanding how work is accomplished.

#### (2) Identifies Waste

Applying VSM to map the current state of the product or service shows value added and non-value added processes and waste during the production process. What is more, the value stream map can clearly identify the seven most common types of waste: Overproduction, Waiting, Transport, Extra processing, Inventory, Motion, and Defects, all of which are summarized in Table 10.

**Table 10. Seven Wastes**

<b>Waste</b>	<b>Example</b>
Overproduction	Precast concrete is produced at a level higher than the owner required. This leads to waste and an increase in inventory and waiting time.
Waiting	Work will be delayed due to broken equipment, bad weather.
Transportation	Unnecessary movement of information, products or components from one place to another.
Extra Processing	Following the process accurately to eliminate potential costs in installation or rework.
Inventory	Unused products wait for further processing. Poor planning will increase cost of the worksite and occupy valuable warehouse space.
Motion	Poor material layout will produce unnecessary movements by workers on the work site.
Defects	Defective materials and damaged machines can lead to rework and increase costs.

(3) Generates improvement plans

Once wastes are identified in the production process, the team can start building an improvement plan using lean concepts to eliminate waste and to add value. VSM focuses on calculated experimentation in certain parts of the process before disturbing the flow of the rest of the business.

### 3.1.3 Value Stream Mapping Tools

Hines and Rich (1997) conducted a study describing the seven VALSAT in terms of the seven wastes mentioned above. The seven tools and their relationships are shown in Table 11 below.

**Table 11. The Seven Value Stream Mapping Tools (Hines and Rich, 1997)**

Wastes/structure	Mapping tool						Physical structure (a) volume (b) value
	Process activity mapping	Supply chain response matrix	Production variety funnel	Quality filter mapping	Demand amplification mapping	Decision point analysis	
Overproduction	L	M		L	M	M	
Waiting	H	H	L		M	M	
Transport	H						L
Inappropriate processing	H		M	L		L	
Unnecessary inventory	M	H	M		H	M	L
Unnecessary motion	H	L					
Defects	L			H			
Overall structure	L	L	M	L	H	M	H

**Notes:** H = High correlation and usefulness  
M = Medium correlation and usefulness  
L = Low correlation and usefulness

Hines and Rich (1997) discussed problems related to existing tools for conducting value streams. The seven tools are used to eliminate potential waste and provide a comprehensive view of the value stream in a new and improved configuration. The first tool, Process Activity Mapping, focuses on creating solutions to eliminate waste. The second tool, Supply Chain Response Matrix, identifies activities constraining the process so that these activities can be targeted for elimination or improvement. The third tool, Production Variety Funnel, helps the team understand how products or services are produced. The fourth tool, Quality Filter Mapping, identifies problems

related to quality. The fifth tool, Demand Amplification Mapping, shows changes along a supply chain and identifies a decision support system. The sixth tool, Decision Point Analysis, helps identify “the point in the supply chain where actual demand-pull informs forecast-driven push” (Hines and Rich, 1997). The seventh tool, Physical Structure, helps develop a holistic view of the supply chain, for example, understanding how the industry operates and where it might be improved. Using the Value Stream Mapping Analysis Tools (VALSAT) approach is an effective method for selecting the best tool at different steps.

### **3.2 Value Stream Mapping in Construction**

Based on the literature search, the application of VSM in construction is divided into these three themes: construction process, macro-process, and construction support processes.

#### *3.2.1 Construction Process*

In the construction process, high costs and consumption of unnecessary resources generate significant waste and high customer dissatisfaction. However, research indicates that the industry currently focuses on the design and operation stages of projects rather than on the construction process.

Three studies have discussed how to use VSM to improve the construction process. Pasqualini and Zawislak (2005) applied the VSM to define a product family. In VSM construction, structural elements like walls, slabs and columns are the main product family analyzed. Unlike a product in manufacturing, where the amount of inventory can be simply counted, the units on a construction site are diffuse and the units

flowing through the value stream are different. So this study selected the masonry stage. For the current state map, the time of production in construction is too long to collect in a single day. Therefore, the average time of a stage is used. In the analysis of the current state map, based on a schedule developed from the contract, the takt time can be calculated, which is the effectively available worked time multiplied by the amount of area worked. As a result, takt of construction will indicate the time in which an area should be worked, or the rhythm of production according to the contract stating the customer's demand. Based on an analysis of the current state map, a future state map can be drawn in the same way as in a manufacturing context.

In similar case studies conducted by Rosenbaum, Toledo, & Gonzalez (2014) and Fontanini et al. (2013), the masonry stage was also selected as the product family analyzed for understanding VSM in construction.

These cases demonstrate that VSM is a tool used to identify the sources of environmental and production waste, quantify them, and suggest reduction strategies.

VSM application in construction is hindered by the following identified factors:

- (1) A hidden essential for effective VSM is the repetition of the production process.
- (2) VSM is a quantitative tool that uses a list of process data to portray the current state of the process and to figure out the future state. However, most construction companies do not fully track construction processes and data.
- (3) Key concepts/elements used in VSM, such as inventory, cycle time, takt time and change-over time, are defined in the manufacturing context; this differs from the construction context (Yu, Tweed, Al-Hussein, & Nasser, 2009).



Therefore, modifications of VSM are necessary, due to the differences between manufacturing and construction (Pasqualini & Zawislak 2005). Pasqualini & Zawislak (2005) utilized a modified Value Stream Mapping and made some adjustments at each stage to enhance the production process in a Brazilian construction company. Yu et al (2009) used the modified VSM to reduce waste in housing construction. In this study, the products of production home building can be seen as a single product family, because they are constructed following similar processing steps and sharing the same sub-contractors. On a construction site, houses do not move along a production line; however, workers move from one house to another. Thus, the operations performed by a trade crew can be viewed as a continuous flow. In this case, one house production process was divided into five stages after considering the size of the value stream map, logical relationships and the total duration of the construction activities. These five stages are foundation, lock-up, interior and siding, pre-finals and finals. After identifying the target stage to be improved, which is the foundation stage in this case, a current state map can be drawn. Figure 1 shows the current state map:

