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The Seven Deadly Wastes of Logistics: Applying Toyota Production System Principles to Create Logistics Value

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Abstract

A business value chain is an end-to-end set of activities that can be applied to a product or service making it ready for the next activity. Most resources used in an activity add value—some do not. The resources consumed (such as people, time or equipment) that do not add value add cost and should be eliminated. This is the essence of the Toyota Production System, or *Lean* (the term used in the U.S. for what was originally known as the "Toyota Production System").

This article reviews the evolution of Lean principles from the beginning of Henry Ford's revolutionary assembly line process for his Model T automobile in the early 1900's, through Taiichi Ohno's creation of the famous Toyota Production System in the mid-20th century, to adoption of these principles in addressing today's logistics and transportation challenges. This paper presents real examples from executives who worked within the Toyota Production System and were effective in expanding these principles beyond the traditional manufacturing/ assembly environment.

Introduction

Henry Ford said that "Quality means doing it right when no one is looking." If Henry Ford knew the value of doing it right the first time, then why does this basic practice seem to be missing from so many companies today? The answer is…because it's hard. It requires a rigorous approach to problem solving, a relentless effort to identify and eliminate all forms of inefficiency, and a commitment to change the corporate culture that few firms are willing to embrace.
In fact, a recent study by the management consulting firm Bain & Company found that only 19% of companies that have attempted to implement lean are happy with the results.

Early in the twentieth century, Henry Ford took all the elements of a manufacturing system and arranged them in a continuous system for manufacturing the Model T automobile. After World War II, Taiichi Ohno at Toyota Motor Company recognized the benefits of this system and began to incorporate the Ford production system into an approach called the Toyota Production System (TPS), a system even better than Ford's at doing it right the first time by applying continuous problem solving by every employee to make the system ever stronger.

In the decades that have followed, Toyota has diligently applied these principles and, in the first quarter of 2007, passed General Motors to become the world's No. 1 auto seller (www.msnbc.msn.com/id/18286221).

Fundamentals of TPS: Muda, Process Focus, Genchi Genbutsu, Kaizen, Mutual Respect

While TPS has been discussed and written about for decades, a precise process has never been documented. An effective manual or a "how to" book has never been created that provides a step-by-step approach for understanding and implementing TPS—nor can such a complex process be adequately documented. Instead, newcomers to TPS are provided a daily lesson by Japanese mentors in the art of identifying and eliminating waste. Much like a child learns and forms habits from every action his or her parents take, newcomers to TPS learn from their Japanese "parents".

For example, within TPS there are many *Toyota Way* principles that need to be clearly understood and successfully applied before the benefits of TPS can be fully realized. But there are five in particular that are fundamental to TPS process. Once you grasp these you'll be able to take the first steps on your Lean journey. TPS strives for total elimination of **muda** (anything that is wasteful and doesn't add value), through a **process focus** (where managers work cross-organizationally to develop and sustain robust business processes), using **genchi genbutsu** (collecting facts and data at the actual site of the work or problem), and **kaizen** (continuous and incremental process improvement), with a value of **mutual respect** (between management and employees and business partners).

Muda adds unnecessary cost, quality problems, and lead-time to business processes. Process focus creates a capable and stable value stream. Applying genchi genbutsu provides the necessary understanding of how work is actually done so standardized processes can be developed, and lets us see problem causes for kaizen problem solving to eliminate muda. This may be the most difficult principle for traditional companies and managers to embrace, since it requires an attention to detail that seems to fly in the face of making Wall Street quarterly numbers and speedy decision making. The purpose of kaizen is to involve every employee in the identification and elimination of all forms of muda, thereby creating value. This is commonly referred to as the kaizen process, which uses the scientific method of problem solving at the lowest possible level in the organization. Mutual respect between management and employees reflects a true respect and sense of responsibility from management. This mutual respect is exemplified by employee safety, lifelong learning, and nurturing and coaching of every employee to enable them to contribute their full human potential to improve their job and business processes for the betterment of the company. This is core to the kaizen process.

