

HOW DO YOU UNDERSTAND LEAN?

Maila E. Herrala¹, Aki Pekuri² and Aki Aapaoja³

ABSTRACT

The critical starting point for lean thinking is value. All process improvement actions should focus on eliminating steps in the value stream that do not create value and make the value-creating steps flow smoothly toward the customer. This research reviews how Californian construction industry professionals understand lean and how these views correlate with the basic principles of lean. Research results are based on semi-structured interviews conducted in the San Francisco Bay Area (California, U.S.), where lean management practices have been applied in dozens of large and small construction projects. According to the interview data, there are three prevailing understandings of lean—eliminating waste, improving efficiency and implementing tools. This shows a limited understanding of lean as a value creation process that may hinder system-wide performance improvements and jeopardize the sustainability of lean transformation. By focusing more on providing customer value, companies could differentiate themselves, gain competitive advantage and increase profits.

KEYWORDS

benefit realization, culture, implementation, lean construction, mind-set, transformation, value

INTRODUCTION

Lean, originally developed on the shop floors of Japanese car manufacturers, is still sometimes understood as a synonym for Toyota Production System (TPS). TPS included innovations such as the just-in-time (JIT) production system, the kanban method of pull production, automated mistake proofing, respect for employees and high levels of employee problem-solving that were used for eliminating waste from the tactical product flows at Toyota.

Soon, encouraged by Toyota's success, numerous companies emulated the structural parts of lean but found it difficult to introduce the organizational culture and mindset (Hines et al. 2004). Consequently, many early efforts fell short of the intended impact on the overall system's performance (Holweg and Pil 2001), which was mostly a consequence of the tool-focused implementation neglecting the human aspect (Hines et al. 2004). After 1990, focus gradually widened away from the shop floor to an approach that contingently sought to enhance value to both internal and external customers. The key development linked value to customer requirements and was no longer defined through its opposite, waste, on the shop floor (Hines et al. 2004).

¹ Post-doctoral research fellow, Maila.Herrala@oulu.fi

² Ph.D. student, Aki.Pekuri@oulu.fi

³ Ph.D. student, Aki.Aapaoja@oulu.fi

All authors are from the Department of Industrial Engineering and Management, PO Box 4610, 90014 University of Oulu, Finland.

Koskela (1992) was the first to discuss applying lean to construction and referred to this method as “the new production philosophy.” He argued that, in the construction industry, transforming inputs into outputs is overemphasized, which leads to sub-optimization and poor overall outcome. The resultant managerial methods are counterproductive and neglect or violate the principles of value and flow (Koskela 2000). However, even today, the emphasis in the construction industry seems to be on implementing different tools and techniques for eliminating waste and improving efficiency. Even in academia, there has been remarkably little discussion of lean principles and the philosophical perspective of lean. This research reviews how Californian construction industry professionals understand lean and how these views correlate with the basic principles of lean.

The first section of this research presents a literature study on how lean is generally understood in the manufacturing and construction industries. The main source of empirical data was semi-structured interviews conducted in the San Francisco Bay Area (California, U.S.), where lean construction practices have been applied in dozens of large and small construction projects. Participants took part in a single one-on-one interview during the fall of 2011. In total, 35 construction professionals from 11 companies were interviewed. All interviews were taped and transcribed for easier analysis. The interview included a range of questions related to lean implementation from which this research paper summarizes answers to the questions, “How do you understand lean? What does it mean?” The answers are then compared to the basic principles of lean.

LEAN DEFINITIONS

Lean is multi-faceted, which is why it is difficult for many to unambiguously define what it means (Pettersen 2009). Lean from a practical or operational perspective involves implementing a set of shop-floor tools and techniques aimed at reducing waste within the production process (Liker 2004, Shah and Ward 2003, Shah and Ward 2007, Scherrer-Rathje et al. 2009). Such tools and techniques in manufacturing include, for example, just-in-time, kanban, 5S and kaizen. For many, this practical perspective has become dominant not least because the idea of eliminating waste by using tools is easy to grasp but also because of its applicability and relatively easy implementation. People tend to say they are implementing lean although they are actually implementing only one or two of the tools or techniques (Chase 1999). This perspective, however, is oversimplified and neglects the focus on the final customer.

