



Sloan Consulting

PRODUCTIVITY, QUALITY, INFORMATION AND BUSINESS SYSTEM SOLUTIONS

Lean Manufacturing/Service Reading List and Time Line

Henry Ford's first autobiography, *My Life and Work* (1922). written with Samuel Crowther, is the definitive 1920-2006 "Lean," "Toyota Production System," "World Class Manufacturing," "Japanese Management," "Business Excellence," and "Operational Excellence" reference text. His second autobiography, also written with Crowther, *Today and Tomorrow* (1926) details ideas introduced in *My Life and Work*.

To quote Ford, and all lean thinkers since, "Life flows." (Page 43) To Ford the foundation of a real business was service to people. Be it manufacturing, health care or any other enterprise. "Profit is the result of service." Key 1913 to 2004 lean manufacturing and service principles outlined in Ford's first book include but are not limited to:

- 1) Simplicity is the core value. (page 13) Banish all waste from every process.
- 2) Constantly experiment with new ideas. (page 17) Ford relied on measurement precision. The ability to replicate perfect results was his analysis guide. Ford carried out costs to the fourth decimal. (page 58 *Today and Tomorrow*)

Measurement specifications and tolerances were routinely set to the thousandth and ten thousandth of an inch. Ford hired Carl E. Johansson the inventor of Johansson gauge blocks. By the 1920's the resolution of their 'near perfect theoretical planes' reached a millionth of an inch. (pages 75-76 *Today and Tomorrow*)
- 3) Draw a plan first. (page 32)
- 4) Standardize in ways that allow a process to develop, thereby eliminating all forms of waste. (page 49)
- 5) Absolute cleanliness throughout every department is mandatory. (page 60)
- 6) Fool proof designs. (page 67) Place people and tools in the sequence of operations so each component of the service or manufacturing process travels the least distance. (Page 80).
- 7) Measure time using a stop watch. With the aid of scientific study, increase the speed of production so that everything aspect of every motion, service or product delivery takes less time. (page 81)



- 8) If a machine can be made to be automatic, make it automatic. (page 90)
- 9) Make individual responsibility complete. (page 92)
- 10) When you come right down to it, most jobs are repetitive. (page 103) Drive the drudgery out of work (page 278) by creating opportunities for people to do the most difficult work, thinking. (248-250)

Ford and Crowther's *Today and Tomorrow* (1926) is an informative work. Ford uses the phrase continuous process to emphasize the importance of flow. (Page 55) His chapter, "Learning from Waste," teaches readers that the purpose of banishing waste is to save human labor.

To Ford, and the lean thinkers who followed his footsteps, the invisible waste of time in misdirected human labor is extraordinarily expensive. "Wasted time does not litter the floor like wasted material." (Page 101)

Ford wrote, "We are, as a matter of policy, against hard work—we will not put on the back of a man what we can put on a machine." There is a difference between working hard and hard work. (Page 137) "The world does not pay for sweat. It pays for results." (Page 197)

Ohno, Taiichi. *Toyota Production System, Beyond Large Scale Production*. New York: Productivity Press, 1988. Original Japanese Edition *Toyota seisan hoshiki* published by Diamond, Inc., Toyko, Japan, 1978. Ohno credits his production system to Henry Ford.

Where Ford demonstrated how to produce high volume with low variety—customers can have whatever color they want so long as it is black—Ohno's genius showed industry how to deliver highly varied goods and services in small volumes. Customers can now get what they want exactly when they want it.

Ohno's Glossary of Terms repeats Ford's 1913 Highland Park plant tools and production methods verbatim. For example, Toyota's Andon light is Ford's signaling light. Ohno's automation with a human touch, is Ford's entirely mechanized continuous flow processes. Just-in-time deliveries distinguished both Toyota and Ford systems.



Ohno's seven wastes (page 19-20) are virtual Henry Ford quotes. They are bedrock 21st Century Lean Manufacturing principles. Ohno's equation reflects current thinking: Present Capacity = work + waste.

