Lean Thinking
Lecturas recomendadas

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Introduction to Lean Principles

History:

- Henry Ford credited with starting original movement
- Kiichiro Toyoda and Taiichi Ohno: 1930's developed the Toyota Production System.
- Popularized by Jim Womack, author of *Lean Thinking*, *The Machine that Changed the World* and *Lean Solutions*

Why Use Lean?

Lean principles help to examine business processes and focus on minimizing unnecessary costs, reducing waste and improving inefficient procedures.

Benefits:

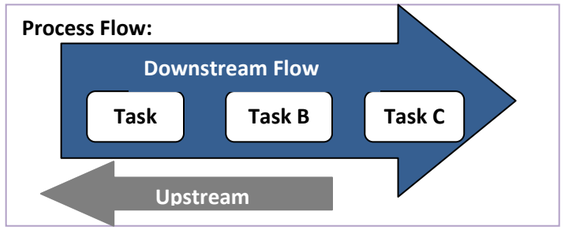
- Identifies problem areas and bottlenecks
- Increases business efficiencies – make sure staff time is spent on value-added activities.
- Save money – reduce overhead in paperwork
- Simplify processes
- Conform to rules & regulations and codes of conduct – standardizing processes using Lean

What is Lean?

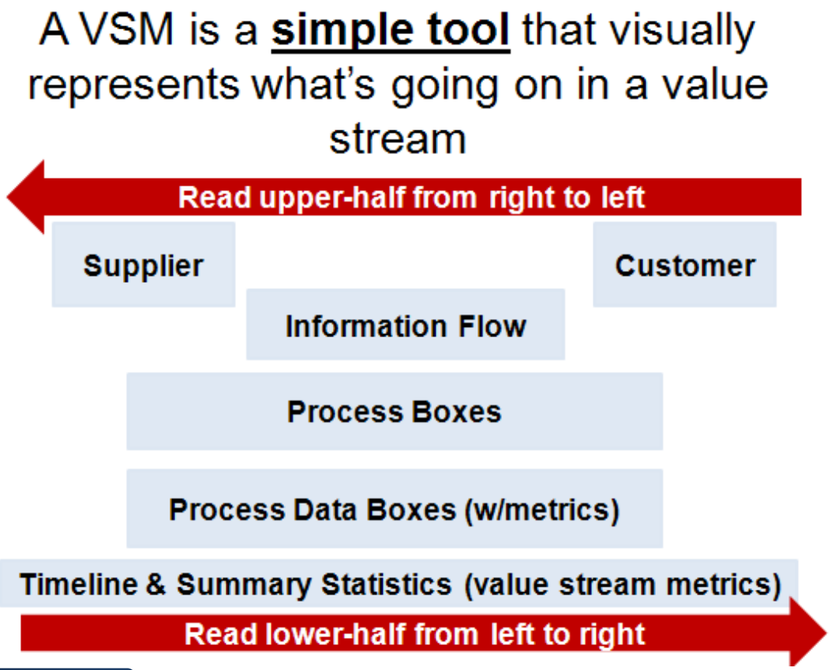
Lean consists of proven tools and techniques that focus on minimizing wasteful activity and adding value to the end product to meet customer needs. The 8 areas of waste can be used to understand the inefficiencies:

Waiting	**Inventory**	**Under**	**Correction / Rework**
Overproduction	**Motion**	**Material Movement / Transportation**	**Extra Processing**

A mapping method called Value-Stream mapping is typically used to capture the "current state" process, including both the value-added and non-value added steps. Value-stream mapping provides an overall view of business processes as they are now, mapping the material and information flows and can be used to create the "future state" process after the "leaning" has taken place.



Look at process through the customer's perspective and identify "waste" in the process.



Lean Terminology/Metrics:

Non-value added: Activities or actions taken that add no real value to the product or service, making the activity or action a form of waste.

Value-added: Activities or actions taken that add real value to the product or service.

Incidental Work: Activities needed to stay in business legally.

Internal Customer: Receiver of the product or service inside the organization, often the individual downstream process.

External Customer: Receiver of the product or service outside the organization.

Kaizen Philosophy: Japanese for "improvement" or "change for the better". Frequent small improvements, the cycle is:

- Standardize an operation
- Measure the standardized operation
- Gauge measurements against requirements
- Innovate to meet requirements and increase productivity
- Standardize the new, improved operations

Lean Metrics:

1. **Process Time (P/T)** – actual "touch time" of one work item; exclude interruptions
2. **Delay Time (D/T)** – time work item is delayed or not touched
3. **Lead Time (L/T)** – start time to finish time; L/T=P/T + D/T
4. **% Complete and Accurate (%C/A)** - % of work entering a process that is complete and accurate.

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Understanding 8 Areas of Waste:

WAITING:

- System downtime or response time
- Approvals from others
- Information from customers
- Meetings starting late
- Late reports, paychecks, or projects

INVENTORY: Too much of anything and any form of batch processing

- Excessive office supplies
- Full "in-boxes" (electronic or paper)
- Computer files never used

UNDERUTILIZATION OF PEOPLE

- Limiting employee authority and responsibility for tasks
- Inadequate business tools available
- Delaying implementation of computer system components
- Restricting or not offering training on technical resources

CORRECTION/REWORK: Correction of any error

- Order entry errors
- Grammar and punctuation
- Inaccurate reports or data
- Lack of standardized work
- Incomplete communications

OVERPRODUCTION: Producing more sooner or faster than is required for the next process

- Printing hardcopies of forms
- Purchasing items just in case they are needed
- Processing paperwork before the next person in the process is ready
- Preparing reports that are not used or read

MOTION: Unnecessary physical movement

- Copy machine too far away from users
- Digging through stacks of paper
- Reaching for commonly used tools
- Misplacing equipment/items
- Using too many layers for electronic folders

MATERIAL MOVEMENT/TRANSPORTATION (transporting, sorting, or arranging items unnecessarily)

- Filing papers that will never be used again
- Stock piling supplies far from their point of use
- Burying extra supplies in drawers or storerooms
- Requiring multiple approvals
- Hand Delivery
- Late reports, paychecks, or projects

EXTRA PROCESSING: Extra mental or physical non-value added steps

- Producing repetitive documents from scratch
- Poor filing system
- Lack of visual controls
- Too many approvals required for action
- Unclear reports/memos published
- Reviewing a document multiple times to determine action
- Meetings without agendas for action

WASTE WALK

Audit questions to determine "pain points" in an area to be Leaned

WAITING

1. Are there excessive signatures or approvals required?
2. Is there too much dependency on others to complete a task?
3. Are there delays in receiving information?
4. Are there computer program version problems causing delays?
5. System downtime or response time causing delays?
6. Are there cross-departmental resource commitment issues?

INVENTORY –

1. Are files (or work) awaiting excessive signatures or approvals?
2. Are files awaiting task completion by other?
3. Are there delays in receiving information?
4. Are we purchasing excessive supplies of any kind?
5. Do we have any obsolete files (electronic or hardcopy) in the area?
6. Do we have obsolete equipment in the area?
7. Is there batch processing of transactions or reports?

UNDERUTILIZATION OF PEOPLE –

1. Are we in positions we were trained to do?
2. Can we assist other areas when work is slow in an area?
3. Can we be trained to do more within the organization?
4. Are the business tools adequate for the job?
5. Are you restricting or not offering training on technical resources?
6. Are you delaying implementation of computer components or software?

CORRECTION/REWORK –

1. Do we have any data entry errors?
2. Do we have pricing, quoting, billing, or coding errors?
3. Do we forward partial documentation?
4. Do we ever lose files or records?
5. Do we ever encounter **in**correct information on a document?
6. Is there a lack of standardized work?

OVERPRODUCTION –

1. Are making extra copies, more than needed?
2. Are we printing, faxing, e-mailing more than what is needed?
3. Are we entering repetitive information on multiple work documents or forms?
4. Are we ordering more tests or services than what is required by the customer?
5. Are we purchasing items just in-case they are needed?
6. Are we preparing reports that are not used or read?
7. Are we having meetings without the necessary information for action?

MOTION –

1. Are you searching for computer files on your desktop or using too many layers for electronic folders?
2. Are you searching for work documents (files) in cabinets and/or drawers?
3. Are you constantly reviewing the same manuals for information?
4. Are you hand-carrying paper work to another process or department regularly?
5. Are you misplacing equipment/items?
6. Are you reaching for commonly used tools?

MATERIAL MOVEMENT/TRANSPORTATION –

1. Are you delivering documents that are not required?
2. Are you doing excessive filing of work documents or filing documents that will never be used again?
3. Are you requiring multiple approvals?
4. Are you hand delivering items that can be sent in interoffice mail?

EXTRA PROCESSING –

1. Are we producing repetitive documents from scratch?
2. Do we have a poor filing system?
3. Is there a lack of visual controls?
4. Are we too many approvals required for action?
5. Are we entering repetitive information?
6. Are we doing more work than is required for that process?

5S ORGANIZATION SYSTEM

Tool to organize spaces and introduce Lean concepts

Description of conducting 5S improvement: Sort, Set in Order, Shine, Standardize, Sustain	**Audit questions for 5S area.** Ratings: No problems – 0, 1 problem – 1, 2 problems – 2, 3 problems – 3, and 4 or more problems -4. Goal is to have a low total number. Correct problems immediately.
SORT – When in doubt, sort it out! Ask questions about use Set Criteria for sorting Place items in holding until all have had a chance to review items being discarded	----- Excess/unneeded equipment, tools, furniture in area ___Unneeded/outdated items on walls ___ Items are present in aisle ways, corners, etc. ___ Excess/unneeded inventory, supplies, material in area
SET IN ORDER – A place for everything and everything in its place! Identify location for items Relocated items Use visual controls – labels Logical design flow	___ Correct places for items are not clearly marked or labeled ___ Items are not marked or labeled with "return addresses" ___ Aisle ways, workplace, equipment locations are not marked ___ Items are not put away immediately after use ___ Height and quantity limits are not clearly marked
SHINE – Inspection through cleaning! Clean Organize loose cords Replace damaged items Place small items on trays for easy cleaning	___ Floors, walls, stairs, and surfaces are dirty ___ Equipment is dirty ___ Appropriate cleaning materials are not available in area ___ Lines, labels, signs, etc. are dirty and hard to see ___ Other cleaning problems are present
STANDARDIZE – Everything in a state of readiness! Rules to maintain and control system (checklist, audits, and visual controls) Minimum and maximum limits Quick reference checklist	___ Standards to maintain sort and set in order do not exist ___ Checklist for all cleaning and maintenance jobs do not exist ___ Standards are not visible in the area and know to area stakeholders ___ Quantities and limits cannot easily be seen ___ Items needed to do job function cannot be located in 30 seconds
SUSTAIN – Training, reinforcement and measurement! Communicate importance Train on rules Share success in meetings Effective visual controls	___ Workers in area have not been trained in 5S ___ Daily 5S was not done this week ___ Personal belongings cannot be easily stored ___ 5S checklist/standards are not available or up-to-date ___ Scheduled 5S audits have not been completed this week

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an NHS Confederation leading edge report

THE NHS CONFEDERATION

Lean thinking for the NHS

Daniel Jones and Alan Mitchell, Lean Enterprise Academy UK

A report commissioned by the NHS Confederation

The voice of NHS leadership

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Foreword

We asked the Lean Enterprise Academy to look at how Toyota's approach to production could be applied to healthcare. This is not as odd as it first appears. The Toyota system – often known as Lean – has been applied in many environments, including healthcare (and not just manufacturing) for some time now, with staggering improvements in quality and efficiency. The underpinning values of removing activities that don't add value and of respect for people and society lie at the heart of healthcare. And the principles on which Lean is based are generic. They can be applied anywhere: at home, in a bank, GP practice or hospital.

A number of things have struck me about places I have visited where people are implementing Lean. Firstly, the clinicians are involved and enthusiastic. People seem to be having fun. Secondly, the scale of the improvements is often extraordinary. More problematically, the transformations require whole processes to be looked at, with teams sometimes taking an entire week out – often more than once. It is also striking how far Lean principles run counter to received common sense – they challenge the whole idea of economies of scale, of batching and queueing work, triage and de-skilling. Many of these ideas about the organisation of work are deeply held and often wrong. Most counter-intuitive of all is the idea that we can get more done by working the system less hard.

