"Lean" and the Toyota Production System

Robert W. Hall

Many companies emulate the Toyota Production System (TPS), but there's only one original — Toyota's. Each Toyota location has its own personnel and process history, so each learning journey has assumed a local flavor. To prevent the system's DNA from being corrupted, a "mother plant" sows its TPS seeds in each new Toyota location, almost always a green field site. Most Toyota experience converting another system to TPS is with suppliers and other companies they have assisted.

Whenever Toyota transplanted the system to other companies, variations appeared; no Toyota supplier has DNA identical to Toyota. As others re-interpreted TPS, variations became more distinct. Some of these have clustered in "lean manufacturing," a descendent of TPS made popular by the Lean Manufacturing Institute.[1]

Comparing the offshoots with the rootstock is inevitable when attending "Overview of the Toyota Production System," a workshop being given twice a year for AME audiences by TSSC, a Toyota subsidiary. The biggest differences relate to how TPS, much more than lean, emphasizes developing people to solve basic process problems.

In Brief

Differences between the Toyota Production System, as practiced by Toyota, and lean manufacturing are significant. Two of those are that TPS emphasizes worker development for problem solving and spends much more time creating standardized work, which lean seldom incorporates.

Process Mapping vs. True North

Lean implementations are likely to start with overall process flow charts called Value Stream Maps, a term attractive to the dollar minded. These help leaders visualize how to proceed with implementation. First they construct an "as is" flow chart, sometimes opening their eyes to how much waste lards their operations. Then they construct a "to be" chart representing a slimmer, trimmer future. Comparing the "as is" with the "to be" chart generates a vision for implementation, including a few driving performance indicators. They also identify big blobs of muda as initial targets for kaizen event teams.

The charts also prompt up front strategic decisions. What will be the effect on capacity, employment, and cash flow? Why

kaizen processes that should be outsourced or eliminated entirely? For example, companies have found that, in modest volumes, printed circuit boards can't be made on-site competitively if waste were zero — can't afford the capital and can't keep up with the technology.

Guided by Value Stream Maps, management leads the implementation. Overall goals are quantified as indicators for a "dashboard" to track progress toward the vision. Kaizen events then start attacking sub-processes. Staff are likely to direct the attacks.

Toyota doesn't start with Value Stream Maps. Initially they marshal the changes in sub-processes by heading them all True North. "Material and information flow" charts appear much later to link processes and march them along together.

True North is what we *should* do, not what we *can* do, the ultimate ideal for the overall process, and for every sub-process within it. There is no other vision. Point every person and every sub-process True North; once they are all loping along in the same direction, they will easily merge into a common takt time. That is, Toyota grubs the waste out of sub-processes before linking them closely.

In Figure 1, both human development and process revision (for customer satisfaction) are trekking True North. The word selection of the last bullet point under "human development" intimates more. "Professional development," by direct experience more than formal training, intertwines with process improvement. Everyone, including all workers, learns how to solve problems and improve processes. If someone else does it, then "turns the process over to production," workers are ill prepared to continue kaizen on their own. To become professional workers in this sense, they should experience how and why their process was developed. TPS grows people in all their talents — even some they didn't know they had.

On the customer satisfaction side of Figure 1, the ideals of True North are absolute. Zero defects means zero — none. Not even Six Sigma is good enough. If one customer in a million receives a defect, we're not at True North — zero unhappy customers. The same rigor applies to zero waste and lot sizes of one in sequence. Of course, Toyota rarely reaches absolute zero, but going for it prevents complacency about performance that is great by other people's standards. As long as Toyota is south of True North, they have problems to work on — somewhere.