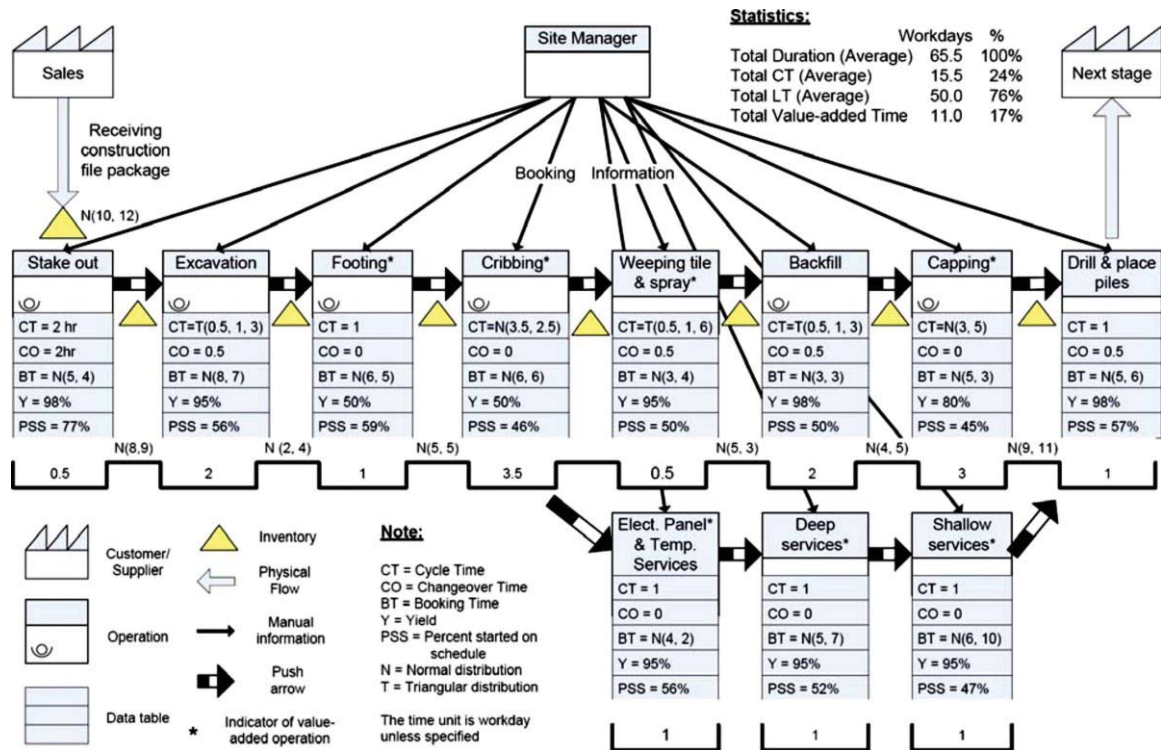


Figure 1. Current-State Map of Home Building Process (stage 1). Reprinted from Yu et al. (2009).

The future state map can be developed after an analysis of the current state map, during which waste is identified. The focus of the future state map is to eliminate the cause of waste and improve the value stream into a smooth flow. Four measures are used in future state mapping. They are establishing a production flow and synchronizing it to takt time; leveling production at the pacemaker task; restructuring work and improving operational reliability with work standardization; and total quality management for this study. Figure 2 shows the future state map:

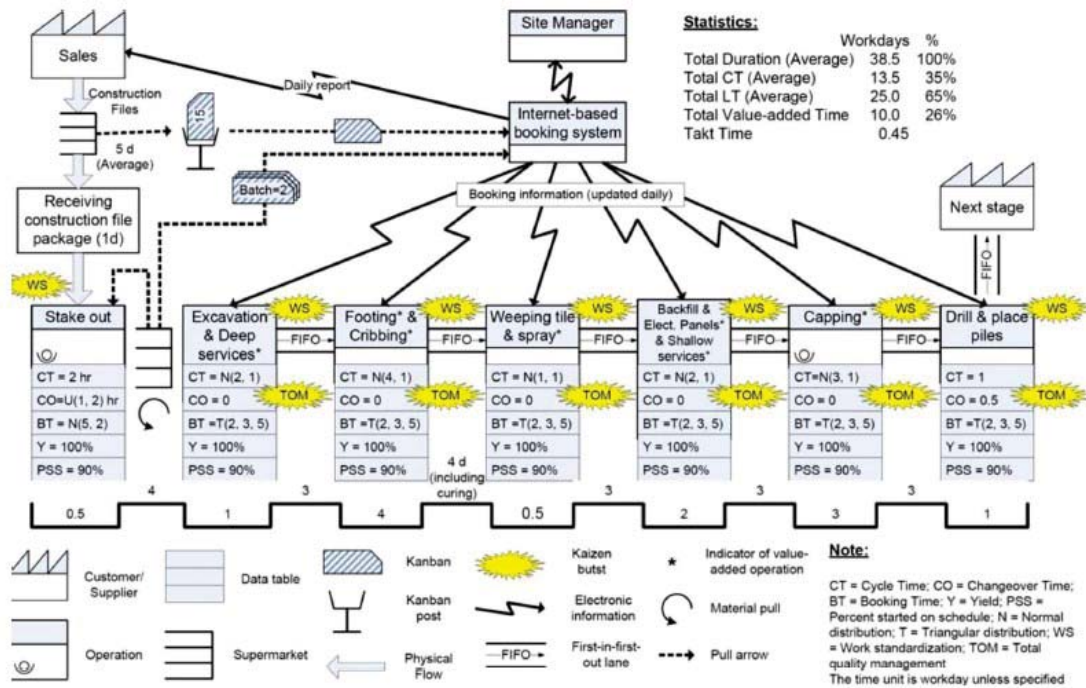


Figure 2. Future-State Map of Home Building Process (stage 1). Reprinted from Yu et al. (2009).

### 3.2.2 Macro-process

Another principle issue for the construction industry consists of the competition for projects that is mainly cost centered: the cheapest bid wins and an extremely traditionalist industry contributes little time, money or vitality in advance, thus acknowledging only incremental changes.

Due to this problem, Matt, Krause and Rauch (2013) presented an agreeable and interdisciplinary research project, “build4future,” that plans to create and implement a cooperative project platform for an industrialized, coordinated construction project. The fundamental target of “build4future” is to reconsider and update the entire value chain for customized construction, including a discrete number of diverse players, and to achieve

a level of productivity and industrialization known in different industries. The author utilized a case study of a client scenario of medium-value wooden houses to show its application. In the first step, the author grouped the client scenario as "middle-class wooden house." The second step is to model lean-optimized procedure patterns, which are computed taking into account the weighted necessities for the client scenario. Four utilitarian bunches of procedure patterns, which demonstrated that the most noteworthy estimation of advantages must be decided to design the value stream, appeared in the following: request satisfaction, hierarchical, project control, procurement logistics. This case demonstrated how to design an integrated and customized value stream map for the construction industry.

Another study conducted by Mastroianni and Abdelhamid (2003) demonstrated the application of value stream mapping in project delivery. Owners of projects are expanding their desires about how a project is conveyed and its final result. A capital project at Walbrideg Aldinger was tested by the client (Ford Motor Company) to use lean manufacturing ideas for the construction. In the study, WA applied VSM to interior issues to test its viability for enhancing processes. The outcome was both time and cost savings.

### *3.2.3 Construction Support Process*

In this paper, construction support process focuses on the construction supply chain. Construction is a fragmented industry, with risks shared among owners, designers and contractors, suppliers, and vendors. This fragmentation results in higher coordination requirements in the autonomous supply chain during construction, when

compared with other industries. Identifying and eliminating hidden waste is the main objective for those intending to enhance system performance, because scholars have demonstrated that waste is ubiquitous in construction supply chains (Luhtala, Kilpinen, & Anttila, 1994; Vrijhoef and Koskela, 2000). The accompanying research demonstrates VSM utilization in the supply chain.

Womack and Jones (2002) extended VSM to Value Stream Macro Mapping (VSMM) to delineate an entire supply chain, involving several companies. Then Fontanini and Pichi (2004) introduced an exploratory case study of the utilization of VSMM on the aluminum supply chain, from crude materials to the job site installation of aluminum components. This tool was applied to distinguish waste among several actors in the aluminum components supply chain, such as designers, contractors, aluminum windows manufacturers and aluminum manufacturers.