The results are potentially very significant. Lean's focus on delivering care is a refreshing antidote to benchmarks, targets and the traditional approach to performance management. The emphasis it puts on looking at the whole system is valuable.

For me, one of the most important insights is that many traditional approaches to efficiency improvement are futile and focus on the wrong thing.

- In most organisations of whatever type, there is at least nine times more non-value-adding activity than there is work that actually meets the patients' needs. So even if the value-adding component is improved by 50 per cent this will have a very small impact on overall productivity.
- Improving value-adding components in isolation without addressing the whole process may not improve efficiency at all. A faster machine in pathology or a quicker transfer from accident and emergency to a ward may simply mean that the specimen or the patient waits somewhere different and longer for the next stage in the process.
- Lean focuses the improvement effort on things that matter to patients and clinicians, and on the things that cause them stress and get in the way of care – as opposed to external benchmarks or national targets, which tend to be expressed in terms that are only indirectly related to improving patient care.

There is one other key insight I have gained from talking to people developing Lean approaches. Lean has to be locally led and be part of the organisation's strategy. It cannot be imposed from outside: a sure way to kill it would be for there to be a national or regional programme.

The Lean Enterprise Academy has set up a Lean Healthcare Network to help people exchange ideas and experience. The NHS Confederation's Future Healthcare Network is also investigating the very significant implications for the design and size of buildings. Details can be found at the end of this report.

Nigel Edwards, Policy Director
NHS Confederation

The need for change

Although the NHS has made significant progress over the last few years, there is a nagging doubt that the improvements should have been more significant. Also, there are many significant challenges that still need to be addressed, including:

- financial deficits
- hospital-acquired infections and avoidable injury and death
- capacity constraints
- accusations of endemic inefficiency
- public and political concern about waiting lists and costs.

But problems like these are common to many industries. Poor safety and quality, capacity constraints and queues, cash-flow crises, low levels of efficiency and low levels of staff motivation are not confined to the NHS. They plague organisations across the world, particularly in healthcare.

So here is the good news. It is possible to improve quality (to deliver better and more timely patient care), to make working lives less stressful and more rewarding for staff and to boost efficiency and productivity (thereby pleasing politicians and taxpayers), all at the same time.

And it's possible to do all these things without painful restructurings, cash injections or massive new investments in infrastructure or IT – by applying the principles of Lean to the health service.

This report introduces the concept of Lean. It shows how Lean is already being applied in the health sector, and why it is essential to a strong, successful NHS. Its message is simple.

Lean can help save healthcare

Sceptical? So you should be. But please remember three things as you read on.

1 An enormous amount of work has already been done in the NHS which has prepared the ground for Lean: work done to clear bottlenecks at every point in the patient's journey; to understand the scale and the causes of variability of demand and to smooth it where possible. Lean builds on this large body of excellent work, adding some more tools and providing more of a framework.

2 Remember that Lean is not a management fad. It is a tried and tested methodology for improving the way work gets done. Lean has been spreading slowly and inexorably from industry to industry for over half a century as its principles have been fine-tuned, tested, demonstrated and proved – largely against the better judgement of people who looked at it and declared "it will never work here!"

3 If your hospital is struggling with end-of-year financial deficits, ward closures and redundancies, Lean is not going to be your saviour in the short term. Lean will make immediate improvements and help you avoid deficits in the medium to long term, but it cannot help you resolve immediate financial crises. Indeed, because Lean principles take time to embed, and because their application relies on the positive commitment and support of staff in their day-to-day work, the best way to squander the opportunity presented by Lean is to link it to short-term slash-and-burn cost-cutting.

In other words, Lean is about building a positive future – managing healthcare organisations in a completely different way so that short-term fire-fighting becomes a thing of the past.

So, bearing these points in mind, what is so special about Lean?

A good start

Like many NHS services, the pathology department at the Bolton Hospital has grown like topsy. It currently employs over 100 staff across many specialisms. Their daily work conducting thousands of tests each day, using a wide range of specialist equipment, is vital to the effective functioning of the hospital and the NHS trust as a whole. But both its users and its staff experience daily frustrations. Tests take longer than they should, causing delays. Staff feel they are under constant pressure.

Mapping the work

Recently, however, a team of staff at the hospital took a step back to see how their department really worked. They followed blood samples on their journey from the patient, through the haematology, biochemistry and microbiology laboratories and back again, and painstakingly tracked every step the sample took – received with a request form, checked to make sure the sample is from the right patient, assigned a unique laboratory number for processing through the IT system, information input into the computer, and so on.

When they looked at the department's processes like this, end to end, a number of blockages and unnecessary steps became immediately obvious. For example, they could not analyse a sample before the information had been put into the computer but inputting delays are common, caused by samples arriving in large batches. And once they had the information, taking the sample to the analyser could be quite a trek.

Over the years, as the department grew, new space was found in two buildings separated by the main hospital corridor, upstairs and downstairs, in a number of separate rooms. And as new machines were purchased, they were placed wherever room could be found: some on the ground floor on one side of the corridor, others on the first floor on the other side. Staff stored work before making the journey from one location to another (otherwise every day would be a marathon). Samples were analysed on a batch and queue basis, with one day's samples gathered together for analysing the next day. This meant a minimum 24-hour turnaround standard for some tests.

Having seen how the system actually worked, the staff saw many ways to improve it. Why not:

- knock rooms together so that staff can go directly from A to B instead of having to travel via the corridor?
- place analysers together so that staff don't have to trek up and down stairs to access them?
- move the central sample receiving point to the middle of the department, to minimise the sample's journey from receipt to analysis?
- create a standard sample request form for blood sciences that can be scanned into the computer, thereby eliminating a large amount of time-wasting, non-value-adding clerical work?
- analyse each rack as soon as it is filled rather than accumulate a whole batch of samples?

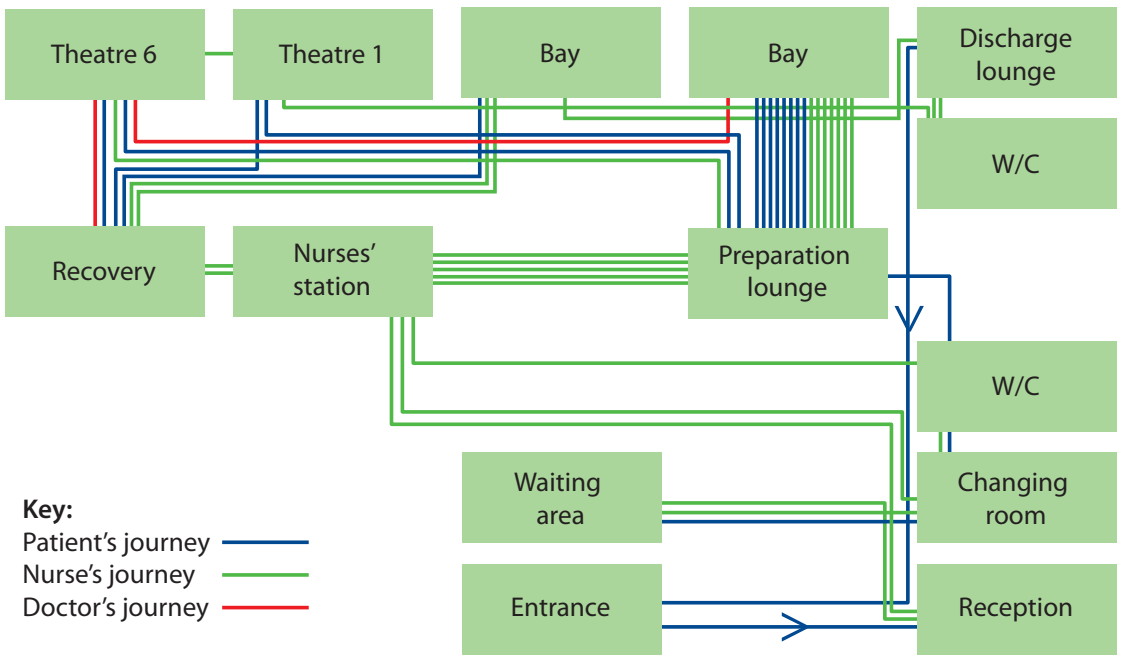
Such detailed suggestion may not sound like much. But put together in the right way, the results were dramatic. A routine blood sample's journey once involved 309 steps, but with a redesign of work, machine relocation and so on, this could be reduced to just 57 steps. Urgent blood sample steps could be reduced from 75 to 57, and so on. Simply relocating two analysers from the first floor to the ground floor and redesigning the workspace would reduce the distance staff have to walk each day by 80 per cent – saving huge amounts of both time and energy. All in all, the time taken to process samples for endocrinology and haematinics could be cut from between 24 and 30 hours to between two and three hours.

What's more, the same amount of work could be done with fewer staff (who are being redeployed to more productive activities), and the actual amount of space used by the department could be reduced by 50 per cent. This had further knock-on benefits for the blood transfusion department. Before, the department was located at the end of a long corridor which staff had to walk up and down in order to collect or deliver blood products. Now it could be moved closer to the wards, saving even more time and energy.

It is certain that Bolton's pathology department is typical of every healthcare system around the developed world and the improvements can be replicated across the entire NHS.

Figure 1 shows a 'spaghetti diagram' like the one drawn up at Bolton Hospital's pathology department. Spaghetti diagrams highlight wasted journeys and effort. This example is from a Wirral Hospital analysis of its day care unit.

Figure 1. Analysis of day care unit, Wirral Hospital



The benefits of Lean

Flinders Medical Centre, a medium-sized public sector teaching hospital in Adelaide, South Australia, has been implementing Lean principles for just over two and a half years.

Professor David Ben-Tovim, the director of the team responsible for redesigning care at the hospital, reports the following results: "We have found that we can do 15 to 20 per cent more work, offer a safer service, on the same budget, using the same infrastructure, staff and technology. Everything has improved: cost, quality, delivery, service – and staff morale."

Before introducing Lean, Flinders was close to meltdown. David Ben-Tovim said: "We found ourselves struggling with an absolutely critical problem delivering safe care. Our emergency department was so congested that it was an unsafe place to be. Patients were waiting an unacceptably long time to see a doctor, and we had a worrying increase in really serious adverse events.

"We hadn't been sitting on our hands. We had tried everything that was common practice for dealing with this kind of problem. But nothing had a big enough effect to really help us out."

Before, "we simply did not have any sense of being in control", says Professor Ben-Tovim. "Now the institution as a whole is much more optimistic. This year, it is coming in below its budgeted costs. So, for the first time in years, it is able to invest some of this surplus in much-needed equipment. At the same time, gross errors are being squeezed out of the system. For example, the number of notifications [where the hospital is sued for errors that cause death or disability] has fallen dramatically from 87 when we started to 32 last year. And many of these notifications are coming from areas of the hospital we haven't reached with Lean yet."

The Lean progression

What Lean is not

Lean is not mean

One of the key principles of the Toyota system on which Lean is based is respect for people and society. Lean is not about headcount reductions. It is about being able to do more – improve patient care – with existing resources. Lean often means the same things can be achieved using fewer people. This means people and resources can be redeployed to create even more value. The purpose of Lean is not to make staff redundant. It is to deliver better healthcare at lower overall cost.

Typically, implementation of Lean principles brings four waves of benefit:

- improved quality and safety – fewer mistakes, accidents and errors, resulting in better patient care
- improved delivery – better work gets done sooner
- improved throughput – the same people, using the same equipment, find they are capable of achieving much more
- accelerating momentum – a stable working environment with clear, standardised procedures creates the foundations for constant improvement.

There is another benefit that comes with each wave. Staff morale improves. "What makes Lean so powerful", says David Fillingham, chief executive of Bolton NHS Trust, "is that it engages the enthusiasm of front-line staff."

Flinders and Bolton are still at the beginning of their journeys. But both are now convinced Lean can save healthcare. But why? And how?

Why Lean works

Why does Lean work? The answer is simple. Lean tackles the heart of the matter: how the organisation's work gets done.

The Lean insight is that when it comes to work, there are countless different ways for organisations to fritter away time, energy and resources doing things that don't add value for the customer – in our case, the patient. It is very easy for layer upon layer of these waste-causing activities to accumulate, until a very high proportion of everything the organisation does is non-value adding rather than value-adding. Eventually this suffocates its potential.

Let's look at how things often go wrong.

