E X C H A N G E

The Toyota Way in Services: The Case of Lean Product Development

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Executive Overview

Toyota's Production System (TPS) is based on "lean" principles including a focus on the customer, continual improvement and quality through waste reduction, and tightly integrated upstream and downstream processes as part of a lean value chain. Most manufacturing companies have adopted some type of "lean initiative," and the lean movement recently has gone beyond the shop floor to white-collar offices and is even spreading to service industries. Unfortunately, most of these efforts represent limited, piecemeal approaches—quick fixes to reduce lead time and costs and to increase quality—that almost never create a true learning culture. We outline and illustrate the management principles of TPS that can be applied beyond manufacturing to any technical or service process. It is a true systems approach that effectively integrates people, processes, and technology—one that must be adopted as a continual, comprehensive, and coordinated effort for change and learning across the organization.

Introduction

These days it is difficult to get through a business school curriculum without analyzing case examples of Toyota and Toyota group companies. Viewed as one of the excellent companies in the world, most cases and discussions revolve around the famed Toyota Production System (TPS). TPS is the foundation for what has become a global movement to "think lean." Most manufacturing companies in the world have adopted some type of "lean initiative," and this concept is now spreading to a diverse range of organizations, including the defense department, hospitals, financial institutions, and construction companies. *The Toyota Way* (2004) became an international bestseller because it delves more deeply into the underlying culture and thinking that manifests as the tools and techniques generally associated with lean manufacturing.

Many manufacturing companies have learned the hard way that the isolated application of lean tools and techniques does not lead to sustainable improvement. The broader organizational culture of the firm separates the short-term improvements from the long-term lean enterprises. And, to be effective, lean thinking cannot stop at the shop floor. Management principles must extend beyond the shop floor, as they do at Toyota, and be found in the board room, the sales offices, and quite clearly in the product development process.

The Machine that Changed the World (Womack et al. 1990) introduced the term "lean" and then essentially described Toyota. While there were many companies studied, we later learned in *Lean Thinking* (Womack and Jones 1996) that Toyota was in fact the model for lean. Womack and Jones have emphasized that the production floor was just one chapter in *The Machine that Changed the World*. The book was about a total enterprise working together to give customers what they

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want while eliminating waste in the value stream and striving for perfection. This was *not* just a manufacturing book.

Since the 1980s, companies throughout the world have been looking to Toyota as a model for manufacturing. Now it is almost a given that a manufacturing company needs some sort of "lean" program to be competitive. The traditional big-batch mass production model has been supplanted by a lean production model. However, the movement recently has gone beyond the shop floor to white-collar offices and is even spreading to service industries. For example, one would be hard-pressed to find a hospital in the United States that is not aware of lean principles and considering some sort of lean program. Applying lean concepts to technical and service operations, where work is much less repetitive than the shop floor and the product less tangible, is not straightforward, however.

Clearer lessons for lean services can be found not in the manufacturing side but by examining Toyota's Product Development System, which is thriving on lean principles that were derived separately from the manufacturing operation. Toyota has taken the same underlying principles of the Toyota Way and evolved a product development system that is second to none. It is lean in the broadest sense—customer focused, continually improved through waste reduction, and tightly integrated with upstream and downstream processes as part of a lean value chain.

Toyota's Product Development System has enabled it to consistently develop higher quality vehicles faster, for less cost, and at a greater profit than their competitors. They also manage more new vehicle launches annually than most of their competitors, thus creating a steady flow of high-quality new products to meet consumer demand. This ability has fueled industry-leading profits (reaching a Japanese record of ten billion dollars by 2004 and exceeding that in 2005) and a market capitalization greater than GM, Ford, and DCX combined with a continuing growth in market share targeted to be 15 percent of the global market, which will make Toyota the world's largest auto maker.

One of the important drivers of this performance is the quality of new Toyota products. Objective data show that Toyota excels in new product quality. The J.D. Powers survey for initial quality in the first 90 days of ownership is an indicator, which Toyota has dominated during this decade, with 39 first-place vehicles since 2001, including a phenomenal ranking of 10 first place vehicles out of 16 categories in 2005. Regarding speed to market and product freshness, Toyota can consistently bring a new body with carry-over chassis and powertrain (the most common type of automotive product development) from styling freeze to start of production in just 15 months; more basic categories of vehicles, such as Corolla, require only 12 months. This compares to competitors who require from 20 to 30 months to accomplish the same task.

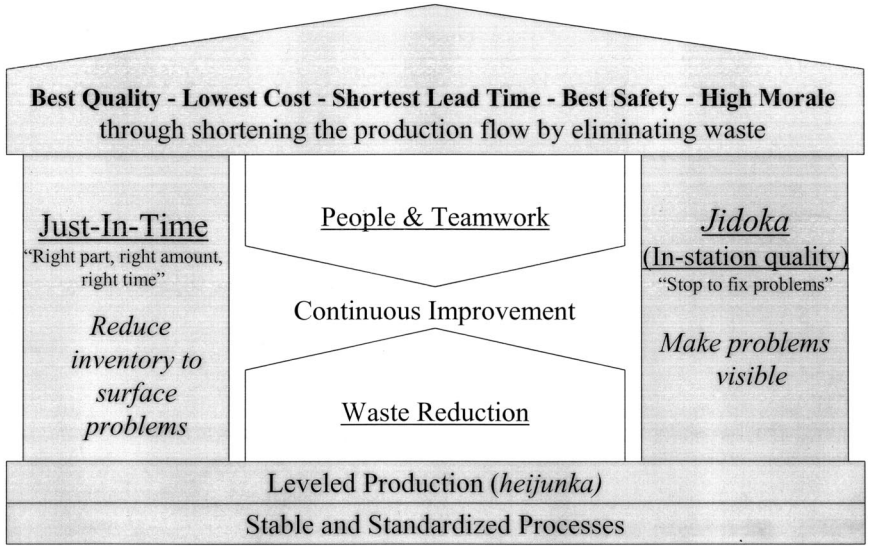
This article outlines and illustrates the management principles of the Toyota product development system that can be applied to any technical or service process (for further information, see Morgan and Liker, 2006). It provides a different look at how the basic principles of the Toyota Way can apply to service operations. We argue that it is a true systems approach that effectively integrates people, processes, and technology. Toyota's approach to product development has evolved as a living system with its own trials and tribulations, but a consistent trend upward through ongoing learning and continuous improvement supports the value in its approach.

