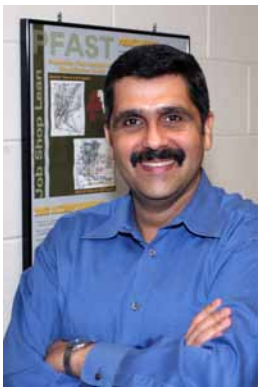
Adapting Lean for High-Mix, Low-Volume Manufacturing Facilities



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A customer has several choices when it comes to buying a service or product that he/she fancies. Boeing competes with Airbus, GM competes with Toyota and a host of other car manufacturers, and so on. Then why expect every manufacturer to pursue continuous improvement by following just the "Toyota Way" using tools pioneered by Toyota for their assembly lines? Toyota is a low-mix, high-volume manufacturer of *only* automobiles. They do not make refrigerators and bicycles on any of their assembly lines! Also, you will find that conveyors are the dominant material handling equipment used in their assembly facilities.

Now let's turn our attention to high-mix, low- or high-volume (HMLV) manufacturers of components, and oftentimes, assemblies built from those components, such as: facilities that manufacture custom configurations of assemblies, remanufacturing facilities, repair and maintenance facilities, and job shops.

Without a doubt, like Toyota, most of the above HMLV small- and medium-size manufacturers with annual sales in the $5 million to $100 million range will surely benefit tremendously by implementing lean, *even though they make hundreds of different components or assemblies*. There are savings to be gained by cutting the costs due to all forms of waste that exist in administrative and manufacturing processes. But, walk through these facilities and you will find that forklifts are the dominant material handling equipment in use. Why? Because these manufacturers have been advised (that) in order to be flexible, job shops should have process-focused facility layouts. That, unfortunately, condemns them to a batch-and-queue production system, which is the root cause of WIP, scrap, MRP-driven production control, etc. For example, Figures 1 and 2 depict the material flow in two forge shops that produce hundreds of different forgings for defense and aerospace customers. Both facilities scheduled their operations and suppliers using infinite-capacity *Material Requirements Planning (MRP)* software.

Numerous books have clearly explained the significant differences that exist between the operating conditions of any assembly production system versus those for any job shop production system when they are compared on various criteria, such as production volume, product variety, workforce skills, equipment flexibility, supplier control, production control and scheduling, etc. So, while it is imperative that HMLV manufacturers embrace lean as a philosophy, maybe they should not do it by following only what is best for an automobile manufacturer.

Unlike any low-mix, high-volume manufacturer like Toyota, job shops have to deal with: considerable volatility in demand; numerous changes in delivery dates forced upon them by customers; greater variety of manufacturing routings; high variability in setup times and cycle times across the different products they make; a diverse customer base; limited resources for workforce training (let alone even one full-time employee devoted to continuous improvement); more complex production control and scheduling; and limited clout to influence the delivery dates set by their suppliers or customers. Finally, these job shops also must deal with the tendency for their product mix to "migrate" as their customer base changes or they hire new sales and marketing staff who bring with them their past business contacts in different sectors of industry.

The popular saying is that a bad carpenter blames his tools. But what if his boss gave him bad tools that were ill-suited to the job that was assigned to him? This is exactly the case when HMLVs implement lean using only the

popular lean tools, many of which are simply unsuitable, if not wrong, when used in non-assembly facilities.

Let's discuss the lean tools that would surely work in job shops. *Top-down leadership* and e*mployee involvement* are essential in just about any business or manufacturing facility. Even job shops need s*tandard work instructions* to minimize the impact of variability and variety on setups, tool changes, material specs, etc., although it is a non-trivial problem to actually standardize the large number of process plans, setup procedures, tooling packages, etc., that they surely have! And I know of no business that has not profited by empowering and training equipment operators to control *quality at source*. S*etup reduction* is equally important in any workplace, kitchens included. Ever seen how smoothly the professional chefs on Food Network shows glide around their kitchens to get anything they need as soon as they need it?

Next let us discuss the lean tools that may not work in job shops. I will discuss them in the context of the relevant steps of the lean thinking process pioneered by James Womack and Daniel Jones. They offered a powerful five-step thought process for guiding the implementation of lean techniques (that) is easy to remember but not always easy to achieve:

Identify value*:* Specify value from the standpoint of the end customer by product family.

Map the value stream*:* Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.

Create flow: Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.

Establish pull: As flow is introduced, let customers pull value from the next upstream activity.

Seek perfection: As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced; begin the process

Tools that will work in any job shop	Tools that may not work in most job shops
5S	Value Stream Mapping
TPM (Total Productive Maintenance)	One-Piece Flow Cells
Setup Reduction (SMED)	Product-specific Kanbans
Error-Proofing (Poka-Yoke)	FIFO Sequencing at Workcenters
Quality At Source	Pacemaker Scheduling
Employee Involvement	Inventory Supermarkets
Strategic Planning	Takt Time/Pitch/Level Loading (Heijunka)
Visual Controls/Visual Management	Single-function Manual Machines
Standardardization of tools, processes, etc.	Assembly Line Balancing
Jidoka	
Top-Down Leadership	
Right-sized Machines	
Standard Work	

