Integrating Lean Thinking Into Laboratory Planning and Design

Used successfully in the manufacturing industry for decades, Lean principles are increasingly being adopted by today’s health-care organizations to deliver care that is timelier, more efficient, and more cost-effective than ever before. Thanks to Lean, health-care organizations throughout the United States are enjoying measurable and significant patient and cost benefits. For example, ThedaCare, a community health system based in Wisconsin, saved $12 million dollars as of December 2005 by integrating Lean principles and conducting multiple weekly rapid improvement events.1 Similarly, health insurer Wellmark pared more than $24 million dollars from medical and administrative costs due to the employment of Lean Thinking and tools.2

While the health-care literature on Lean projects in many areas is expanding rapidly, only a handful of documented Lean successes have been published relative to the incorporation of Lean principles into the design of the clinical laboratory. In this article, we would like to discuss the important concepts related to preparing laboratories for a Lean spatial redesign.

Lean Background
In the face of diminishing labor, material, and capital, founders of the Toyota Motor Company developed a production system in the 1950s that aimed to continuously reduce the amount of time and money required to produce a product or service. The system was designed to remove all forms of waste (muda) and achieve a smooth process flow with well-designed steps occurring in tight sequence without interruption. Throughout the remainder of the 20th century and into today, those “Toyota” concepts and tools became more robust and time-tested, eventually leading to the current framework known as Lean manufacturing (see Table 1).

In the clinical laboratory, “value” for customers translates to receiving accurate results in the shortest possible amount of time. For the laboratory, the elimination of waste in helping to create value translates into higher test volumes with the use of less material, capital, space, and human time and effort.

Waste Not Want
In Lean terminology, waste is any element of production, processing, or distribution that does not add value to the final product. Put simply, it is any work for which a customer would not be willing to pay. Waste is present in the clinical laboratory in numerous areas of operation, but the common thread is that it always impedes the ability of the laboratory to create flow and meet customer demand (see Table 2).
TABLE 1
LEAN PRINCIPLES

- Define value from the perspective of the customer
- Identify the value stream for each service or product and remove the waste
- Make each process step occur in tight sequence from beginning to end without interruptions — create continuous flow
- Let the customer pull value from the process — what the customer wants, when the customer wants it
- Pursue perfection — seek to continuously improve

The most significant contributor to waste is unreasonable-ness. Unreasonable-ness is defined as “overburden to a person or process.” Lean projects must begin with a thorough examination of whether the portions of the processes under evaluation are overburdened and if they are either incapable of meeting production requirements or simply under-utilized.

By examining the laboratory’s capacity, planning teams can determine the takt time based on the number of specimens that need to be processed and the amount of available time in a defined period. Takt time is defined as the pace of production required to meet customer demand.

Establishing a takt time allows an operation to see portions of the process that are not being completed fast enough to meet customer demand, as well as instances of overproduction (wasteful practices where products or services are being produced too rapidly). The act of determining the process time for each step in a process and comparing that to the takt time may identify portions of the process that require more resources than others.

In the clinical laboratory, it may be helpful to define takt time for specimen processing. For example, during an eight-hour employee shift, assuming two 15-minute breaks, 450 minutes are available for production. If the laboratory faces a daily demand of 500 specimens, the takt time is 0.9 minutes per specimen. If there is one operator, a specimen must pass through the entire process every 54 seconds. The laboratory may then reconfigure workflow and physical layout based upon that goal. In our experience, many laboratories that begin a Lean project learn very quickly that workflow improvements are going to be tied to facility and workflow redesign in order to synchronize the pace of production with the pace of customer demand.

Tools To Reveal the Work and the Waste
Estimates suggest that up to 50 percent of total operating expenses in a variety of manufacturing settings can be attributed to materials handling.³ In one published study, the authors said that, “Studies have demonstrated that efficient facility design can reduce these costs by 10-30 percent and provide an excellent return on investment over the life of the facility.”³ It follows that laboratory design based on the optimal sequence of steps can reduce worker motion, as well as specimen handling and transport. The first step in improving materials and personnel flow is drawing thorough process diagrams (see Image A).

Diagnosing waste and identifying the tactics best suited to create efficient workflow requires a thorough understanding of current workflow. Several common Lean tools, such as a Value Stream Map, can provide visual representation of all the steps — both value added and wasteful — required to complete a product or service from beginning to end. We
have found that Value Stream Maps are usually more robust than other types of process maps because of their ability to illustrate the flow of information and reveal metrics tied to the performance of the process (see Image B).

A Value Stream Map can serve as a blueprint for improvement. A well-researched map provides an easy way to readily identify and target improvement opportunities. Additional Lean concepts may then be applied to create an optimized workflow.

In planning Lean projects in the clinical laboratory, it is essential to initially gather all available information related to the current operation of the laboratory. To create a process map, or a more complex Value Stream Map, a Lean team "walks" through the specimen process to develop a detailed understanding of the current workflow. Prior to involving laboratory designers, the team can then use this information to develop their ideal workflow, removing the barriers to flow that were identified in the workflow map.

Another effective tool for identifying and eliminating excess motion in the laboratory is a spaghetti diagram. A spaghetti diagram is drawn after following a specific person or product and recording the path it takes throughout the facility/area layout. The typical flow of both the specimen and the employee should be traced on an existing laboratory floor plan to highlight unnecessary human motion and specimen conveyance (see Image C).