Review of TPS Principles

The Toyota Production System (TPS) is the best-known example of lean processes in action. It has become a model for competitive manufacturing throughout the world. It has been evolving within Toyota for decades, although a central tenet of the Toyota way prevented anyone from writing it down. The tenet is that serious learning only comes from action at the *gemba*—where the work is done. So drawing pictures and models of TPS is not value added.

Eventually, the theory behind TPS was represented as a house. The TPS house has become a cultural icon in the manufacturing world. The simplest version is shown in Figure 1. It is repre-

Figure 1
The Toyota Production System House



sented in this way because a house is a system and only as strong as the weakest part of the system. With a weak foundation or a weak pillar, the house is not stable, even if other parts are very strong. The parts work together to create the whole. The parts are as follows:

Just-in-Time

This aspect of the house is the most well-known. It relates to making material flow through processes very fast, getting the right part to the right place at the right time. We might create a manufacturing cell where raw material moves from operation to operation one piece at a time without interruption. In some cases, it is necessary to interrupt the flow to connect separate processes together in some other way. For example, a stamping press might build in batches between changes of dies and cannot be practically put in a cell. So a supermarket concept was used, with stamping refilling a store up to certain maximum levels of inventory and then waiting to replenish only what the customer takes away. Instructions from the customer, called *kanban*, trigger replenishment of the store. This simple concept of pull through replenishing stores can be applied all the way back to raw material suppliers.

Jidoka

Jidoka is a lesser-known and more complex concept. It represents a machine with human intelligence. The intelligence is to do one simple task—detect a deviation from a standard and stop itself while waiting for help. This concept has been extended to manual processes in which operators pull a cord and stop production when there is any problem. When a machine or person stops for problems, they also need to signal for help. An *andon* is the use of lights and sounds to call for help. Pull the cord, and an *andon* lights up, music plays, and a team leader or group leader is called to come help—not in the next few hours but in the next few seconds. By stopping for problems the problem is contained in an area before it leaks out, possibly even leading to a defect for the customer. Problems are also constantly being surfaced, leading to continuous improvement.

Heijunka and Stable, Standardized Processes

The foundation of the house needs to provide the overall stability on which just-in-time systems can be built and the system constantly adjusted by stopping to fix problems. *Heijunka* means leveling. The goal is to create a leveled stream of orders and a level work load. When the work load is leveled, there are opportunities to standardize processes. And leveling the work load is also necessary to know how much

inventory to hold in the supermarkets. If there can be a run on the store for a particular product, the system will not be able to keep up. Stable, standardized processes are necessary, or just-in-time production will mean no production. Without inventory to compensate for instability, the system will constantly shut down. And this will be even worse if someone is pulling the cord and stopping the line every time there is a problem.

People Engaged in Kaizen

Kaizen has practically become a universal word. But is rarely practiced in most organizations as true continuous improvement that spreads throughout the organization. *Kaizen* is not optional in a lean system. Lowering inventory means problems truly shut down the operation, starving downstream processes for parts. *Jidoka* means machines and people are shutting down the system when there is a problem. This surfaces problems and is great if people are skilled and motivated enough to solve the problems very quickly. Otherwise the result is simply an erosion of production efficiency and competitiveness.

It should be clear that this really is a system. Toyota uses the analogy of trying to navigate through waters while lowering the water level to reveal the rocks. The water level is like inventory. The rocks are problems. When you lower the inventory problems are exposed and unless they are solved the boat will crash on the rocks. *Jidoka* also reveals rocks throughout the day. Surfacing problems is only valuable if people working on the process have the tools and are motivated to first contain the problems and then solve them at the root cause. It is an endless journey of improvement.

Many companies are trying to take TPS principles beyond the shop floor to service operations and even to professional operations. But there is confusion about how to imitate TPS in the service environment. Should *kanban* be circulated to everybody so they can order the next small batch of services? Should an *andon* be hung over each person's desk to call for help? Should we set people up in cells passing paper or doing a piece of computer work one step at a time? In varying degrees and ways, all of these things have been tried with some success in service operations (Liker 2004). But is there more to it than this? As we look at different components of Toyota's product-process development system, we see similar principles to TPS emerging but applied in a somewhat different way.

Toyota's Management Principles in Lean PPD

Based on over 15 years of research at the University of Michigan, more than 20 years of product development experience, and privileged access to Toyota and the patient guidance of our Toyota *Sensei*, we developed a model of a Lean Product-Process Development System. The research base began with studies by Liker, Ward, and their students that led to the creation of the set-based concurrent engineering model (Ward et al. 1995; Sobek et al. 1999). Durward Sobek took this research a step forward in his dissertation through a broad comparison of Toyota's product development system to Chrysler's then emerging platform organization of product development (Sobek 1997; Sobek et al. 1998).

Building on this stream of research, Jim Morgan in his dissertation drew on his decades of direct product development experience and conducted a two-and-a-half-year, in-depth study of Toyota's automotive body development, as compared to one of the American "Big 3" automakers (Morgan 2002). The scope of Morgan's study included body engineering, manufacturing engineering, prototype development, die manufacture, and die and stamping approval. Data and information were gathered through interviews with Toyota and supplier representatives and site visits. Over 1,000 hours of interviews were held with 40 people at 12 different sites in the U.S. and Japan. Company representatives from executive management, body engineering, manufacturing or production engineering, tool manufacture, as well as several Chief Engineers participated in the interviews.

