

An outline of:

Lean Thinking

Banish Waste and Create Wealth in Your Corporation

By James P. Womack and Daniel T. Jones

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Preface to the 2003 Edition. Forecasts are always wrong. That is why lean thinkers strive to reduce order-to-delivery time. During the 2002 meltdown, this 1996 book went back on the *Business Week* bestseller list. We have added what we have learned since 1996 in this edition. *Lean Thinking* is more relevant today. Lean ideas are the single most powerful tool available for creating value and eliminating waste in any organization.

Part I: Lean Principles

Taiichi Ohno (1912 – 1990), a Toyota executive, identified seven types of waste found in any process:

- **Transportation.** Unnecessary transport of parts under production.
- **Inventory.** Stacks of parts waiting to be completed or finished products waiting to be shipped.
- **Motion.** Unnecessary movement of people working on products.
- **Waiting.** Unnecessary waiting by people to begin the next step.
- **Over-Processing** the product with extra steps.
- **Over-Production** of products not needed.
- **Defects** in the product.

We have added an eighth waste: goods and services that do not meet the customer's needs. Other authors have added: underutilization of people.

Lean Thinking is the antidote to waste. There are (5) Lean Principles:

- **Specify Value.** Value can be defined only by the ultimate customer. Value is distorted by pre-existing organizations, especially engineers and experts. They add complexity of no interest to the customer.
- **Identify the Value Stream.** The Value Stream is *all* the actions needed to bring a product to the customer. If the melter, forger, machiner, and assembler never talk, duplicate steps *will* exist.
- **Flow.** Make the value-creating steps flow. Eliminate departments that execute a single-task process on large batches.
- **Pull.** Let the customer pull the product from you. Sell, one. Make one.
- **Pursue Perfection.** There is no end to the process of reducing time, space, cost and mistakes.

Lean is doing more with less. Use the *least* amount of effort, energy, equipment, time, facility space, materials, and capital – while giving customers *exactly* what they want.

The Prize We Can Grasp Now. Converting a batch-and-queue system to continuous flow, with pull, will:

- **Double** labor productivity
- **Cut** throughput time by 90%
- **Reduce** inventory by 90%
- **Cut** errors by 50%
- **Cut** injuries

1: Value

A House or a Hassle-Free Experience? Doyle Wilson Homebuilder found that customers “valued” a hassle-free design process and on-time delivery. All his processes were then re-aligned to meet this goal.

Define Value in Terms of the Whole Product. As the product flows, each firm defines value differently. Think of air travel. Each firm – agent, airline, taxi, currency exchange, customs, immigration – defines their own priorities, duplicates efforts, and works in disharmony with the whole process. The customer is not satisfied.

2: The Value Stream

The View from the Aisle. A value stream “map” identifies every action to design, order, and make a specific product. Each step is then sorted into three categories: (1) those that add value, (2) those that add no value but are currently necessary, and (3) those that add no value and can be eliminated. After the third category has been eliminated, the second category should be addressed through flow, pull, and perfection techniques.

The Value Stream for a Carton of Cola. The British grocery chain Tesco retails products with thousands of value streams. In the canned cola value stream, three hours of value-added activity take 319 days to perform.

3: Flow

The World of Batch-and-Queue. Five-sixths of home-building is *waiting* for the next set of specialists or *rework*. Flow principles typically cut half the effort and the time required.

The Techniques of Flow. The 1st step is to maintain focus on the product. The 2nd step is to ignore job boundaries and departments IOT remove impediments to continuous flow of the specific product. The 3rd step is to rethink work practices to eliminate backflow, scrap, and stoppages IOT make the product continuously.

- **Takt time** synchronizes the rate of production to the rate of sales. (48) bikes per day sold divided by (8) hours of production = (6) bikes and hour, or (1) bike every ten minutes.
- **Flow** requires all workers and machines to be capable at all times. This requires cross-training.
- **Flow** requires workers to know the status of production at all times. This requires visual controls.
- **All activities can flow.** Concentrate on the value stream for a specific product, eliminate organizational barriers, and relocate and right-size tools.

4: Pull

Pull means that no one upstream should produce anything until the customer downstream asks for it. “Don’t make anything until it is needed, then make it very quickly.” “Sell one, buy one.” “Ship one, make one.”

The Bad Old Days of Production. The Toyota bumper replacement system suffered long lead times. The ability to get parts quickly from the next upstream producer enabled re-orders in small amounts. This is the secret to reducing inventory. Cut lead times and inventories. Demand should instantly generate new supply.

5: Perfection

The Incremental Path. Freudenberg-NOK, a gasket manufacturer, improved a single process *six* times in three years. “Why didn’t they get it right the first time?” Because perfection is continuous.

