**VALUE STREAM MAPPING**

[**Manufacturing Engineering**](http://findarticles.com/p/articles/mi_qa3618/)**,** [**May 2006**](http://findarticles.com/p/articles/mi_qa3618/is_200605/) **by** [**Womack, James P**](http://findarticles.com/p/search/?qa=Womack,%20James%20P)

This lean tool can help companies level production, resulting in dramatic reductions in throughput time and costs, and improved quality

All value produced by an organization is the end result of a complex process, a series of actions that lean thinkers call a value stream. What's more, the customer, whether external or internal, is interested only in the value flowing to them, not in the weighted average of an organization's efforts for all products or in value flowing to other customers. This being the case, it is surprising how hard it seems to be for managers to focus on the value stream for each product for each customer to improve it for the benefit both of the customer and the value-creating organization.

Toyota has known how to do this for many years, using what are usually called information and material flow diagrams. Even in the late 1990s, however, I observed that these techniques were largely unknown outside of Toyota. I therefore asked Mike Rother and John Shook to use their knowledge of Toyota practice to create a simple way for managers to see the flow of value. We called it value stream mapping, as introduced in the Lean Enterprise Institute (LEI) workbook Learning to See in 1998.

The first step in any mapping activity is to identify a product family. This is the group of similar items that proceed through the same basic steps and equipment within the organization. Mapping is greatly simplified, and the benefits of mapping are maximized, if careful thought is given at the very outset to the appropriate classification of products by families.

The second step, often using A3 analysis, is to determine the current problem with the value stream for this product from the standpoint of the customer and from the standpoint of the organization. For example, the customer may be demanding a price reduction and planning to go elsewhere if the new price (based on lower costs) can't be obtained. Or the producing organization may be providing value acceptable to the customer, but at a margin unacceptable to the business. Or there may be chronic quality problems. Or there may be disruptive turnover in employees working along the value stream because of stress inherent to the current organization of the work. Or there may be a need to increase output without significant spending on new equipment and facilities. Etc.

Whatever the problem, it's critical to have agreement with the customer and within the organization on just what that problem is prior to the start of mapping. Otherwise, it's likely that mapping will fail to address the real issues. Or, equally likely, mapping will fail to spur any improvement in the process at all.

Let's suppose that the problem with the current configuration of a value stream has been identified. Now it's time to take a walk along the value stream to draw a map of the current state. Ideally this will be done as a team by everyone who touches the value stream, so that complete agreement can be reached on the condition of the entire stream. In some cases, of course, this isn't practical. But lean thinkers have learned over the years that if a much smaller team, or even one person, walks the value stream it's critical to walk it from one end to the other, so that the whole value stream is captured. The alternative of assigning small teams or individuals to walk different segments of the stream usually leads to inaccurate maps that aren't trusted-even by the team that draws them.

Note that getting the current state right is critical, because the performance problems in the value stream are the direct result of the way it is configured and managed. Improvement can only be based on accurately identifying the problems with the current state, so the map must capture these. In practice, this is more often a challenge for human rather than technical reasons. The employees and managers involved in the current state are usually working very hard to make higher-level managers happy, and it's natural for them to explain away problems that are observed while mapping as abnormalities not worth worrying about. So it's critically important to record real data on how the value stream works, not data on how it is supposed to work on days when nothing goes wrong, no customer changes an order at the last minute, no supplier makes any mistakes, etc.

Once the problem with the current-state value stream is specified, and a team is organized to walk the value stream in order to map it, it's time to get the job done. But there is still a key question: Where to start?

After many years of mapping experience, I always start at the customer end of the value stream. I then walk back up the stream to the furthest point appropriate to map in light of the problem definition. For example, if the problem is clearly within one organization, then the map can stop at the point of receipt of supplied items from organizations further upstream. By contrast, if the problem seems to lie in the hand-offs between upstream and downstream organizations, it's important to map the value stream through both the downstream and upstream organizations. In either case, it's important to develop a standard method and a common language, because many members of the organization will need to conduct value stream mapping over time.

The objective in drawing the map is to identify each significant action required to create the desired value. These are carefully written down, along with information about the performance of each action.