This in-depth study of Toyota's approach to product-process development led to the identification of a set of 13 management principles that can be considered a foundation for lean product development more generally. We organized these

into a framework of process, people, and tools-technology, which can be applied to service industries and professional operations. The important lesson to note is that it is a systems model. What makes it work at Toyota is that all the pieces fit together and support each other. Pull out a piece of the system and it collapses. Toyota Vice-Chairman Fujio Cho explained it this way:

> The key to the Toyota Way and what makes Toyota stand out is not any of the individual elements. . . But what is important is integrating all the elements together into a system. It must be practiced every day in a very consistent manner—not in spurts.

Process. When thinking of process improvement, we often think of simple repetitive processes. In manufacturing, we can watch a worker do a job and time it several times and try to *kaizen* out seconds of work. This is obviously not the case with product development. Yet, Toyota views product development as a process—albeit a broader, more complex, and less precise process than most short-cycle manufacturing jobs. In so doing Toyota has been able to standardize the process, refine it, eliminate waste, and continually reduce both lead time and cost from program to program. The process starts with specific stretch objectives for each program and the teams virtually always achieve the targets.

People. Driving the lean process and rigorous standardization are people who work hard as a team to achieve common objectives. They not only do the work with high levels of skill and discipline but also reflect on the process and work to improve it. This activity happens on a continuing basis. It is true continuous improvement. To do this work requires people with "towering technical competence" who learn the specific technology they are engineering in tremendous depth and also learn through intense mentoring in the "Toyota Way" of identifying problems, analyzing them, developing countermeasures, communicating, and improving. The deep technical knowledge is the baseline skill, and the Toyota Way is the higher level meta-improvement method that is part of the culture of the company.

Tools. Technology to Toyota is a set of tools to enable the people to execute and improve the process—no more and no less. As one Toyota Vice President explained: "Computer technology does not change the way we work. It simply helps us do what we do faster." Doing wasteful work such as rework faster is still waste. If you cannot do a good job of defining the project, identifying problems, developing appropriate solutions, communicating effectively to the right people, and meeting deadlines, then technology will not solve your problem. It may even mask the problems. Toyota does not subordinate good thinking to technology.

We describe each of these elements of the system in greater detail below. Next, we give examples of how they mutually support each other as a system. Finally, we discuss some of the challenges of learning from Toyota.

The Right Process Will Yield the Right Results

We often think of process improvement as a technical issue. Get the right technical methodology (these days, often analogous to business processes for software use), justify its cost, implement it, and it runs. If it does not run as planned, it is a management problem. Identify the offending manager who failed to properly execute the business process, get rid of him or her, find a "good manager," and hopefully the problem is solved.

Toyota has a very different perspective. At Toyota there is a philosophy of having a good process. It is as much a philosophical issue as a technical issue. There are a set of beliefs about what makes up a good process. A good process is not defined by technology but by good process principles, and then people create and improve the process according to these principles.

A summary of the process principles of lean product development is provided in Table 1. We will discuss each principle in turn.

Establish Customer-Defined Value

The customer is always the starting point for any process. This is not an unusual statement. Any company exposed to Total Quality Management, Baldridge concepts, or any of the myriad articles on quality in the last 20 years has some variation of this approach in their mission statements. The difference is talk versus action. Toyota has made

this value a part of the culture of the company. Culture goes below the surface of artifacts and slogans to the values, beliefs, and taken-for-granted assumptions of employees.

"Customer first" creates alignment out of conflict. As an example, a common problem in automotive development is what seems to be inherent conflict between those who style the car, essentially artists, and those who engineer the car. Stylists want looks. Engineers want functionality and manufacturability. The two do not always meet. Ask body engineers at Toyota about this conflict and they are genuinely confused, especially if they did not already work for another auto company. They see no conflict. "We are both serving the customer, so why would there be a conflict?"

Second, adding value at Toyota is defined by customer value. The famous passion to eliminate waste in the Toyota Production System also applies in product development. Waste is what costs time and money and resources but does not add value from the customer's perspective. Eliminating waste to focus on adding value to customers provides a common reference point for engineers working to improve the process.

Finally, Toyota has created specific tools and methods such as the *Obeya* team system (described later) to align, execute, track, and deliver customer-driven objectives throughout the program team.

Front-Load the Product Development Process

This is another bit of common wisdom in product development and part of the quality movement's philosophy as well. Do it right the first time to avoid very costly downstream design changes that introduce dangerous last-minute variation and delay product introductions. At Toyota, preventing this means deep exploration of a wide range of potential problems and alternative solutions early in the process.

Toyota's definition of early is quite early. In many automotive companies serious engineering in body development does not begin until after clay freeze. This is the point at which the stylists who create the vehicle appearance through sketches and clay models are finished and the executives have signed off on a single body style. This is then digitized and the surface is transferred to CAD and engineering departments. This often represents the starting point for body engineering, which has to develop the detailed part designs used to tool up the vehicle. A good deal of both structural and manufacturing engineering has to be done to develop safe, manufacturable body structures. Yet for Toyota most of the important simultaneous engineering of the product and manufacturing process begins much earlier than clay model freeze, during what they refer to as *Kentou* or study period. During this time cross-functional teams generate hundreds of *Kentouzu*, or study drawings, as they investigate alternatives for opti-

Table 1
Process Principles of Lean Product Development

Principle	Description
1. Establish customer-defined value to separate value added from waste.	Lean is a never ending journey of waste elimination. Waste is non-value added defined by first defining customer value.
2. Front load the product development process to thoroughly explore alternative Solutions while there is Maximum Design Space.	Defining the wrong problem or premature convergence on the wrong solution will have costs throughout the product life cycle. Taking time to thoroughly explore alternatives and solve anticipated problems at the root cause has exponential benefits.
3. Create a leveled Product Development Process Flow.	Leveling the flow starts with stabilizing the process so it can be predicted and appropriately planned. This allows product planning to reduce wild swings in work load. Predictable work load swings can be staffed through flexible labor pools.
4. Utilize Rigorous Standardization to Reduce Variation, and Create Flexibility and Predictable Outcomes.	Standardization is the basis for continuous improvement. Standardization of the product and process is a foundation for all the other process principles.

mal solutions (Sobek 1997; Morgan 2002). In this way they are able to work on system compatibility before individual design completion, eliminating most of the late engineering changes. This front loading process also isolates much of the variability that is inherent to product development allowing for speed and precision during the execution phase of product development.