Thais and Iris (2005) examined the utilization of VSM for make-to-order products in the fabrication of Heating Ventilating and Air Conditioning (HVAC) sheet metal ductwork. The authors explore, understand and depict job shops as dynamic systems. In this environment, takt times, batch, and buffer sizes must be constantly updated to reflect changes in the system. The VSM for a job shop must be adaptable to manage the dynamic functioning of job shops, e.g., maps may change day to day, as indicated by the products planned for manufacture. To manage successive changes on approaching requests from project sites, different parts of the production system for sheet metal ducts that ought to be caught in the maps incorporate the accessibility of a diverse workforce for shop and site work; single stream of product and worker; and improvement of

estimates and limited portions. However, the system investigated does not systematically keep track of the data needed to develop lean future state maps. Some critical reference markers like takt time, execution measurements, EPE, and batch sizes cannot be figured because of the absence of data about the system examined. The trouble in setting these numbers hampers the execution of lean concepts and tactics to streamline production flow in a job shop.

#### *3.2.4 Summary of the Application of VSM in Construction*

After analyzing current papers, the application of VSM in the construction industry could be grouped into three categories:

- (1) Construction process: VSM identified wastes in environmental and production performance; modified VSM identified waste during a stage of the construction process;
- (2) Macro-process: use an integrated and customized VSM to eliminate waste; use VSM as lean tool to reduce waste and add value in the project delivery to satisfy customers;
- (3) Construction Support Process: use VSM to re-engineer the production process; VSMM may improve the supply chain; application of VSM on job shop.

Although several papers address using VSM as a lean tool to reduce waste and add value during the construction process, no detailed and unified VSM instructions exist concerning how to implement it in construction. Unlike manufacturing, a construction project is unique, with no repetition of the production process, barely tracking construction processes, and highly variable. VSM has potential but cannot be used in

construction. As currently understood, VSM must be re-thought and re-designed if it is to be used as a lean tool in the construction industry.

### **3.3 Value Stream Mapping in Manufacturing Industry**

To meet aggressive prerequisites and diminish costs, manufacturing is swinging to lean manufacturing techniques to radically reduce cycle time and expand their focused edge. The positive effects of LM standards in manufacturing exercises came about because standards have connected over product development, supply chain management, and administration activities (Womack and Jones, 2002). Rother et al. (2003) presented findings that wherever a product is created for the customer, there ought to be a value stream. VSM is a vital device that helps managers comprehend the current operational conditions and perceive changing opportunities to enhance operational execution (Abdulmalek, Rajgopal, & Needy, 2006). In a VSM, a group strolls through the manufacturing system and records actualities, for example, cycle time, buffer sizes and personnel requirements. The realities are then transformed into a map that depicts the framework with institutionalized symbols. At the point when a present circumstance is recorded, a parallel map is created that instead depicts the perfect future state. This future state is utilized as a base for improving activities.

VSM can be grouped into two themes: production process and supply chain.

#### *3.3.1 Production Process*

Traditionally, Value Stream Mapping (VSM) is used for quick examinations of product flows through a manufacturing system, from crude material to the conveyance. However, because of the complex nature of manufacturing and expansion of business

activities day by day, newer value stream tools are emerging. Consequently, a large number of tools and techniques have been created to satisfy distinctive objectives and waste reduction. Many research studies have mentioned using simulations based on VSM as the methodology to improve a production system. Simulation has played an important role in industrial development in recent years. Simulation is a developing innovation, and a developing tool also in non-engineering areas, such as health care, finance, agriculture and ergonomics, but in the application described in this study, the focus is on production systems (Solding & Gullander, 2009).

The following research applies simulations on the VSM to the production system:

McDonald, Van Aken, and Rentes (2002) describe an application of VSM improved by simulation to a product line in an engineer-to-order motion control products manufacturing plant. This case study has demonstrated that simulation analysis can be a valuable and imperative part of VSM. In particular, as found in this case, when there is product complexity, parallel processing steps and distinct number of movements utilized over a generation line, a simulation can offer essential data to supplement that obtained from future state mapping. Besides, simulation encourages process visualization, creating a mutual consensus about the process and where changes can be made.

Rather than simply utilizing traditional Value Stream Mapping, Solding and Gullander (2009) use Discrete Event Simulation (DES) for investigations of complex manufacturing systems with several products; a complex plan is then presented. This paper introduced a concept for making dynamic value stream maps of a system using



simulation. Dynamic value stream maps make it conceivable to analyze more complex systems than with traditional VSMS, and the outcomes can still be visualized in a language the lean coordinators perceive. The value stream map shown in the spreadsheet can be modified any way the group needs. Some standard icons are predefined, taking into account traditional VSM icons. One or more products can be visualized at the same time and simulation runs and results compared immediately, helping decide the best solution.

Ramesh, Prasad and Srinivas (2008) conducted research to study waste in the production line and to suggest new design layout taking into account lean manufacturing techniques. This paper presents a case study of an existing cellular manufacturing system in an electronics assembly plant; the main improvement tool used was Value Stream Mapping (VSM). The major concern in this research was the lead time, which is most critical for meeting the customer's requirements for the product. From the simulation study, the VSM tool effectively accomplished its destinations in which to identify waste and presented a solution for the problems. It is important that the lead time was decreased by more than half from current practice. Meantime, the research demonstrated the utilization of simulation models with Maynard Operations Sequences Techniques (MOST) to recognize the loading and unloading time.

### *3.3.2 Supply Chain*

Supply chain management gets considerable attention when facing intense competition in the manufacturing industry. Dealing with the stream of materials from supply sources to the customer is a major challenge for today's project managers. Some

developing countries apply Value Stream Mapping as a methodology to improve the supply chain. Boonthonsatit and Jungthawan (2015) conducted research about lean supply chain management based on the VSM. According to the research, the automotive industry in Thailand has competed extremely well. To increase the competitiveness of the automotive industry along its supply chain, the author presented the idea of lean management as lean supply chain management (LSCM). One of the most useful LSCM methods is value stream mapping (VSM), which is used for mapping the current state of a value stream, and creating the future-state map of an automotive plant. In the case study, the application of VSM decreased production lead-time by 80%. It also decreased process duration by 21.3% and increased worth by 293.33%.

Another study conducted by Seth and Goel (2008) utilized VSM to identify different wastes in the supply chain of the consumable cottonseed oil industry (the processing side). In this study, open-ended questions were used to understand the processes involved in the value chain of the cottonseed oil industry. Additionally, different chains were explored through personal visits. VSM in this study was applied as an approach by the industry to identify and remove non-value-adding (NVA) activities. The author discovered that there is an excess cumulative inventory of 244 days in the entire supply chain. The industry is exceptionally divided with an expansive number of small players present, which impedes the utilization of economies of scale. There are NVA activities present in the supply chain, for example, in the moving of cottonseed oil from expeller mill to refinery.

Sparks and Badurdeen (2014) combine the Sustainable Value Stream Mapping and Simulation to assess supply chain performance in developing countries. The Sus-VSM methodology extends the VSM tool to capture sustainability. Sus-VSM keeps the economic metrics from traditional VSM and incorporates metrics that encompass environmental and societal aspects so that companies can utilize this tool to assess sustainability inside of a manufacturing line. This paper presents research to expand the utility of Sus-VSM to supply chain networks. Metrics are recognized to evaluate financial, ecological, and societal manageability for supply chain networks while keeping congruency with process level Sus-VSM when attainable. Visual symbols represent metrics in the supply chain Sus-VSM to allow users to distinguish areas where sustainability can progress. Discrete event simulation (DES) modeling is used for a case scenario to create future state maps, taking into account quicker evaluation and identification of improvement areas to achieve ideal sustainability performance.