- 1) Overproduction.
- 2) Time.
- 3) Transportation.
- 4) Processing waste itself.
- 5) Inventory.
- 6) Movement.
- 7) Defective parts.

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Suzaki, Kiyoshi. *The New Manufacturing Challenge, Techniques for Continuous Improvement*. New York: The Free Press, 1987.

Schonberger, Richard J., *Building a Chain of Customers, Linking Business Functions to Create the World Class Company*. New York: The Free Press, 1990.

Womack, James P., Jones, Daniel T., and Roos, Daniel. *The Machine that Changed the World, Based on the Massachusetts Institute of Technology 5-million-Dollar-5-Year Study on the Future of the Automobile*. New York: Simon and Schuster, 1990.

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Womack, James P., Jones, Daniel T., and Roos, Daniel. *Lean Thinking- Banish Waste and Create Wealth in Your Corporation*. New York, Simon and Schuster, 1996 and 2003.

Rother, Mike and Shook, John, with foreword by Womack, James P., Jones, Dan. *Learning to See – value stream mapping to add value and eliminate muda*. www.lean.org. Version 1.2 June 1999.



Marchwinski and Shook, John with foreword by Ferro, Jose, Jones, Dan and Jim Womack. *Lean Lexicon – a graphical glossary for Lean Thinkers*. Brookline: Lean Enterprise Institute. Version 1.0 2003.

Sloan, M. Daniel and Boyles, Russell A. *Profit Signals – How Evidence-Based Decisions Power Six Sigma Breakthroughs*. (Seattle, Evidence-Based Decisions, Inc.) 2003. This book demystifies data analysis. Its contribution to lean is that it explains the theory and details methods for eliminating all waste related to analysis errors and the misinterpretation of numbers.

Lean Evolution Time Line

1793: Eli Whitney invents the cotton gin. In 1798 he invents the interchangeable part. Interchangeable parts let him mass produce 10,000 affordably-priced muskets. Flexibility and standardization create unheard of speeds in manufacturing, marketing, and repair. <http://www.northstar.k12.ak.us/schools/ryn/projects/inventors/whitney/whitney.html>

1892: Following relentless experimentation, Henry Ford invents his first motor car. He envisions the mass production of affordable automobiles with entirely standardized/interchangeable parts. Ford will eventually emulate Whitney’s cotton gin idea with flax, so that linen can be used to replace cotton in automobile manufacturing.

1889: Rashomon Sakichi Toyoda’s perfected a textile loom in 1898 that stopped automatically when a thread broke. (Time Asia, 1993, vol. 154 No 7/8.) This fool-proofed (poke yoke) machine demonstrated an aspect of “human intelligence.”

It assured quality and minimized waste automatically. It allowed operators to simultaneously manage multiple machines. Profits from the Toyoda Company and the philosophy embodied in fool-proofing machinery with a human touch set the stage for the Toyota Motor Company three decades later.

1903: The Ford Motor Company is founded.

1910: Sakichi Toyoda visits the United States for the first time and witnesses the impact automobiles had on America. (Ohno, 1988, page 78)

Henry Ford and Charles E. Sorensen, who would become Ford Company’s first president, implement mass production work flow. Waste worried Ford and those who worked for him. Ford’s own words from his written works *My Life and Work* and *Moving Forward*, read like quotes from quality statistician, W. Edwards Deming, “Drive out fear,” (page 221) and Toyota’s Taiichi Ohno, “No methods or formulas can be devised to substitute for human judgment and leadership.” Ohno



correctly credits Ford with setting up the first experiments in production *flow* around 1910,

Though Henry Ford's worry over waste and his production flow idea remain as the central Lean tenets, Japan's perpetual natural resource and raw material shortages, economic hardships, along with the unique Toyoda/Toyota philosophy eliminated Ford's warehousing system. Almost everything—as dictated by geology, culture, and geography—by necessity, was always just-in-time in Japan during the 20th Century. By contrast, the Twentieth Century United States of America was a land of abundant resources that seemingly could be squandered with impunity.