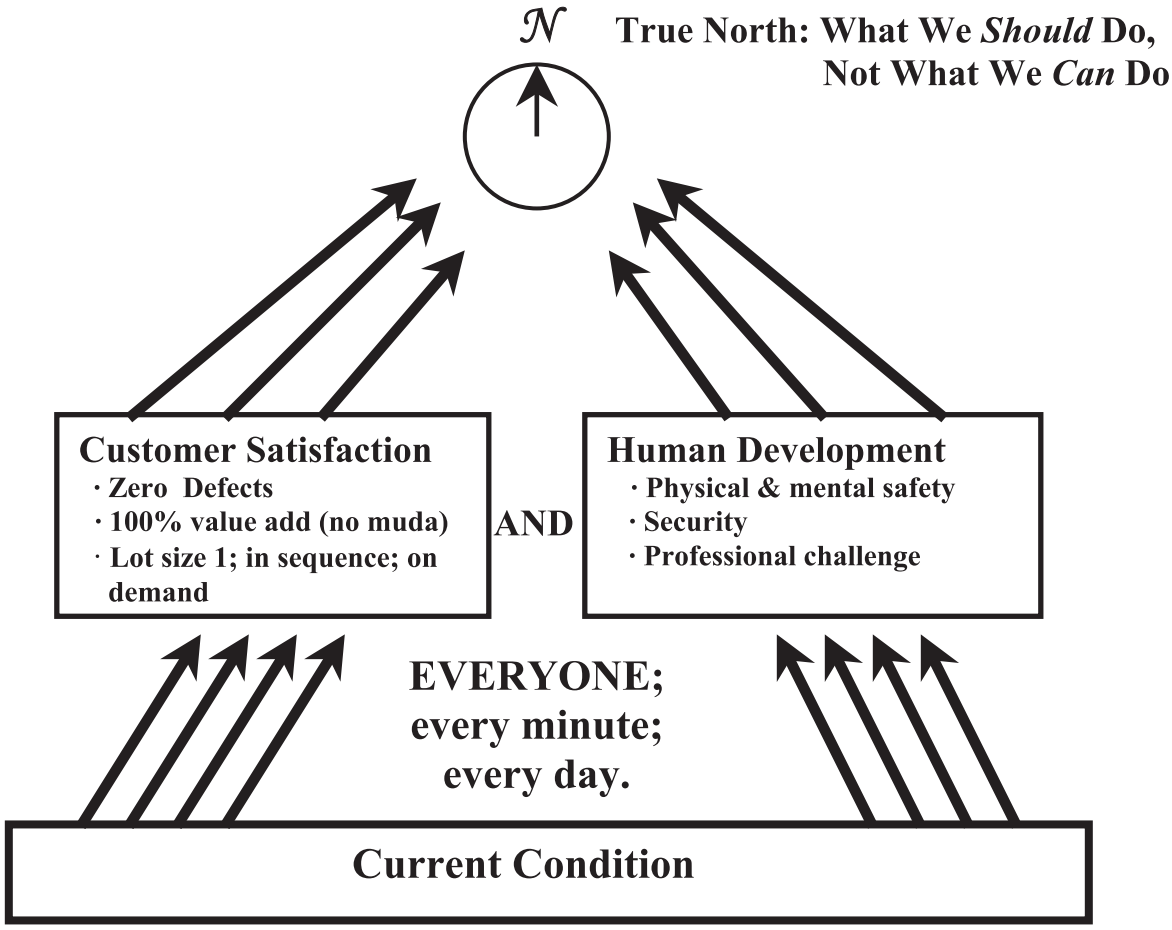
The purpose of TPS is not rapid material per se, but process visibility. Smooth flow is only one factor that makes it easier to spot that one-in-million problem. Visibility spotlights the teeniest little bits of waste, prompting more kaizen. Of the seven classic wastes, Toyota deems overproduction the most serious; any of the other six may begin with that one.

Because deployment depends on each site's history of processes and working culture, neither Toyota nor lean practitioners employ unwavering formulas for it. However, Toyota's "creates" TPS. Lean practitioners more likely "implement lean." Toyota stresses that TPS is human development. Lean organizations frequently try to stretch the worker-to-supervisor ratio. Toyota keeps foremen or team leaders, converting them into coaches and backups for workers. However, everyone agrees that the human side, learning new patterns of working and thinking is the highest hurdle.

Lean Implementation

In a lean implementation, leaders as well as workers may be feeling their way, coaching less from experience than discovery as you go. Sensing that the work culture must build up to lean, leadership may first do something to engage people in problem solving, become familiar with process visibility, and improve teamwork as a way of life. For example, they may institute 5S before starting cell building, and big cultural leaps, like moving from an independent craft tradition, can be painful and time-consuming. A few go "cold turkey" to cell building.

But once they begin integrated operational conversion, lean leaders convert



Adapted from presentation diagram by TSSC, a subsidiary of Toyota Motor Manufacturing North America

Note that development of people, all personnel, to head True North is equally weighted with the development of processes toward True North.

Figure 1. The Toyota concept of heading for True North.