Lean from a *philosophical or strategic perspective* considers value creation, and concentrates on understanding customer value (Hines et al. 2004). As early as 1960, Levitt (p. 10) stated “*a truly marketing-minded firm tries to create value-satisfying good and services that consumers want to buy.*” Thus, lean is not just a set of tools, but a way of thinking in which tools are not the end but the means for providing customer value. When lean is seen as a philosophy, it becomes a way of thinking that governs how one looks at the business or processes (Bhasin and Burcher 2005). Womack and Jones (1996) crystallized value as the first principle of lean thinking. They argued that all process improvement actions should be focused on eliminating steps in the value stream that do not create value and make the value-creating steps flow smoothly toward the customer.

FIVE PRINCIPLES OF LEAN

According to Womack and Jones (1996) and Liker (2004), lean thinking focuses on identifying customer value and delivering it by making the product flow through value-adding processes without interruption hence bringing waste to the surface and giving the opportunity to eliminate it. Womack and Jones (1996) capture this thinking in the following principles:

- *Specify value* – specify what creates value from the customer’s perspective.
- *Identify the value stream* – identify all the steps along the process chain.
- *Flow* – make the value process flow.
- *Pull* – make only what is needed by the customer.
- *Perfection* – strive for perfection by continually attempting to produce exactly what the customer needs.

Specify value

According to Womack and Jones (1996), the critical starting point for lean thinking is value. They argue that lean thinking must start with a conscious attempt to precisely define value through a dialogue with a specific customer, since only they can define what is valuable to them. Womack and Jones (1996) also suggest that existing assets and technologies should be ignored and the whole process rethought to include only what is needed to specify and create value to the customer. Providing the wrong good or service, although you might do it the right way or efficiently, is wasteful.

Identify the value stream

The value stream is a series of actions produced by an organization to create value for the customer. Analyzing the value stream aims to identify value-adding activities that are necessary for producing and delivering a product or service to the customer. (Womack and Jones 1996, Rother and Shook 1999). It also helps identify non-value-adding activities, i.e., waste, that prevents the flow of value through the process (Rother and Shook 1999). Womack (2006) argues that discussing the current problems with the customer, in addition within the organization, is also critical to address the real issues when mapping the process.

Flow

In an ideal value stream, the product or services never stops moving from start to finish (Womack 2006). The objective is to make parts move from one value-adding step directly to the next value-adding step, and then to the customer without waiting, downtime or waste within or between the steps (Womack and Jones 1996, Rother 2010). This continuous, or one-by-one, flow has been a central concern of the Toyota Production System where a long-term vision is to have a one-piece flow, in sequence and on demand (Rother 2010).

Pull

According to Womack and Jones (1996), pull in the simplest terms means that nothing should be produced upstream until the downstream customer asks for it. In an ideal one-by-one flow, the product flows continually to the customer only after the

signal from the requesting customer (Womack 2006). The objective is thus to produce only what the customer wants just when the customer wants it, thereby requiring the system to be able to accommodate shifting demand immediately (Womack and Jones 1996, Rother 2010).

Perfection

As you implement the first four principles, you should start to understand the system better and consequently be able to generate more ideas for improvement. The drive for perfection becomes very strong when you are able to make the value flow faster and expose more hidden waste that needs to be removed. It dawns on those involved that there is no end to the continuous process improvements (i.e., reducing effort, time, space, cost and mistakes) while offering value that is increasingly closer to the customer's real needs (Womack and Jones 1996).

LEAN CONSTRUCTION

Lean construction, like lean in general, is a somewhat vague concept and is understood slightly differently by everyone you ask. Green and May (2005: 503) even argue that the meaning of lean construction "is continuously renegotiated within localized contexts." The Lean Construction Institute (LCI) defines lean construction as "a production management-based approach to project delivery -- a new way to design and build capital facilities. ... Lean Construction extends from the objectives of a lean production system - maximize value and minimize waste - to specific techniques and applies them in a new project delivery process."⁴

Lean construction seems to combine a set of tools and techniques such as the Last Planner System[®] (e.g., Ballard 2000, Al Sehami et al. 2007), target value design (e.g., Ballard 2011), relational contracting (e.g., Matthews and Howell 2005, Toolanen and Olofsson 2006, Lichtig 2007), value-stream mapping (Arbulu et al. 2003, Lima et al. 2010), choosing by advantages, BIM, increased visualization and 5S to achieve higher performance outcomes in construction projects (Salem et al. 2004). These tools have been developed or borrowed to replace old tools such as the work breakdown structure and the critical path method that have failed to deliver quality projects on time and on budget (Abdelhamid 2004).