### *3.3.3 Summary of Application of VSM in Manufacturing*

By analyzing the literature of VSM in manufacturing, I divided VSM implementation in manufacturing into two categories:

- (1) Production Process: simulation based on VSM for product complexity, parallel processing steps and different number of shifts used across a production line; DES based on VSM to analyze complex manufacturing systems; Maynard Operations Sequences Techniques (MOST) based on VSM to study waste in production line;
- (2) Supply Chain: use VSM to shorten lead time, reduce cycle time and increase value added; identify waste in inventory and process of delivery; use Sustainable Value

Stream Mapping and Simulation (DES) to evaluate supply chain performance.

With the increase of competition and the complexity of manufacturing, conventional Value Stream Mapping is not sufficient as a lean tool to identify waste and non-value activities. Therefore, simulations based on the VSM and Sus-VSM offer promising trends for using VSM in the manufacturing and they deserve more attention.

## CHAPTER IV

### DISCUSSION

#### 4.1 Summary of the Utilization of VSM in Construction and Manufacturing

Table 12 and 13 show the summary of VSM application in construction and manufacturing respectively.

**Table 12. Summary of the Application of VSM in Construction**

<b>Application of VAM in Construction</b>		
1	Construction Process	VSM identified wastes in the masonry stage; modified VSM enhanced the construction process; modified VSM reduced the waste of housing construction
2	Macro-Process	VSM created a cooperative project platform for coordinated construction; VSM improved the project delivery
3	Construction Support Process	VSM distinguished the wastes and improve the construction supply chain

**Table 13. Summary the Application of VSM in Manufacturing**

<b>Application of VSM in Manufacturing</b>		
1	Production Process	VSM with simulation to improve the product line in an engineer-to-order motion control products; Simulations combine with VSM to investigate the complex manufacturing systems with several products; VSM identified wastes in production line
2	Supply Chain	Lean supply chain management based on the VSM reduced production lead-time, production duration, and increased value; VSM identified different wastes in the supply chain; SVSM and simulation assessed the supply chain performance

## **4.2 Production Process**

VSM as a lean tool could be used to identify waste during the production process in the construction industry. However, compared with manufacturing, the nature of production is different. A construction project is unique, has no repetition and is not easy for collecting data. In order to use VSM during the construction process, some adaptations are necessary, in each stage, such as: change of concepts and product family, etc. When it comes to manufacturing, with the increase of competition and complexity of manufacturing, conventional VSM in the production process is turning to simulations based on VSM, in which the application of VSM is enhanced. Therefore, traditional VSM is no longer able to meet the requirements of the current construction and manufacturing industries. Modified VSM and simulation represent an important and growing trend for the future.

## **4.3 Supply Chain**

The application of VSM to the supply chain has been widely applied in manufacturing. It can identify waste, shorten lead time, reduce the cycle time, and add value. However, due to the dependence and variation of construction supply chains, only limited studies of the application of VSM to the construction supply chain are presented. Some research has applied new methods combine with VSM to improve the supply chain in construction.

#### **4.4 The Differences and Similarities of Utilization of VSM in Construction and Manufacturing**

According to the summaries of VSM utilization, and the above discussions that focus on the production process and supply chain, the differences and similarities of VSM application in construction and manufacturing industries are presented below:

In both construction and manufacturing, several current research studies have demonstrated that VSM as a lean tool could improve the production process and supply chain. Besides, new methods have enhanced the utilization of VSM in construction and manufacturing, for example, some studies demonstrated that modified VSM could improve the production process in construction and simulation combined with VSM could enhance the product line. Thus, the similarities of the application of VSM in construction and manufacturing industries are application fields and utilization of new methods.

The differences of the application of VSM in construction and manufacturing are shown below:

(1) The nature of the product is different:

Construction commonly refers to the formulation of physical frameworks such as buildings, roadways or bridges. Manufacturing generally refers to the production of finished products sold to traders, retailers or customers. Manufacturing involves automated processes that turn raw material into finished products. However, every construction project is unique and has different design, specifications and unique construction process.



(2) VSM is a quantitative tool:

Due to VSM being a quantitative tool, process data are collected to depict the current state map of the process. However, most construction companies do not fully track construction processes and data.

(3) Key concepts /elements are defined in manufacturing context:

Key concepts/ elements such as takt time, cycle time and inventory, are interpreted in manufacturing. In order to use these concepts in the construction context, researchers need to redesign and redefined them.

## CHAPTER V

### CONCLUSION

Based on the structured literature review of current research relevant to VSM in construction and manufacturing, VSM utilization in construction is grouped into three categories: construction process, macro process and construction support process. The applications of VSM in manufacturing are organized into two categories: production process and supply chain. The similarities and differences are summarized based on the analysis of VSM application on the production process and supply chain in construction and manufacturing industries. The similarities are presented in the applicant field and the utilization of new methods. The differences are shown in the following aspects: the nature of the product is different, VSM is a quantitative tool that uses data to depict the current state map, and key concepts/elements are defined in the manufacturing context.

This study used a Structured Literature Review to develop a better understanding of VSM and how it is currently employed in the construction and manufacturing industries to recommend what needs to be done in future research. From the literature, a better understanding is achieved of the obstacles that impede the application of VSM in construction.

Future research could focus on how to apply modified VSM and combine with other tactics of VSM to improve the application of VSM in the construction industry.

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## APPENDIX



**A-1. Literature Selection Table**

Item	Paper topic	Authors	Journal/citation of the publication	Applicable to research			Reason	Notes
				Year	YES	NO		
10	The effectiveness of value stream mapping (VSM) as an improvement tool for the manufacturing operation	Che Ani, M. N., Razali, M. A., & Rhaflor, K. A.	Applied Mechanics and Materials	2014		x	using vsm to reduce wastes in production line and to recommended new design layout	production line
11	Visualizing sustainability performance of manufacturing systems using sustainable value stream mapping (sus-VSM)	Faulkner, W., Templeton, W., Gullett, D., & Badurdeen, F.	International Conference on Industrial Engineering and Operations Management	2012	x		Sus-VSM and case study	manufacturing
12	Sustainable value stream mapping (sus-VSM): Methodology to visualize and assess manufacturing sustainability performance.	Faulkner, W., & Badurdeen, F.	Journal of Cleaner Production	2014	x		Sus-VSM and case study	manufacturing
13	Design of lean manufacturing systems using value stream mapping with simulation: A case study.	Gurumurthy, A., & Kodali, R.	Journal of Manufacturing Technology Management	2011	x		an applicatiomm of VSM with simulation, case study, a literatue review of VSM	manufacturing
14	Lean manufacturing implementation using value stream mapping as a tool	Jasti, N. V. K., & Sharma, A	International Journal of Lean Six Sigma	2014		x	the importance of VSM in LMenvironment in an Indian auto components industry	manufacturing
15	Value stream mapping in construction: A case study in a brazilian construction company	Pasqualini, F., & Zawislak, P. A.	13th International Group for Lean Construction Conference	2005	x		describes the modiffications and application of the VSM in a Brazilian construction company	construction
16	Evaluation of value stream mapping in manufacturing system redesign.	Serrano, I., Ochoa, C., & De Castro, R.	International Journal of Production Research	2008		x	evaluate the real applicability of VSM to redesign disconnected flow lines, six industrial companies	manufacturing