The late Allen Ward led the development of a design theory called "set-based concurrent engineering" (Ward et al. 1995; Sobek et al. 1999). The concept seemed counterintuitive. Go faster in the product development process by considering a broader set of alternatives earlier and delaying certain decisions. It was referred to as "the second Toyota paradox," the first being Just-In-Time where holding less inventory can make it more likely you will have the parts you really need when you need them. Of course, reducing inventory by itself or taking a long time to make decisions by itself does not ensure success. The set-based search process must be systematic and well executed.

Create a Leveled Product Development Process Flow

Once you define value and have resolved the majority of engineering and design challenges (i.e., achieved basic design stability), lean product development requires a waste-free process to speed the product to market. You can manage and improve the PD process much like any other process. Although you may have many specific and unique design challenges, the tasks you must perform and their sequences are usually similar across programs. In this sense, a lean product development system is a knowledge work job shop, and as such you can continuously improve it using adapted forms of tools used in repetitive manufacturing processes, such as value stream mapping and queuing theory, to eliminate waste and synchronize cross-functional activities. Toyota utilizes this powerful perspective of a knowledge work job shop to level workload, create and shorten management event cadence to work to a customer-demand rate and minimize queues, synchronize processes across functional departments and supporting technologies, and virtually eliminate rework.

We do not mean to imply Toyota has directly applied the concepts from the Toyota Production System to product development. But they have developed a specific set of powerful tools and methods to create leveled flow in their product development process based on principles quite similar to those that underpin the Toyota way in manufacturing. Consequently, much of what they do is intuitive within the product development process itself.

For example, through experience running product development programs from concept to full-scale production focusing on learning, continuous improvement, and process standardization, Toyota can predict with great accuracy the engineering labor hour requirements at various points in the process and reliably predict fluctuations in PD system resource demands. It looks roughly like a bell-shaped curve with few people early on reaching a maximum around the middle when designs are finalized and then winds down into production launch. They have stabilized the process to the point that this plan fits reality quite well. But they do not want to have all the people needed at the peak of programs on the program for the entire time, even when they are not needed. So they assign people to programs in a leveled way, peaking at some level and drawing on flexible labor pools for people needed above this level at the peak of the program. The flexible labor pool includes a central pool of technicians and engineers from outside suppliers. This approach allows them to level the schedule of engineers and fully utilize the time of the engineers.

Utilize Rigorous Standardization to Reduce Variation and to Create Flexibility and Predictable Outcomes

The challenge in product development is to reduce variation while preserving the creativity that is necessary to the creative process. In fact, Toyota creates higher-level system flexibility by standardizing lower level tasks. There are three broad categories of standardization at Toyota.

1. Design Standardization is achieved through common architecture, modularity, reusability, and shared components.
2. Process Standardization is accomplished by de-

signing products and building foot-printed manufacturing facilities based on standard lean manufacturing processes.
3. Standardized Skill Sets for Their Engineers gives flexibility in staffing and program planning and minimizes task variation.

Standardization provides the foundation for Toyota to develop elegant solutions to traditionally highly cyclic resource demands inherent in most PD systems. It also allows them to create highly stable and predictable outcomes with both quality and timing in an unpredictable environment. We recall a young American engineer hired by the Toyota Technical Center in Michigan saying: "When I worked on my first design they gave me the checklist for that body part. The part practically designed itself. All I had to do was go through the checklist."

One might expect that this engineer felt hamstrung by the checklist and rigidity of the standards. Yet, the engineer felt highly challenged and in fact overwhelmed by his first Toyota vehicle program. He had first worked for an American auto company and said he "felt sorry for his friends still there. They only get to work on one piece of the program where I take my part from start to launch." He explained there are so many well thought out processes at every step of Toyota's product development that he always has something new to learn. At the end of one program he had just gone through all this once and his head was swimming. It would take years of going through the process multiple times to become confident and really begin to innovate with the product itself.

People Systems

People provide the intelligence and energy to any lean system. People Systems includes the recruitment and selection of engineers, training and professional development, leadership styles, organizational structure, institutional learning and memory, and the elusive thing called organizational culture. Culture refers to shared language, symbols, beliefs, and values. A measure of the strength of the culture is the degree to which these things are truly shared across members of the organization, and Toyota has a very strong culture.

While many companies are attempting to reduce reliance on people to cut costs through methods like automation or shipping out engineering work to low-wage engineering service firms, Toyota's system is built around people who are thoroughly immersed in the Toyota Way. It must be part of their DNA, according to Toyota. This reduces the ability to instantly move work from one country to another in the virtual world, unless Toyota has made the investment in developing people and deep relationships in those other countries. The principles of people systems are all about developing people who challenge, think, and continuously improve the product and process (see Table 2).