Value Stream Maps into to key process measures and blitz processes with kaizen events. Kaizen teams may pounce on some fat targets first, but to integrate the effort, they usually start at final assembly and work back, setting up work to flow, as in a cell. They calculate takt times and balance station workloads to them. Often, but not always, conversion is kaizen event by kaizen event, each one addressing problems that plug workflow, such as quality, setup times, maintenance, training, scheduling system, and so on. Pull systems start tying the flow of operations together.

Staff and management almost always direct a lean conversion. Usually, a consultant more experienced in the journey guides them at first. Workers participate, and one objective of most kaizen events is to give them first hand experience learning and using the tools of process improvement. Training varies, but almost all companies add instruction in lean techniques to the formal training of all employees.

Being sidetracked by current operating pressures is always a hazard, but with persistent top management leadership, within a year or two most work flows by a pull sys-

tem from door-to-door. With most of the initial heavy moving over, a plant may declare itself lean, although there is much more to do. Improvement never ends. Management raises the vision, refreshes the indicators on the "dashboard," and drives again, this time extending the effort beyond the plant into product design, engineering, office work, perhaps even sales and suppliers. While every case is unique, this general theme describes many sustained lean conversion stories.

TPS Creation

Conversion concentrates on the shop floor, led by veterans of the system, relatively sure of where they are going. Key process measurements are quality and leadtimes. The shop floor rarely sees unit cost measurements. If muda is disappearing, costs will come down; it's that simple. Plant efficiency is defined as ability to meet exact customer requirements with minimum resources: people, leadtime, and space. (It may have extra equipment.) Toyota's logical pattern is to introduce tools to increase process visibility, gradually stepping up the effectiveness of problem seeing and problem solving. When people and process are ready, move on.

Stabilization: Stability is the dependability of man, machine, material, and method, the classic old 4Ms. The first objective is to convert people from firefighting to deliberative problem solving. First create increased visibility in the current process and expose problems, teaching people how to solve them using the five why's and the Deming Circle — and giving them their head to do it. Coach people early and often to carefully observe and document what they are doing now. Give them the means to habitually improve their own work and the processes around them. Don't go to continuous flow if big problems with quality, maintenance, or supply would be overwhelming.

Continuous Flow: This is the big step increasing process visibility. The process is still loaded with waste, but predictable enough that it won't choke on continuous flow. Set up local flows to produce only the quantity needed when needed. Any pull systems between areas are simple, like min-max kanban squares. The emphasis is on condensing cells and layout; cutting setup times; minimizing lot sizes. Where possible go to one-piece flow with no stock between stations. Doing this effectively requires mastering multi-functional work and group problem solving. Keep this up until the workforce does it routinely.

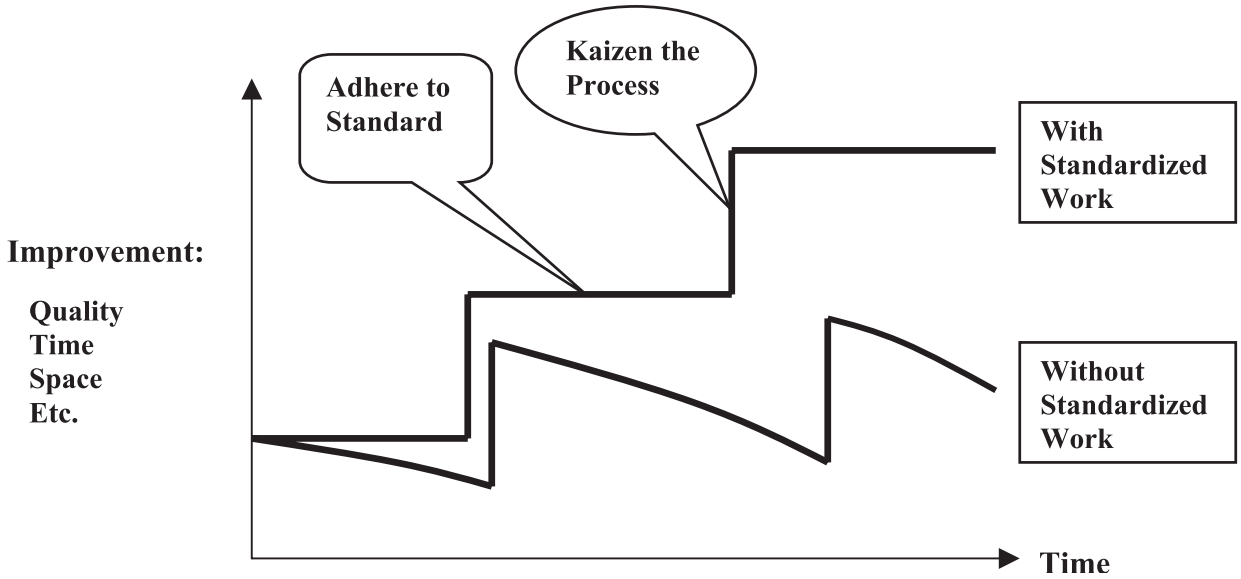
Quality problems always lurk in product, in equipment, and elsewhere. Learn to build quality into each step of a process. Eliminate inspections using andons, poke yoke methods, and so on. Shorten the feedback time for correction by cell building, juxtaposing workstations, and cutting the inventory and leadtimes until process variation is reduced because machines stop (or beg for adjustment) before a defect is actually made. Doing this deepens the visibility, expanding the opportunities for problem solving.