Since all costs related to warehousing [economic ordering quantities or EOQ, waiting, accounting time, and inventory to name a few] were eliminated from Toyota production expenses, significant competitive advantages became a natural by product of lean management technology.

1919: Ford Hospital in Detroit, Michigan is designed, built and managed as an experiment. Ford's principles produce high, quality, affordable, profitable care.

1929: Kiichiro Toyoda, eldest son of Sakichi Toyoda who had challenged Kiichiro to build a Japanese car with Japanese hands (Time Asia, 1993, vol. 154 No 7/8.), visits Ford River Rouge Plant in Detroit. (Womack, 1990)

In 1929 a British textile manufacturer paid Toyoda approximately £100,000 for rights to one of his modern looms. Kiichiro used this money to develop Toyoda's Automatic Loom Works automotive department in 1933.

1936: Lean manufacturing develops under the leadership of Kiichiro. (Kiichiro's cousin, Eiji Toyoda received his mechanical engineering degree in 1936.) History documents that automation, poke-yoke/fool-proofing, just-in-time delivery, flow, and Ford's plant designs were in place when the company's first car was produced in 1936. Japan's preparations for World War II forced the company into military production and away from meeting civilian transportation needs.

Eiji Toyoda, born in 1913 and named President of Toyota Motor Corporation in 1967, grew up in and around a textile mill. Eiji and a loom machinist Taiichi Ohno worked together to promote small batch, product flow and the precursor to bar coding inventory systems known as *kanban*. (Business Week Online, May 24, 2004). Ohno's production philosophy called for extremely skilled workforce. Knowledge flowed freely under his leadership.

1950: Eiji Toyoda makes a 90 day trip to visit Ford's Rouge River Plant. He saw opportunities to improve the production system. His envisioned improvements reflected the values of a man and a nation of people with limited natural resources. The Japanese



ethic of hard work and frugality set the tone for an emphasis on eliminating wasted time, motion, processing, resources, and inventories. His vision evolved into what is now called “Lean Manufacturing.”

1973: The impact of Organization of Petroleum Exporting Countries (OPEC) policies drew attention to Toyota’s relative prosperity during exceptionally difficult economic times. Toyota’s 1) just in time system and 2) autonotation, or automation with a human touch, embodied in Toyoda’s “self correcting” textile loom, focus on what Ohno called his vision “The Power of Individual Skill and Teamwork.” (Ohno, 1978) Numerous authorities suggest Ohno is the individual who is most responsible for the Toyota Production System.

Automated and fool-proofed systems, visual control, maximum flexibility, continuous cost reduction and the development of human abilities to their highest capacity topped Ohno’s list of values. The work of 100 people could, and must, be done by 10.

1978: Taiichi Ohno publishes his book which was published a decade later in English as, *The Toyota Production System*. It remains the classic in the field. Ohno again credits Henry Ford’s relentless questioning of traditions that shackle imagination as the inspiration for asking, “Why?” five times. As an example, he cites Ford’s decision to question the use of cotton as the best material for production.

Up until Ford’s habitual questioning was directed at textiles, Ford’s company had been using 100,000 yards of cotton cloth per day. Cotton was seemingly the *easiest* material to get; linen was stronger.

Ford’s team experimented, emulating Ford’s hero and friend Thomas Edison. Applied science pays. Through systematic experimentation they discovered, invented, and learned how to use machinery to eliminate all the hand labor that previously had been considered to be absolutely essential to the processing that turned flax into linen.

By growing flax in Michigan, Ford eliminated all the transportation costs of shipping cotton to his factory in Dearborn. Ford’s management vision and decision cut time from production. (Ford’s *Today and Tomorrow* 1926 pages 90-92 cited in Ohno’s book.)

Ford’s ghost is manifest in Ohno’s cotton analogy and “seven wastes” formula for lean production: **Present capacity = work + waste.**

- 1) Overproduction was wasteful. (In Henry Ford’s imaginative world view, no cotton needed to be produced at all for automobiles.)
- 2) Waiting wasted time. (Having a ready supply of flax on hand in Michigan saved Ford time. Convenience led to a higher quality, more durable product.)



