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# What is “lean” about product development?

## An overview of Lean Product Development

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*What is Lean Product Development? The term has many different meanings. This article describes the varieties of approaches that call themselves Lean Product Development and explains how lean principles and practices place customer value at the center of product development.*

Lean Product Development can mean many different things. In some companies, lean product development simply stands for “doing more with less.” In others, it has become a euphemism for downsizing, off-shoring, and de-investing in product development. Companies with “Lean” or “Six Sigma” corporate initiatives often use lean product development to describe how

they apply their toolkit in the product development function. But very few of these definitions describe how a lean approach can help a product development team deliver products better, faster, and cheaper than they have been able to do in the past.

raw materials, inventory, and labor—and did it significantly faster and cheaper than traditional mass-production techniques.<sup>2</sup> Since then, “lean” has leapt into the corporate lexicon: Lean Manufacturing, Lean Office, Lean Enterprise, Lean Supply Chain, Lean Six Sigma, and now Lean Product Development.

In 1996, James Womack and Daniel Jones published *Lean Thinking*,<sup>3</sup> which outlined five principles that they believed a lean organization embodied throughout the enterprise: (1) value, (2) identifying the value stream, (3) flow, (4) pull, and (5) perfection. A lean organization understands what value means—for a specific customer at a specific point in time, knows how the value stream creates that value, improves the flow of value to the customer, leverages the power of pull systems, and relentlessly pursues perfection.

Lean manufacturing has evolved a number of specific tools for improving production productivity. These tools include value stream mapping, a tool for visualizing flow in a factory process; 5S, which cleans up and organizes a physical space; and kanbans, which control the flow of work-in-progress inventory through the factory. It seemed natural to the proponents of these tools to move

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To add to the confusion, the consultants and authors who tout lean product development talk about a wide variety of different things. Some emphasize waste elimination. Others talk about how to improve flow in product development. Visiting the experts’ Web sites leads to more confusion as the lean jargon proliferates: kanban systems, value stream maps, 5S, A3, obeya, etc. (See the PDMA Glossary at [www.pdma.org](http://www.pdma.org) for a definition of some of these terms.)

We are writing this article to clear up some of the confusion about lean product development and to show how some of the ideas can help any team develop products more effectively, whether or not “lean” is the right label for your improvement efforts.

### Whence comes Lean Product Development?

In our experience, it helps to introduce people to lean product development with a short history lesson.

In 1990, the researchers of the MIT International Motor Vehicle Program (IMVP) published *The Machine that Changed the World: The Story of Lean Production*.<sup>1</sup> John Krafcik coined the term “Lean Production” to describe an approach that used less of everything—less manufacturing space, tooling,



Toyota’s product development system is considered a model of “lean” product development. Shown here is the company’s 2007 RAV 4.

## Top Five Questions to Help Start Your Lean Journey

1. What is value to your customers—both end users and intermediate customers?
2. How can you transcend tradeoffs between delivering value to intermediate customers and end users?
3. What required process deliverables create waste?
4. What process deliverables (required or optional) directly contribute to customer value?
5. What activities in your process add needless waste?

them upstream into product development, especially when teams began running into issues that only a design change could fix. That led to attempts to translate the tools into product development, especially value stream mapping.

There now are numerous publications, workshops, conferences, and so on to help translate lean from production to other parts of organizations; yet the adoption in product development has been slow and in some cases problematic. We believe the reason is that lean product development as practiced by most companies has been driven too much by tools (particularly those of lean manufacturing) and has not focused enough on how Toyota and other lean companies create more value from their investments in product development.

### Creating value in product development

“Value” in the lean world is “a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer.”<sup>4</sup> This strict definition forces a business first to understand customer value deeply and second to focus relentlessly on delivering that value. This laser focus on value is the key differentiator between Toyota and Honda, the two prototypical lean companies in the automotive industry, from General Motors, Ford, and the rest.