Start separating the work of people from that of machines; workers learn to tend multiple machines. Develop them to make maximum use of their abilities, adding value with every touch, rather than wasting time merely monitoring machines or inspecting parts. People may balance work cycle times, but we have not yet gotten to takt times.

Standardized Work: This is the *big* difference between TPS and lean, begun while still in continuous flow. Standardized work isn't only documentation. It's also an improvement process; layout; work sequence, and work methods. Emphasis is on human motion. To pace work, introduce takt times, and coach people to develop efficient work flow to a takt time considering safety, quality, quantity, and cost (use of resources). Continue coaching until workers with their team leaders can generate their own standard work. This usually takes the longest time, but Toyota considers standardized work to be necessary to sustain the gains going True North, as illustrated by Figure 2.

Because standardized work takes a long time to mature, some Toyota plants

Relationship Between Standardized Work and Improvement



This diagram is a version of similar diagrams much used within Toyota.

Figure 2.

are much better developed than others. Tell-tale signs:

- Near the work areas is evidence of worker problem solving, real things in real time like scribbled flip charts, not sanitized computer graphic summaries.
- Work details at each station are crisp; 5S is detailed, so you can identify more than the main flows of material.
- Workers aren't moving at breakneck pace, but are so concentrated on value added activity that they've less time to banter or even smile at visitors.

Thus TPS standardized work combines the disciplines of improving work with that of holding the improvement, which sets up the ongoing elimination of waste that most lean implementations never get to. Standardized work documentation is but the script for a play, often rewritten, which all actors that substitute roles adhere to and help rewrite. The unfolding play is the thing, the distant customer its unseeing audience.

Getting It All Together: Now orchestrate improvement toward True North. If an overall takt time is at all possible, everything is connected with production of end product using takt times and a pull system. (That's right; a detailed pull system goes in late.) Plant workload is balanced with a heijunka box, container lot sizes, and standard inventory at various points in the system. Decreasing inventories a bit here and there stresses the system just enough to allow the workers, now capable of standardized work, to press as a total group toward True North. Sustained visibility shines light on every little pebble in the path to True North, so every process improver in every little nook of the total process should see something to think about and to work on.

Summary

Lean implementations, mapped and planned, tend to be more "engineered" by staff than TPS. If well planned, lean implementers may better anticipate business issues, like increasing sales to absorb the idle capacity released from productivity improvement. They may also anticipate the cultural changes that will be necessary. Unfortunately, not all are carefully planned, and some cultural changes, as for standardized work, are rarely anticipated at all. A

well-structured lean implementation may consider adoption of the tools to be a success, but allow people to remain underdeveloped in problem solving, and detailed process problems to remain hidden.

Paradoxically, TPS creation, while more organic and intent on developing people to the max, just "bulldozes" through. TPS creation starts immediately on the shop floor, developing people to unravel problems. TPS tools are merely a method to change the work culture to problem solving mode, and TPS leaders may pay little heed to the cultural shock associated with this. The premise is that workers have vast, untapped potential waiting to be tapped. Any system, IT or otherwise, that gets in the way of this goal is discarded on faith that something better will be invented from the chaos. To an extent rarely found in lean manufacturing, TPS develops people to concentrate unrelentingly on machines, maintenance, quality, processes, or any other waste that stands in the way of total customer satisfaction — True North.

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Footnote:

1. The adjective "lean" was first used to describe operations by Toyota and other Japanese auto companies in *The Machine that Changed the World*, James P. Womack, Daniel T. Jones, and Daniel Roos, MIT International Motor Vehicle Program, 1990. "Lean manufacturing" rapidly became popular afterward.