Things are hard to see

When errors are investigated – for example drug errors resulting from similar products with similar labels being stored next to each other – it is generally discovered that similar mistakes have been made many times before, and that many, many times before staff have come close to making such a mistake – and avoided it only by a last-minute check. It has taken a national intervention to take the apparently simple step of ensuring that drugs were packaged, labelled and stored in such a way that mistakes became almost impossible to make in the first place. And until the development of the National Patient Safety Agency there wasn't a national system in place for people to raise issues like these.

Responsibilities are not clear

Too many older patients with fractured hips end up suffering from dehydration. Why? Because, very often, they also have a heart, lung or other medical condition which is only discovered when they are being prepared for surgery, causing the operation to be delayed. But because the patient has been fasting in preparation for the operation, they are more prone to dehydration. The problem is exacerbated because patients are scattered around the hospital (fitted into whatever bed has become available), with orthopaedic consultants focusing on one problem, medical staff focusing on the other problems, and not enough communication between them.

Unnecessary work keeps on being created

Because a new machine has been placed where a place can be found for it, every time staff want to use it they have to make an extra journey. Because there is no clear system for bed allocations, staff have to keep on phoning, again and again, to see if they have got a slot for a patient. Because there isn't a standard approach to treating a particular ailment or condition, doctors order tests which, strictly speaking, aren't necessary. Because nurses don't have the right materials or information available at the right place at the right time, they spend a large portion of their day tracking things down rather than actually doing nursing.

Once work is looked at through Lean eyes, it becomes clear that people often do more unnecessary work than necessary work: they are having to work very hard just to get into a position where they can do their jobs.

Processes are not joined up

A test is not ready for when the consultant does his rounds so a decision is delayed and a patient remains in a bed that could be used for someone else. A patient is being readied for discharge but social services have not liaised with voluntary services, or an ambulance hasn't been ordered, so the discharge falls through. 'Disconnects' like these are common in hospitals which, like many organisations, are organised around departmental silos.

Figure 2. Process complexity and likelihood of error

Number of process steps	Probability of success, each process step		
	0.95	0.99	0.999
1	0.95	0.99	0.999
25	0.28	0.78	0.98
50	0.08	0.61	0.95

Disconnects are also compounded by cultures of expertise where specialists create islands of excellence at what they actually do, but everything else is invisible to them. In fact, in the NHS today, nobody ever sees the end-to-end patient journey from admission through to discharge (except for patients themselves); it is no-one's job to manage this journey as a whole. So disconnects are almost built in to how the system operates.

Inappropriate measures and targets

Many accounting measures such as unit cost and asset utilisation focus on just one isolated part of a complex process. Subsequent attempts to improve efficiency and productivity simply pass costs on to another department rather than improving the efficiency of the process as a whole. For example, a buyer buys bulk supplies to qualify for a volume discount, which reduces unit costs. But because the supplies are not needed immediately, cash is tied up in inventory and extra time and money has to be spent storing the excess stock, accessing it etc.

Problems are not resolved

When things go wrong, it creates extra pressure to 'get the job done', whereas, invariably, getting to the root of the problem takes extra time and effort and usually requires the co-operation of some other party. The nurse cannot tell drug companies or the pharmacy to label products better. So the cause of the problem never gets addressed.

Things get compounded

A basic lack of visibility, confused responsibilities, unnecessary work, disconnects, extra work-arounds: they all add up and tangle with one another. And the more complex things become, the greater the chance of errors that undermines quality and/or threaten safety. For example, if there is a 5 per cent chance of making a mistake for each step in a series of tasks, and if there are 50 steps, the chance of getting them all right is less than 10 per cent (see Figure 2). Many NHS processes involve hundreds of steps, so what chance is there for an error-free outcome?

Frustration dissipates energy

Because the quality of the organisation's core processes is poor, mistakes are made and the organisation gets sucked into endless fire-fighting. A blaming culture can take root. More and more of the organisation's resources are dissipated working around, rather than resolving, its underlying problems. Staff want to do a good job, but the system doesn't let them.

The Lean opportunity

Lean brings two things to the party. First, it turns a big problem into a huge opportunity. From a Lean perspective about 95 per cent of everything most organisations do is not value adding. Some of these activities are very hard to eliminate. (Paying invoices doesn't directly improve patient care, for example, but it has to be done.) On the other hand, many of these non-value-adding activities are avoidable.

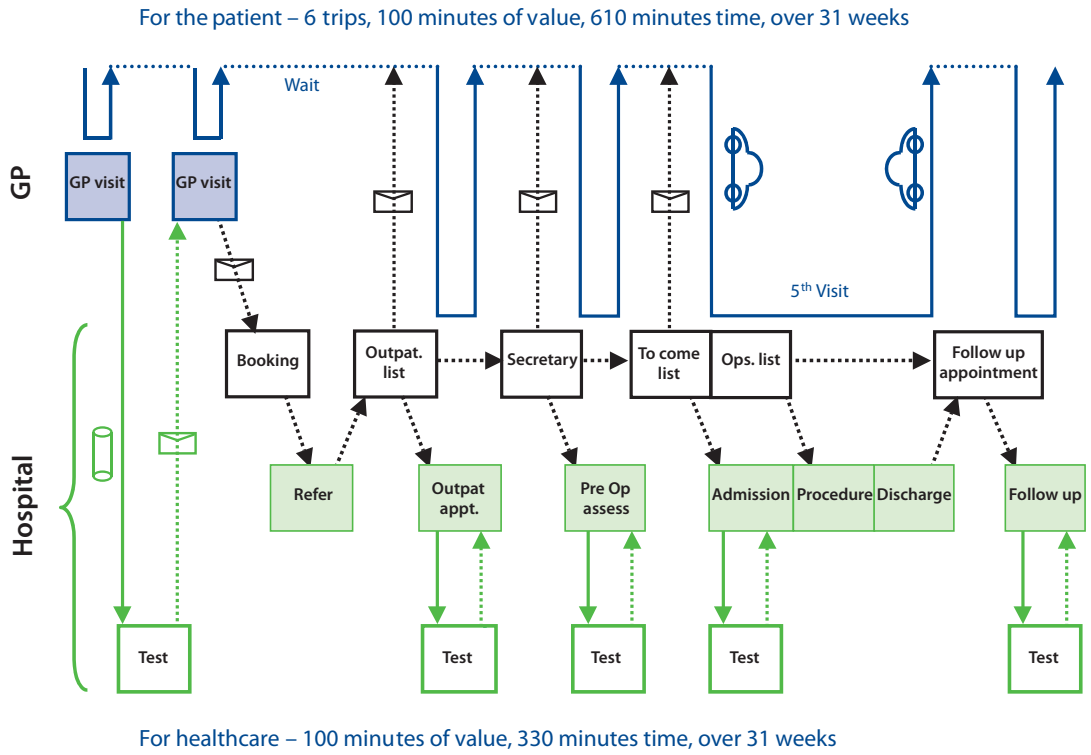
Take this example from the Wirral Hospital (see Figure 3) which shows the results of a value stream mapping exercise.

The chart depicts the steps taken by the GP, hospital, hospital administration, support services and the patient himself, in order to complete a treatment.

The time spent actually treating the patient was 100 minutes. The total time actually required to deliver this treatment was 610 minutes on the part of the patient, and 330 minutes on the part of the hospital. But the whole process took 31 weeks, most of which was spent waiting or doing work not directly related to the treatment. Wirral Hospital is not an exception. It is pretty typical. Just imagine if all this wasted time, effort and resource was released to add new value instead!

Figure 3. A high-level value stream mapping exercise charts the time taken by each main party in the treatment process at each step, and between each step. Like most organisations, there is no one in the NHS responsible for managing and improving such processes from end to end, start to finish.

Figure 3. Time taken in treatment process by each party



The second thing Lean contributes is a set of principles and tools to disentangle the various forms of waste and tackle their root causes. Used separately, these tools are helpful. Used together, in a planned, disciplined and co-ordinated way, they can chip away at accumulated layers of waste to release the organisation's real potential.

Here is a selection of these tools and approaches:

- focus on improving the end-to-end process
- where things are hard to see, make them as visible as possible so that everyone can see when and if there is a problem
- where responsibilities are not clear, create detailed, standardised processes to avoid error, ambiguity and confusion – and as a springboard for improvement
- where there is unnecessary work or waste, whether it is in the form of excess inventory, excess processing, excess movement of people or things, waiting and queuing, redesign the work
- where problems are not resolved, ferret out their root cause ('five whys').

We have not mentioned targets. Targets can be useful. They focus the mind. They can motivate people to work hard. But the point of setting a target is not to reach the target come what may (by squeezing other, non-targeted activities for example, or by working the system). The real point is to create a system capable of reaching the targets on an everyday 'as per usual' basis. That is what Lean is about: creating a continually improving system which is capable of achieving more, using less.

What Lean is not

Lean is not cost-cutting

Every organisation incurs two types of cost:

- costs that deliver value to customers or patients. These costs are good and are to be encouraged. They result in the value that people pay for either directly or through their taxes.
- costs that are incurred but don't end up delivering value to customers or patients. These costs are waste. Lean is about eliminating the waste and improving flow, to improve the proportion of good costs to bad.

Too many cost-cutting exercises fail to discriminate between the two forms of cost, which is why they often end up causing as much harm as good. One insight of Lean lies is this distinction between waste and value.

Lean is not the same as productivity improvements

Productivity usually means sweating existing assets – whether machines or people – harder. But working harder at doing the wrong things is pointless. Wasting effort more efficiently is still waste. So Lean is not simply about productivity. It is about aligning every bit of work that is done up, down, through and across the organisation so that the patient flows through the process from end to end with minimal interruptions and with a supply of skill, expertise, materials and information that exactly meets demand.

How Lean works

Lean works by restoring the organisation's work to its natural rhythm, so the work flows naturally.

Imagine a situation where there is a perfect match between supply and demand: say, traffic load of 1,000 vehicles an hour and a two-lane road capable of carrying exactly this number. How could we mess this perfect match up?

One thing we could do is let slow-moving lorries travel in both lanes so that they slow down faster-moving cars. That's a surefire way of creating queues and illustrates one of the core insights of Lean: if you mix two different value streams – that is, sequences of value-adding steps that follow a different logic and move at different paces – then they will interfere with each other to create the worst of both worlds.

An example from Flinders

Two years ago, the emergency department at Flinders Medical Centre in Adelaide, South Australia was bursting at the seams. Around 50,000 patients were attending Flinders' emergency department every year, some 40 per cent of whom were admitted to hospital, and the complicated triage system it was using just couldn't cope. Under this system each patient was placed into one of five urgency categories, and each category of patient was supposed to be seen within a certain time frame.

Managing this system required a great deal of work: each patient had to be assessed and allocated a category and a time slot. It also involved a lot of re-work. Every time a new patient came in, he or she had to be slotted into the queue at the right place: patients in the less urgent categories were continually pushed down the queue. In September 2003 more than 1,000 patients waited in the emergency department for more than eight hours before being treated. At times, there were up to 80 patients waiting in the department.

Then Flinders staff realised that the emergency department was not one, but at least two value streams:

- patients who can be treated and discharged more or less immediately
- patients who need to be admitted into a ward for further treatment.

So they decided to separate out, at triage, the two groups of patients, literally placing them in different physical locations and treating them in different – and more appropriate – ways. Provided there was no threat to life or limb, patients deemed 'likely to go home' were treated on a first in, first out basis (thereby simplifying the triage process considerably).

The effects were instant. Average emergency department waiting times fell 25 per cent (with 70 per cent of patients going home within four hours). Also, the numbers leaving the department without seeing a doctor fell by 41 per cent. Staff felt the pressure ease.

By improving the flow of work through the department they were able to make much better use of its capacity.

Many NHS hospitals will be familiar with the Flinders approach. See and Treat and the Modernisation Agency's Emergency Services Collaborative utilised Lean principles. So, all those hospitals that have been streaming patients through accident and emergency, identifying and eliminating bottlenecks and improving flow have been adopting Lean methods, even though they may not have fully realised it.

So that is one way Lean works: by enabling different value streams to flow according to their own logic and pace, without interference.

Connecting the parts better

Returning to the example of the motorway, another way to clog the traffic flow would be to construct it in different sections with poor connections between them. The NHS is full of such disconnects. We've seen some examples already. A test fails to arrive before a consultant does his round, so treatment gets delayed. Liaison with social services and transport services breaks down, so the patient isn't discharged as planned.