Koskela et al. (2002: 211) defines lean construction as a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value." Mossman (2009) also takes a stand on the importance of value by stating that focusing on customer value is the only way to reduce waste and create wealth. He argues that setting out to eliminate waste in isolation from the value purpose of the project or organization is potentially wasteful and distracts from the main purpose.

Consequently, researchers have started to develop frameworks, tools and practices for managing value in the construction industry. For example, Emmitt et al. (2004) argue that value is the end goal and present a value-based design management framework that takes a more holistic and integrated approach based on the agreement of value parameters at the project outset. In addition, Björnfort and Stehn (2007) state that customer value is clearly the primary concern and propose applying product offer as a lean construction strategy for managing value. They argue that the "fundamental

⁴ <http://www.leanconstruction.org/whatis.htm>

aim of Lean Construction is to aid in the delivery of external value by managing the internal value generation process” (Björnfort and Stehn 2007: 35).

Despite Koskela’s (1992, 2000) seminal work and a few other initiatives, the discussion in the construction industry still seems to focus more on the different tools and techniques used to reach goals such as stabilizing work flow, reducing flow variation and improving downstream performance (see e.g. Howell and Ballard 1994a,b,c) than on customer value. Common practices and tools for reaching these goals are waste minimization, responsiveness to change, reducing variability and irregularity, just-in-time, effective relationships within the value stream, continuous improvement and quality (see e.g. Howell 1999, Murman et al. 2002, Salem et al. 2004). This indicates that the construction industry seems to fall into the same trap as so many other industries by focusing too much on applying isolated tools and techniques (Santos 1999). This kind of application, neglecting the philosophical and system perspectives, is a major reason for poor implementation of lean concepts, at least in manufacturing (Rother 1997, Shook 1997).

RESEARCH RESULTS

The interviews revealed that there are three somewhat intertwined understandings of lean—eliminating waste, improving efficiency and implementing tools. More than half of the respondents mentioned one, two or all of the three aforementioned definitions of lean. These three general viewpoints are easily detected in three informants’ comments:

*“Lean is driving out the waste in the project.” - Project Superintendent,
Subcontractor*

*“Lean to me is getting and implementing tools to help you do your job better.” -
Project Manager, General Contractor-*

*“[Lean to me] is to be efficient, and to maximize a resource.” -Project Manager,
Subcontractor-*

Many informants did not see lean only as eliminating waste or improving efficiency or using certain tools. They were often linked together in a way that one explains, or leads, to another. Some mentioned that lean is about using certain tools to eliminate waste. Others explained that lean is about eliminating waste to become more efficient. One informant linked all three by stating that lean is about using tools to eliminate waste to drive efficiency into the project. These viewpoints are seen in the following citations.

*“I know it's a bunch of principles. I know that the basic one is to eliminate waste,
and there's many things, many tools available to eliminate waste: Last Planner, Pull
Scheduling, use of BIM ...” -Technical Architect-*

*“It’s basically a way to do something better than what we’ve been doing it for less
time and less money. So it’s ways to eliminate a lot of waste and be productive.” –Sr.
Project Manager, Subcontractor-*

*“In simplest state, it means using tools that are developed to, you know, drive
efficiency into the project. You know, less waste... I mean, most fundamentally, all*

those tools really drive efficiency, eliminate waste as much as possible” -Project Engineer, General Contractor-

Approximately one fifth of the responses linked lean to continuous improvement. As one informant argued, lean is not about using tools but to get employees to relentlessly pursue waste elimination and make them believe that they have to improve themselves. A few informants also linked lean to improving processes and see it as a way of doing things smarter and better.

