A Lean alternative to total laboratory automation

Mick Chomyn and Martin Fottles from Path Links Pathology Service illustrate how Lean work cells deliver faster turnaround times, higher productivity and efficiency, increased flexibility, improved space utilisation, and quality.

The management system referred to as Lean originated in Japan in the 1950s and was developed by Toyota over subsequent decades. A fundamental goal of Lean is to achieve a continuous flow of work through a process. Batch processing is inherently inefficient, causing delays and bottlenecks. Simply by applying Lean to improve work flow, dramatic improvements to productivity and quality can be achieved. Consequently, over recent years, Lean principles have been applied to almost all manufacturing, commercial and public sectors, including healthcare.

As a single pathology service operating from five laboratories over 2000 square miles and providing a service to over one million inhabitants, Path Links has fully embraced Lean principles in its daily clinical laboratory routines to realise many efficiency and productivity gains. This article will briefly describe Lean principles and focus on its practical application from the experiences of this large hospital laboratory group.

Testing times

Improving quality, increasing staff productivity, and reducing costs are challenges typically driving clinical laboratories towards higher levels of automation. Particularly in the blood sciences of clinical chemistry and haematology, there is a bewildering spectrum of equipment available, ranging from discrete automation (across the pre-analytical, analytical and post-analytical phases), through modular systems linked by tracks, to fully robotic total laboratory automated solutions.

Although fully automated systems are widespread, Lean is emerging as a viable and cost-effective option, the theory and practise of which is readily applicable to the clinical laboratory. The focus of Lean is 'how to do more for less' through the elimination of waste in all its various forms. There is a variety of tools and techniques available to achieve this aim. By eliminating waste and optimising work processes, Lean achieves the same goals of improving quality, increasing staff productivity and reducing costs, but at a fraction of the cost of deploying automated systems.

This is not to suggest that Lean is an alternative to automation per se, but rather as a methodology that may guide the appropriate choice of equipment and its utilisation in the laboratory. Path Links has adopted this approach to develop a 'total Lean solution' for its clinical laboratories. This has delivered greater flexibility, a significant reduction in space requirements, and avoidance of the large investment and maintenance requirements of tracked systems.

Fig 1. U-shaped Lean analytical work cell at Path Links' Lincoln laboratory.

Lean in a nutshell

While a detailed overview of Lean is beyond the scope of this article, the following are some important principles:

- The elimination of waste is the main focus of Lean. Typically, there are seven wastes described: Defects; Over-production; Waiting; Transport; Motion; Inventory; and Over-processing. A further two are increasingly recognised, those of Under-utilising People and Inappropriate Automation. The target of Lean is to identify, eliminate or minimise all forms of waste that add no value (from a customer perspective) to the product or service provided.
- Value-stream mapping is a critical tool in the Lean armoury. It accurately captures all activities and information flows in a process by direct observation and data collection, thereby differentiating between what is actually happening and what we think is happening. All non-value-adding steps in a process, and those