Table 2
People Principles of Lean Product Development

Principle	Description
5. Develop a "Chief Engineer System" to Integrate Development from start to finish.	The chief engineer is the master architect with final authority and responsibility for the entire product development process. The chief engineer is the overarching source of product and process integration.
6. Organize to balance Functional Expertise and Cross-functional Integration.	Deep functional expertise combined with superordinate goals and the chief engineer system provides the balance sought by matrix organization.
7. Develop Towering Technical Competence in all Engineers.	Engineers must have deep specialized knowledge of the product and process that comes from direct experience at the *gemba*.
8. Fully Integrate Suppliers into the Product Development System.	Suppliers of components must be seamlessly integrated into the development process with compatible capabilities and culture.
9. Build in Learning and Continuous Improvement.	Organizational learning is a necessary condition for continuous improvement and builds on all of the other principles.
10. Build a Culture to Support Excellence and Relentless Improvement.	Excellence and *kaizen* in the final analysis reflect the organizational culture.

Develop a Chief Engineer System to Integrate Development from Start to Finish

In many companies, different functional departments are responsible for different pieces of PD (or other service processes) but nobody is responsible. Try to identify exactly what the status of the project is or where decisions are made and you get lost in the morass of endless departments. At Toyota the answer is clear. The chief engineer is responsible and can tell you the exact status of the project. Any difficult decisions will find their way to the chief engineer. The chief engineer is not just a project manager, but a leader and technical systems integrator. While many companies have someone with the title of chief engineer or program manager they often play the role of project manager, managing people and timing but not serving as a chief technical architect like at Toyota. This unique role is the glue that holds the whole PD system together at Toyota.

The chief engineer is not a manager in the traditional sense. The chief engineer is an engineer in the ideal sense. The chief engineer is the chief architect and systems integrator. Ask engineers working on a program how they know what customers want and they say we learn that from the chief engineer. Ask them how they make tough technical decisions about tradeoffs in objectives and they say we ask the chief engineer. Eventually all roads seem to point back to this one person. Ask the chief engineer how he (they are all men so far) knows everything and can make so many tough decisions and he will say something like: "That is what keeps me awake at night."

Chief engineers are only human. But they are selected and developed over decades to be the best and brightest engineers and system integrators. They have a remarkable combination of technical depth, systems awareness, market savvy, and leadership skills. At the end of the day it truly is "the Chief Engineer's car." Not every service organization needs a chief engineer, but whatever the product or service, who is responsible for taking it from start to finish with the deep expertise to see it is all done effectively with a high degree of expertise?

Organize to Balance Functional Expertise and Cross-Functional Integration

One of the more difficult tasks in developing a high-performance PD system is striking a balance between the essential need for functional excellence within specific disciplines, such as Body Engineering, Electrical Engineering, or Manufacturing Engineering, while achieving the seamless integration of those experts across departments required for the success of any individual program. While Toyota is fundamentally a functionally-organized company with emphasis on obtaining strong functional skills and skill-based hierarchy, it has augmented this approach with the unofficial power of the Chief Engineer, module development teams, and an *Obeya* system ("big room") that enhances cross-functional integration and provides a PD program focus.

Toyota has never been willing to abandon the basic functional organization. Engineers report to functional managers in their technical area (e.g., powertrain, body structures, chassis). These functional managers at Toyota are selected and grown to be teachers and mentors with deep technical knowledge. The result is deep technical expertise in every function—they know what they are doing down to a very detailed level.

Like many other companies, Toyota has found the matrix organization structure is the best balance of functional expertise and product focus. On the product side of the matrix are the chief engineers. None of the actual engineers designing cars report to the Chief Engineer. Rather they report formally up the functional hierarchy. But everybody understands they are there to serve the customer and the Chief Engineer represents the customer. So in a sense everybody works for the Chief Engineer.

Toyota is continuously improving the engineering organization. They have found a number of additional innovations to help build strong horizontal relationships while maintaining strong functional expertise. Module development teams are cross-functional teams that bring together product engineers and production engineers around a certain part of the vehicle.

"Obeya" is an innovation to improve commu-

nication and decision-making between the Chief Engineer and the functional managers. The Chief Engineer meets in the big room with a senior engineering leader from each functional organization at least every other day. There are daily meetings in the *Obeya,* where the focus is on integration across parts of the car. Visual management is used to display on walls trend charts, schedules, problems and countermeasures and other information which displays the status of the project across all the functional groups.

Develop Towering Technical Competence in All Engineers

Technical excellence in engineering and design resources is fundamental to lean product development. The modern automobile is a complex system of highly technical, interdependent components that demands knowledge of computer technology, aero and fluid dynamics, mechanics, and electronics, just to name a few disciplines. That is why it is so surprising that many automakers pay little more than lip service to truly developing technical superstars, preferring their engineers to broaden rather than deepen their experience. In fact, much of the "training" encouraged or available in many types of organizations is often so general as to be of questionable value at all.

At Toyota technical excellence is revered, which is partly why Toyota engineers spend a high percentage of their time on core engineering. Toyota begins with a rigorous hiring process, and then designs a career path that emphasizes deep technical skill acquisition within a specific discipline, focusing on mentoring of critical tactical skills that are required for engineering excellence. The principle of *genchi genbutsu* (actual part, actual place) at Toyota pushes engineers to get their hands dirty and go directly to see for themselves how the work is getting done and what the problems are. In fact in their first year engineers spend months working on the production line building cars.

Fully Integrate Suppliers into the Product Development System

Suppliers provide more than 50 percent of vehicle content for most automakers and over 75 percent in the case of Toyota. It is clear that suppliers must be a fundamental part of your lean product development system. Companies should manage and nurture their suppliers in much the same way they manage and nurture internal manufacturing and engineering resources. At Toyota, suppliers are valued for their technical expertise in addition to their parts-making capability. Pre-sourcing arrangements get them on board from the start so that they are involved from the earliest stages in concept development. Using methods like having guest engineers from suppliers work full-time in Toyota's engineering offices cement the intimate relationship between Toyota and its suppliers. It is also important to note that while Toyota does fully integrate suppliers into the process they maintain valuable commodity knowledge internally and never relinquish vehicle system responsibility.