Such strict definitions challenge conventional thinking about how to run a business. For example, companies spend inordinate amounts of resources on documentation and reporting. Product developers report on project status, write detailed specifications and technical briefs, conduct extensive market analysis, etc., all of which contribute absolutely nothing to customer value. In the lean world, these activities are all waste.

The lean enterprise differentiates between waste that is completely unnecessary (such as rework to fix a mistake) and waste that is necessary (such as regulatory requirements and some management activities). All unnecessary waste should be eliminated and the necessary waste should be minimized. For status reporting, this directive means replacing fancy PowerPoint® presentations with simple one-page status summaries.

Since customer value is at the center of lean thinking, Toyota has gone to great lengths to put direct understanding of customer value in the hands of the people who need it most. At Toyota, chief engineers lead development projects and are chosen for their abil-

ity to integrate customer, technical, and process knowledge into a vision for a superb automobile. The company charges them with delivering a car that will exceed the customer’s expectations *and* meet cost targets *and* hit a specific delivery date.

Toyota expects its chief engineers to obtain a firsthand understanding of customer value. The chief engineer for a Lexus may travel to Germany to drive the top-of-the-line Mercedes on the Autobahn. The chief engineer for the Sienna minivan spent a month living with the typical soccer mom in the United States. U.S. companies often dismiss such activities as too “fuzzy” and too expensive. Lean companies know that this direct experience of customer value is too important to do on the cheap. Toyota values the judgment and experience of its chief engineers as much as hard data, such as marketing research.<sup>5</sup>

We create more value in product development by doing things better, faster, and/or cheaper than we have been able to do things in the past. In other words, we shorten time-to-market, we decrease product costs over the entire life cycle of a product, we better align our product’s feature set with the things our customers value, and we produce a higher quality product. Every product development organization tries to achieve these objectives, usually with one or two that take priority over the others.

These objectives make sense for our customers and for our businesses. Faster time-to-market gets innovation into the hands of our customers more quickly—and it increases our sales and market leadership. Delivering a product with lower costs directly benefits the bottom line while it makes products less expensive to purchase.

We decide which of the dimensions of value to optimize and how to allocate that value between ourselves and our customers. As our organization improves, we eventually gain the ability to deliver products better *and* faster *and* cheaper than our competitors. Once we have achieved that level of mastery, we will be very difficult for our competitors to catch.

### Major approaches to Lean Product Development

There are five major schools of thought on how to implement lean product development, as shown in Exhibit 1 on page 13. Of those, we believe that three have the greatest potential to maximize value in product development, one has limited usefulness, and one is simply “lean” in name alone. Each approach has some elements that are unique and some areas of overlap.

“Some of the (lean) ideas can help any team develop products more effectively.”

Exhibit 1 presents a visual model of the lean product development landscape and how these approaches relate to each other. Exhibit 3 on page 14 compares the approaches, including summarizing the benefits to be gained to help you determine which approach(es) to lean will fit your organization and your most pressing needs.

#### (1) Toyota Product Development System

This approach to lean product development is grounded in research that describes how Toyota develops its own products better, faster, and cheaper than U.S. automakers. This research shows that Toyota’s product development system developed alongside the famous Toyota Production System, and the two support each other.

While they share the relentless pursuit of perfection and a “kaizen” mindset that makes every member of every team responsible for finding ways to do things better, they are not the same.

The hallmarks of Toyota’s product development process include frontloading the effort into the early stages of development to ensure a smooth transition to production at the end of development, the chief engineer, set-based concurrent engineering, true partnerships with suppliers, and a deep understanding of the role that knowledge plays in product development.

The University of Michigan began researching Toyota’s product development in 1995. The findings are best documented in two books published in the last 18 months. *The Toyota Product Development System* by James

“ The hallmarks of Toyota’s product development process include frontloading the effort into the early stages of development.”