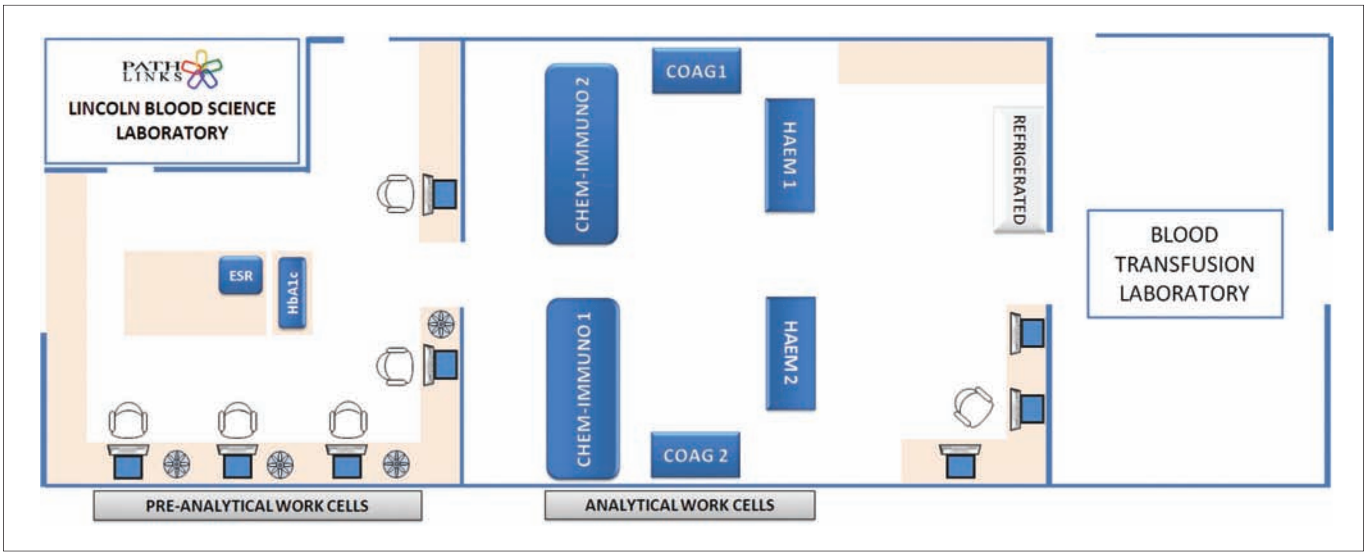

Fig 2. Typical Lean-optimised layout achieves perfect 'line of sight' for visual control of all operations to ensure smooth workflows at Path Links' Lincoln laboratory.

activities that create waste, can then be identified. Subsequent elimination speeds up the process (improves flow), optimises activity, improves quality and reduces costs.

- Flow is the continual movement of products or services through a process, avoiding stop-start interruptions that cause unnecessary delays and bottlenecks. It is also much easier to identify problems rapidly within a process where continuous flow is achieved.

In essence, Lean enables the delivery of products and services in the least possible time, with the minimum amount of effort and the fewest resources.

Optimising layout, processes and procedures

By far the biggest wastes typically found in the laboratory are associated with poorly designed layout and processes. Improving workflow is the ultimate goal of optimising these factors. By moving samples through a process without delay, defect or backflow (re-processing or repeat sampling), continuous flow should be achieved.

> 'The strength of a Lean approach is to understand and optimise work processes and use this knowledge to guide the correct choice of equipment'

Ideal Lean layout

A key factor to ensuring smooth workflow is the layout and space utilisation of the laboratory environment. A well-designed and properly configured laboratory delivers significant benefits in terms of capacity, productivity and workflow. The experience from manufacturing industry is that a U-shaped Lean work cell provides the optimum configuration, minimising walking distance and allowing different combinations of work tasks to be undertaken by the cell operator. Lean work cells are designed to eliminate waste in terms of time spent travelling, improve flow and help to optimise material, people and information flows. Communication is enhanced because operators work closer together and, through improved visual control, they can see and manage the entire process more effectively.

Through achieving and maintaining efficient continuous work flow, Lean work cells deliver shorter lead times (turnaround times), higher productivity and efficiency, increased flexibility, improved space utilisation and improved quality.

As applied to Path Links' blood science laboratories, such as Lincoln, analytical work cells typically bring together all routine automated equipment accounting for over 80% of laboratory activity and include clinical chemistry/immunoassay, haematology and coagulation (Fig 1). All other activity (eg microscopy) is located at the periphery of the laboratory, or co-located as close as possible to the analytical cell. Data management and validation work stations are similarly co-located, but away from the analytical cell.

Allied to the development of a blood science analytical work cell is the

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requirement to address layout and location issues simultaneously in specimen reception and blood transfusion laboratories. Ideally, both functions should be co-located or within close proximity to the core blood science laboratory.

Figure 2 illustrates the Lincoln laboratory layout, which represents a typical Lean configuration for a blood science clinical laboratory. The optimised layout achieves perfect 'line of sight' to ensure appropriate visual control of operations and the ability to identify and address rapidly any issues that impact on work flow. Travel distances for staff are minimised and the co-location of equipment allows a single operator complete control over the work process, distributing incoming samples quickly to the next available analyser to minimise processing time and achieve faster throughput.

Batch and queue

Processing samples in batches can be intuitive and often compounded by the type of equipment available in the laboratory. For example, large laboratory centrifuges typically have a capacity of up to 64 standard tubes. During busy periods it would seem sensible to run the centrifuge at maximum capacity. However, this creates a 'batch and queue' process that will adversely

Fig 3. Path Links has applied Lean methodology to redesign its pre-analytical process and improve sample flow.

impact on laboratory productivity, analytical capacity and processing time by inhibiting flow.

Taking the centrifuge as an example, to prepare 64 tubes would take approximately 25 minutes to load (allowing 20 seconds to de-bag, check and barcode label each sample), and a further 15 minutes centrifugation and unloading time. At best, it would take a minimum of 40 minutes from sample receipt to presentation to the analytical phase. At peak times, and where multiple centrifuges are used, this will result in large batches of samples being loaded onto the analyser simultaneously. This in turn may lead to further inefficiencies should analytical capacity be exceeded. Worse still, the routine perception of an analyser's inability to cope with peak demand increasingly fuels the desire for higher-capacity and faster-throughput analysers with greater levels of automation.