Build in Learning and Continuous Improvement

The ability for a company to learn and improve may well be the most sustainable competitive advantage it has in its arsenal. At Toyota, learning and continuous improvement are a basic part of their day-to-day operations and their faster lead times create shorter learning cycles and form the basis for their continued dominance of their industry (Morgan 2002). Toyota is a leader in gathering, diffusing, and applying performance-enhancing information and takes on major challenges that primarily benefit learning. Their short development lead times combined with their unparalleled ability to learn as an organization create fast, effective learning cycles which accelerate their continuous improvement engine. Specific product development learning mechanisms such as the previously discussed mentoring system and learning events called *Hansei,* or reflection, are built into the basic development process to create opportunities to learn from every program.

Build a Culture to Support Excellence and Relentless Improvement

The DNA of Toyota is about very strongly held beliefs and values that are shared across managers and working-level engineers. These core beliefs compel the organization to work harmoniously toward common goals. For example, satisfying custom-

ers is a core value of all Toyota's employees and provides the basis for key decision-making. This is not the case at some auto companies, where decisions seem to be based on individual career enhancement. As one engineer who had recently joined Toyota from another auto company told us, "At my old company the focus was on building careers, at Toyota we focus on building cars." At Toyota the culture is the system. Building a culture to support excellence is a fundamental part of leadership who behave in a manner consistent with the core beliefs they espouse. All of the other principles work because the culture itself makes the principles a living part of how Toyota gets things done.

Tools and Technology

The third subsystem involves the tools and technologies employed to develop and build the product. This subsystem not only includes CAD systems, machine technology, and digital manufacturing and testing technologies, but all the "soft" tools that support the effort of the people involved in the development project whether it be for problem solving, learning, or standardizing best practices (see Table 3).

Adapt Technology to Fit Your People and Processes

Companies err when they believe that technology alone will provide the silver bullet necessary to achieve high levels of performance in product development, especially without regard to the ways in which this technology will impact current processes or people. Adding technology to a fundamentally flawed product development system will do little to help performance, and may even retard it, especially for the short term. Toyota recognizes that technology in and of itself seldom represents a meaningful competitive advantage. In fact, they see it as the least sustainable competitive advantage because it is so easily replicated. It is much more important to take the time and effort to ensure that the technology fits and enhances already optimized and disciplined processes and highly skilled and organized people. That is why they spend significant time up front and effort customizing design software and other digital simulation tools according to the Toyota Way before implementing them. It is crucial to get the process and people systems right first, and then add technological accelerators that leverage specific opportunities in your product development system.

Align your Organization through Simple, Visual Communication

While culture and customer focus is the glue that holds the organization together, at Toyota simple tools are used to help align the many designers and engineers focusing on their technical specialties. One well-known Japanese management tool is *hoshin kanri*, also known as policy deployment. This method breaks down high-level corporate goals into meaningful objectives at the working level of the organization. This method is also used in Toyota to break down vehicle objectives to specific system objectives for performance, weight, cost, safety, etc. To support this process and that of solving the many problems that naturally occur when things do not go exactly as planned, Toyota uses very simple visual methods for communicating information, often on one side of one sheet of paper. This A3 report (named after the A3 paper size) has four minor variations: proposals, problem solving, status reporting, and competitive analysis. However, the basic concept is the same, and the

Table 3
Tools and Technology Principles of Lean Product Development

Principle	Description
11. Adapt Technology to Fit your People and Process.	Technology must be customized and always subordinated to the people and process.
12. Align your Organization through Simple, Visual Communication.	Aligned goals must be cascaded down and joint problem solving is enabled by simple, visual communication.
13. Use Powerful Tools for Standardization and Organizational Learning.	Powerful tools can be simple. Their power comes from enabling standardization which is necessary for organizational learning.

document communicates only the most pertinent information in a simple visual format. This too is used to develop consensus among a group of people.

Use Powerful Tools for Standardization and Organizational Learning

How can the company learn from program to program? A well-known principle of *kaizen* is that you cannot have continuous improvement without standardization. Toyota has evolved very powerful tools to standardize learning from program to program at the macro-level, mapping how the design process itself transfers to individual lessons at the detailed technical component level through engineering check lists.

The most important thing about these tools is that they are simple as well as owned and maintained by the people doing the work. A bumper engineer must own the standards related to bumpers and work to keep them up to date and communicated. Turning this over to a corporate "standards" department will make these documents bureaucratic and lifeless.

Putting It All Together to Create a Coherent System

Lean is a system. What does that mean? It means the parts interact, overlap, are interdependent, and work together as a coherent whole. This is perhaps the key insight from our research. Changes to one subsystem will always have implications for the others. Think about a simple mechanical system like an engine. It is quite possible to have the best piston, the best cylinders, and the best fuel injectors. But if they do not fit together—for example, the sizes are all different—you have a bunch of great engine parts that together do nothing. Product development organizations are many times more complex because of the complexity of human systems, making the need for a systemic perspective even more critical.

Integrating people, process, and tools and technology into a coherent system requires that that subsystems are purposefully designed, aligned, and mutually supportive. After understanding the value from the customer's perspective, the focus shifts to the task to be accomplished and the development of a waste free workflow or process by which to accomplish it. However, a highly efficient process is of no use if the people in the organization do not possess the skills required to carry out the required tasks, or if they are not organized such that the right people are available at the right time. Consequently, we must next consider those skills, practices, and organizational characteristics that will be required to execute the process. Finally, tools and technologies that do not fit the process or support the activities of the people will not achieve their potential and may even hinder performance. Tools and technologies must fit the system by supporting the process and enabling the people.