Any contact needed between members of staff to achieve a task is known as a hand-off and is a source of potential delay or error. When Bolton Hospital mapped the hand-offs needed to complete a complex discharge, it discovered more than 250 (see Figure 4). The more hand-offs there are, the greater the chance of something going wrong. Then traffic comes to a halt when it should be flowing.

Figure 4. Steps taken to discharge a patient

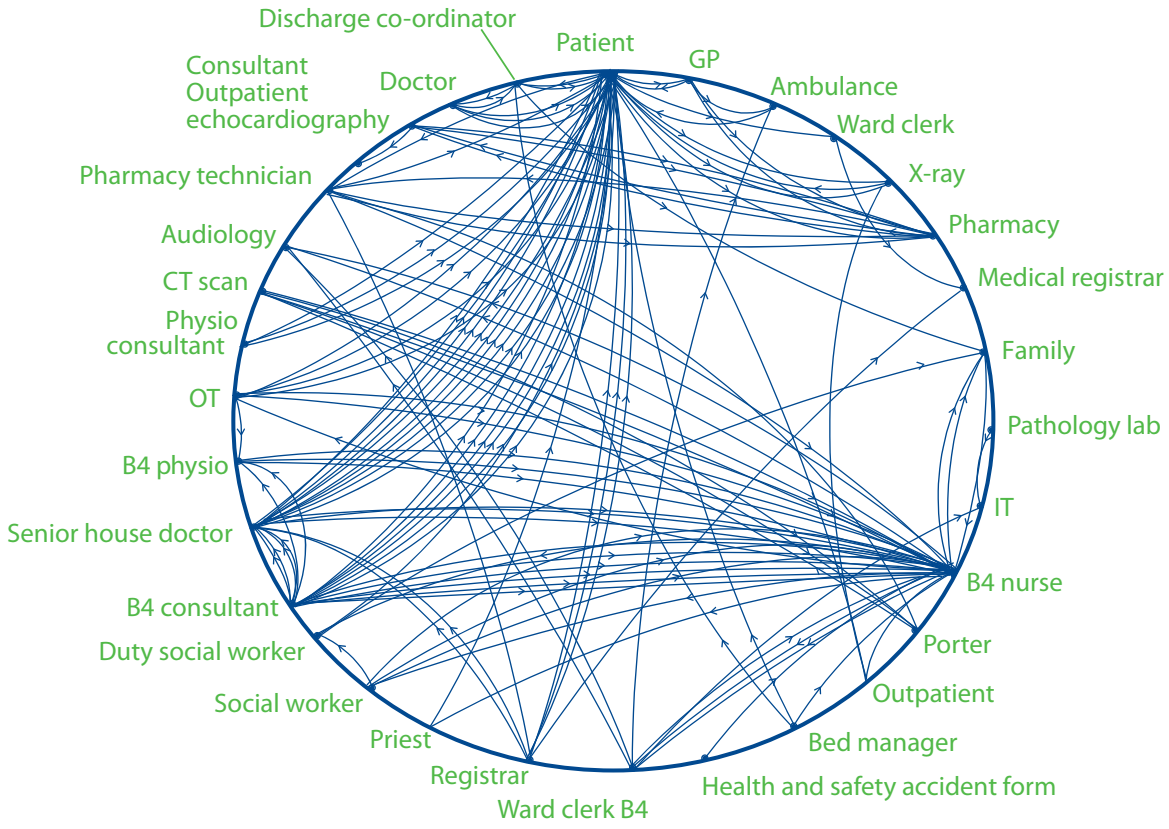


Figure 4. Steps taken to discharge a patient from Bolton hospital – results of a mapping exercise undertaken by hospital staff.

Earlier, we mentioned the problems often faced by older patients with fractures: concurrent medical problems complicate treatment, and patient care suffers as specialists fail to communicate and co-ordinate. To tackle this problem, Bolton borrowed a concept straight from Toyota – the work team or cell – by creating a special trauma unit with its own physical space that combines all the skills (geriatricians, orthopaedic surgeons, medics and other clinical specialists) needed to care for the patient in a single team.

It then created standardised processes for the hand-offs between each team member so that issues are identified and addressed as and when they need to be, regardless of who is on duty, on leave or tied up elsewhere. It is too early to be sure (statistically speaking), but early indications suggest that post-operative mortality rates for fractured hips have halved as a result of these changes.

Easing the flow

Yet another way to clog the motorway is by creating rush hours: shoehorn 3,000 vehicles onto the road in one hour, with hardly any traffic at other times. Artificially induced rush hours are endemic in the NHS: in day care when all patients are asked to arrive at 8am even if some of them won't be treated until noon; when samples are held back in pathology so that they can be processed in batches; when a surgeon conducts many similar operations one after the other thus flooding wards with a sudden rush of patients needing similar treatments, and so on.

People working within the NHS experience daily volatility and unpredictability. But most of this volatility is not created by patients but by the way the NHS itself works. Figure 5 below shows variations in accident and elective admissions for a large teaching hospital between February 2002

Figure 5. Variation in elective and emergency admissions

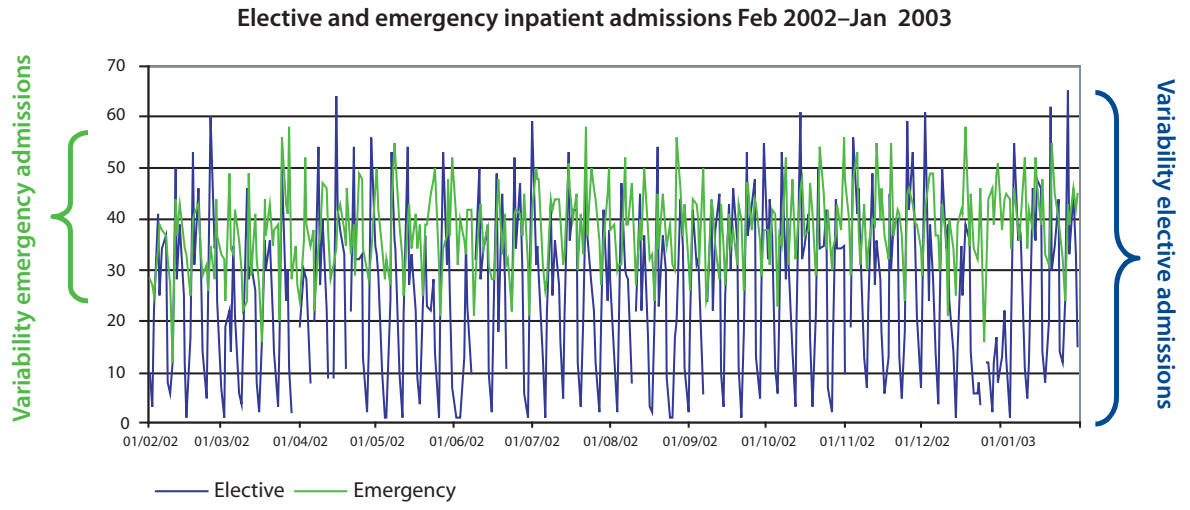


Figure 5: Large teaching hospital: variation in elective admissions is twice that of emergency admissions.

Source: Dr Richard Lendon, Kate Silvester and Richard Steyn, *Flow across healthcare systems*, June 2004.

and January 2003. Variation in elective admissions is twice as high as emergency admission – a by-product of the hospital's policies, not real patient demand.

So Lean works by smoothing demand where it can be smoothed, and by developing the flexibility to cope with variability when it is unavoidable. By moving from batch and queue towards flow – processing ever smaller volumes ever more frequently – the twin evils of batch (too much work in some parts of the system and too little in the others) can be avoided and capacity can be used much more efficiently.

Wirral Hospital is currently working on a scheme to increase flow through its surgeries. Instead of conducting many of the same operations on one day and many of another type of operation on the next day, it plans to move to a system where it does a few of each type of operation each day. This will have the effect of reducing waiting times for patients while also reducing pressure on wards.

Working to real demand

Our original motorway was a resource that was perfectly aligned to demand. But with poor management of traffic flows (value streams), disconnects and rush hours (batch and queue), we still managed to clog it up. Lean solves such problems by pulling value through the system from end to end as and when it is needed, instead of pushing it.

If we know that underlying demand is for, say, 100 admissions a day, that means we need to discharge

Figure 6. The Lean ideal

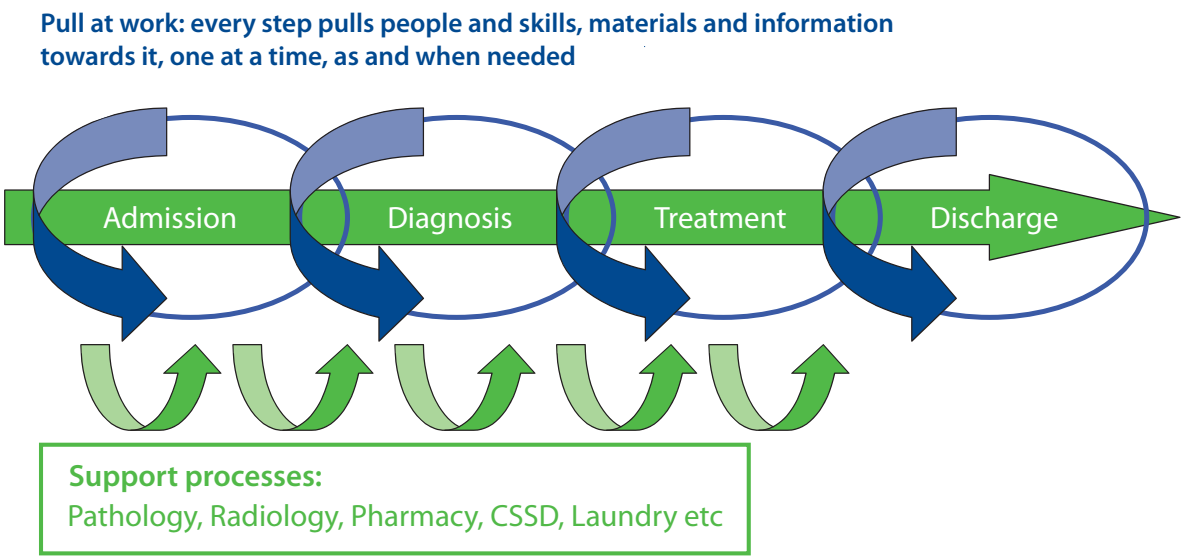


Figure 6. The Lean ideal: patients are 'pulled' through the hospital system at a rate that keeps pace with demand. Discharge pulls patients from wards, wards pull patients from surgery and admissions while pulling support processes from support departments, all with zero waiting time or wasted effort.

100 patients a day, the wards have to be in a position to take on 100 patients a day, admission ready to admit 100 patients, and so on. Lean practitioners call this 'takt' time: the amount of time you need to spend on each activity if you want to achieve output in line with demand. Takt time is a way of identifying how fast work, materials etc should be flowing through the system, from department to department, task to task. This means shifting our thinking from measuring activity to understanding demand – one is not a proxy for the other.

Achieving this sort of flow involves revisiting and redesigning every key process along the way (admissions, surgery, bed management, discharge) and all the interfaces between them. The ultimate aim is to create a pull system where each step of the process – from discharge backwards – pulls patients towards it as and when it is ready (see Figure 6).

Pressure in perspective

Three myths dog the NHS:

- demand for health services is effectively infinite
- demand for health services is volatile and unpredictable
- there is not (and might never be) enough capacity to keep up with the scale and/or variability of demand. So we have to ration services, and this rationing takes the form of queues.

Yes, we could always find new ways to spend more money on new and better drugs, treatments and machines. But in reality demand for most health services is relatively stable and finite (there are only so many cancer patients, heart patients, diabetics, accidents and emergencies, etc). And as we've seen, short-term demand is also surprisingly stable – it falls within predictable ranges.

It may – or may not – be true that the NHS needs more resources or lacks capacity. We cannot know for sure because of all the disconnects and blockages that currently undermine its performance. What we do know, however, is that with or without extra resource there is a huge amount of untapped potential just waiting to be unleashed.

Lean and process improvement

Lean thinking brings together several strands of process improvement. It starts by defining the purpose of the process (value for the customer), then redesigns the process to deliver this value with minimum wasted time, effort and cost. It then organises people and organisations to manage this value delivery process.