“Improvement, in one word. ... Constant strive for a better success.” -Project Engineer, Subcontractor-

“I think it's more about understanding ways of developing better process to get a better end for everyone.” -Architect-

The answers support the current perception that lean is often seen as a set of tools that improve ways of working. This tendency to implement lean “tools-first” has already been recognized in other industries, and it seems that the construction industry is not an exception. A few people did not see lean as anything new; for example, they felt their organization was already “doing” lean because without continuous improvement the company would not even survive. An informant criticizes as follows:

“It was like somebody had packaged something that was already there and decided to call it something else ... it's been difficult for me to accept that this is really anything new. That I necessarily need to change.” -Preconstruction Manager, General Contractor-

Of all the respondents, only five mentioned that lean is something that creates added value for the client. That lean is about delivering customer value by optimizing what the customer is going to get. This lack of understanding shows the difficulty of seeing lean as a value creation process that provides increased customer value.

“It's about delivering customer value and treating everybody like a customer.” - Project Manager, Owner-

“It's optimizing what the owner is going to get at the end of day.” -Sr. Project Manager, General Contractor-

DISCUSSION

According to the interview data, there are three prevailing understandings of lean among construction industry professionals—eliminating waste, improving efficiency and implementing tools. However, we argue that lean is not just eliminating waste. If you do not know what is valuable to the customer, it is difficult to identify waste (as Womack and Jones (1996) argue, waste is ultimately defined by the customer). Nor is lean just using different tools. If you do not know why exactly you are using tools, it is difficult to use the right ones in the right way. Lean is not just being efficient, either. You can be as efficient as you want, but if you do not provide customer value, you are wasting your resources.

According to this research, the academics and the industry professionals seem to focus mainly on the operational perspective of lean. This shows the relative ease of implementing lean as a set of tools that improve the ways of working and the difficulty of seeing it as a value creation process. This, however, exhibits a limited

understanding of the philosophical perspective of lean that concentrates on understanding customers' needs and creating value by responding exactly to that need (Hines et al. 2004). Unfortunately, this was understood by only five interviewees, of whom four used the exact word "value" when describing lean.

Even though the idea of identifying and creating customer value might not have taken root within the project practitioners, it does not mean that the project is not creating value. However, the projects' approach to move "tools-first" undermines the philosophical perspective of lean. If you do not understand the underlying philosophy of lean, you might not see lean as anything new, you might not understand why you have to do things differently and you might use the tools incorrectly or modify them unfavorably to the overall project.

The findings are somewhat in line with Green and May's (2005) research in which UK policymakers associate lean construction with 1) waste elimination, 2) partnering and 3) structuring the context. Their research supports the view that lean construction is a multifaceted concept that defies universal definition. As Shah and Ward (2007) argue, lean is not a singular concept referring only to waste elimination or some specific tools but is a multifaceted concept that includes a strategic value creation dimension. Consequently, the authors agree with Womack and Jones (1996) and Liker (2004) in that lean should be understood as a mindset that focuses on identifying and delivering customer value through streamlined value-adding processes. It is crucial to understanding lean as a whole since customer-centered strategic thinking applies everywhere while the shop-floor tools do not (Hines et al. 2004). Convis (2001) proposes that lean is actually an interlocking set of three underlying elements: the philosophical underpinnings, the managerial culture and the technical tools. If you are able to apply the right combination of long-term philosophy, processes, people and problem solving, you are likely to convert your organization into a lean, learning organization that provides customer value (Liker 2004).

Neglecting the focus on customer value and not understanding lean as a value creation process may hinder system-wide performance improvements and jeopardize the sustainability of lean transformation (see e.g. Holweg and Pil 2001, Hines et al. 2004). If companies ignore the fact that they should create customer value, they might end up creating something that the customer is not willing to buy or pay for. It is not valuable to provide wrong things efficiently, which is why companies should concentrate on doing the right things in an extraordinary manner instead (Elliott 2001). As Bozdogan (2010) argues, the primary emphasis on efficiency [doing things right] should give way to effectiveness [doing the right things] in contemporary lean enterprise systems. In the construction industry, cost cutting is often seen as the only way to increase profits and increase efficiency, but there are limits how far down this road you can go. Consequently, companies could concentrate more on providing extraordinary customer value, and thereby differentiate themselves, gain competitive advantage and increase profit.

CONCLUSIONS

The critical starting point for lean thinking is value. All process improvement actions should focus on eliminating steps in the value stream that do not create value and make the value-creating steps flow smoothly toward the customer. This research

reviews how Californian construction industry professionals understand lean and how these views correlate with the basic principles of lean.