Continuous Radical and Incremental Improvement. If you are spending capital, you are doing it wrong. Once leaders understand the first four lean principles – value specification, value stream identification, flow, and pull – their perfection step starts with policy: a vision of the ideal process, and the step-wise goals and projects to get there. Transparency is everything. Everyone must know what you are attempting to achieve and what area is the first priority. The force behind this is the leader known as the *change agent*.

Part II: From Thinking to Action: The Lean Leap

6: The Simple Case

Lantech manufacturers stretch wrap machines. “Process Villages” – Sawing department, Machining department, Welding department, Painting department, and Sub-assembly department – all generated long lead times. Batches of ten were manufactured to ship one. Inventory overwhelmed the factory. Order changes created havoc in the plant. “The more inventory you have, the less likely you will have the part you need.”

- **The Lean Revolution.** Ron Hicks leaned Lantech. He created four cells, one for each product. He defined standard work: on time, on spec, every time. Takt time was introduced: number of products needed per day divided by number of hours ($8/8 = 1$ hour). He right-sized machines to fit inside work cells. He implemented quick changeover to make multiple different parts with little machine downtime.
- **Result.** Lantech cut 30% excess space, doubled product output, cut defects from 8 per product to 0.8 per product, and cut lead time from sixteen weeks to fourteen hours. On-time shipping rose from 20 to 90%.

7: A Harder Case

The Change Agent. Art Byrne was hired as CEO of Wiremold in 1991. “CEOs are timid to change the shop floor.” Byrne led lean training using a manual he wrote himself. He led tours of the plant to observe waste that his managers were now able to see.

- **Improvements Must be Fast.** Three days was Byrne’s standard.
- **Post a Scorecard for Each Product Team.** Wiremold tracked: Productivity – sales per employee, Service – percent delivered on-time, Inventory – turns, and Quality – mistakes.
- **Teach People How to See.** Create a lean training function. Teach all employees the five principles of lean: Value, Value Stream, Flow, Pull, and Perfection. Teach all employees lean techniques: standard work, takt time, visual control, pull scheduling, and single-piece flow.
- **Results.** Wiremold freed 50% factory floor space, eliminated a warehouse, and converted \$11M of inventory into \$24M in sales. Lead time fell from four weeks to two days.

8: The Acid Test

Pratt & Whitney (P&W). In 1991, CEO Karl Krapek and cost-cutter Mark Coran leaned P&W.

- **Jet Engines.** Founded in 1860, P&W led the aircraft engine business by 1929. When they abandoned piston engines to gamble on jets in 1946, business soared. Production inefficiencies were overlooked.
- **Overcapacity.** Faced with competition in the 1980s, P&W rationalized plant layout and addressed development costs. They needed lower production costs and flexibility to react to customer needs. Why did P&W need so much space, tools, inventory and people to get so little done? Daily output of engines and spare parts could fit inside CEO’s office. Failure to manage assets. P&W cut people, cut managers, and overhauled their entire production culture and processes.

- **The Monument of all Monuments.** A “monument” is a machine or process too big to be moved and whose scale requires operating in batch mode. Monuments are evil, generating huge amounts of waste. P&W had an \$80M grinding system, representing obsolete thinking. Although speeding up grinding from 75 minutes to 3 minutes and eliminating multiple manual grinding jobs, in actuality grinding jobs took longer (due to eight-hour changeovers and batch scheduling), and required more people (22 computer technicians). P&W retired the \$80M monument, returned to 75-minute production.

9: Lean Thinking versus German *Technik*

Porche. Chairman Wendelin Wiedeking introduced lean thinking to Porche. In 1994, the first-ever Porsche rolled off the line with nothing wrong with it.

- **Engineers.** Porche is led by engineers, intrigued with unique solutions that are difficult to manufacture. Workers are craftsmen. Unfortunately, much craftsmanship is waste. Tinkering with the product – repairing and polishing raw materials, troubleshooting, re-assembling elements, repainting and re-fitting – were thought to be necessary activities to produce a high-quality product.
- **Crisis.** 1986 was the boom year. 1992 was the crash. Porche products were too expensive. Costs and throughput time had to be slashed. New quality focus: “Stop fixing mistakes that should never have been made.” Reduction in inventory: “Where is the factory? This is the warehouse!”
- **Just-in-Time (JIT) Game.** Porche asked all their suppliers to play a simulation to learn lean concepts. Lean concepts were critical across all firms contributing to the Porche value stream.
- **The Remarkable Lean Transition at Porche.** In five years, through 1997, Porch doubled its productivity, cut manufacturing space in half, cut lead time for a finished vehicle from six weeks to three days, cut supplier defects 90%, cut inventories 90%, and cut first-time-through errors by 55%.
- **The German Tradition.** The Germans need to stop prioritizing the engineer’s definition of value, “voice of the engineer,” over the customer’s definition of value, “voice of the customer.” A German weakness is a fondness for monster machines that produce large batches: paint booths are an example.
- **Variety and Refinement Cost.** Volkswagen makes four exterior mirrors, nineteen parts each, in seventeen colors. Nissan has four-part mirrors in four colors. Excess variety often exceeds the ability of the customer to notice, and his willingness to pay.