The contributions of quality improvement initiatives, such as Total Quality and Six Sigma, in measuring the root causes of variance (using, for instance, statistical process control charts) are essential if activities are to be linked into a continuous flow. Total Productive Maintenance (TPM) helps improving equipment availability. The Theory of Constraints (TOC) shows how to manage bottlenecks until we can remove them. Systems dynamics helps to understand how to optimise the whole process (rather than optimising individual activities) over time.

Core principles

We are now in a position to summarise the Lean approach to performance improvement.

Patient perspective

Under Lean, value is defined solely from the customer's perspective – in our case, this will generally be the patient. Anything that helps treat the patient is value-adding. Everything else is waste. Lean eliminates waste and reinvests released resources in value creation.

Pull

To create value we need to provide services in line with demand. No less. And no more. Delivering care in line with demand means not producing it to meet some other, artificially imposed metric such as a productivity, asset utilisation or unit cost target. (Performance is a by-product of how the system works and not an end in itself. If we eliminate waste, budgets and targets will be met along the way).

Delivering services in line with demand also means all work, materials and information should be pulled towards the task as and when needed. Not before. Not after. Any time spent waiting or queuing is another form of waste: resources are being used up but are idle.

Flow

Pull leads to flow where each patient is worked with, one unit at a time, and passed on for the next step of the process without any delay. A preoccupation of Lean is to identify blockages and obstacles that cause delay, and to remove them.

Value streams

For flow to happen we need to design and manage each value stream – each sequence of steps that adds value for the patient from the start of the journey to the finish – as a single integrated whole. Each step in the process needs to be designed with an eye to the effects it has on the steps that precede it and follow it – so that they all link together seamlessly.

What Lean is not

Lean is not restructuring

Lean is about changing the work itself, not about who gives what orders or who reports to whom. All too often, organisational restructuring and reorganisation is merely a displacement activity. If the actual work people do does not change and improve, then restructuring is irrelevant. And if restructuring interferes in the way work should be done (as it often does) it is worse than useless. Sometimes, organisations need restructuring. But the general rule of thumb is that restructuring should happen after the basic work problems have been sorted out, not before.

Perfection

By creating clear, easily seen, standardised processes we can create a foundation for continuous improvement, where each new improvement in the process becomes a platform for the next one.

Ward pull in practice

Moving to flow and enabling pull is often counter-intuitive to traditionally trained managers, who tend to think in terms of push – for example when a patient is ready for admission in accident and emergency they are found a bed. Like many hospitals, Flinders Hospital in Adelaide used to organise bed allocations in this way, with beds allocated to patients according to an assessment of clinical priority – urgent cases were put in any bed

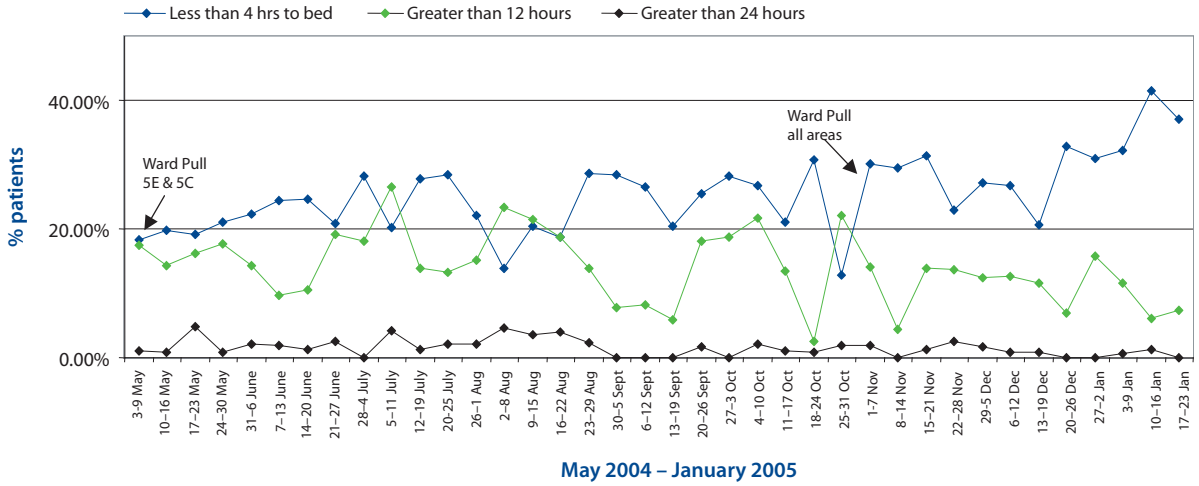
that became vacant. To manage these bed allocations, the hospital developed a complex central bed management role. Bed managers were responsible for pushing patients into wards, even if the ward did not specialise in that illness or injury. This not only generated conflict and irritation, it also created inefficiencies and safety concerns. For example, clinical teams had to spend increasing amounts of time and effort travelling to and from as many as ten different wards – just to see their patients.

Now Flinders has moved to ward pull, where specialist wards pull appropriate patients towards them as and when beds become free. To cope with situations when the best ward is full, much effort has been put into identifying next best wards for each category of patient.

The new system means doctors, nurses and equipment appropriate to the condition are closer to hand more of the time, meaning less travel and fewer occasions when people or equipment are not available. The number of outliers (patients in wards not related to their condition) has halved, patient turnover has increased 20 per cent, with the median length of stay reduced by one day. At the same time, there has been greatly improved opportunity for team work, better communication between specialists, and the development of a nurse team skill-base appropriate to the condition.

Figure 7: The effect of 'ward pull' on patient waiting times for beds, Flinders Medical Centre, Adelaide. Over the six months after ward pull was introduced, the proportion of patients having to wait longer than 12 hours for a bed fell and the proportion of those waiting for less than four hours rose.
Source: Flinders Medical Centre

Figure 7. The effect of ward pull on patient waiting times for beds



Getting started

So, how can hospitals start the journey towards Lean? Most Lean initiatives involve three basic steps:

- identify value streams
- map value streams
- identify and implement immediate, medium-term and long-term improvements.

Let's touch on each of these in turn.

Value streams

A value stream is all the actions (both value-adding and non-value-adding) and associated information required to bring a product (in our case, a patient) through the value-adding process from beginning to end.

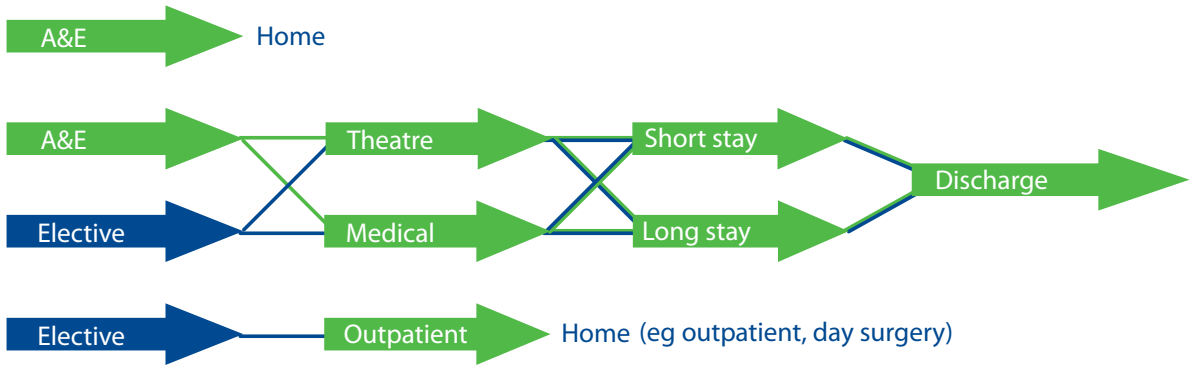
In hospitals it is a natural tendency to group patients by clinical similarity – a lot of useful work has been done on patient pathways, for example, which define the issues and actions we would expect for different patients, at different times, with different conditions. The difference with Lean is that we focus not on similar clinical conditions but similar processes.

As David Ben-Tovim at Flinders puts it: "In a hospital a value stream is the end-to-end process of caring for a group of patients (a patient-care family) whose overall care processes have enough in common for them to be managed together, irrespective of clinical diagnosis or existing professional boundaries: short things, long things, simple things, complicated things."

Seen in this light, the main value streams of a hospital can be outlined (in extremely simplified form) as shown in Figure 8. The challenge then is to map exactly what happens at each step and stage along the patient journey from admission to discharge,

Figure 8. Value streams group patients together by similarity of process rather than condition. Similar value streams flow at a similar pace and require similar infrastructure, processes, etc. Once a value stream has been identified, it can be worked on, end-to-end, to remove obstacles and improve flow.

Figure 8. Different hospital value streams (simplified)



and to redesign these systems to enable flow – each patient moving on to the next stage seamlessly, without any unnecessary work or waiting. No traffic lights. No disconnects. No ambiguity or confusion.

It is often hard to see value streams. A preliminary high-level map can provide a big-picture overview that allows the value streams to become visible (as illustrated in Figure 3). Ideally, all levels of staff should be involved in drawing this big-picture map. Then they will all see the process end to end – probably for the first time.

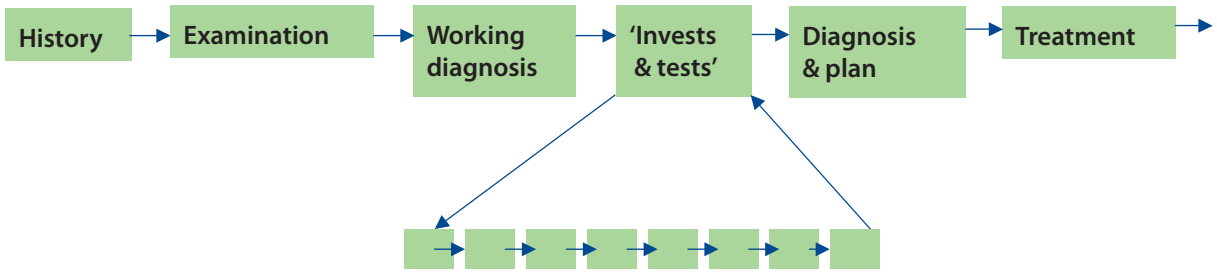
Value stream mapping

The next step is to map every action that is currently taken along a particular value stream – whether necessary or unnecessary – to get the patient moving through the system from one stage to another. Who does what, when, and how long does it take them? What materials or equipment do they need? What information do they use, input or pass on?

Because (almost certainly) nobody has ever done this before, this mapping process is likely to be a huge eye-opener. All sorts of absurdities, possibilities for error and confusion, blockages and bottlenecks are revealed for all to see. Figure 9 shows a small outline example of process mapping. It takes just one stage on the process – in this case, investigations and tests, and lists every step of work that is currently done. Amounts of time, distance travelled, materials needed and so on can be appended to each such step. It quickly becomes obvious that a lot of work is being done without adding much value. The question is how can we redesign these value streams to eliminate or reduce non-value-adding steps and focus resources on improving patient flow and value creation?

Figure 9: Mapping the 'current state' of the process invariably highlights all sorts of activities and procedures that are not necessary, do not add value or could be redesigned.

Figure 9. Where is the value?



Doctor requests 'test'
Porter picks up request
Porter delivers request to department
Clerk logs request
Clerks puts request for prioritisation
Consultant prioritises request
Consultant returns request

Clerk files request
Clerk draws request from file
Clerk makes appointment
Clerk sends appointment by post (>6 steps)
Patient receives appointment
Patient checks in at reception
etc

Rapid improvement events

This mapping process – and the identification of improvement opportunities – is normally done by and with existing staff, so that everybody sees the same picture, and the effects of one person's actions on others become clear for all to see. It is vital that mapping is seen as an exercise in joint discovery and understanding, not as an excuse to point fingers and blame one another for things that go wrong (see 'Involving staff', page 21).

A common next step is to conduct a rapid improvement event. These are usually week-long events which bring together representatives of every skill and process needed to make a department work or a task happen, to pool their knowledge and expertise to create an ideal 'future state' map – what the process could and should look like if it were working perfectly.

Rapid improvement events are action-oriented. Their goal is not to plan, but to do. If there are things that can be done now – today – staff will break out of their formal session to go and do it, there and then. To move machines, create new work areas, design new hand-offs etc. By the end of the week, many people's jobs will have changed significantly. And for ever. It is then up to the team leaders to make sure that the medium- and long-term changes that could not be implemented immediately are followed through.