Anyone who has experienced TPS first-hand is well aware of how these five principles are applied and interconnected. It would be common, for example, to see an experienced Toyota veteran observing a production or distribution operation and taking notes—often for hours at a time. To the uninitiated observer, it would appear that little value was being created, when in fact the opposite is true. There is a well known story about one of the techniques used by Ohno when visiting a plant. It is said that Ohno would draw a circle—the "Ohno circle"—on the floor and order one member of his staff to stand within the circle, sometimes for the entire day. The objective was to closely observe the operation (genchi genbutsu, identify inefficiencies (muda), and record areas of opportunity. Next, a plan for process improvement would be developed and executed. This is what genchi genbutsu and kaizen are all about.

When teaching American managers about problem solving for kaizen, a Japanese staff member would typically apply the "Five Why's" process (the practice of repeatedly asking why about the suspected cause at least five times to get to the root cause or causes of the problem). For example, after observing and identifying an opportunity for improvement, a Japanese staff member would discuss the opportunity with his American counterpart. Rather than identifying the actual improvement and dictating a solution, the Japanese staff member would ask a series of questions (the "Five Why's) that would nudge the American to make a decision that he had already determined through analysis was appropriate. This is the cultural educational process that all Americans (or non-Japanese) must go through to learn and ultimately master TPS. Here is an example of how the "Five Why's" might be applied:

> The Washington Monument was disintegrating
> Why? Use of harsh chemicals
> Why? To clean pigeon poop
> Why so many pigeons? They eat spiders and there are a lot of spiders at the monument
> Why so many spiders? They eat gnats and there are a lot of gnats at the monument
> Why are there so many gnats? They are attracted to the light at dusk
> Solution: Turn on the lights at a later time.

The Seven Deadly Wastes of the Toyota Production System

The relentless elimination of waste is as important today as it was when Taiichi Ohno identified the primary sources of waste, which he called "The Seven Deadly Wastes". These are:

1. Overproduction: Producing more than is needed for immediate use.
2. Delay/Waiting: Any delay between the end of one process and the start of the next activity.
3. Transportation/Conveyance: Unnecessary movement of products, materials or information.
4. Motion: Unnecessary movement of people, such as walking, reaching and stretching.
5. Inventory: Any raw material, work-in-process, or finished goods that exceed what is required to meet customer needs just in time and to maintain process stability.
6. Over-processing: Using more energy or activity than is needed to produce a product - or adding more value than the agreed standard.
7. Defects/Correction: Any production that results in rework or scrap.

The Seven Deadly Wastes of Logistics

While The Seven Deadly Wastes were originally intended for production operations, the concept is rapidly catching on in the service sector. What follows is an application of TPS principles that can be applied to the logistics area. Within logistics, we have determined that there are also seven areas of waste. We call these "The Seven Deadly Wastes of Logistics".

1. **Overproduction:** Delivering products before they are needed is overproduction. More serious for the entire supply chain is demand information overproduction—what Toyota calls "created demand." Created demand is caused by requesting a quantity greater than needed for end use or requesting it earlier than needed. Created demand typically adds 40% to supply chain volume fluctuation at the part number level.
2. **Delay/Waiting:** Any delay between the end of one activity and the start of the next activity. Examples include the time between the arrival of a truck for a pick-up and the loading of the trailer, and the delay between receiving the customer's order information and beginning to work on fulfilling the order.
3. **Transportation/Conveyance:** Unnecessary transport that results in added cost. Examples include out-of-route stops, excessive backhaul, and locating fast-moving inventory to the back of the warehouse causing unnecessary material handling distances to be incurred.
4. **Motion:** Unnecessary movement of people, such as walking, reaching and stretching. Examples include extra travel or reaching due to poor storage arrangement or poor ergonomic design of packaging work areas.
5. **Inventory:** Any logistics activity that results in more inventory being positioned than needed or in a location other than where needed. Examples include early deliveries, receipt of order for a quantity greater than needed, and inventory in the wrong DC.
6. **Space:** Use of space that is less than optimal. Examples include less than full/optimal trailer loads, cartons that are not filled to capacity, inefficient use of warehouse space, and even loads in excess of capacity.
7. **Errors:** Any activity that causes rework, unnecessary adjustments or returns. Examples include billing errors, inventory discrepancies and adjustments, and damaged/defective/wrong/mislabeled product.