10: Mighty Toyota; Tiny Showa

Showa has been transformed by its relationship with Toyota. Showa, a radiator manufacturer, had “Process villages” for casting, cleaning, stamping, welding, painting and assembly. Each was run in batch mode with long intervals between tool changes. Mountains of parts were transported and stored between steps.

- **The Initial Struggle.** Taiichi Ohno, lean advisor, promised to reduce three months of inventory to three days, double labor productivity, and halve plant space for zero capital investment. This he did.
- **The Final Element: Rethinking Order-Taking and Scheduling.** Showa then leaned order-taking by scheduling *backwards*, working to takt time, to synchronize orders with production slots, *exactly* four days before shipment time. Orders with incorrect information were never passed along.
- **“...The Advantage of a Defiant Attitude.”** Two basic lean concepts in production – automatic line stopping when a mistake is made so no bad parts are passed forward, and a pull system to trigger the fabrication of only those parts that are actually needed – were developed at Toyota in the 1920s and 1930s. When Taiichi Ohno led Toyota Motor engine works in 1948, he had three insights. First, people spent their time watching machines. Machines with error triggers freed up people to operate many machines. Second, “when you have lots of inventory, you are always one part short,” so parts should only be made if the next step needs them. Third, machines should be moved away from process

villages and into horse-shoe-shaped cells, in the exact sequence needed. Thus focus is on the product and not the machines and their maintenance. Ohno's favorite saying was "common sense is almost always wrong."

- **Toyota Today.** Lesson: high-tech automation only works if the plant can run at 100 percent output and if the cost of indirect technical support and high-tech tools is less than the cost of direct labor saved.

11: An Action Plan

Getting Started [Months 1 – 6]

- **Find a Change Agent** with ability and authority.
- **Get the Knowledge** through an advisor.
- **Seize a Crisis** or create one. Focus on fixing an obvious problem. Small wins. Don't spend money.
- **Map** your current value streams.
- **Begin** as soon as possible with an important, visible activity. Convert managers with hand-on activity.
- **Demand Immediate Results.** Everyone should see results which create psychological momentum. One week: less planning, more doing. Identify waste and remove it. Communicate with your people by showing results at the scene of action.
- **Expand Your Scope.** Move from flow to pull.

Creating an Organization to Channel Your Streams [Months 6 – 24]

- **Reorganize Your Firm** by product and value streams. Put a Change Agent in charge of each product.
- **Create a Lean Promotion Team.**
- **Deal with Excess People Early.**
- **Devise a Growth Strategy.**
- **Remove the Anchor Draggers.**
- **When You've Fixed Something, Fix It Again.**

Install Business Systems to Encourage Lean Thinking [Months 24 – 48]

- **Create new ways to keep score.**
- **Create new ways to reward people.**
- **Make everything transparent** so everyone can see progress.
- **Teach lean. Learn lean.**
- **Right-size Your Tools** to insert directly into the value stream. Large and fast is more efficient but less effective. This wrong assumption is the cornerstone of batch-and-queue thinking.
- **Pay a bonus.** Tie bonus amounts to the profitability of the firm.

Completing the Transformation [Months 48 – 60] Convert to bottom-up initiatives. Lean ideas are democratic and not top-down. Layers of management can be stripped away.

The Inevitable Results of a Five-Year Commitment

Part III: Lean Enterprise

12: A Channel for the Stream; a Valley for the Channel

The Lean Enterprise. No one watches the performance of the whole value stream. Identify all actions to bring a product to the customer, across all firms. There is no privacy. Each firm's costs become transparent.

13: Dreaming About Perfection

Long-Distance Travel. Each organization ignores the role of the other parties. The time, cost, and comfort of the total trip are key performance measures. What would travel times be without queues?

Medical Care is queues. Providers organize by function. What if patient time and comfort were the key performance measures? Medical cells with right-sized equipment would flow patients. Some right-sized equipment has already gone home with the patient, just like most office equipment has now shifted to the home.

Construction. 80% of home building is hurry-up and wait, then re-working the construction errors.

The Prize We Can Grasp Right Now. Lean thinking can boost productivity while reducing errors, inventories, accidents, space requirements, production lead times, and costs in general. Lean thinking requires little capital.

Part IV: Epilogue

14: A Steady Advance of Lean Thinking

This chapter an updated review of Wiremold, Toyota, Porsche, Lantech, and Pratt & Whitney.

15: Institutionalizing the Revolution

An Enhanced Action Plan is the 2003 update to the 1996 plan from Chapter 11.