## A-1. Continued

17	Production improvement in an aircraft manufacturing company using value stream mapping approach	Wahab, M. S., Abd, M. S., Yahya, M. S., & Ahmat, M. M.	5th International Conference on Mechanical and Manufacturing Engineering, ICME2014	2014		x	develop a value stream mapping for a production in an aircraft manufacturing company. ARENA simulation software package was used to simulate a systematic approach based on value stream mapping technique is developed	manufacturing
18	Development of lean model for house construction using value stream mapping	Yu, H., Tweed, T., Al-Hussein, M., & Nasser, R.	Journal of Construction Engineering and Management	2009	x			construction
20	Concepts for simulation based value stream mapping	Solding, P., & Gullander, P	2009 Winter Simulation Conference, WSC	2009	x		why simulation, compare with the traditional VSM	VSM and simulation
21	Improving environmental and production performance in construction projects using value-stream mapping: Case study	Rosenbaum, S., Toledo, M., & Gonzalez, V	Journal of Construction Engineering and Management	2014	x		use VSM to improve the environmental and production performance in the constructive process	construction
22	Value stream analysis of a re-engineered construction supply chain	Arbulu, R. J., Tommelein, I. D., Walsh, K. D., & Hershauer, J. C.	Building Research and Information	2003	x		a good paper about using VSM on supply chain	construction
23	Adaptation of the value stream mapping approach to the design of lean engineer-to-order production systems: A case study.	Matt, D. T.	Journal of Manufacturing Technology Management	2014		x	present a set of guidelines based on the VSM to improve the ETO production system in an Italian steel construction company	construction
24	A Comparative Approach of Japanese Project Management in Construction, Manufacturing and IT Industries	Low Foon Siang, Chong Heap Yih	International Conference on Asia Pacific Business Innovation and Technology Management	2012	x		an example of how to do the comparative analysis	methodology
25	Value stream mapping: a distribution industry application	Hines, P., Rich, N., & Esain, A	Benchmarking: An International Journal	1999		x	VSM on a supplier network around distributor of electronic, electrical and mechanical components	suppliers
26	Learning to See: Value Stream Mapping to Add and Eliminate Muda	Rother, M., Shook, J.	The Lean Enterprise Institute	1999	x		a good book introduces VSM and its application	vsm

**A-1. Continued**

27	Building operations management theory through case and field research	Meredith, J.	Journal of Operations Management	1998						operation management
28	The Machine that Changed the World	Womack, J.P., Jones, D.T. and Roos, D.	Rawson Associates	1990			x		history of lean manufacturing, lean production's application	lean manufacturing
29	Value stream mapping for make-to-order products in a job shop environment	Alves, T. D. C. L., Tommelein, I. D., & Ballard, G	Construction Research Congress 2005: Broadening Perspectives - Proceedings of the Congress	2005	x				example of the utilization of VSM in a job shop	construction
30	Lean construction: from theory to practice	A. Conte, D. Gransberg	AACE International Transactions	2001		x				
31	Lean supply chain management-based value stream mapping in a case of thailand automotive industry	Boonthonsatit, K., & Jungthawan, S	2015 4th International Conference on Advanced Logistics and Transport (ICALT)	2015		x			vsm on the supply chain	manufacturing
32	Better thinking, better results: case study and analysis of an enterprise-wide lean transformation	Emiliani, Bob; Stec, David; Grasso, Lawrence; Stodder, James	Center for Lean Business Management	2007			x		How do you conduct a Lean transformation	lean
33	Sustainable value stream mapping (sus-VSM): Methodology to visualize and assess manufacturing sustainability performance	Faulkner, W., & Badurdeen, F	Methodology to visualize and assess manufacturing sustainability performance	2014		x			sus-vsm	manufacturing
34	Value stream macro mapping—a case study of aluminum windows for construction supply chain	Fontanini, P. S., & Picchi, F. A.	Twelfth Conference of the International Group for Lean Construction (IGLC 12)	2004		x			an example of using VSM in construction supply chain	construction
35	Learning from less successful Kaizen Events: A case study	Jennifer A. Farris, Eileen M. Van Aken, Toni. L. Dooleen, June Worley	Engineering Management Journal	2008			x		implementation of kaizen event	lean
36	The Toyota way: 14 Management principles from the world's greatest manufacturer	Liker, J. K.	McGraw-Hill Education	2004			x		introduction of lean	lean

### A-1. Continued

37	Value stream mapping: how to visualize work and align leadership for organizational transformation.	Martin, K., & Osterling, M.	McGraw-Hill Education	2013	x			introduction of vsm, tools, application	vsm
38	Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry.	Ramesh, V., Sreenivas Prasad, K.V, Srinivas, T.R.	Journal of Industrial and Systems Engineering	2008	x			vsm in a manufacturing industry, case study	manufacturing
39	Evaluation of value stream mapping in manufacturing system redesign	Serrano, I., Ochoa, C., & De Castro, R	International Journal of Production Research	2008	x			manufacturing system redesign by other methods and VSM ,multiple case studies	manufacturing
40	Application of value stream mapping (VSM) for minimization of wastes in the processing side of supply chain of cottonseed oil industry in indian context	Seth, D., Seth, N., & Goel, D	Journal of Manufacturing Technology Management	2008	x			vsm on supply chain	manufacturing
41	Combining sustainable value stream mapping and simulation to assess supply chain performance	Sparks, D., & Badurdeen, F	IIE Annual Conference and Expo	2014	x			a new method created based on the vsm,improvement of supply chain	manufacturing
42	Utilizing Simulation to Enhance Value Stream Mapping- A Manufacturing Case Application	Thomas McDonald, Eileen M. Van Aken & Antonio F. Rentes	International Journal of Logistic Research and Applications: A Leading Journal of Supply Chain Management	2002	x			present a case study that demonstrate the method of simulation enhance VSM	manufacturing
43	From lean production to lean enterprise	Womack, J.P. and Jones, D.T.	Harvard Business Review	1994			x	lean enterprise	lean

## A-2. Reference Matrix

№	Title	Bibliograph	key words researched	Aims	Research Methodolog	Summary of results	Usefull references
1	The seven value stream mapping tools	Hines, P., & Rich, N	value stream mapping	The motivation behind this paper is to develop a typology to take into consideration a compelling utilization of sub-sets of the complete suite of tool and utilization of this suite of tools is to help researchers or professionals to distinguish waste in individual value streams and, hence, locate a proper course for removal, or possibly decrease, of this waste.	grounded theory	describes a toolkit consisting of seven tools : 1. overproduction 2. waiting 3. transport 4.inappropriate processing 5. unnecessary inventory 6. unnecessary motion and 7. defects. The article discusses problems with existing tools for analyzing value streams. The main problem identified was that each of these tools was too limited in scope and did not integrate well with one another in order to provide a comprehensive view of the value stream. The seven tools presented in the article were specifically designed to eliminate this problem. The first tool, process activity mapping, aids in developing solutions to reduce waste. The second tool, supply chain response matrix, aids in identifying the activities constraining the process so that these activities can be targeted for improvement. The third tool, production variety funnel, is similar to VAI analysis and helps one understand how products are produced. The fourth tool, quality filter mapping, aids in identifying where quality problems occur. The fifth tool, demand amplification mapping, aids in analyzing the increase in demand "variability as one travels up the supply chain. The sixth tool, decision point analysis, aid in identifying "the point in the supply chain where actual demand pull gives way to forecast-driven push". The seventh tool, physical structure, aids in developing a high-level understanding of the supply chain.	Womack, J. and Jones, D., "From lean production to the lean enterprise". Harvard Business Review, March-April 1994, pp. 93-103.
2	Concrete slab value stream mapping of Brazilian residential buildings: a lean construction case study	Panicia Stella Pucharelli Fontanini, Caroline de Souza Milano, Aparecido Fujimoto, etc.	value stream mapping Construction	This paper presents the value stream mapping could improve the production and environmental performance	Case Study	This paper presented the application of VSM and the preliminary sustainable analyses too. The execution of research started with the diagnosis of lean and sustainable concepts selected, and an analysis initial of the value stream mapping applicability in the concrete slab processes. In the first step, three visits were carried out at the residential works, aiming to detect and to observe the waste inherent in construction processes. In a second step, the authors analyzed the company. In the third step, the search consisted in the implementation of semi-structured interviews with the engineer responsible for the work and other work employees. In the sequence, it was chosen a standardized process for value stream mapping of current state (concrete slab process). As a result, through the analysis of the mapping performed, it was possible to identify waste that could be prevented and then it was proposed a future state for the flow that resulted in a better performance of the process making it more lean and sustainable. This paper gave a case example of how VSM contributes to making decisions about the flow represented making it logical and simplified, the production process, addressing lean techniques and concept as a whole.	J.P. Womack: <i>the challenge of value stream management</i> . Lean Enterprise institute value stream management conference. Dearborn, 2000. M.Rother. <i>Crossroads: which way will you turn on the road to lean?</i> In: LIKER, J.K. (Editor) <i>Becoming lean: inside stories of U.S. Manufactures</i> . Portland, Oregon, USA: Productivity press,1997