Specifically, we want to know whether each action (also called a process step) is:

\* Valuable, meaning whether it actually creates value from the standpoint of the customer. The simplest measure of the value of a step is to ask if the customer would be less satisfied with the product if this step could be left out. For example, leaving out the step of painting a car would be a problem for practically all customers for motor vehicles. They think that paint adds to the value of the product. But leaving out all rework and touch-up required to get a good paint finish wouldn't bother any customer. These latter activities are waste and need to be steadily reduced.

\* Capable, meaning the degree to which a good quality result is achieved every time. This is the core concern of the quality movement, and the starting point for many Six Sigma projects.

\* Available, meaning the degree to which the step is able to operate when it is needed. This is the core concern of Total Productive Maintenance. In typical operations, many steps can't produce a good result a significant fraction of the time (a capability problem), and won't run at all a significant fraction of the time (an availability problem). Toyota often combines the issue of capability with the issue of availability to estimate the stability of an action.

\* Adequate, meaning the degree to which capacity is in place to respond to customer orders as needed. Adequacy is commonly the focus of Theory of Constraints and bottleneck analysis, and analysis of bottlenecks is often essential to improve the performance of a value stream. As I walk along value streams all over the world, however, what I more commonly see is vast excess capacity. Most steps have more than adequate capacity, and this creates waste of a different type. This waste occurs because equipment designers still want to build large machines designed for lowest cost per step at high target volumes. However, from a lean thinker's standpoint, the one thing that is certain is that market forecasts of demand are wrong. Such errors lead either to chronic overcapacity or intractable undercapacity, when getting even a small amount of additional capacity requires purchase of another large machine. The lean thinker's answer is to "right size" equipment whenever possible to create the possibility for labor and capital linearity. This means the ability to add and subtract small increments of machinery and manpower, so that both are fully utilized over a wide range of volumes.

\* Flexible, means the degree to which a process step can switch over quickly and at low cost from one member of a product family to another. Flexibility permits the production of very small batches, or even lots of one, with many benefits for the entire value stream-as we will see in a moment. Flexibility has, of course, been a hallmark of the Toyota Production System.

When drawing a map, lean thinkers create a data box underneath each step to record information on these attributes. Sometimes additional information is needed, depending on the situation, and an important reality of mapping is that every map for every value stream will be slightly different. Efforts to force every value stream into an identical format will only produce frustration.

With all of the steps identified and characterized, it's time for a harder task, which is to map the movement of product and the information flow that regulates the value stream. Mappers are looking to capture three critical attributes of each, value stream:

Flow versus stagnation, as shown by the amount of inventories along the stream. In the ideal value stream, the product never stops moving from start to finish. This permits almost instant response to customer desires, and often makes it possible to transition from build-to-stock to build-to-order. Creating continuous flow-and particularly in upstream fabrication activities, not just in final assembly-has been a central concern of the Toyota Production System.

Push versus pull, as shown by the way production information is regulated. In the ideal value stream with completely continuous flow, no information is required except for the signal at the top of the value stream to make the next product of a particular specification for the customer just requesting it. (From that point, the product flows continually to the customer. No additional production-control information is needed.) In most value streams, however; even at Toyota, there are disconnects between different parts of the stream due to physical realities that disrupt flow. In these situations, the ideal information system permits each downstream step to signal each upstream step as to its immediate needs, which can be supplied quickly in small amounts because the upstream step is capable, available, adequate, and flexible. Under the sometimes confusing label oijust in Time, the focus on pull has been perhaps the most widely known aspect of the Toyota Production System.

In practice, value stream mappers can indicate the size of inventories along a value stream with simple triangle icons, and note inside or beneath each triangle the amount of inventory on hand.

Capturing the information-management system is more complicated, involving drawing arrows that track each flow of information along the entire value stream, indicating the start and stop points for each production instruction.

Level versus erratic as shown by the degree to which the demand of the customer has been smoothed from a single scheduling point, so that all upstream steps can be conducted without disruption. This addresses the problems of mura-uneveness, and muri-overburden of the value stream driven by a desperate need to keep up with events, that Toyota believes are the largest generators of muda, which is waste.