Getting Started [Months 1 – 6]

- **Find a Change Agent** with ability and authority.
- **Get the Knowledge** through an advisor. Start at the big picture before addressing small steps.
- **Seize a Crisis** or create one. Focus on fixing an obvious problem. Small wins. Don't spend money.
- **Map** your current value streams. Managers need to *see*. Map also the flow of information going upstream to create a closed circuit. See Rother and Shook, *Learning to See*, 1998.
 - Analyze each step of the **Current State**. Does this step create value? Is this step capable, available, flexible? Is capacity sufficient? Excessive? Does the information flow from the customer smoothly? Every process has a box score: total lead time, value creating time, changeover time, uptime, rework, inventory, every part made every x minutes. **If this step went away, what would happen?**
 - Envision the **Future State**. Draw it.
- **Begin** as soon as possible with an important, visible activity. Convert managers with hand-on activity.
- **Demand Immediate Results**. Everyone should see results which create psychological momentum. One week: less planning, more doing. Identify the waste and remove it. Communicate with your people by showing results at the scene of action.

- **Expand Your Scope.** Move from flow to pull.

Creating an Organization to Channel Your Streams [Months 6 – 24]

- **Reorganize Your Firm** by product and value streams. Put a Change Agent in charge of each product.
- **Create a Lean Promotion Team.**
- **Deal with Excess People Early.**
- **Devise a Growth Strategy.**
- **Remove the Anchor Draggers.**
- **When You've Fixed Something, Fix It Again.**
- **New: Convince Your Suppliers and Customers to Take the Steps Just Described.**

Install Business Systems to Encourage Lean Thinking [Months 24 – 48]

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- **Create new ways to reward people.**
- **Make everything transparent** so everyone can see progress.
- **Teach lean. Learn lean.**
- **Right-size Your Tools** to insert directly into the value stream. Large and fast is more efficient but less effective. This wrong assumption is the cornerstone of batch-and-queue thinking.
- **Pay a bonus.** Tie bonus amount to the profitability of the firm.

Completing the Transformation [Months 48 – 60] Convert to bottom-up initiatives. Lean ideas are democratic and not top-down. Layers of management can be stripped away.

New: Convert From Top-Down Leadership to Bottom-Up Initiatives. Toyota gets brilliant results from average managers using brilliant procedures. Competitors get mediocre results from brilliant managers using mediocre procedures. Don't search for brilliant managers. Perfect your processes.

The Inevitable Results of a Five-Year Commitment

Afterword: The Lean Network Individuals and Organizations Who Helped

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Glossary

batch-and-queue	Making large lots, then sending the lot to wait in queue for the next operation.
cells	The layout of machines in a tight U-shaped sequence, permitting single piece flow and multi-machine working. Contrast with <i>process villages</i> .
just-in-time	Producing and delivering just the right item at the right time in the right amount. <i>Flow, pull, and standard work</i> are the pre-requisites.
kaizen	Continuous, incremental improvement.
lead time	The total time a customer must wait to receive a product after placing an order. If the order can start production immediately, then <i>production time</i> and <i>lead time</i> are the same.

monument	Any design, schedule, or technology with scale requirements necessitating that products be brought there to wait in a queue for processing.
muda	Waste. Any activity that consumes resources but creates no value.
multi-machine working	Training employees to operate multiple machines. This is essential to creating production cells where each worker uses many machines.
process villages	Grouping machines and people by type of operation performed. Contrast with <i>cells</i> .
queue time	The time a product spends in a line awaiting the next step.
right-sized tool	A design that can be fitted directly into a production cell and permit the flow of products so the products do not need to be transported to a monument and wait in a queue.
seven muda	Ohno's original seven types of waste found in production: Transportation, Inventory, Motion, Waiting, Over-Processing, Over-Production, and Defects
standard work	A precise description of each work activity, specifying cycle time, takt time, sequence, inventory, and standards.

Reviewer's Comments

In 1988 James Womack first described Toyota as a "lean" corporation. Womack and co-writer Daniel Jones described the Toyota Production System (TPS) in The Machine That Changed the World. In 1990, the two toured companies in Europe, North American, and Japan presenting ideas on how to convert mass production practices to lean practices. Lean Thinking, first published in 1996, is a survey of the lean movement. It clearly describes the waste found in mass production, explains the five principles of lean thinking, and then draws lessons from real companies who have successfully implemented lean ideas. Lean Thinking is not a technical how-to text on production, but an enlightened overview of top-level lean ideas and applications. This updated edition includes lessons that the authors have collected between 1996 and 2003, especially the concept of a lean enterprise – a collection of companies working lean together to produce a single product with the least wasted effort and capital. The book is well-written, researched, and organized, and the authors make a strong case that lean is universal and will benefit any organization in any endeavor. Lean thinking and practices are the single most powerful tool for eliminating waste in any organization.

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