- 3) Transportation wasted resources. (Cotton transportation costs were eliminated.)
- 4) Waste requires processing, which in itself created more waste. (Accounting, storage, handling and other costs related to cotton were eliminated. Arduous and dehumanizing hand labor previously required to process flax was eliminated by machines. Ford's contributions to the mechanization of agriculture are legendary.)
- 5) Inventory caused financial waste. (Here, Ford's production system may seem to fall short of the "Lean" mark. However, since Ford owned the farms that grew the flax, he was his own supplier. Ford was its own vertically integrated industry.)
- 6) Motions were often wasteful. (Ford's questions decreased worker motion and safer working conditions for people. This class of industrial improvement is now known as ergonomics.)
- 7) Defects were waste. (Ford's more durable product pleased customers. As evidence, Ford wrote in his 1930 book *Moving Forward*, "Our problem has always been to keep profits down, not up.")

1981: Shigeo Shingo, once the Director of Training for Toyota, self-publishes his book, *Study of Toyota Production System from Industrial Engineering Viewpoint*. The English Translation was published in 1989. Shingo proposes that the pursuit of improvement is carried out along the three axes of the Cartesian coordinate system: X, Y, and Z. The X axis is a focus on improvement goals. The Y axis recognizes multiple goals. The Z axis pursues goals systematically working gradually toward underlying or fundamental goals.

Dr. Shingo's casual three dimensional analogies match the disciplined foundation for 20th Century science, quality improvement and vector analysis.

Although Shingo makes no mention of either Eli Whitney or Henry Ford, he rediscovered their principles. Shingo champions the Internal Exchange of Die (IED) and Outer or external Exchange of Die (OED) to achieve an unprecedented Single Minute Exchange of Die (SMED).

With the hands-on leadership of Shingo, the flexibility, speed and affordability of standardized parts now become flexible, fast, standardized processes any worker can use. Cross trained workers dramatically improved flow by leveling production and synchronizing all aspects of production.

The Shingo Prize which recognizes business excellence in the U.S., Canada, and Mexico was established in 1988 by Utah State University.

1990: The word "Lean" is coined in a book entitled *The Machine that Changed the World* by James P. Womack, Daniel T. Jones, and Daniel Roos. Today's "Lean Revolution" begins with the re-packaging of old ideas and savvy marketing!



Prior to that book, the Toyota Production Method, had been successfully re-labeled as *World Class Manufacturing* by Richard Schonberger. Best selling “Lean” books in 2004 follow the well worn Japanese management literature path. William Ouchi’s *Theory Z How American Management Can Meet the Japanese Challenge* (1981) is only one of hundreds that influenced the evolution and promotion of lean.

Womack, Jones and Roos may, or may not, have intended their book’s title to be a double-entendre. The book is obviously about the machinery and the history of the automobile. In addition, on page 62 they write, “Ohno’s idea was simply to convert a vast group of suppliers and parts plants into one large machine, like Henry Ford’s Highland Park plant, by dictating that parts would only be produced at each previous step to supply the immediate demand of the next step.”

[Did the authors mean to suggest that the Toyota Production System is the machine that changed the world? Does the Toyota Production System dehumanize people in the way that Charlie Chaplin’s 1936 film critique of Henry Ford’s production system *Modern Times* suggested? Henry Ford, Taiichi Ohno, Ronald A. Fisher, Walter Shewhart, W. Edwards Deming, George Box, and others reject the Chaplinesque interpretation of manufacturing history.]

Ohno’s “reverse” perspective of watching the flow of a process from the end point to the beginning calls to mind the “reverse/right to left” Japanese writing style. Shigeo Shingo’s Structure of Production Figure 1 in his book uses arrows pointing from right to left rather than the Western left-to-right convention. This reversed perspective is a helpful method that can be used to establish a Lean “pull” system.

1999: The American Society for Quality makes “Lean” production techniques part of its Six Sigma Body of Knowledge required for its Six Sigma Black Belt Certification Program.