A final step in mapping the current state is to summarize the most critical feature of the value stream, and this is usually throughput time. Taiichi Ohno, the legendary architect of the Toyota Production System, often noted that his objective was simply to minimize the amount of time elapsed from order to delivery. Therefore, capturing the total time from the start of work on a product until it is ready for the customer is often the most helpful way to characterize the performance of the entire stream.

One map I've shown is for a simple manufactured product. Maps that are similar in concept can be drawn for any process within a business. A current-state map for a process occurring in an office rather than a factory-processing insurance claims-is also shown in this article, and looks very much like the current-state map for the car part. The major difference between a physical product and an office process is often that the product in the latter is information packaged in a certain way. Thus, there are two information flows-the information that constitutes the product and the information about how to regulate the flow of the product-and it's important to treat them separately.

With a completed current-state map in hand, it's time to think about a better future state that will help both the customer and the provider organization. Getting there may involve a number of actions. However, in practice we note that certain types of improvements in the value stream are likely to have the highest payoffs.

One is to challenge each step as to whether it really creates value. Rework and storage of items are rarely of any value to the customer, and need to be eliminated whenever possible. Increasing the capability of individual steps so there is no rework, and organizing many process steps in a continuous flow, are excellent ways to eliminate waste while making the customer happier because of better quality and more rapid delivery.

A second step is to place as many actions as possible in continuous flow. This can dramatically reduce throughput time, and almost always reduces costs substantially. Achieving continuous flow frequently requires the relocation of processing equipment employing different technologies into a tight process sequence. And it may require the introduction or even the invention of new processing technologies that can be right-sized to the specific value stream, and which are inherently more capable, available, and flexible.

A problem we often note is a rush by an organization to relocate and tightly link process technologies that are neither capable nor available. In the absence of basic stability (which is capability times availability), it is more likely that there will be no flow rather than continuous flow. Although it seems to be against the spirit of rapid kaizen, we find that it is often better to attack capability and availability problems before tightly linking process steps. Once these attributes of the process steps are improved, progress toward continuous flow can be both rapid and sustainable.

A third step on the path to an improved future state is to level the output of the value stream and, when necessary, to divide what was originally one value stream into two or three value streams suited to processing products with different challenges.

The idea of leveling is very simple: Identify one spot along the value stream-the pacemaker step-where orders from the customer are transformed into production instructions. Then create a standard inventory at this point to permit every step upstream and downstream to operate in a level, smoothed manner, using first-in/first-out scheduling downstream from the pacemaker and pull signals upstream.

The pacemaker point is almost always that point at which the final specification of the product is set. For a make-to-stock product, this will be at the assembly point at the downstream end of the value stream. For a make-to-order product, it will often be at a point far up the value stream. (Note in the two maps I've provided that the car part is made to stock while the insurance claim is made to order, partly because no claims can be processed before the customer triggers the process, and the issues with each claim may be slightly different.)

By creating a standard inventory large enough to buffer the value stream from gyrations in demand while still responding to customer needs in a timely manner, it's possible to remove most of the mura and muri in the value stream. Doing so always leads to lower costs and higher quality.

As organizations try to level and smooth production, they will often discover that a major cause of muda and mûri is the attempt to run very dissimilar products down the value stream. In the insurance example, it was found that about 80% of the claims could be processed correctly with no stops or backflows along the value stream, while 20% were much more complicated and required a higher level of analysis, and a higher skill level among the employees operating the stream. By failing to distinguish the different types of claims from a processing-requirements standpoint, the organization had created inventories and backflows at every point along the stream that slowed down the processing of the 80% of the claims that could easily go directly through the process. Thus one value stream needed to become two.

The maps show the future state created for the car-part and insurance-claim value streams. In both cases, the introduction of continuous flow at the pull of the downstream customer with leveled production resulted in a dramatic reduction in throughput time, a dramatic reduction in costs, and a substantial improvement in quality. This, rather than simply drawing maps, is the objective of value stream mapping.

Once the future state is achieved, it's time for the lean thinker to start over by specifying the value desired by the customer, the gaps in the performance of the value stream from the standpoint of customer and producing organization, and the needs of the employees operating the process. At LEI we have mapped hundreds of value streams over the past decade, but we have never found a value stream that couldn't be improved further-and we never expect to.

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