Continuous improvement

The point of rapid improvement events is not simply to make rapid improvements, however. The real aim is to create a culture of continuous improvement. Some institutions, like Flinders, have formed improvement teams to learn about Lean and pass their learning on by working with other staff members on specific projects.

Continuous improvement is now a catch-phrase that has become widely misunderstood. For example, continuous improvement is not possible without the creation of clear, standardised processes: without standardisation you have no foundation to improve on. Indeed, without standardisation any improvements you make are unlikely to last.

When Flinders introduced ward pull, for example, the team assumed that, once implemented, the system would work automatically. However, only when clear, standardised processes were put into place – a daily bed management meeting including all wards, an appropriate IT spreadsheet, etc – did the system become embedded in 'the way we work'.

Also, continuous improvement is not some abstract ideal or goal. It is what actually happens when organisations apply Lean principles. Without the cycle of process improvement, standardisation and waste avoidance (which paves the way for further improvement and investment), continuous improvement is just an empty slogan. With this cycle, a ratchet effect is created where each new level of attainment becomes the platform or springboard for even further improvement – to generate accelerating momentum.

Lean and management consultants

Long experience of Lean teaches us that the only things that last are the things people do for themselves.

To get started on a Lean journey, you may need to employ management consultants who have experience of what to do and how. But Lean is not, and should not become, a consultants' gravy train. Any group of well motivated hospital staff members can understand the principles of Lean. So the purpose of bringing in consultants is not to get the consultants' help in solving a particular problem. It is for them to teach staff how to solve their problems by themselves.

Involving staff

To succeed Lean needs to clear a crucial hurdle. An almost inevitable result of Lean initiatives is that fewer people are needed to achieve the same (or more) results. So, potentially, people could lose their jobs. What's more, the changes made in Lean improvement projects can happen unsettlingly quickly: once a Rapid Improvement Event is under way, working practices that have been 'the way we do things around here' for years can be swept away within a week. So feathers will get ruffled.

Yet, for Lean to work, it needs the active, enthusiastic cooperation of staff: it will never happen by order of the management. Indeed, because Lean is about changing the way people work, the most important people in any Lean exercise are not managers, consultants or any other form of expert, but the people who know this work inside out: staff themselves.

So how can this circle of apparent threats to job security and the need for staff involvement be squared? The lesson from long experience is that Lean initiatives rarely succeed unless continuity of staff employment is guaranteed in advance. That is why implementation of Lean has to be separated explicitly from short-term, end-of-year budget balancing crisis measures. Lean may be a way of avoiding crises like these in the future. But it is not a magic wand to wave once the organisation is facing one, (although it was the impetus that set Flinders on its journey.)

A second lesson is that all levels of staff must be involved, from porter to consultant surgeon, from ward assistant to top-ranking administrator. While every individual staff member knows more about his or her particular job than anyone else, most people's in-depth understanding stops there. No matter how clever, expert or professional they are, they do not know or understand the work other people do and will not see how the parts fit together to make the whole. By involving staff at every level, across every function and department, Lean exercises help everybody see how the complete 'value stream' works from end to end, and where the waste is.

"You need to create a shared, joint view of what is going on," says David Ben-Tovim at Flinders. "This is very important because, for example, in hospitals doctors find it hard to listen to anyone else. If they want to, doctors can stop things from happening. And we need them on board."

A third lesson is that people's pride and dignity need to be protected when collecting information about what actually happens – because invariably it will throw up practices which, when seen in the cold light of day, look stupid. That makes the underlying Lean message all the more important: any problems that are uncovered are not the fault of the individual but the system.

Says Ben-Tovim: "We work hard to make sure that everybody's voice is heard, that there is no hierarchy, that there is no culture of blame, and that people go away feeling listened to. It has to be about respect. Our basic assumption is that people want to do a good job and that we have been making it impossible for them to do a good job. We use humour, for example, because it is very important to make people feel OK about having their deficiencies exposed."

The upside is this: once these foundations – jobs not threatened, involvement at all levels, respect for people – are in place, Lean initiatives can unleash waves of enthusiasm. "When we started out, some people were very sceptical," says Bolton chief executive David Fillingham. "But I've never seen anything that energises staff in this way."

Three secrets of successful implementation

1. No redundancies as a result of Lean exercises.
2. Involve staff from all levels. They are the experts. They will make it happen.
3. Show and practice respect for people.

The Lean journey

We started out in this report talking about improvements now being made in one small part of one hospital: the pathology department at Bolton. A 70 per cent reduction in the number of steps needed to complete most tasks; a 40 per cent reduction in the floor space needed; up to 90 per cent reductions in the times taken to do its job – all achieved with less, not more, staff and with limited capital investment (mostly building works to knock a few walls down). Just imagine if similar results were achieved across the whole NHS!

As we saw with the Bolton pathology example this is impossible unless every step of the patient journey is tackled in a similar way. In fact, there are at least three levels of Lean implementation:

1. All the points in the patient journeys can be redesigned to make sure they connect, to improve the process as a whole from end to end: admission through diagnosis and treatment to discharge. This requires that every step of patient care, and every support process, goes through the process of value-stream mapping and redesign. Lean practitioners call this 'system kaizen'.

2. Lean approaches can be used to reorganise the way a particular task is done or a particular department works, (for example, Bolton pathology department). Lean practitioners call this 'point kaizen'.

3. Lean principles can be used to guide strategic decisions such as investment in future capacity and to redesign the way the system itself works. For example, in this report we have only talked about hospitals. We have not talked about primary care. We have not even mentioned fundamental questions such as 'should the patient be treated in a hospital in the first place? Or would it be much better if they were treated in some local facility, or even at home?'

Lean is the way forward for health for four reasons, argues David Fillingham:

- it provides an overall philosophy and a way of setting priorities.
- it has a body of evidence-based tools and techniques.
- there is a vibrant Lean community willing to share experience and expertise.
- it focuses on safety and quality from the patient's perspective but enables these to be delivered at lower cost.

The potential for continuous improvement is therefore genuinely huge: so far, we have barely scratched the surface.

Conclusion

The Lean message is 100 per cent positive. Lean can improve safety and quality, improve staff morale and reduce costs – all at the same time. By freeing human potential it can add value to patient care and improve quality, and create a virtuous circle rather than perpetuating vicious ones.

But Lean won't just happen on its own. It needs leadership and leaders. People willing and able to gather colleagues around them, find out how to do it and win senior management support. It needs managers with the vision to give staff licence to experiment.

Pioneers at places like Flinders, Bolton and Wirral have already learned a lot about implementing Lean, which they are willing to share. Many more in the Lean Healthcare Network have begun their own journeys. But in each case, progress happened because of a few people who were prepared to lead the charge. What about your organisation? Who is leading the charge in your organisation? How about you?

Where to learn more

If you want to learn more, we recommend you get involved with the Lean Healthcare Network in the UK. Find out more at **www.leanhealthcare.org.uk**.

There is a rich store of materials from a number of sources, including:

Lean Enterprise Academy, UK **www.leanuk.org**
Lean Enterprise Institute, USA **www.lean.org**
Lean Enterprise Australia **www.lean.org.au**
Institute for Healthcare Improvement, USA
www.ihi.org
Osprey Clinical Systems Engineering Programme, UK
www.steyn.org.uk
Bolton Hospitals NHS Trust
www.boltonhospitals.nhs.uk
Wirral Hospitals NHS Trust **www.whnt.nhs.uk**
Flinders Medical Centre Redesigning
Care Programme
www.flinders.sa.gov.au/redesigningcare
Future Healthcare Network **www.fhn.org.uk**

Good books on Lean, available through the Lean Enterprise Academy at **www.leanuk.org**, Amazon and good booksellers, include:

The machine that changed the world, by James Womack and Daniel Jones
The original story of Lean in the auto industry

Lean thinking, by James Womack and Daniel Jones
The Lean principles and action path for manufacturers

Lean solutions, by James Womack and Daniel Jones
Lean for service delivery organisations and healthcare

The Toyota way, by Jeff Liker
Recent description of Toyota's business system

Learning to see, by John Shook and Mike Rother
The action guide to value-stream mapping

Breaking through to flow, by Ian Glenday
The action guide to creating the conditions for flow

The gold mine, by Freddy and Michael Balle
A Lean novel charting a Lean transformation

The Lean Enterprise Academy is a non-profit education and research organisation dedicated to spreading Lean thinking across every sector. It is part of the Lean Global Network of institutes in 13 countries across the globe.

For full details of its activities and the Global Network, go to **www.leanuk.org** or contact us at:
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Lean thinking for the NHS

Lean Enterprise Academy UK

Although the NHS has made significant progress in the past few years, some have expressed concerns that even greater changes have not been achieved. Certainly the NHS still faces major challenges, and increasing public and political pressure to deliver. However, some of the problems the NHS faces – financial problems, safety concerns and skill shortages, for example, are common to many industries.

The concept of Lean was developed for Toyota and has since been used extensively in manufacturing, project management, and product and service development. In this NHS Confederation Leading edge report the authors describe how Lean can also be applied to healthcare. They explain how Lean can be used to build on much of the work already undertaken in the NHS to improve the patient's journey. Far from being a management fad, Lean is described here as a tried and tested approach, as applicable to healthcare as commerce. It takes time to embed; while it will not provide a quick fix for all the NHS' ills, it promises to deliver significant improvements over the medium- to long-term.

Lean thinking for the NHS will be required reading for NHS boards and all those working with them to ensure the NHS is effectively run.

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Value Stream Mapping

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

By James P. Womack, Chairman

Lean Enterprise Institute

Brookline, MA

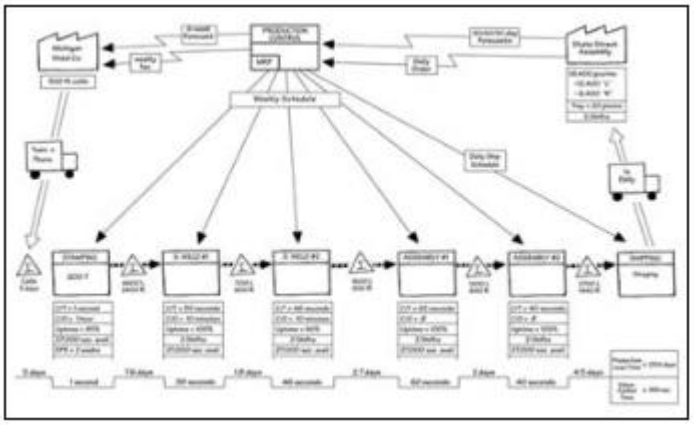
All value produced by an organization is the end result of a complex process, a series of actions that lean thinkers call a value stream. What's more, the customer, whether external or internal, is interested only in the value flowing to them, not in the weighted average of an organization's efforts 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.

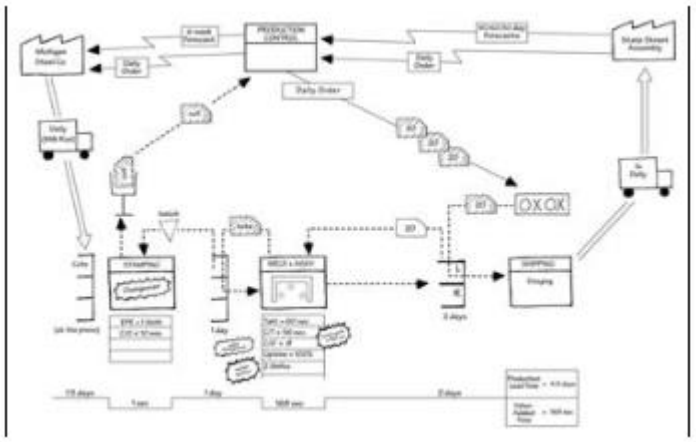
Available, meaning the degree to which the step is able to operate when it is needed. This is the core concern of Total Productive Maintenance. In typical operations, many steps can't produce a good result a significant fraction of the time (a capability problem), and won't run at all a significant fraction 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 of Just 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.