Examples of The Seven Deadly Wastes of Logistics and Solutions

Following are real examples of The Seven Deadly Wastes of Logistics, including applied solutions and actual results.

1. Overproduction

- **Example 1.1:** Overproduction (producing or preparing products before they are needed by the customer process) is the worst muda of all because overproduction contributes to the other six forms of muda. Unfortunately, many people do not see the impacts of overproduction of demand information on their supply chain. Let's look at how Toyota managed the overproduction (and underproduction) of demand information.

  Before computers, automobile dealers used Cardex files to manage their service parts inventories. This manual process limited dealer parts managers to monthly stock replenishment orders. Having to forecast customer demand more than one month into the future created a lot of forecast error and demand fluctuation. When computers were introduced, the industry moved to weekly stock replenishment orders, but traditional sales policies (e.g., volume discounts and month-end sales pushes) continued to cause large volume fluctuations that distorted true demand and overburdened suppliers, warehouse operations and transportation. At Toyota, weekly dealer service parts stock replenishment orders were received throughout the day and processed to the warehouses on night batch. Starting the next morning, orders were picked and staged on the shipping dock where the day's critical order parts were added prior to shipment. Trucks would leave in the evening for delivery to dealers the following day. Order cutoff to receipt time averaged over 40 hours. Weekly stock replenishment and supply lead-time required dealers to carry 70 days' supply of inventory.

  - **Solution 1.1:** Leading the industry in transitioning to daily stock order replenishment using a "sell one, buy one" method, Toyota scheduled separate order cutoff times by delivery route. Immediately after the cutoff time, orders were processed, picked, packed and shipped. With daily stock order replenishment and Toyota's industry leading fill rate, critical orders dropped to 1-3% of volume from over 30%. Average order cutoff to receipt time dropped to 14 hours. Daily stock replenishment and lead-time reduction allowed dealers to reduce their supply of inventory to 35 days (-50%) while increasing the number of part numbers stocked by 50%. Leveling demand dramatically improved supplier efficiency and delivery performance (up to 50% higher than competitors). Eliminating "created demand", enabled Toyota to cut its inventory and increase productivity.

- **Example 1.2:** At ConAgra, a total of between 15,000 and 20,000 head of cattle were slaughtered each day at four meat packing plants (located in Colorado, Kansas, Nebraska, and Texas). The focus was on maximizing production and yield every day with little consideration given to actual demand for the products. While production numbers may have been impressive, this caused serious problems for logistics. Logistics had less than one day of finished inventory storage capacity in its automated warehousing network, which meant that the inventory had to move, regardless of demand. This frequently required loading trailers and shipping products (generally eastbound with no firm destination) while the sales department desperately searched for customers to buy the product. Every hour that passed and every mile driven required price reductions until a customer could be found. If no customer was found, the product was delivered to a refrigerated warehouse where the product was flash-frozen and stored until the product could be sold – usually at a significant loss.
  - **Solution 1.2:** Applying genchi genbutsu techniques, ConAgra discovered that its problems were rooted in inadequate demand planning for their finished product. Weather patterns and economic shifts played an important role in determining the type of product to produce. Cold weather meant more roasts; warm weather meant more steaks or burgers grilled outside. A depressed economy might force a spike in demand for lower-cost cuts of meat while a robust economy might support more filet mignon. While this might be intuitively apparent, ConAgra possessed no reliable demand-planning tool to predict these changing demand patterns. To address this problem, a sophisticated demand-planning tool was developed and implemented, taking all the variables into account. ConAgra was now able to effectively align production with demand and develop more accurate production plans. These improvements resulted in a 35% increase in sales forecast accuracy.