P. Morgan and Jeffrey K. Liker describes the elements of Toyota’s product development in detail.<sup>6</sup> Dr. Allen C. Ward’s book, *Lean Product and Process Development* was just published in February 2007.<sup>7</sup> It describes the concepts and practices that Dr. Ward observed in his early attempts to translate the ideas into U.S. companies. Unfortunately, Dr. Ward died in a plane crash in 2004 before he could see his ideas translated into reality.

This version of lean product development is the one that we have seen achieve the most dramatic results. The practices that Toyota uses internally to grow and share knowledge—its lean system—are readily transferable to other organizations, which can begin to see results quickly. Unlike other forms of lean product development, these practices help the entire product development team spend more time directly creating customer value immediately.

## (2) Lean principles in product development

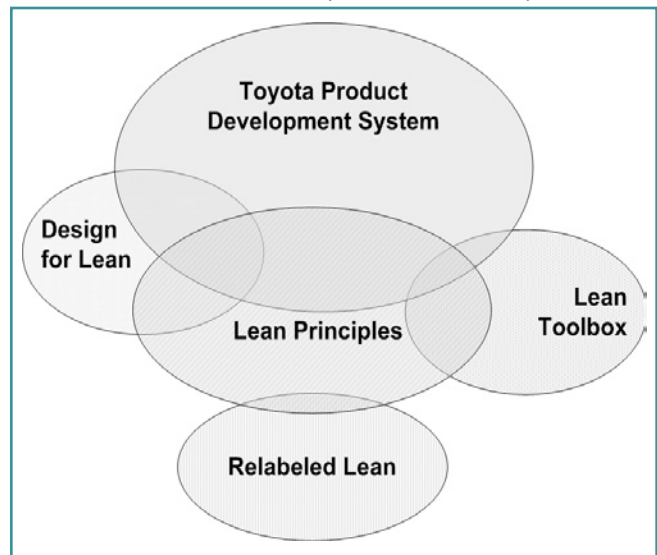
Some of the most interesting work in lean product development has taken a value-centric approach. These authors apply the lean principles to New Product Development and let the tools and methods emerge from their observations.

The most frequently cited sources for this work are Don Reinertsen’s *Managing the Design Factory*<sup>8</sup> and Mary and Tom Poppendieck’s *Lean Software Development*.<sup>9</sup> Reinertsen and the Poppendiecks use the original principles behind lean—value, the value stream, flow, pull, and perfection—as their point of departure. They then ask, “What do these principles mean in a product development organization?” While the authors end up in very different places, the advice they have for product development teams is highly insightful and relevant.

Reinertsen integrates the concept of flow with queuing theory, information theory, and the theory of constraints to develop an approach to managing flow in a product development organization. The Poppendiecks begin with the concept of value and the value stream in a software development project. They synthesize lean concepts of waste elimination, pull, and perfection with best practices from agile software development to gain some insights that apply to any product development team—not just software teams.

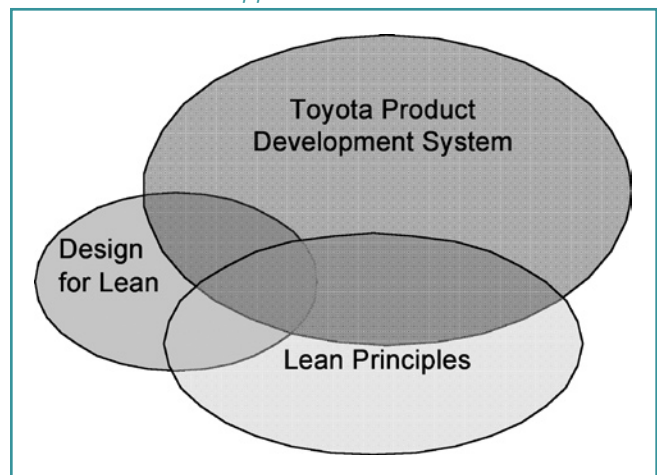
Both sets of authors have suggestions for improving resource

Exhibit 1: The Landscape of Lean Development



SOURCE: The Author

Exhibit 2: Lean Approaches with the Most Potential



SOURCE: The Author

The authors explain that there are five primary approaches to lean (Exhibit 1). They believe that of these three have the greatest potential to maximize value of product development (Exhibit 2).

utilization to improve flow—which gets more products out the door faster with the same resources.