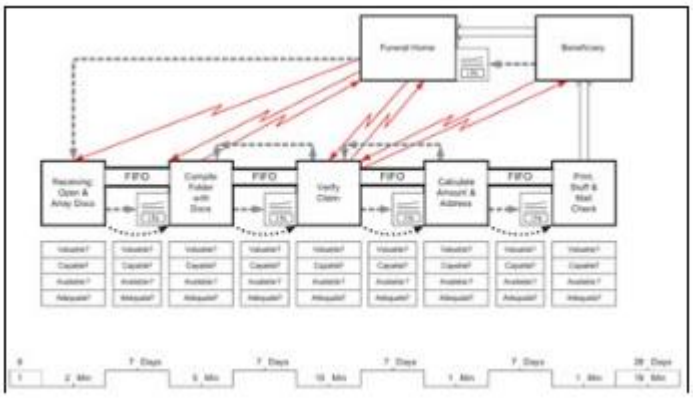
Capturing the information-management system is more complicated, involving drawing arrows that track each flow of information along the entire value stream, indicating the start and stop points for each production instruction.

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 muri 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.

James P. Womack

James P. Womack, PhD, is the founder and chairman of the Lean Enterprise Institute, a nonprofit training, publishing, and research organization advancing a set of ideas known as lean production and lean thinking, based on the Toyota Production System. He is the co-author with Daniel Jones of the recently published Lean Solutions (Simon & Schuster, 2005), Lean Thinking (Simon & Schuster, 1996), Seeing The Whole: mapping the extended value stream (Lean Enterprise Institute, 2001), and The Machine That Changed the World (Macmillan/Rawson Associates, 1990).

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THE BENEFITS OF LEAN MANUFACTURING
What Lean Thinking has to Offer the Process Industries

T. MELTON*

MIME Solutions Ltd, Chester, UK

How many people in the manufacturing industry can truly say that they have not heard of LEAN? Not many. Yet how many of these believe in lean, have implemented lean, are the passionate change agents who have convinced senior stakeholders than lean is the way forward for their company? Less. Much Less. Lean is a revolution—it isn't just about using tools, or changing a few steps in our manufacturing processes—it's about the complete change of our businesses—how the supply chain operates, how the directors direct, how the managers manage, how employees—people—go about their daily work. Everything. So what is this revolution, and how is it impacting the process industries? The background of lean thinking is based in the history of Japanese manufacturing techniques which have now been applied world-wide within many types of industry.

Keywords: lean manufacturing; waste; value; flow; value stream; bottleneck.

A BRIEF HISTORY OF 'LEAN'

Mention 'lean' and most 'lean thinkers' will know that this is a reference to the lean production approach pioneered by Toyota but also the subject of *The Machine that Changed the World* (Womack *et al.*, 1990); a book which first highlighted Japanese production methods as compared to traditional Western mass production systems; it also highlighted the superior performance of the former. The follow-on book, *Lean Thinking: Banish Waste and Create Wealth in your Organisation* (Womack and Jones, 1996), is equally a key step in the history of lean as it summarizes the lean principles which 'guide action'. It also coined the phrase 'Lean Production'.

But let's go back to the beginning—the birth of lean was in Japan within Toyota in the 1940s: The Toyota Production System was based around the desire to produce in a continuous flow which did not rely on long production runs to be efficient; it was based around the recognition that only a small fraction of the total time and effort to process a product added value to the end customer. This was clearly the opposite of what the Western world was doing—here mass production based around materials resource planning (MRP) and complex computerized systems was developing alongside the mass production philosophies originally developed by Henry Ford, i.e., large high volume production of standardized products with minimal product changeovers.

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Taiichi Ohno had started work on the Toyota Production system in the 1940s and continued it's development into the late 1980s unhindered by the advancements in computers which had allowed mass production to be further 'enhanced' by MRP Systems. By the 1970s Toyota's own supply base was 'lean'; by the 1980s their distribution base was also 'lean'.

Key tools and techniques within the 'lean' system, included:

- Kanban—a visual signal to support flow by 'pulling' product through the manufacturing process as required by the customer.
- 5 S's—a visual housekeeping technique which devolved control to the shopfloor.
- Visual control—a method of measuring performance at the 'shop floor' which was visual and owned by the operator team.
- Poke yoke—an 'error-proofing' technique.
- SMED (single minute exchange of dies)—a changeover reduction technique.

However let us return to the 1990s and the two landmark works discussed at the start of this section.

The Machine that Changed the World (Womack *et al.*, 1990) compared and contrasted the Mass Production System seen in the US and Europe, with the Lean Production System, seen in Japan, within the automotive industry.

Table 1 is a summary of some of the comparisons highlighted by Womack *et al.* (1990).

- The mass producers were able to maintain long production runs using standard designs which ensured that the customer got a lower cost; they also got less variety

Table 1. Production Systems Compared.

	Mass production	Lean production
Basis	• Henry Ford	• Toyota
People–design	• Narrowly skilled professionals	• Teams of multi-skilled workers at all levels in the organization
People–production	• Unskilled or semi-skilled workers	• Teams of multi-skilled workers at all levels in the organization
Equipment	• Expensive, single-purpose machines	• Manual and automated systems which can produce large volumes with large product variety
Production methods	• Make high volumes of standardized products	• Make products which the customer has ordered
Organizational philosophy	• Hierarchical—management take responsibility	• Value streams using appropriate levels of empowerment—pushing responsibility further down the organization
Philosophy	• Aim for 'good enough'	• Aim for perfection

as did the workforce who found this mode of operation tedious.
- In comparison, the term 'lean' comes from the 'upside' of the production method which requires 'half the human effort, half the manufacturing space, half the investment and half the engineering hours to develop a new product in half the time'.

However, it is not difficult to see that the world of car-parts and conveyor belt production lines did not immediately grab the interest and excitement of the process industries. Apart from the packaging lines the analogies seemed hard to find.

However, *Lean Thinking* (Womack and Jones, 1996) helped us to understand the principles of lean:

- The identification of *value*.
- The elimination of *waste*.
- The generation of *flow* (of value to the customer).

It clearly demonstrated that this was not a philosophy or technique which was only applicable to the automotive industry.

THE BENEFITS OF BEING 'LEAN'

The benefits seen within non-process industries (see Figure 1), such as the automotive industry, are well documented:

- decreased lead times for customers;
- reduced inventories for manufacturers;
- improved knowledge management;
- more robust processes (as measured by less errors and therefore less rework).

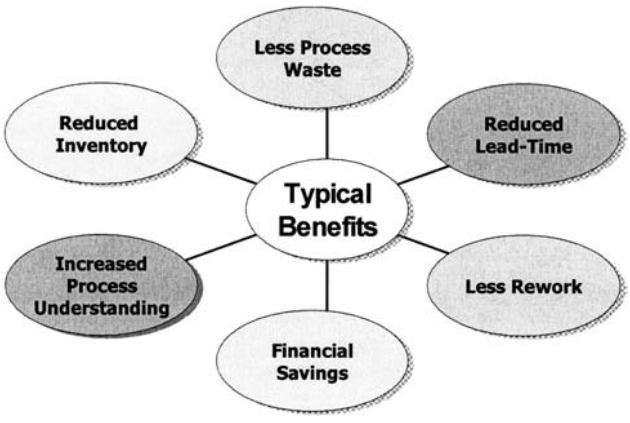

Figure 1. The benefits of 'lean'.

This makes lean a very real and physical concept—especially for manufacturing.

Lean production has now expanded and lean thinking has been applied to all aspects of the supply chain. There are many well documented examples of the application of 'lean thinking' to business processes such as project management (Melton, 2003); construction, design, and so on.

Lean can be applied to all aspects of the supply chain and should be if the maximum benefits within the organization are to be sustainably realized. The two biggest problems with the application of lean to business processes are the perceived lack of tangible benefits and the view that many business processes are already efficient. Both assumptions can be challenged (Melton, 2004):

- There are many tangible benefits associated with lean business processes. A lean business process will be faster, e.g. the speed of response to a request for the business process will be faster, and as most business processes are linked to organizational supply chains, then this can deliver significant financial benefits to a company.
- The perception that a business process is already efficient is all too often an illusion. Functionally, many business processes may appear very efficient, however the application of Lean Thinking forces us to review the whole supply chain in which the business process sits, and this frequently reveals bottlenecks and pockets of inefficiency.

But for now let us return to the world of manufacturing within the process industries.

WHAT'S STOPPING US?

With the benefits so apparently obvious the question has to be—what's stopping us?

For some in the process industries the answer is simple—nothing! There are good examples of the implementation of lean philosophies across the process industries. For example, PICME (Process Industries Centre for Manufacturing Excellence), an organization part funded by the DTI to specifically help manufacturing in the process industries to become more efficient and more competitive, quote estimated projected savings of over £75 million over their first 5 years of operation (PICME, 2004).

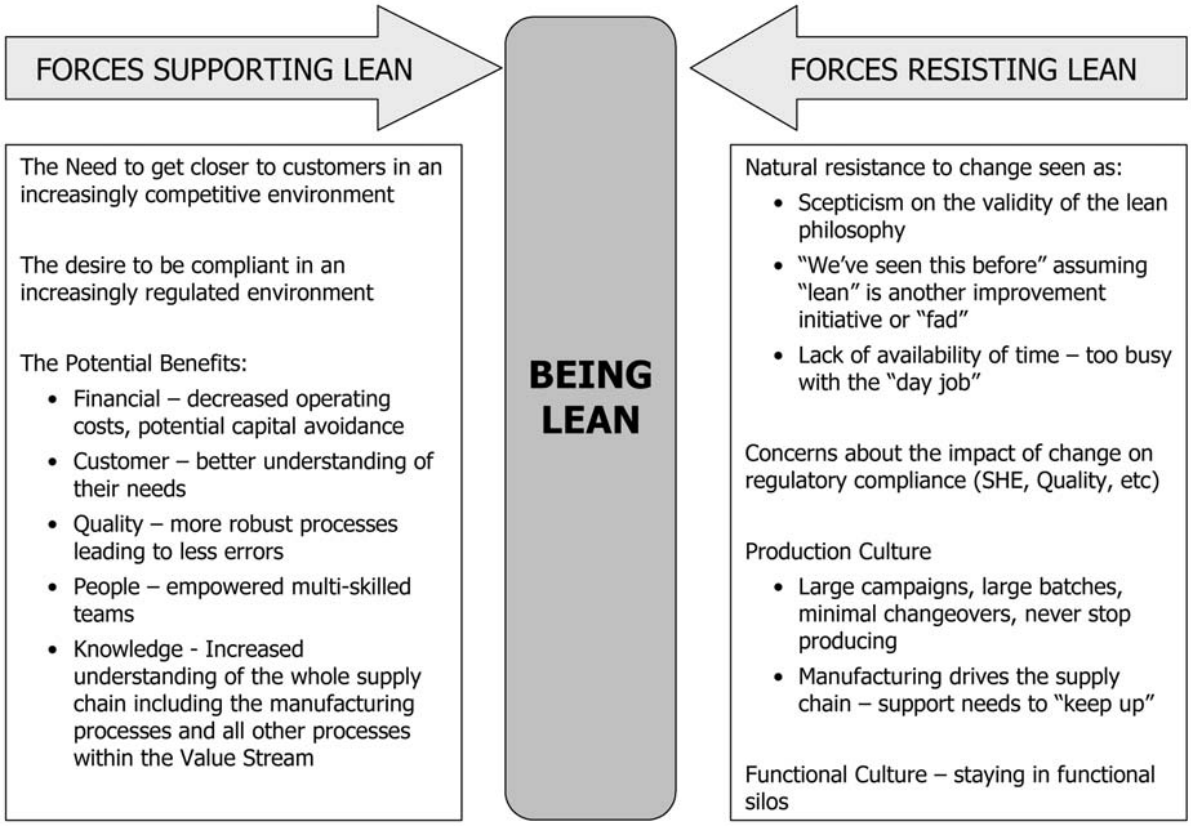

Figure 2. The forces opposing and driving a change to 'lean'.

But for some the 'case for change' cannot be as compelling as it would appear to be. Figure 2 is a force field diagram which shows some of the drivers and resistors within the manufacturing sector of the process industries; it is only when the specific driving forces for an organization are greater than the opposing forces that the change will occur. The ultimate sustainability then requires additional supporting forces to further reduce and eliminate opposition.

Within the process industries specific sectors have been under increasing pressure:

- Chemical Industry—the continuing pressure on the cost base.
- Pharmaceutical manufacturing—the pressure on the supply chain has increased as there are more external competitive pressures for manufacturers to deliver new, safe efficacious drugs quicker than ever before.

But—lean manufacturing has now been applied within the pharmaceutical sector both within primary and secondary operations and the use within the wider process industries is increasingly likely as the breadth of benefits are demonstrated and the driving forces for change increase.