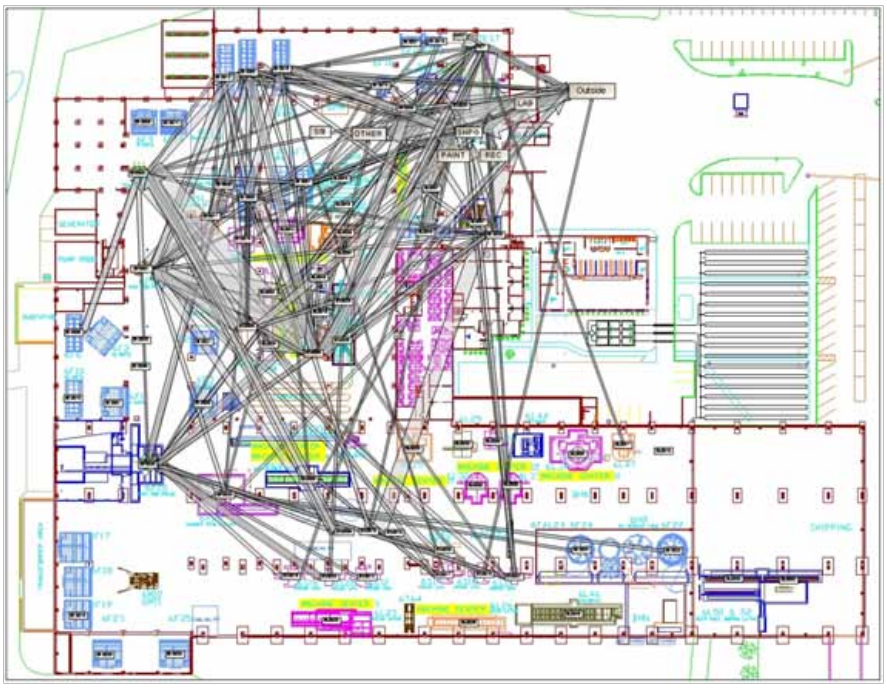

Figure 1—Material Flow Network at a Department Of Defense (DOD) Supplier

again and continue it until a state of perfection is reached in which perfect value is created with no waste.

Here is why several of these highly-popular lean tools cannot address the complexity of a job shop. Identifying value is trying to deliver to the customer what they want, when they want it at a competitive price. This is universally applicable to just about any business. But, it is not that easy to achieve *quality*, *cost* and *delivery* when the benefit of learning by repeating the same work over and over again is absent, as is the case in any job shop.

Value stream mapping (VSM) is a manual method. I have yet to see a single VSM that has mapped multiple interacting value streams that dynamically share resources. Besides, the "theory" of VSM is based on assembly line balancing. No job shop that is a multi-product remanufacturer or project-oriented custom manufacturer has a cadence (aka takt time) in their work flow. Nor does VSM have the ability to identify all the product families that may exist in any job shop's product mix.

One-piece flow cells are infeasible in job shops beyond a small portion of their product mix; instead, using group technology and production flow analysis, the job shop can be divided into two areas: One side consisting of flexible manufacturing cells ("mini-job shops") with each cell dedicated to a product family and the other side being a "remainder shop" where the spare parts, prototypes and one-off orders are produced. Flexible cells may not allow perfect one-piece flow, as in any assembly line. Still, due to increased proximity between consecutively used workstations, small batches of parts can be easily moved by hand or by using wheeled carts, short roller conveyors or Gorbel cranes.

A job shop is a make-to-order (MTO) business; i.e., orders are pulled into production based on actual demand.

In contrast, all the lean tools that suit assembly line production are based on a make-to-stock (MTS) inventory model. I see no reason to use tools for MTS production scheduling when there are tools for MTO production scheduling at our disposal, such as finite load order release, finite capacity scheduling, electronic Gantt charts, manufacturing execution systems, etc. I wholeheartedly agree that a job shop should pursue continuous improvement one part family at a time.

U.S. manufacturers are now in the 21st Century and competing against countries where manufacturers have already availed themselves of the best consultants with expertise in lean and Six Sigma. If the United States can boast of innovation-driven IT giants like Google, Apple, Microsoft, Facebook, etc., this may be a good time for the hundreds of thousands of HMLV manufacturers in the U.S. to explore a new approach that could make them not only lean, but also flexible, agile and adaptable.

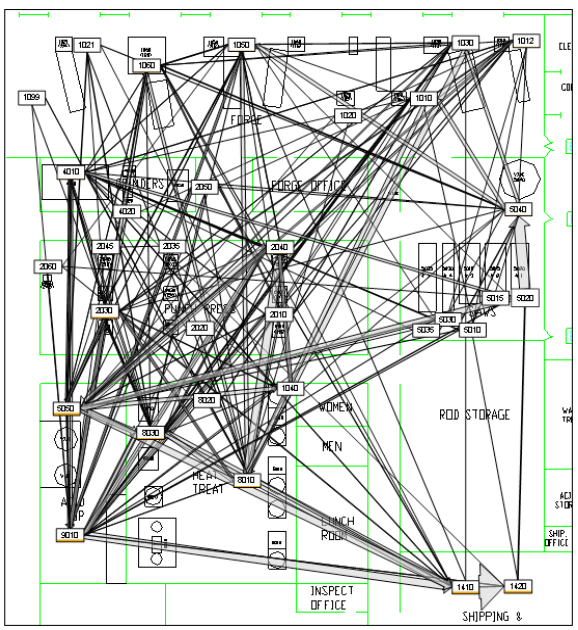

Figure 2—Material Flow Network at a Defense Logistics Agency (DLA) Supplier