Globalizing the Toyota Way

This task is recognized by Toyota as their single biggest challenge. Toyota old-timers in Toyota City often joke that they are "country bumpkins." Toyota City was farmland before Toyota built a global powerhouse, and Toyota leaders have the spirit of farmers—e.g., tough, strong work ethic, solve each problem as it comes, do the best you can with what you have. But farmers are also locally oriented rather than cosmopolitan, and one can make a case that Toyota is still a local company that has spread out globally.

Toyota's way includes a deep set of values and principles that are taught to all new members over many years through intense mentorship. Toyota is not willing to compromise the Toyota Way as it globalizes, seeing its "DNA" as its main source of competitive strength. This of course raises the challenge of how to spread this unique blend of Toyota and Japanese culture to different cultures with engineers who have not grown up in this culture. There are many ways that Toyota has been doing this quite successfully:

1. **Coordinator System**. How do you transfer the DNA of your company? Toyota knows only one way—through people. So they realized they needed to make a major investment in people. They have deployed around the world thousands of "coordinators" whose primary job is to transfer the DNA. Every manager and above had a full-time Japanese coordinator when Toyota first opened manufacturing

plants in the USA and started the Toyota Technical Center in Michigan. The coordinator was a daily coach teaching Americans day in and day out for years on how to think, speak, and act in the Toyota Way. Since then there are fewer Japanese coordinators to go around so they are developing more efficient methods.

2. **Careful Selection**. Even with the coordinator system you need the right raw materials. Toyota carefully selects its people in Japan and elsewhere, identifying people who will fit the DNA of the company. They look for smart, dedicated, hard working, committed people who are excited about cars, like to work in teams, have a curiosity about solving problems, and are open to learning. Usually they hire people with good grades in school but the best students in school are often not well-suited for the Toyota Way in other respects. And they do not want fast trackers whose focus is climbing their way to the top.
3. **Trips to Japan**. Every visit to the mother ship in Toyota City, Japan, is an opportunity for indoctrination. It is such a different environment that most visitors cannot help but experience cultural shock, which opens them up to learning. The energy, efficiency, and problem-solving exhibited across the Toyota organization in Japan is striking, and Toyota overseas employees are generally quite impressed as well as humbled by the experience. While in Japan they are given challenging tasks and learn a different level of problem-solving than they have experienced.
4. **Chief engineer system**. The Chief Engineer does a lot of teaching and coaching in the course of leading product development projects. The Chief Engineer is a charismatic figure, and American engineers will excitedly recount stories of their encounters with Chief Engineers. It is well known that much of our learning occurs during significant emotional events and working with the chief engineer under the pressure of Toyota's highly compressed product development programs are emotionally charged learning opportunities.

Along the way Toyota has encountered many problems in transferring the culture. In an ideal sense the Toyota Way is about taking problems as opportunities to reflect and improve. Below are a few examples.

Transferring Hansei. *Hansei* is roughly translated as reflection, but it means much more in Japan. Young children know that when they do something wrong they will be asked to do the *hansei*. They are being asked to reflect, come back, and express how deeply sorry they are about their failing, and vow to improve and never do it again. The adult version in companies is to take responsibility for problems, feel really sorry, and explain what you will do to prevent that mistake from happening again via a written plan. Toyota leaders view *hansei* as what drives *kaizen*—the deep desire for continual improvement with an eye toward ultimate perfection. So when a Japanese manager finds a weakness in a project the engineer is expected to take it constructively as an opportunity for improvement.

American Toyota employees did not take it that way. They started using phrases like "the obligatory negative" that the Japanese managers must put into every assessment of every project. The Americans wanted praise for all the good things they did, not criticism for the few weaknesses. The Japanese could not see how such praise would be beneficial for continuous improvement.

There were painful experiences in America because of these different perspectives toward *hansei*. At one point, the Toyota Technical Center stopped using the phrase entirely. Then about ten years later, *hansei* made a comeback, as there was more trust between the Americans and Japanese managers, and the Japanese had learned how to balance positive and negative feedback. This learning has been important in Japan as well because the younger generation of Japanese engineers are more Westernized and expect praise while being less willing to accept harsh criticism.

Work-Life Balance. It is well known in Japan that the company comes before the individual's personal or family life. Talk to senior or retired Toyota engineers about their work hours when they were young engineers and the story is the

same. They worked 10 to 14 hours a day either 6 or 7 days a week. Men were expected to work these hours while their wives raised the family. This was especially true during peak periods of product development when the only life priority was doing what was necessary for the program. Product development programs are always very consuming and engineers typically work long hours during the pressure points of the program. Even though Toyota has squeezed out enough waste to make resource demands more constant and leveled the flow of work to help reduce the level of peak human resource requirements so that they can begin to lessen some of the more difficult demands on individual engineers, make no mistake, Toyota engineers in Japan work incredibly hard.

However, in America and other Western cultures there is a higher value placed on personal and family life so Toyota managers were hammered over and over again with the issue of "work-life balance." This is another thing they have gradually been working on first overseas and then to a degree back in Japan. For example, at the Toyota Technical Center in Michigan they instituted flex time and younger engineers can set work hours within some constraints to give them flexibility to be at key family events (e.g., children's soccer games). The surprising thing about this is that they actually had to agree there should be a start and a stop time, whereas in Japan it seemed that however early an engineer started the ending time was late in the evening or even approaching midnight.

Individual Versus Group Rewards. In Japan, dedication to the company and the team is expected by Toyota. In fact, individuals are usually very embarrassed if they are singled out for praise. Their response will be: "It was the team that accomplished this, not me personally." Americans expect to be singled out for praise when they feel they have accomplished something significant. So Toyota has had to institute certain individual-based rewards in America. For example, the twice per year bonus in Japan is strictly based on how the company performs and not related to performance of any individual or any specific department. In America the bonus includes a component based on individual performance.