## A-2. Continued

No	Title	Bibliograph	key words resear	Aims	Research Met	Summary of results	Useful references
3	Development of Lean Model for House Construction Using Value Stream Mapping	Hairao Yu, Terry Tweed, Mohamed AL-Hussein and Reza Nasseri	value stream mapping Construction	using VSM to improve the constructive process	Case Study	Lean construction has recently attracted considerable attention in the home building industry. Lengthy delivery time and significant waste in the construction process have caused many home builders	Alves, T.C.L., Tommelein, ID., and Ballard, G (2005). "Value stream mapping for make-to-order products in a job shop environment."
4	The challenge the impetus for change to lean project delivery	Remo Mastroianni and Tanq Abdelhamid	value stream mapping Construction	best practices to deliver projects better, cheaper, and faster	Case Study	The study demonstrated the application of value stream mapping in project delivery. The purpose of this paper is to discuss some of the tools and methods or "Best Practices" that are shaping the Lean Project delivery approach to reduce waste and add value in the delivery of capital projects at Walbridge Aldinger. WA was challenged by its customer Ford Motor Company to utilize lean manufacturing concepts for construction of capital facilities. In the study, Ford Motor Company helped WA understand that value stream mapping is a powerful tool. WA piloted this tool for several administrative external problems to test its effectiveness to improve processes. The result was time and cost savings.	Hines, P., and Rich, N. (1997). "The seven value stream mapping tools". International Journal of Operations & Production Management, 17(1), 46-64. Rother, M., and Shook, J. (1998). Learning to See: Value Stream Mapping to Create Value and Eliminate Muda. v.1.1. Oct., The Lean Enterprise Inst., Brookline, Mass.
5	The Effectiveness of Value Stream Mapping (VSM) as an Improvement Tool for the Manufacturing Operation	Mohd Norzaini Che Ani, Mohd Adb Razali, band Kanthar A Rhaifar	value stream mapping maanufacture	The objectives of this project are to study critical wastes in production line and to recommended new design layout based on Lean Manufacturing techniques.	Case Study	The objectives of this venture are to contemplate segregating misuses in progress line and to show new diagram outline in light of Lean Manufacturing systems. Incline speaks the reality execution more with minimized the time, stock, space, work, and money. The instrument of VSM used as a piece of this endeavor adequately refined its destinations to recognize waste and proposing the response for with respect to issues. The lead time was diminished altogether, the value included extent was extended without a doubt and the procedure length of time was upgraded by minimize the dealing with time. VSM was a baffling gadget that containers reveals of all the data, issue, strategy, operation and general stream of techniques to verify thing.	Chen, L., & Meng, B. "The Application of Value Stream Mapping Based Lean Production System", (2010)Silva, S.X.P.N." Applicability of Value Stream Mapping (VSM) in the Apparel Industry in Sri Lanka". International Journal of Lean Thinking Volume 3, Issue 1 (2012)
6							

## A-2. Continued

No	Title	Bibliograph	key words resear	Aims	Research Met	Summary of results	Useful references
6	Adaptation of the value stream optimization approach to collaborative company networks in the construction industry.	D.T. Mata, D. Krause, R. Raucha	value stream mapping Construction	a methodology to design an integrated and customized value stream map for construction industries requirements	Case Study	While in the car or aeronautic trade the utilization of computerization innovation and forms and the use of machine assembling strategies are regular these days, the development business is lagging behind these advancements. In this connection, with the assistance of worth stream outline, to a great extent known in large scale manufacturing yet as of late likewise in vantage escalated producing, the procedure streams inside of single organizations however particularly amongst the accomplices in such a communication system can be planned in an exceedingly client situated and proficient way. Along these lines, this paper depicts in detail a philosophy to plan an incorporated and tweaked worth stream map for development businesses necessities. The methodology was produced and checked in light of a community venture of connected examination with the "build4future"	Rother, M., Shook, J., 1999. Learning to See Value-stream mapping to create value and eliminate muda. Lean Enterprise Institute.
7	Design of lean manufacturing systems using value stream mapping with simulation: A case study.	Anand Gurusurthy;Rambabu Kodali	value stream mapping manufacture simulation	The motivation behind this paper is to introduce a use of VSM with reenactment amid the outline of incline assembling frameworks (LMS) utilizing a contextual analysis of an association taking after a vocation shop generation framework to fabricate entryways and windows.	Case Study	Simulation studies were completed for distinctive situations, for example, "beforeLM" (current state VSM) and "after LM" (future state VSM). It was found that the case association can accomplish critical change in execution and can take care of the expanding demand with no extra assets. Down to earth suggestions – It is trusted that this paper will empower professionals to welcome the part of reproduction in assisting them with seeing how the operations division of the case association will be changed amid the outline of LMS	Grewal, C. (2008). "An initiative to implement lean manufacturing using value stream mapping in a small company". International Journal of Manufacturing Technology and Management, Vol. 13 Nos 3/4, pp. 404-417. McDonald, T., Van Aken, E.M. and Rentas, A.F. (2002), "Utilising simulation to enhance value stream mapping: a manufacturing case application". International Journal of Logistics Research and Applications, Vol. 5 No. 2, pp. 213-32. Mittelhuber, B., Löffler, B. and Langsdorff, P.V. (2002), "Simulation-based value stream mapping". Industrie-Management, Vol. 18 No. 1, pp. 44-7. Serrano, I., Ochoa, C. and De Castro, F. (2008), "Evaluation of value stream mapping in manufacturing system redesign". International Journal of Production Research, Vol. 46 No. 16, pp. 4409-30.