According to the research results, the general understanding of lean in the Californian construction industry seems to be that lean is about using different tools and techniques to eliminate waste and thereby improve the efficiency of the process. The interviewees, most of them deeply involved in the daily operations of their project, did not seem to internalize the basic philosophy of lean, but understand it as a set of tools to reach the desired outcome—to finish the project and make a profit. Using tools, eliminating waste and pursuing efficiency are more “means” than “ends” to reach the desired outcome—increased customer value. Lean should be understood as a mindset that guides to specify and create (exceptional) customer value through streamlined processes. This research thus shows that there is still some way to go toward changing the mindset of construction industry professionals.

These professionals should understand the importance of customer value as a starting point for lean thinking, as well as for all lean actions, or else implementation will fall short, and people will continue to question whether lean is anything new. Consequently, lean initiatives should not just focus on efficiency (using different tools and techniques to reduce waste) but emphasize effectiveness (meeting customer requirements by doing the right things). Identifying and responding to customers’ needs will eventually bear fruit by increasing profits and increasing the company’s competitiveness.

The interviews were conducted in the San Francisco Bay Area, which does not reveal an overall understanding of lean among construction professionals around the world. In addition, this research presents the informants’ answers to only one interview question “How do you understand lean?” which might not adequately reflect the informant’s “whole” understanding of the subject. However, since the interview included a range of questions related to lean implementation, the interviewee was left with a general feeling that the focus was indeed on using different tools and techniques, while only few seemed to understand the underlying philosophy.

Future research should look more closely into what kind of processes exist for identifying customers and customer values and how well these value expectations are followed through throughout the projects. It would also be interesting to compare if there are differences in understanding between different continents and different countries.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Civil and Environmental Engineering at the University of California Berkeley for hosting Dr. Herrala as a research scholar during the fall of 2011. The authors would also like to thank Tekes – the Finnish Funding Agency for Technology and Innovation for financing this study within the LCIFIN1 research project.

REFERENCES

- Al Sehami, A., Tzortzopoulos P. and Koskela, L. (2007). “Last Planner System: Experiences from pilot implementation in the Middle East”. *Proc. IGLC-17*, Taipei, Taiwan.

- Abdelhamid, T., S. (2004). "The Self-Destruction and Renewal of Lean Construction Theory: A Prediction From Boyd's Theory". *Proc. IGLC-12*, Helsingør, Denmark.
- Arbulu, R.J., Tommelein, I.D., Walsh, K.D. and Hershauer, J.C. (2003) "Value stream analysis of a re-engineered construction supply chain". *Building Research & Information*, 31 (2) 161–171.
- Ballard, G. (2000). "The Last Planner System of Production Control". *Thesis (Ph.D.)*, School of Civil Engineering, Faculty of Engineering, The University of Birmingham.
- Ballard, G. (2011). "Target Value Design: Current Benchmark (1.0)". *Lean Construction Journal*, 79-84.
- Bhasin, S. and Burcher, P. (2006). "Lean viewed as a philosophy". *J. of Manufacturing Technology Management*, 17 (1) 56-72.
- Björnfot, A. and Stehn, L. (2007). "Value Delivery through Product Offers: A Lean Leap in Multi-Storey Timber Housing Construction". *Lean Construction Journal*, 3 (1) 33-45.
- Bozdogan, K. (2010). "Evolution of the Lean Enterprise System – A Critical Synthesis and Agenda for the Future". *Encyclopedia of Aerospace Engineering*.
- Chase, N. (1999). "Lose the waste – get lean!", *Quality*, 38 (3) 34-39.
- Convis, G. (2001). "Role of management in a lean manufacturing environment", *Automotive Manufacturing and Production*, 7, 1-7.
- Emmitt, S., Sander, D. and Christoffersen, K. (2004). "Implementing value through lean design management." *Proc. IGLC-13*, Sydney, Australia.
- Green, S. D. and May, S. C. (2005). "Lean construction: arenas of enactment, models of diffusion and the meaning of 'leanness'". *Building Research & Information*, 33 (6) 498-511.
- Hines, P., Holweg, M. and Rich, N. (2004). "Learning to evolve - A review of contemporary lean thinking". *Int. J. of Operations & Production Management*, 24 (10) 994-1011.
- Holweg, M. and Pil, F. (2001). "Successful build-to-order strategies start with the customer", *Sloan Management Review*, 43 (1) 74-83.
- Howell, G. and Ballard, G. (1994a). "Implementing lean construction - improving downstream performance". *Proc. IGLC-2*, Santiago, Chile.
- Howell, G. and Ballard, G. (1994b). "Implementing lean construction – reducing flow variance". *Proc. IGLC-2*, Santiago, Chile.
- Howell, G. and Ballard, G. (1994c). "Implementing lean construction – stabilizing work flow". *Proc. IGLC-2*, Santiago, Chile.
- Howell, G. A. (1999). "What is lean construction?" *Proc. IGLC-7*, Berkeley, California.
- Koskela, L. (1992). "Application of the new production philosophy to construction". *CIFE Technical Report #72*, Stanford University. (available at <http://www.leanconstruction.org/pdf/Koskela-TR72.pdf>).
- Koskela, L. (2000). "An exploration towards a production theory and its application to construction." VTT Publications 408, Espoo.
- Koskela, L., Howell, G., Ballard, G., and Tommelein, I. (2002). "The Foundations of Lean Construction." in R. Best, and G. de Valence, eds., *Design and construction: building in value*, Butterworth-Heinemann, Elsevier, Oxford, UK.