2. **Delay/Waiting**
   - **Example 2.1:** Because of the separation of production, warehousing and transportation activities, each of these functions is often unaware of the schedule for the subsequent process. Many operations and modes of transportation operate with cutoff times. For example, FedEx and UPS have cutoff times at the end of the workday so that shipments

can clear their hubs and be loaded on night flights to destination hubs; railroads have cutoff times for railcars to reach their switching yards for train makeup; ocean carriers have cutoff times for containers to arrive at their terminals to be loaded on specific vessels.

  - **Solution 2.1:** By coordinating production and shipping operations with these cutoff times, shippers can avoid having their shipments delayed and waiting for the next shipment by their logistics partner.

- **Example 2.2**: The Formica production and warehousing work force was unionized and the work rules and multiple job classifications restrictive. It was not allowed, for example, for production personnel to move product beyond an imaginary line in the facility that separated manufacturing operations from the finished goods storage and distribution operation. When receiving product, forklift drivers could take product no further than the dock. From the dock, designated forklift drivers could take the product no further than the end of the row where product was to be stored. These products were then picked up and put away by yet another forklift operator. For shipping operations, similar restrictions applied. In total, there were some 29 job classifications that caused serious delays and overall productivity levels that led to a significant loss of market share for the company.
  - **Solution 2.2:** Applying genchi genbutsu techniques, each production and distribution activity was closely observed and opportunities identified for improvement by both qualified industrial engineers and union stewards. These opportunities were then evaluated for their impact on productivity improvements and a plan developed to present to the union for approval. The goal was to significantly reduce and rationalize the number of restrictive work rules in order to eliminate delays and increase productivity. With the ultimate support of the union, the work rules were rationalized (from 29 to 18) and unnecessary delays were dramatically reduced.

3. **Transportation/Conveyance**

- **Example 3.1:** Service parts for the nine large Toyota dealers in the Denver area were shipped from a parts depot in Kansas City—600 miles away. In the days of weekly stock order replenishment, five dealers got their parts on Wednesday and four on Thursday (two shipments per week). Usually one semi-trailer for each day was sufficient, but occasionally (such as after a month-end sales push) an extra truck (dispatched partially empty, of course) had to be called in for the overflow. When Toyota transitioned to daily stock order replenishment, the carrier got out his rate book and quoted a price for five trucks per week servicing all nine Denver dealers each day—150% more money than two trucks per week.
  - **Solution 3.1:** Toyota's "systems thinking" approach to JIT logistics dramatically reduced demand fluctuation, allowing Toyota to promise its carrier 40% of a truckload from Kansas City to Denver each day. Toyota asked the carrier to throw out his rate book and go sell his daily, time-specific 60% of a truckload to other customers. This solution was revenue neutral with the old way.
- **Example 3.2:** Transplace, a North American third party logistics service provider (3PL), managed dozens of major shippers' transportation needs independent of each other. There were significant wasted (i.e., deadhead) miles in many of these shippers' networks between the unloading process and driving to pick up the next assigned load.
  - **Solution 3.2:** Employing genchi genbutsu techniques, various account teams methodically identified specific lanes and the deadhead (i.e., empty) miles that were traveled within each of their respective account networks. Working collaboratively with other account teams, they systematically combined multiple shipper networks into a single network and identified regular backhaul lanes for one shipper that were regular headhaul lanes for another shipper. Then, by negotiating "dedicated" lane agreements

with select truckload carriers, they were able to offer dedicated services within specific lanes that dramatically reduced deadhead miles. This also provided a reduction in transportation costs and, due to more dependable service reliability, overall inventory reductions. Kaizen processes continue to identify more freight to add to the overall network.