Smooth operation

As an alternative, Path Links has applied Lean methodology to redesign its pre-analytical process and improve sample flow (Fig 3). Standard laboratory centrifuges have been replaced with smaller-capacity (eight tubes) rapid centrifuges, the rationale being to force a reduction in batch size (from 64 tubes to eight) and to shorten the spin time (from 10 minutes to three minutes). Applying the same criteria, it would take just three minutes to load and four minutes for centrifugation and unloading, making samples available for analysis after just seven minutes. In this way, sample analysis commences 33 minutes earlier than in the 'batch and queue' process example. Importantly, the significantly reduced batch size presented to the analytical platform ensures a smooth, continuous operation well beneath the analytical capacity threshold of the analyser. This overcomes the requirement for 'bigger and faster' analysers simply to cope with periods of peak demand, which would represent significant over capacity (and waste) at all other times when activity is low.

The layout of the Path Links pre-analytical work cell has been standardised so that each one is identical. Samples are processed individually thus achieving 'single piece flow' on a 'first in, first out' basis. Problem samples are taken out of the process at this stage in order not to interrupt the work flow. The entire process is designed to optimise throughput and eliminate the opportunity for error.

Lean automation?

The above example not only demonstrates the benefits of improving flow but also illustrates the '9th Waste of Lean', that of automating a bad process. A decision to increase automation in the absence of a full understanding of the entire process, and implementing process improvement, is a bad one. Quite simply, automating a poor process only serves to automate waste and can lead to higher expenditure.

Consequently, automation should only be considered as Lean if it improves workflow and supports dynamic optimised layout. Important characteristics such as automated random access, reflex testing, automatic re-runs and integrated solutions such as slide preparation and staining systems are all features that support improved work flow. The concept of a dynamic, optimised layout requires equipment to be of compact design while, ideally, being trolley mounted to facilitate rapid reconfiguration if required. This not only achieves an optimised layout but also provides greater flexibility and opportunities for future improvement

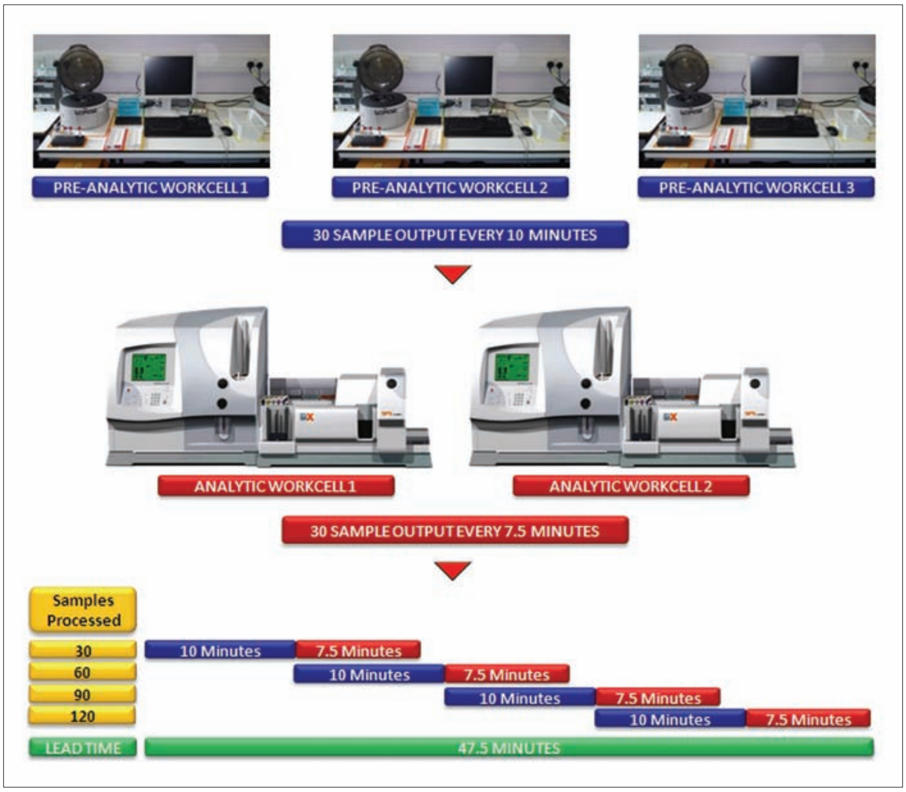

Fig 4. The development and deployment of Lean analytical work flows at Path Links has typically led to dramatic improvements in laboratory efficiency and productivity.