## (3) Design for lean production

This approach optimizes product designs so that they are easier to make in a lean production environment, including the manufacturing, assembly, supply chain, and distribution. Much of the impetus for applying this approach has been from the manufacturing functions, particularly as companies make increasing efforts to move lean tools and practices through the enterprise. Although some teams have focused exclusively here, most have combined this approach with one or more of the other approaches to lean.

This approach consists of a set of tools for reducing the downstream costs of the product in manufacturing, service, and support. The tools draw from methods used inside Toyota and elsewhere to make products easier to manufacture and assemble. The best

book on this subject is *Design for Six Sigma* by Dr. Kai Yang and Basem El-Haik.<sup>10</sup>

Design for lean production does not attempt to change the product development system at all and says nothing about how to help a product development organization work more effectively, so changes in time-to-market or engineering capacity will be small. The techniques, however, can dramatically lower total product costs and improve product reliability.

“ If a practice is not centered on delivering a lot more value from product development, it’s not lean.”

together a value stream map for the product development process. Less frequently, they will use other tools from lean manufacturing, such as 5S, work cells, and kanban systems in the engineering environment.

We are skeptical about how much this approach increases actual value creation in product development. Engineers, scientists, and marketing analysts are not production workers; and product development takes place over months and years, not hours and days. These tools have the potential to do more harm than good, especially if trying to force information and knowledge creation processes into a linear flow. As stated earlier, these tools are not the ones that Toyota uses in its own product development process.

There are areas within product development that look more like manufacturing, and these areas do benefit from lean manufacturing tools. Prototype and model shops, procurement teams, and testing departments often do repetitive tasks on short cycle times. These micro-processes are natural candidates for transactional waste

elimination tools so that engineers obtain what they need more quickly and departments can run less expensively.

However, such actions will never result in the kind of change that leads to a major improvement. These tools are simply unable to show a development team that they need a product platform strategy or that the high number of engineering change orders at release-to-production can only be eliminated with more thorough investigation during the feasibility phase of development. They do not address the knowledge sharing or the early problem-solving and technical learning through experimentation that is inherent in the Toyota Product Development System.

**(4) Lean toolbox**

This approach attempts to apply techniques from lean manufacturing in product development. Most often, a team will try to put

**(5) Relabeled lean**

Unfortunately, “lean” is considered a hot word right now; and it has been co-opted inappropriately by tools and methods that have little to no actual connection with lean thinking or lean principles. Some use “lean product development” to describe a kit of tools that improve product development performance but without the overall theme of increasing value or eliminating waste.

Others take ideas that have been around for a long time in product development, such as phase-gate life cycles, and apply a lean label to them. If one looks below the surface, it’s essentially the same tool with a “lean” label on it.

Lean is more than just a toolbox or a label. If a practice is not centered on delivering a lot more value from product development, it’s not lean.

**Recommended approach**

Exhibit 2 on page 13 visually depicts what we believe is the best combination of approaches. We have found that the best approach to lean product development integrates the Toyota Product Development System with the lean-principles-centered approaches of Reinertsen and the Poppendiecks, and supplements with design for lean production tools. This synergistic combination helps product