Each of these examples is really part of a series of learning experiments for Toyota. As a learning organization, Toyota tries things, evaluates, reflects, and selects a further course of action. Deming taught them to Plan, Do, Check, and Act (PDCA). They practice this problem-solving cycle at a remarkably high level compared to other companies. There is no single solution; this tenet is true for transferring the Toyota Way to other countries. No one in Toyota would say they have this problem solved. They would say they are working on it and have learned a great deal.

Learning from the Toyota Way

Many companies throughout the world are seeking to learn from Toyota's system. Typically they limit their exploration to a few superficial "lean" tools. Companies that have seen success with lean tools in manufacturing plants want to apply them to their own product development processes. What they look for are quick fixes to reduce lead time and costs and to increase quality. However, they almost never create a true learning culture in the factory, while remaining convinced they had "gone lean" on the shop floor. Then, despite never really getting the conversion in the factory, they move on to the product development process to attempt to create "lean" offices.

What can other companies learn from the Toyota Way? The journey is far more complex than applying a few tools or holding some classes. It truly is a cultural transformation. It truly is a PDCA learning process. You need to start on the learning journey and then keep going and never stop. You need to practice deep reflection and learn. Toyota is continually learning. They are far from perfect—and would become very nervous if anyone thought they were. What we can take away from Toyota is the importance of becoming a humble, learning organization.

Toyota has developed a true learning organization focused on adding value to its associates, the community, and society and as such is a model other companies can look to for inspiration, ideas, and methodologies. As a complex living system,

Toyota's leaders have consistently guided it to make the parts of the system work together. This has been a self-conscious effort. All of Toyota's executives understand the importance of the overall system of management and deeper culture of the Toyota way. As Vice Chairman Katsuhiro Nakagawa put it, "without the Toyota way we are just like any other automobile company."

The case of product development should give new insights into how Toyota's management principles can be applied outside the production floor, even in technical service operations. There are service operations all over the world that are busily engaged in trying to "become lean." These include hospitals such as the famous case of Virginia Mason Hospital in Seattle, information system services provided by off-shore Indian companies such as Wipro Ltd., and even banks and financial institutions that are trying to learn to be lean.

When organizations adopt a "lean program," what are they really doing? What do they really want? They start with the Toyota Production System and look at the success of Toyota in delivering high quality at low cost. They study the tools of TPS and try to figure out how to adapt them to whatever their processes are. They see that the focus of TPS is on reduction of lead time which then has benefits in cost, quality, and delivery, so they look to reduce lead time through waste elimination. Mostly the tools apply in an obvious way to repetitive operations. For example, hospitals can look at the process of testing blood, or how tools and supplies are stocked and brought to the point of use, or how the operating room is changed over for new patients. These are all analogous operations to what one would see on the shop floor.

When we look through the lens of how Toyota has applied its principles to product development, we notice that by and large service operations are focusing narrowly on a few lean tools in the "process" piece of the integrated system of process, people, and technology. The typical approach:

1. Identify a repetitive process to improve.
2. Apply value stream mapping to identify waste and then a future state map with waste removed (a method to map the process and show the value added and non-value added steps).
3. Implement the changes.
4. Celebrate success.

This is just a start. Once an organization has gone through this exercise a number of times one can ask a broader set of questions about what has been accomplished:

1. Are the changes leading to new standardized processes that are the basis for further waste reduction?
2. Are people throughout the organization engaged in continuous improvement and aligned around a common set of objectives?
3. Are all the soft tools and harder technologies being used to support people improving the delivery of products and services to customers?

If we take a hard, honest look at most organizations trying to "implement lean"—or six sigma for that matter—the answer to each of these questions is a resounding no! They have not gotten much further than applying a few tools to a few processes.

One of the concerns companies will have about applying the "lean" methodology to service operations is its impact on professional employees. Professionals are not like workers on the shop floor. They are educated, well paid, and expect to have autonomy and be creative in their work. A common image of a lean shop floor can be quite negative. Imagine these professionals in their natural work environment being pressured to follow standard procedures for everything they do and constantly pull minutes of non-value added activity out of the process leading to more intense and tightly controlled work for all hours of the day and night. Once the work has become standardized the next step is to monitor it carefully providing rewards and punishments based on scores on key metrics. It is no wonder we often see resistance from professionals when the concept of lean is discussed.

If you believe the analysis of the Toyota Way in this article and the work of scholars like Paul Adler, you will agree that Toyota has created a different type of standardization and a different type of bureaucracy. Paul Adler (1999) talks about the negative view of a machine-like, controlling bureaucracy

as coercive, and what Toyota has done is create a different kind of "enabling bureaucracy." In Toyota's version, standardization is part of continuous improvement and a tool in the hands of the people doing the work. It is in fact liberating rather than confining. Indeed, *The Toyota Way* also provides a very positive view of how Toyota invests in and develops its people from the offices to the labs to the shop floor to take on challenges and accomplish remarkable feats. It is enriching and challenging work in which people grow and become better people. Which view is correct? Is it a bleak bureaucracy or a colorful and rich learning organization?

As usual the answer is probably somewhere in between and also depends on one's perspective. Certainly Toyota managers and engineers work very hard. There are pressures to perform. Failure is never an option and creating constant wins means working long and late hours and stressing people. Many overseas managers and engineers working for Toyota have admitted that the pressures of being so perfect and working whenever it is needed are too much for them to sustain over an entire career. On the other hand, other managers describe working for Toyota as "coming home" where they can finally be part of something they can believe in. They would not want to work for any other company.

Ultimately, a company must envision what it wants to become. It does not need to look exactly like Toyota. In fact, as a living system that grows and evolves in complex ways in a particular environment it could not possibly look like Toyota. So the only alternative is to try to understand the message of what it means to become a lean learning organization and the hard work required to start to build such a culture piece by piece over many years. Maybe the result will be better than Toyota. The spirit of challenge and always trying to get better is the central message of the Toyota Way.

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