AN IDEAL LEAN HAEMATOLOGY ANALYSER

Lean processes can certainly encompass automation if it improves workflow and supports dynamic optimised layout. The ABX Pentra DX 120 SPS haematology analyser from Horiba Medical supports these important requirements, making it an ideal haematology analyser for Lean working. It has key attributes that ensure enhanced workflows, including: automated random access, reflex testing, automatic re-runs and integrated solutions, such as sample management and slide preparation and staining systems. Supporting optimised Lean layout, this high-throughput analyser is compact in design with an inbuilt compressor, enabling it to be trolley mounted and moved easily should changes to work processes require rapid laboratory reconfiguration.

By incorporating the ABX Pentra DX 120 SPS haematology analyser into a Lean analytical work cell, laboratories can benefit from greater flexibility, significant reduction in the space needed, and the avoidance of ongoing maintenance requirements of a tracked system. Path Links uses the ABX Pentra DX 120 SPS as the main haematology analyser in all five of its laboratories. Further information is available on the company's website (www.horiba.com/uk/medical).

The ABX Pentra DX 120 SPS haematology analyser.

in activities. Therefore, automation needs to be dynamic rather than static, meeting the requirements of changing internal work processes as opposed to dictating them.

This differentiates the Lean configuration from automated tracked systems. In the design of a Lean laboratory, achieving optimised layout, work processes and sample flow is of primary importance, and aids the selection of appropriate automated equipment. In other words, automation is selected to 'fit the process' and not the other way around. While highly automated, tracked systems to an extent may be configurable, they largely dictate space utilisation and work processes to 'fit the automation'. If the entire laboratory process is not clearly understood then there is an inherent risk of 'automating a bad process'.

Leaning Path Links

Rather than looking toward tracked automated systems, Path Links has found Lean applications to processes and equipment choice to be a highly effective alternative. The Path Links process is visualised in Figure 4 where three pre-analytical work cells, assuming manual data entry, and two analytical work cells can output 120 samples (full blood counts [FBCs]) in under 50 minutes from sample receipt. Work flows are continuous yet analyser capacity is never exceeded. The establishment of Lean pre-analytic work cells and associated work processes has, in turn, demonstrated greater efficiency and improved speed compared with automated pre-analytical systems previously in use in the laboratory.

Efficiency and productivity gains

The development and deployment of Lean work cells at Path Links has led to dramatic improvements in laboratory efficiency and productivity. Hospital in-patient turnaround times have improved by 40% and median turnaround times for emergency department requests are down to 14 minutes for haematology (FBC) and 29 minutes for chemistry (urea and electrolytes [U&E]/troponin I). Completion of routine daily work has been reduced by over two hours, resulting in the ability to reduce staff coverage during the evening work period.

A further benefit of work cells is that they are scalable to match variable workload activity throughout the day. During quiet periods only a single work cell will be operational, increasing to maximum deployment at peak times. From Path Links data, the throughput of each pre-analytical work cell is 60 per hour for manual data entry and up to 240 for electronic order requests. At peak times, utilising three work cells to ensure smooth and continuous flow, a rate of delivery of 45–180 samples to the analytical work cells is achievable every 15 minutes.

Taking the Figure 4 illustration further, in a scenario where 300 samples are received in the laboratory, the operation of three pre-analytical work cells would deliver 30 FBC samples every 10 minutes (assuming manual data entry) to the analytical work cells. With a total analytical capacity of 240 samples per hour from two analysers, the total processing time for 30 samples would be 7.5 minutes; these being processed before the next delivery of 30 samples from the pre-analytical work cells. By ensuring a smooth and continuous flow of samples to the analytical work cells, the entire 300-sample workload is completed in just one hour and 50 minutes from the time of arrival, with the first result available after only 12 minutes. Importantly, the analytical capacity of the analysers is not exceeded, with both systems running maximally at 75% of total capacity throughout the period.

Lean conclusions

The adoption of Lean principles and methodologies provides significant improvement opportunities for the clinical laboratory. The strength of a Lean approach is to understand and optimise work processes and use this knowledge to guide the correct choice of equipment. In other words, it makes the equipment fit the process rather than fitting a process around the equipment. Lean processes aim to implement appropriately sized equipment which is usually smaller, less complex, more flexible and less expensive than highly automated systems.

In collaboration with Horiba Medical, Path Links Pathology Service has published a White Paper on the application of Lean principles to healthcare entitled 'TLA – the LEAN Alternative'. This is available to download from the Horiba website (www.horiba.com/uk/medical/feedback/tla-the-lean-alternative-white-paper).