4. **Motion**
   - **Example 4.1:** Storage arrangement in warehouses can have a surprisingly significant impact of labor productivity and space/equipment utilization. Toyota's U.S. service parts warehouse network and inventory control system were originally set up in the 1960s through mid 1980s by managers hired from U.S. automakers and run in a traditional fashion. Rapid sales growth put a great strain on warehouse facilities and people, potentially adding greatly to costs. Most of the regional depots were running out of space, and labor productivity was similar to industry average.
     - **Solution 4.1:** By the late 1980s, Toyota Japan had successfully deployed Toyota Production System concepts to their service parts distribution operations. In 1987, Toyota's Japanese warehouse experts began supporting hungry learners in Toyota's U.S. Parts operations to implement TPS and JIT logistics. During a 13-year period when sales grew 126% and stocked part numbers grew 72%, only 14% was added to warehouse space, greatly reducing capital investment. This more dense storage and intelligent location of parts, combined with efficient small batch processing, enabled Toyota to achieve a 50% labor productivity advantage over competitors.
5. **Inventory**
   - **Example 5.1:** About 30 years ago, Toyota had eight months supply of service parts inventory in its U.S. regional parts distribution centers.
     - **Solution 5.1:** By implementing frequent small lot ordering throughout the supply chain and managing inventory at the part number level, inventories were reduced to under one month's supply.
   - **Example 5.2:** At Curtin Matheson Scientific (now part of Fisher Scientific) thousands of SKUs were distributed throughout the 48 contiguous states. These products were segmented into Clinical and Industrial groupings depending on the type of customer they were sold to. Virtually all of these products were stocked at each of the 22 U.S. distribution centers (DC's), even though the typical customers for each line were dramatically different.
     - **Solution 5.2:** In a kaizen, supported by sales and marketing, it was determined that the ordering processes and lead time requirements were significantly different for these two customer groups. Industrial customers were typically large manufacturing operations that placed replenishment orders with a 30-day order-to-delivery lead time. Clinical customers were typically small doctor's offices or clinics that relied on nurses or other support staff to place orders. It was not unusual in this environment to place an order when supplies were nearly out or entirely depleted and expect a next-day delivery. The result of these findings was that the company was able to consolidate Industrial products into five DCs with Clinical supplies stocked in all 22 DCs. After further kaizen, it was determined that the necessary delivery requirements could be met with only 19 DCs. Additional kaizen resulted in slow-moving or dead stock being located in one central DC. The result was an overall inventory reduction of nearly 40%.
6. **Space**
   - **Example 6.1:** Rapid growth at Toyota's first North American parts center began causing congestion at the shipping dock doors. Warehouse operations management submitted a capital proposal to construct additional dock doors.

  - **Solution 6.1.1:** Practicing genchi genbutsu (supported by Toyota warehouse experts from Japan) it was discovered that there was some unused space in many outgoing trucks (estimated at 6% additional capacity). A kaizen activity involving the loaders effectively utilized this additional space, eliminating the need for additional dock doors and cutting transportation costs by 6%.
  - **Solution 6.1.2:** Further genchi genbutsu revealed (1) that the cartons used by some North American suppliers had more empty space than like parts previously sourced from Japanese suppliers, and (2) that the cartons into which parts picked by different pickers were consolidated into were not completely filled. Kaizen activities by the responsible personnel further improved the density of shipments, allowing more sales growth before investing in new dock doors and saving 10% in transportation costs.
- **Example 6.2:** At Denso, a manufacturer of electrical components for Toyota (and many other auto makers), pallets measuring 60" x 60" were used for the shipment of air conditioning kits. This created waste when loading trailers since a typical 96" wide trailer could only be loaded one pallet wide—not two, as is optimal with a standard 40" x 48" GMA pallet.
  - **Solution 6.2:** Applying genchi genbutsu techniques, it was discovered that the Freon® tubing used in most Toyota, as well as Honda, models was constructed in one continuous piece, resulting in oversized carton sizes requiring a 60" x 60" pallet. The "Five Whys" technique uncovered an opportunity to redesign the tubes by "breaking" them into several shorter pieces and reconnecting them into a continuous piece during installation into the vehicle. This solution resulted in packaging dimensions that enabled the use of standard pallets. Transportation cost savings were nearly 40%; pallet costs were dramatically reduced since Toyota could now use standard pallets; and the use of dock space was significantly improved since fewer loads were required to ship the same number of air conditioning kits.