*Exhibit 3: Comparison of Lean Product Development Approaches*

Lean NPD Approach	Description and Tools	Major Benefits	Example Proponents
Toyota Product Development System (TPDS)	Grounded in research about Toyota’s product development system: A3 reports, set-based concurrent engineering, chief engineers.	Time-to-market, productivity, quality, rapid learning, fewer changes at the end of development.	Durward K. Sobek II, Ph.D. Allen C. Ward, Ph.D. James Morgan and Jeffrey K. Liker (Description of TPDS) Michael N. Kennedy
Lean Principles	Lean principles applied to product development: value, the value stream, flow, pull, and perfection.	Time-to-market, quality, productivity	Don Reinertsen Mary Poppendieck
Design for Lean Production	Improves product designs so that they cost less, have more reliability and are easier to manufacture: TRIZ, DFMA, Poka-Yoke (Mistake-proofing)	Product cost, quality	Kai Yang, Ph.D. Bart Huthwaite
Lean Toolbox	Lean Manufacturing tools applied in product development: value stream maps, 5S, work cells.	R&D capacity	James Morgan and Jeffrey K. Liker (Implementation approach) Cliff Fiore Pascal Dennis
Relabeled Lean	Best/Good NPD practices given a lean label to make them more marketable. No real connection to lean.	None in terms of Lean and not breakthrough improvements. Some are useful for incremental improvement.	Robert Cooper Lean tool vendors

development fill in the gaps between the explicit elements of the Toyota Product Development System and the things that Toyota takes for granted, several of which are not routine practices in other organizational cultures. Teams that use lean product development in this way achieve significantly more value from New Product Development in a reasonable timeframe.

### Getting more value from product development

How can any product development team use these ideas to improve its product development? We believe the five questions shown in the box on page 14 are particularly important.

First, get a good handle on customer value. How well do you know your end users? What constitutes value for end users? How well do you know your intermediate customers (channel partners, resellers, corporate buyers)? What constitutes value for intermediate customers? What are the inherent

tradeoffs between delivering value to intermediate customers and end users? How can you transcend those tradeoffs?

Next, take a good, hard look at your product development process. Some consultants advocate creating a value stream map of your process, but we do not believe that's necessary. It is usually easy enough to find the low-hanging fruit. Where do you produce documentation that is always out-of-date because no one bothers to read it or no one cares if it's obsolete? Where does your product development process require creating "sales pitches" for internal customers? What deliverables does your process require? Which ones directly contribute to customer value? Which ones just get stuck in a file drawer? Which meetings engage all of the participants and in which ones do participants read E-mail while waiting for the few minutes that are valuable to them?

Think about program leadership: Who in your organization makes the major decisions about product development? How well-integrated are marketing and engineering? Do they have the ability to speak the same language? Do you have anyone like a Toyota chief engineer who has the ability to see the whole picture: customer, market, and technology?

“The practices that Toyota uses internally to grow and share knowledge—its lean system—are readily transferable to other organizations.”

Take a hard look at how much effort you exert in the end of the process versus how much you spend in the beginning, when exploration is relatively cheap. How difficult are your transitions to production? What can you do to “move the mountain” forward—to put more efforts in the early stages of development so that you use fewer resources later and avoid unplanned loop-backs due to failures?

Finally, what organizational barriers foster the waste of reinvention? How easy is it for teams to share information with each other? How easy is it for one product team to benefit from what another product team has learned?

These areas tend to be low-hanging fruit in product development, where putting on a “lean hat” for just a few minutes can help identify new ways of working to achieve better, faster, and cheaper—all at the same time.

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### Endnotes

1. James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine that Changed the World: The Story of Lean Production* (New York: Harper Perennial, 1990).
2. *Ibid.*, 13.
3. James P. Womack and Daniel T. Jones, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (New York: Free Press, 2003 edition). (First published in 1996.)
4. *Ibid.*, 353.
5. Durward K. Sobek II, “Principles that Shape Product Development Systems: A Toyota-Chrysler Comparison” (Ph.D. dissertation, University of Michigan, 1997) 88.
6. James P. Morgan and Jeffrey K. Liker, *The Toyota Product Development System: Integrating People, Process, and Technology*, (New York, N.Y.: Productivity Press, 2006).
7. Allen C. Ward, *Lean Product and Process Development* (Cambridge, Mass.: Lean Enterprise Institute, 2007).
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10. Kai Yang and Basem S. El-Haik, *Design for Six Sigma: A Roadmap for Product Development* (New York: McGraw-Hill Professional, 2003).