## A-2. Continued

No	Title	Bibliograph	key words resear	Aims	Research Met	Summary of results	Useful references
8	Value stream mapping in construction: A case study in a Brazilian construction company	Fernanda Pasqualini and Paulo Antônio Zawiślak	value stream mapping Construction	introduce the ideas of Lean Production in construction in a more systematic way	Case Study	this article portrays the alterations and use of the VSM in a Brazilian development organization. Alterations of VSM were fundamental because of the contrast in the middle of production and development. Through its application it was conceivable to distinguish issues and to think of some as activities for change, transforming it into a more liquid creation, with less stops and expanding the arranged stream versus the expert one.	Alarcon, L. F. and Seguel, L. (2002). "Developing incentive strategies for implementation of Lean Construction." Proceedings of IGLC-10, Gramado.
9	Concepts for simulation based value stream mapping	Peter Solding Per Gullander	value stream mapping manufacture	presents a concept for creating dynamic value stream maps of a system using simulation. Creating dynamic value stream maps makes it possible to analyze more complex systems	Case Study	Generally Value Stream Mapping (VSM) is utilized for speedy examinations of item courses through an assembling framework, from crude material to conveyance. Discrete Event Simulation (DES) is regularly utilized for examinations of complex assembling frameworks with a few items and a piecemeal arranging. These two routines have likenesses additionally contrasts. This paper shows an idea for making element quality stream maps of a framework utilizing reproduction. Making element worth stream maps makes it conceivable to investigate more perplexing frameworks than customary VSMs have the capacity to and still envision the outcomes in a dialect the Lean organizers perceive. The worth stream guide is introduced in a spread sheet that can be changed in the way the group needs. Some standard symbols are predefined, tabing into account customary VSM symbols. One or more items can be imagined in the meantime and reproduction runs and results thought about instantly, helping picking the best arrangement.	
10	Improving environmental and production performance in construction projects using value-stream mapping: Case study	Sergio Rosenbaum; Mauricio Toledo; and Vicente González	value stream mapping Construction	demonstrate the implementation of VSM in construction	Case Study	This paper reports a contextual analysis of the VSM application as a green-incline approach in the development of a doctor's facility to enhance its natural and creation execution amid the auxiliary solid work stage. The principle commitment of this study is to give a completely point by point experience of the VSM application in development, affirming its capacity to identify the wellsprings of natural and creation waste, evaluate them, and recommend decrease systems. It additionally exhibits the improvement of a settled usage procedure of the VSM. The contextual investigation strengthens the adequacy of the proposed green-incline approach for enhancing the feasible execution of development activities in light of the fact that it can help to enhance the utilization of assets and lessen expenses, move forward quality benchmarks, and minimize the ecological effects produced by the development of ventures	Alves, T. C. L., Tommelen, I. D., and Ballard, G. (2005). "Value stream mapping for make-to-order products in a job shop environment." Proc. of the 2005 Construction Research Congress, ASCE, Reston, VA, Arbulu, R. J., and Tommelen, I. D. (2002). Mastroianni, R., and Abdelhamid, T. (2003). "The challenge: The impetus for change to lean project delivery." Proc. of the 11th Annual Conf. of the Int. Group for Lean Construction, 610-621. Pasqualini, F., and Zawiślak, P. A. (2005). "Value stream mapping in construction: A case study in a Brazilian construction company." Proc. of 13th Annual Conf. of Int. Group



## A-2. Continued

No	Title	Bibliograph	Key words/research	Aims	Research Method	Summary of results	Useful references
11	Value stream analysis of a re-engineered construction supply chain	Roberto Arbulu, Iris Tommelein, Kenneth Walsh & James Herschauer	value stream mapping construction supply chain	introduce value stream mapping (VSM) as a methodology for modelling and analysing supply chains.	Case Study	A contextual investigation is displayed that reports the most widely recognized arrangement of the production network for channel backings utilized as a part of force plants in the USA. Recognizing and seeing such inefficiencies, their reasons and potential cures gives a premise to process re-engineering. To model the systems that drive these progressions, information are exhibited from industry releases as quality stream maps that compass authoritative trains and organization limits. Measurements normally utilized as a part of incline development are acquainted with gage framework execution. A present state guide reports how function streams all through the outline, procurement and manufacture periods of channel backings. Investigation of this present state guide highlights worth included and non-stream included times and lead times. A future state outline represents process upgrades that can be acquired by applying different inventory network administration strategies. The strategy connected for this situation study could be connected to other development supply chains similarly well. <sup>10</sup>	Arbulu, R.J. (2002) Improving Construction Supply Chain Performance: Case Study on Pipe Supports Used in Power Plants. Master of Engineering thesis, University of California, Berkeley, CA. Arbulu, R.J. and Tommelein, I.D. (2002a) Value stream analysis of construction supply chains: case study on pipe support used in power plants, in Proceedings of the Tenth Annual Conference on the International Group for Lean Construction (IGLC-10), Gramado, Brazil, pp. 183-195.
12	Value stream mapping for make-to-order products in a job shop environment	Thais da C. L. Alves, Iris D. Tommelein, and Glenn Ballard	value stream mapping Construction, job shop	investigates the use of Value Stream Mapping (VSM) for make-to-order products in a job shop environment	Case Study	paper examines the utilization of Value Stream Mapping (VSM) for make-to-request items in the manufacture of Heating Ventilating and Air Conditioning (HVAC) sheet metal ventilation work. The utilization of VSM for breaking down the generation of tedious units has ended up being effective in distinctive commercial ventures. The utilization of VSM for concentrating on the generation of non-monotonous units requires some adjustment from full unit utilizes as a part of request to effectively catch the characteristics of numerous item families required at distinctive frequencies and volumes. The VSM for an occupation shop environment must be adaptable to manage the dynamic way of employment shops, e.g., maps may change day by day as indicated by the items planned for manufacture. Different parts of the generation framework for sheet metal pipes that ought to be caught in the maps incorporate the accessibility of a multi-gifted workforce for shop and site work, single stream of item and specialist, and advancement of estimates and limit allotment to manage continuous changes on approaching requests from undertaking locals.	Arbulu, R.J. and Tommelein, I.D. (2002) "Value Stream Analysis of Construction Supply Chains: Case Study on Pipe Supports Used in Power Plants." Proc. Tenth Conference of the International Group for Lean Construction (IGLC 10), 6-8 August, held in Gramado, Brazil
13	Lean supply chain management-based value stream mapping in a case of thailand automotive industry	Kanda Boonthonsatti, Sripong Jitngthawan	Automotive industry; Lean supply chain management; Value stream mapping	application of VSM on the supply chain	Case Study	The car business in Thailand have contended seriously. Its late intensity is demonstrated by qualities offered to clients. One of them is adaptability as measured with lead time. To raise the aggressiveness of car industry along its store network, the idea of incline administration is joined as incline inventory network administration (LSCM). A standout amongst the most potential LSCM strategies is quality stream mapping (VSM). It is used for mapping the present condition of a worth stream, and creating the future-state guide of a car plant. As a contextual analysis, the use of VSM is equipped for shortening creation lead time by 80%. It prompts diminishment altogether process duration by 21.3% and increment in quality included by 293.33%. What's more, the shorter lead time adds to lower expense, higher benefit, and more intensity as a definitive objective of this paper.	