- Levitt, T. (1960). "Marketing Myopia". *Harvard Business Review*, July-August, 45-56.
- Lichtig, W. (2007). "The intergrated agreement for lean project delivery". *Construction Lawyer*, 26 (3) 1-8.
- Liker, J.K. (2004). "The Toyota way: 14 management principles from the world's greatest manufacturer". McGraw-Hill, New York.
- Lima, M. Rolim, L. and Alves T. (2010). "Value stream mapping of the architectural executive design in a governmental organization". *Proc. IGLC-18*, Haifa, Israel.
- Matthews, O. and Howell, G.A. (2005). "Integrated Project Delivery - An Example of Relational Contracting". *Lean Construction Journal*, 2 (1) 46-61.
- Monden, Y. (1993). "The Toyota Management System". Productivity Press, Portland.
- Mossman, A. (2009). "Creating value: a sufficient way to eliminate waste in lean design and lean production". *Lean Construction Journal*, 13-23.
- Pettersen, J. (2009) "Defining lean production: some conceptual and practical issues". *The TQM Journal*, 21 (2) 127-142.
- Rother, M. (1997). "Crossroads: which way will you turn on the road to lean?" in J.K. Liker (ed.) *Becoming lean: inside stories of U.S. manufacturers*, Productivity Press, Portland, USA.
- Rother, M. and Shook J. (1999). "Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA". *Lean Enterprise Institute*.
- Rother, M. (2010). "Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results". McGraw-Hill, New York.
- Salem, O., Genaidy, A., Luegring, M., Paez, O. and Solomon, J. (2004). "The path from lean manufacturing to lean construction: implementation and evaluation of lean assembly". *Proc. IGLC-12*, Copenhagen, Denmark.
- Santos, A. (1999). "Application of flow principles in the production management of construction sites". *Thesis (Ph.D.)*, School of Construction and Property Management, The University of Salford.
- Scherrer-Rathje, M., Boyle, T.A. and Deflorin, P. (2009). "Lean, take two! Reflections from the second attempt at lean implementation". *Business Horizons*, 52 (1) 79-88.
- Shah, R. and Ward, P.T. (2003). "Lean manufacturing: Context, practice bundles, and performance". *J. of Operations Management*, 21 (2) 129-149.
- Shah, R. and Ward, P.T. (2007). "Defining and developing measures of lean production". *J. of Operations Management*, 25 (4) 785-805.
- Shewhart, W.A. (1931). "Economic control of quality of manufacture product". Van Nostrand, New York. 501 p.
- Shook, J.Y. (1997) "Bringing the Toyota production system to the United States: a personal perspective". in J.K. Liker (ed.) *Becoming lean: inside stories of U.S. manufacturers*, Productivity Press, Portland, USA.
- Toolanen, B. and Olofsson, T. (2006) "Relational Contracting and Process Design Promoting Cooperation". *Proc. IGLC-14*, Santiago, Chile.
- Womack, J.P. and Daniel T.J. (1996). "Lean Thinking". Free Press, New York.
- Womack, J.P. (2006). "Value Stream Mapping". *Manufacturing Engineering*, 136 (5) 145-156.