7. **Errors**
- **Example 7.1:** In Toyota's service parts packaging operations, mislabeled cartons were the number one cause of errors.
  - **Solution 7.1:** In a kaizen, a very inexpensive and effective countermeasure was implemented. If, for example, a packer had 10 cartons of a part number to pack, he/she was given 12 labels. The first label was stuck on a form with a row of circles below the label for each digit in the part number. The packer would write the part number from the parts to be packed in the circles and compare it with the part number on the label. After packing the 10 cartons, the packer repeated the process with the 12th label and last part. Labeling errors dropped dramatically.
- **Example 7.2:** At Formica Corporation, a wide variety of laminated and solid-surfaced materials was produced. As a result of manufacturing and logistics metrics that rewarded short cycle times and on-time shipments, product was often shipped that was damaged or defective. This resulted in high error rates (i.e., returns, credits, warranty claims) and disgruntled customers. It was recognized that this had led to lost market share and a deterioration of a world-recognized brand.
  - **Solution 7.2:** A cross-functional kaizen team determined that a comprehensive set of performance metrics was needed that would align overall execution with strategy and would eliminate conflicting performance objectives by department—in particular, manufacturing and logistics. Key Performance Metrics (KPIs) were developed that focused on customer requirements and were applied throughout the organization. Rewards were tied to customer satisfaction, market share, and overall corporate performance objectives. The results were impressive, with a 70% reduction in claims, steady market share gains, and improved financial performance.

Eliminating "The Seven Deadly Wastes of Logistics"—Culture is the Key

Companies attempting to adopt and apply TPS principles to the service sector will be challenged to approach the efficiency and quality achieved at Toyota. For this to occur, it is critical that the necessary culture be fully understood, embraced and practiced in order to utilize the full human potential of every employee for the continuous improvement of your business. While there are many seminars and consulting practices geared towards the tools of TPS (or lean/Six Sigma), this is only the tip of the iceberg. TPS requires a top-down approach that becomes part of the corporate fabric. Teaching TPS cannot take place in a classroom or through seminars, but where the operations actually take place. To be effective, everyone must be fully aware of the various forms that waste can take and be constantly vigilant of any opportunities to attack and eliminate these wastes. Senior executives must regularly walk through the operations, observing the activities, asking questions, and demonstrating their commitment to the process. Too often, companies treat these processes as programs that can be started and stopped as needed. They seldom give it the necessary support and time to become part of the corporate culture—what is referred to as the *Human System for Lean Management* by Lean Consulting Associates colleagues who have used their 20-plus years of Toyota experience to document the Toyota business and management culture in North America.

Joel Sutherland served as the Vice President of Operations at Denso, Toyota's largest global supplier and a Toyota group company, where he worked for over a decade. As Denso's most senior American executive Joel had complete supply chain responsibilities including procurement, production planning and scheduling, manufacturing, warehousing and distribution, inventory management, customer service, and reverse logistics. In this capacity, Sutherland had to master the Toyota Production System and pass along the essential cultural and operational principles through rigorous mentoring and "walking the talk" to Denso associates as well as his vast North American supplier base. For the past twenty years he has applied the TPS to other Fortune 500 companies in manufacturing, wholesale distribution and third party logistics with tremendous success. Joel is a past president of the Council of Supply Chain Management Professionals (www.cscmp.org) and is currently Managing Director of Lehigh University's Center for Value Chain Research. For more information on Joel, go to www.lehigh.edu/~jos206

Bob Bennett was the successful leader of the lean transformation throughout Toyota's entire North American service parts supply chain, creating the industry benchmark. During his 28 years at Toyota, Bob managed product planning, service, product development, production operations, procurement and logistics, ultimately serving as a group vice president and officer of Toyota Motor Sales, U.S.A., Inc., and General Manager of Toyota's North American Parts Logistics Division. In this role he led the deployment of the Toyota Production System (TPS) throughout his supply chain of 535 suppliers, 13 distribution centers, 7 North American distributors and 1,400 Toyota and Lexus dealers. Bob's work has been documented in Jim Womack's and Dan Jones' book, Lean Thinking. As President of Lean Consulting Associates, LLC, he is now successfully supporting other executives in becoming effective implementers of the Toyota Production System and the Toyota Way. For more information on Bob and his team of Toyota "alumni" with 1,400 years of experience from the inventors of Lean manufacturing and logistics, go to www.leanconsultingassociates.com