## A-2. Continued

No	Title	Bibliograph	key words resear	Aims	Research Met	Summary of results	Useful references
14	Value stream macro mapping-a case study of aluminum windows for construction supply chain	patricia S.P. Fontanini; Flavio A. Pécchi	supply chain, macro mapping, value stream mapping, lean thinking, aluminum supply chain	demonstrate the application of VSM on the construction supply chain	Case Study	introduced an exploratory case study of the utilization of VSM on the aluminum supply chain, from crude materials to the job site installation of aluminum components. This tool is applied to distinguish waste among several actors of the aluminum components supply chain, such as designers, contractors, aluminum windows manufactures and the aluminum manufactures.	
15	Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry.	V. Ramesh, K.V. Sreenivasa Prasad, T.R. Srinivas	Current state value stream mapping (CVSM), Future state value stream mapping (FVSM), Value added time"	VSM on the manufacturing industry	Case Study	VSM procedure includes flowcharting the strides, exercises, material streams, correspondences, and different procedure components that are included with a procedure or change. In this appreciation, Value stream mapping helps an association to distinguish the non-esteem including components in a focused on procedure and brings an item or a gathering of items that utilization the same assets through the fundamental streams, from crude material to the arms of clients. In this study, a pragmatic study did in an assembling industry for the production of Machining focus is talked about. The primary point was to draw the present state worth stream mapping for the principle segments like Base, Column, Cross Slide, Milling Head and Table. Further, the paper has recognized a forms' percentage which can be done by the sub temporary worker and proposed measures to be taken up by the more elevated amount administration in diminishing the non esteem included procedure. It talks about the dismissal in the set up time and process duration that can be gotten through the execution. This paper likewise talks about the arrangement of activity for enhancing the Future State Value Stream Mapping (FVSM). A FVSM for the production of Base is drawn."	Hines P., Rich N. (1997). The seven value stream mapping tools; International Journal of Operations & Production Management 17(2); 46. 64McDonald T., Van Aken E.M., Rentes A.F. (2002), Utilizing simulation to enhance value stream mapping. A Manufacturing case application; International Journal Of Logistics: Research and Applications 5(2); 213-232.
16	Evaluation of value stream mapping in manufacturing system redesign	Ibon Serrano; Carlos Ochoa; Rodolfo De Castro	Value Stream Mapping, Lean production; Manufacturing system redesign, Case study	the fundamental motivation behind the present examination comprises in investigating and deciding the VSM procedure's genuine relevance for separated stream line situations	Case Study	The VSM system, created inside of the incline generation world-view, was displayed as an inventive realistic method to offer assistance specialists update creation frameworks. This paper exhibits the consequences of a venture whose primary reason for existing is to assess the genuine materialness of VSM to update detached stream lines taking into account fabricating situations with a differences of logistical issues. The exploration was produced utilizing various case study technique in six mechanical organizations. The encounters have served to highlight the accompanying results: (1) the legitimacy of VSM as an overhead apparatus is affirmed; (2) assets required for the application procedure are built up; and (3) the contrasts between hypothetical ideas proposed by VSM and their realworld down to earth applications are demonstrated and broke down. These outcomes have prompted conclusions identifying with: (1) correspondence answers for professionals to acquire most extreme productivity when utilizing VSM; and (2) meanings of hypothetical advancement indicates for VSM turn into a reference among overhead procedures.	Downs, E., Clare, P. and Cole, I., Structured Systems Analysis and Design Method. Application and Content, 1988 (Prentice Hall: London). Hines, P. and Rich, N. The seven value stream mapping tools. Int. J. Oper. Prod. Manag., 1997, 17, 146-164.

## A-2. Continued

No	Title	Bibliograph	key words research	Aims	Research Met	Summary of results	Useful references
17	Application of value stream mapping (VSM) for minimization of wastes in the processing side of supply chain of cottonseed oil industry in indian context	Dhesh Sethi, Nitin Sethi, Deepak Goel	Edible oils, Waste minimization, Supply chain management, Value chain, India	The motivation behind this paper is to recognize and address different squanders in the inventory network of the consumable cottonseed oil industry (particularly the preparing side) utilizing a quality stream mapping (VSM) way to deal with enhance profitability and limit use in an Indian connection.	Case Study	The paper addresses the different squanders in the handling side of the production network of the Indian cottonseed oil industry, utilizing VSM as a methodology which was barely ever endeavored some time recently. Squanders are then exclusively assaulted to lessen or dispose of them from the framework. Recommendations to make the entire chain more fruitful can be summed up and can be recreated in the connection of other creating nations.	Hines, P. and Rich, N. (1996), "The seven value stream mapping tools", Proceedings of the 1996 NAFM Annual Academic Conference, Portland State University, Portland, USA, pp. 69-86, March 21-23.
18	Combining sustainable value stream mapping and simulation to assess supply chain performance	Daniel Thomas Sparks	Sustainable Manufacturing, Supply Chain Assessment, Value Stream Mapping, Sus-VSM, SC Sus-VSM	presents exploration to grow the utility of Sus-VSM to supply chain systems, build up a general methodology towards enhancing production network supportability, and look at the formal of executing reenactment and a configuration of tests (DOE) style investigation	Case Study	Sus-VSM expands upon customary VSM to catch extra supportability parts of the item stream, for example, ecological and societal viewpoints. This work presents examination to grow the utility of Sus-VSM to supply chain systems, add to a general methodology towards enhancing inventory network supportability, and look at the banquet of executing reenactment and an outline of tests (DOE) style investigation. Measurements are recognized to survey monetary, ecological, and societal maintainability for inventory network systems and visual images are created for the Supply Chain Sus-VSM (SC Sus-VSM) to permit clients to effectively recognize areas where supportability can be made strides. A discrete occasion recreation (DES) model is produced to reproduce the production network, permitting simpler formation of future state maps, which are utilized to distinguish areas for maintainability change. A scoring procedure and DOE-style examination are produced to gather more data from the store network. Results from the contextual investigation demonstrate that the SC Sus-VSM meets the objectives sought, and that the DES model guides the map's objectives. It is likewise shown that intercessions in the inventory network ought to first concentrate on monetary upgrades, and then take after by societal and after that natural changes to accomplish the best production network supportability.	Seth, D., Seth, N., Goel, D., (2007), "Application of value stream mapping (VSM) for minimization of wastes in the processing side of supply chain of cottonseed oil industry in Indian context", Journal of Manufacturing Technology Management, Vol. 19 Iss: 4, pp.526-550. Rother, M., Shook, J., (1999), "Learning to See: value stream mapping to add and eliminate muda." The Lean Enterprise Institute, Massachusetts
19	Utilizing Simulation to Enhance Value Stream Mapping: A Manufacturing Case Application	Thomas McDonald, Eileen M. Van Aken & Antonio F. Rentes	value stream mapping, manufacture, simulation	an absence of utilizations of VSM to generation procedures having parallel procedure steps (versus less intricate procedures with just serial steps) and investigate how other demonstrating apparatuses, for example, recreation, could be utilized as a part of a few cases to increase VSM.	Case Study	VSM is endorsed as an incline's feature creation arrangement of devices and has been connected in an assortment of commercial ventures. This paper portrays an utilization of worth stream mapping, upgraded by reenactment, to a committed product offering in a specialist-to-request movement control items assembling plant. This paper makes two essential commitments: a use of quality stream mapping in a real setting and the utilization of recreation to answer addresses that couldn't be tended to just utilizing the static perspective gave by worth stream mapping. This paper portrays both the present state and the future state for the product offering, and in addition the examination and results acquired from reenactment. We finish up with a discourse of future exploration and applications around these.	ROTHER, M. & SHOOK, J. (1999) Learning to See: Value Stream Mapping to Add Value and Eliminate Muda, 1.2 edn (Brookline, MA, The Lean Enterprise Institute)