**Designing for Flexibility**

When Henry Ford developed the first flow production system in 1914, he coined the famous phrase, "You can have any color Model T you want, so long as it is black." But while Ford Motor Company mass produced black car after black car and, for a time, was dominating the marketplace, Toyota adopted the flow production system to become more competitive. This system allowed Toyota to accommodate variety (or, in Lean parlance, "unevenness") in accordance with customer demand.

A successful Lean project demands flexibility to respond to changes in demand with little corresponding effect on operations and quality. To remain efficient and profitable in the face of changing business conditions, a Lean laboratory must have a flexible environment that can accommodate growth and test mix changes. It must have the ability to expand, modify, and completely alter functional relationships and workflow. Utilization of an open laboratory concept offers the most effective means of achieving sufficient flexibility.

*Image A: A sample process diagram showing the flow of specimens through the clinical laboratory.*
In addition to reducing barriers to communication and supervision, an open laboratory design facilitates flexibility in the assignment of staff and the ability to share equipment/instrumentation (see Image D).

Introducing flexible casework is one way to optimize space in the laboratory. Flexible systems allow work stations, base and wall cabinets, shelves, and partitions to be modified and reconfigured to meet the changing needs of the laboratory in an economical and convenient manner. While purchasing casework that provides maximum flexibility may initially be costly, the lifecycle of flexible casework gives it a high return on investment and saves money in the long run given the likely modifications and reconfigurations that will be required by the continuous Lean improvements (see Image E).

Lean laboratory designs must also consider flexibility with laboratory engineering systems such as electrical power, HVAC, laboratory gases, and plumbing. Among the useful items for consideration are ceiling plenum, layering, interstitial floors, and reserved riser space. We implemented an open laboratory layout at DSI Laboratories’ central core laboratory in 1996. More than five years after the initial design, Lean and Six Sigma projects led DSI to convert its layout to a single-piece workflow with minimal renovations necessary.

**Designing For Efficiency**

While laboratory planning and design was historically driven by factors such as hospital bed count, number of full-time equivalents (FTEs), and test volumes, current best practices base spatial needs and overall design on flexibility, capacity, workflow, and equipment. As opposed to function-based layouts where all stations that perform a certain function are grouped together, in Lean work cells, equipment and workstations are arranged based upon the sequence of steps that are required to complete a given product or service. Such a process-based layout facilitates continuous flow and minimizes the batching of work,
Image C: A spaghetti diagram tracing specimen workflow at Yale-New Haven Hospital in New Haven, CT.
excessive specimen transportation, and worker motion often found in functionally-based layouts.

For example, refrigerators located on the laboratory’s periphery can often be replaced by smaller yet adequate refrigerators at individual workstations. Such placement eliminates the need for staff to walk back and forth to a bank of centralized refrigerators to obtain reagents and other necessary supplies.

Only those tools that are absolutely necessary and supplies that are required to complete a certain shift or a particular day should be incorporated into workstations to maximize design accessibility. Lean work cells are often found in a “U” shape that enables the operator to move from function to function in one cell. Ideally, the test sequence will end in a location near the beginning stage of the next piece.

Skilled workers who operate in cellular layouts enhance an organization’s ability to adapt to variation in demand. When demand is low, a skilled worker can perform a series of processes in a particular cell using multiple instruments. As demand increases, additional workers can be added to the cell to meet talit time, maintain process capability, and facilitate continuous flow (see Image F).

The use of cellular layouts can reduce space and workstation requirements and improve visual management. In redesigning their manufacturing facility into a U-shaped configuration, Baxter Healthcare Corporation in Mountain Home, AR, was able to reduce the square footage of its initial plant design by 10,000 square feet. Moreover, using a modular configuration allows organizations to conserve resources and add additional cells only when demand exceeds capacity.

Conclusion
While success stories about the incorporation of Lean principles and tools into production processes have been available for some time in the manufacturing industry, health-care organizations are beginning to introduce Lean concepts in the review and revision of their many processes. With increasing frequency, health-care organizations are pairing with planning, architecture, and design firms to take the fundamental concepts of Lean to the next level by incorporating them into the planning and design process.

In particular, Lean design concepts in the clinical laboratory are being used effectively to provide superior patient care thanks to the elimination of waste and the ability to process higher test volumes in less space, with less material and in shorter time.

References

INTEGRATING LEAN THINKING INTO LABORATORY PLANNING AND DESIGN

Image F: A laboratory technician working in a "U-shaped" station in the Central Laboratory ACL Laboratories in Rosemont, IL.


Vassilios Nicolaou, a Karlsberger Laboratory and Technology Group vice president, is one of the country's leading design consultants to the laboratory industry. His experience includes single hospital based laboratories and large, freestanding reference laboratories that serve both the hospital systems and outreach clients.

With experience in healthcare administration, process improvement, patient safety and the integration of Lean principles into healthcare operations and planning, Amanda Borgsdorf, a member of Karlsberger's Research and Consulting Group, works with teams to create process flow that delivers more appropriate and efficient healthcare services.

Copyright © 2007 by Clinical Laboratory Management Association Inc.