Lean thinkers would probably want an additional driving force for change: lean is easy to implement! But although the principles and tools associated with lean thinking may appear at face value an easy concept to use within an apparently willing industry they present huge 'change' challenges to any business truly wishing to become lean. Perhaps the biggest resisting force for the process industries will be the huge inertia that must be overcome: the resistance to change.

Lean thinking involves a serious challenge to the status quo and for many this level of challenge to the 'way we do things round here' is a sufficient deterrent to application—particularly after the surge of business changes implemented following initiatives seemingly aiming for a similar goal—greater business effectiveness and therefore profit! However it can be demonstrated that the forces supporting the application of lean are greater than those resisting it.

WHAT IS LEAN THINKING?

Lean Thinking starts with the customer and the definition of *value*. Therefore, as a manufacturing process is a vehicle to deliver value (a product) to a customer, the principles of lean thinking should be applicable to the Process Industries and the specific manufacturing processes within that industry.

We can remove *waste* from many steps of our manufacturing processes, from how we develop the initial product and process design, how we assure compliance, to how we design to operate a completed facility. However, to be truly lean we have to link all these elements within a robust supply chain—we need to ensure the *flow of value*. This leads to what many are calling a 'lean enterprise' (LERC, 2004).

The Lean Enterprise Research Centre (LERC, 2004) at Cardiff Business School highlighted that for most production operations:

- 5% of activities add value;
- 35% are necessary non-value activities;
- 60% add no value at all.

Therefore, there is no doubt that the elimination of waste represents a huge potential in terms of manufacturing improvements—the key is to:

- identify both waste and value;
- develop our *knowledge management* base;
- realize that sustainable improvement requires the buy in of the people operating the processes and managing the business, and therefore a culture of *continuous improvement*.

Value

The identification of value and the definition of value propositions for specific customers is the starting point. Without a robust understanding of what the customer values you cannot move forwards (see Table 2). Outside of the process industries there are many examples of what we mean by a 'value proposition'—as a consumer buying a washing machine what we value may be the ability to wash our clothes at home; for others the value may be related to cost or specific design features or even the colour. The challenge for the manufacturer is to develop a product portfolio based on these value propositions.

Table 2 gives some examples of value propositions which manufacturers in the process industries have developed as related to their specific customer group, their product portfolio and their potential capabilities.

For customer A, development of the process they handover to the toll manufacturer is a value added activity; for customer B this would be considered waste.

Table 2. Examples of value propositions within the process industries.

Customer type	Value proposition	Manufacturer type
A. Major pharmaceutical manufacturer of drug products	• Robust process and product development at fast track speed ensuring regulatory compliance	• Toll manufacturer of pharmaceutical intermediates
B. Other manufacturer in a low cost base industry	• Correct specification, low cost and delivered on time in the volumes specified	• Bulk chemicals manufacturer
C. The patient (via the companies who distribute the drugs)	• High quality, safe drugs that 'work' at an appropriate price	• Major pharmaceutical manufacturer of drug products

Waste

Any activity in a process which does not add value to the customer is called 'waste'. Sometimes the waste is a necessary part of the process and adds value to the company and this cannot be eliminated, e.g., financial controls.

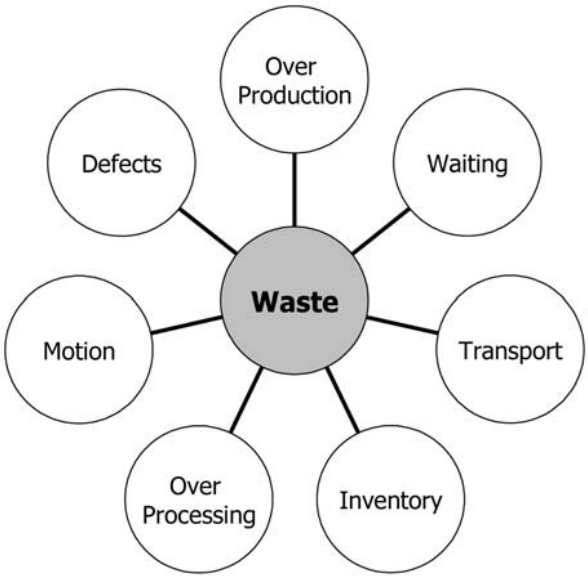

Figure 3. The seven types of waste.

Otherwise all 'Muda', as the Japanese call waste, should be eliminated.

There are seven main types of waste as outlined in Figure 3 and further detailed in Table 3.

Initially, waste can be easily identified in all processes and early changes can reap huge savings. As the processes continually improve, the waste reduction will be more incremental as the company strives to achieve a waste-free process. Continuous improvement is at the core of lean thinking.

The data in Table 3 is only the tip of the iceberg in terms of the amount and types of waste which will be within our manufacturing processes and overall supply chains. The key is to identify it, i.e., to ensure that the root cause—the real waste—is eliminated, not just the symptom.

Flow

Flow is probably the hardest lean concept to understand. It is the concept which most obviously contradicts with mass production systems; the comparison of one piece flow versus batch and queue processes.

It is a lack of flow in our manufacturing processes which accounts for the huge warehouses which house the mass of inventory which consumes the working capital of the business.

To understand flow you need to understand the concept of the *value stream*—that linkage of events or activities which ultimately delivers value to a customer. A value stream crosses functional and, usually, organizational boundaries.

Figure 4 shows a simple value stream which would be typical for a toll manufacturer. The value stream does not show all the supporting activities, only the main value adding stages and the key multi-functional teams involved.

Flow is concerned with processes, people and culture and it is appropriate at this stage to mention the work of Goldratt and Cox (1993) who's book *The Goal* introduced

Table 3. The seven types of waste.

Type of waste	Description	Within the process industry	Example symptom
1. Over production	• Product made for no specific customer • Development of a product, a process or a manufacturing facility for no additional value	• Large campaign—large batch and continuous large-scale manufacturing processes • Development of alternative process routes which are not used or the development of processes which do not support the bottleneck • Redesign of parts of the manufacturing facility which are 'standard', e.g., reactors	• The extent of warehouse space needed and used • Development and production organization imbalance • An ever changing process (tweaked) • Large engineering costs/time associated with facility modifications
2. Waiting	• As people, equipment or product waits to be processed it is not adding any value to the customer	• Storage tanks acting as product buffers in the manufacturing process—waiting to be processed by the next step • Intermediate product which cannot leave site until lab tests and paperwork are complete	• The large amount of 'work in progress' held up in the manufacturing process—often seen on the balance sheet and as 'piles of inventory' around the site
3. Transport	• Moving the product to several locations • Whilst the product is in motion it is not being processed and therefore not adding value to the customer	• Raw materials are made in several locations and transported to one site where a bulk intermediate is made. This is then transported to another site for final product processing • Packaging for customer use may be at a separate site	• Movement of pallets of intermediate product around a site or between sites • Large warehousing and continual movement of intermediate material on and off site rather than final product
4. Inventory	• Storage of products, intermediates, raw materials, and so on, all costs money	• Economically large batches of raw material are purchased for large campaigns and sit in the warehouse for extended periods • Queued batches of intermediate material may require specific warehousing or segregation especially if the lab analysis is yet to be completed or confirmed	• Large buffer stocks within a manufacturing facility and also large warehousing on the site; financially seen as a huge use of working capital
5. Over processing	• When a particular process step does not add value to the product	• A cautious approach to the design of unit operations can extend processing times and can include steps, such as hold or testing, which add no value • The duplication of any steps related to the supply chain process, e.g., sampling, checking	• The reaction stage is typically complete within minutes yet we continue to process for hours or days • We have in process controls which never show a failure • The delay of documents to accompany finished product
6. Motion	• The excessive movement of the people who operate the manufacturing facility is wasteful. Whilst they are in motion they cannot support the processing of the product • Excessive movement of data, decisions and information	• People transporting samples or documentation • People required to move work in progress to and from the warehouse • People required to meet with other people to confirm key decisions in the supply chain process • People entering key data into MRP systems	• Large teams of operators moving to and from the manufacturing unit but less activity actually within the unit • Data entry being seen as a problem within MRP systems
7. Defects	• Errors during the process—either requiring re-work or additional work	• Material out of specification; batch documentation incomplete • Data and data entry errors • General miscommunication	• Missed or late orders • Excessive overtime • Increased operating costs

the Theory of Constraints. This theory aligns with lean thinking in the way it considers an organization as a system consisting of resources which are connected by processes which ultimately make product which can be sold.

It effectively talks about a value stream and the main causes for the lack of flow—constraints in the system.

Godratt and Cox (1993) introduced some development of operational rules to guide how a production plant should be operated based on three measurements:

- *Throughput*: the rate at which the system generates money through sales (use sales not production—if you produce something, but do not sell it, it is not throughput)—this links into the lean philosophy of producing product when the customer 'pulls' for it.
- *Inventory*: all the money that the system has invested in purchasing things which it intends to sell.
- *Operational expense*: all the money the system spends in order to turn inventory into throughput.

They then define the goal of that production operation as increasing throughput while simultaneously reducing both inventory and operating expense and that any plant improvement must be challenged against this, i.e.,

- as a result of this improvement will we:
  - — Sell any more products? (Did *Throughput* go up?)
  - — Reduce the amount of raw materials or overtime? (Did *Operating* Expense go down?)
  - — Reduce the plant *Inventory*?

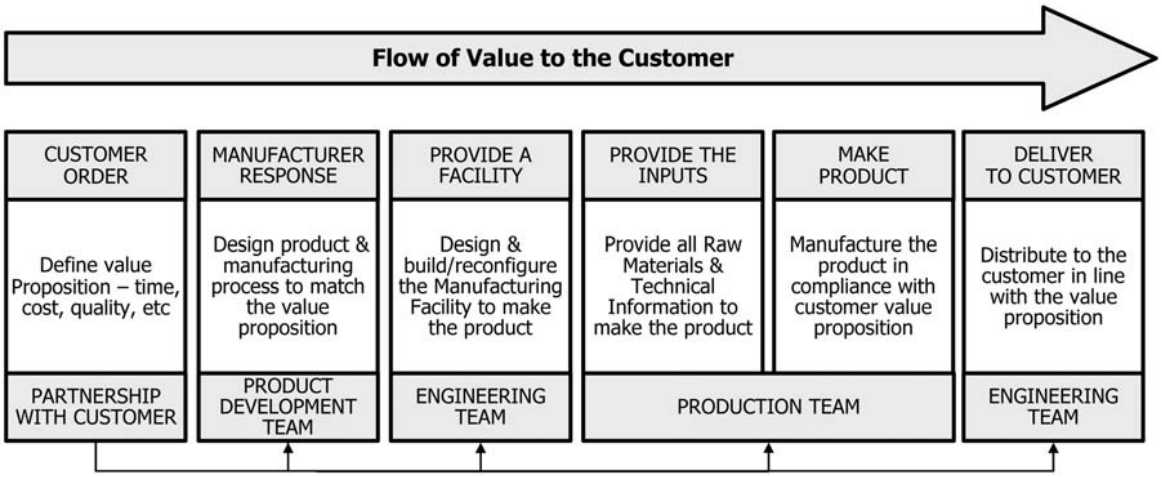

Figure 4. A simple value stream.

The final concept they introduce is that of the *bottleneck*—that step in a process which determines the throughput of the whole process. This also aligns with lean 'pull' production which tells production that it's OK to stop production! (if there is no customer 'pull').

Within the process industries we do strive for production efficiencies, however, 'a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimising the parts' (Rother and Shook, 1999). In other words we need to improve the efficiency and effectiveness of the whole supply chain not just improve one part of it and we need to operate the supply chain not the production unit.

Figure 5 summarizes the above discussion on flow by demonstrating how a part of a supply chain could operate if 'pulled' rather than 'pushed'. In a 'push' system production works as much as it can to fill a warehouse; In a 'pull' system production works only when it needs to at the pull of customer orders.

Figure 5 demonstrates that the process (the grey boxes) only operates when an appropriate 'signal' is seen:

- The packaging operation only operates when it is packaging for a customer order (it's 'signal to pack'). It takes product from a final product silo (kanban).
- When the level in the silo falls past the red line this is a signal for the final product manufacture to commence. Once the silo is at the green level this is a signal for the manufacture to stop. This operation takes its material from the raw materials kanban and the intermediate kanban.

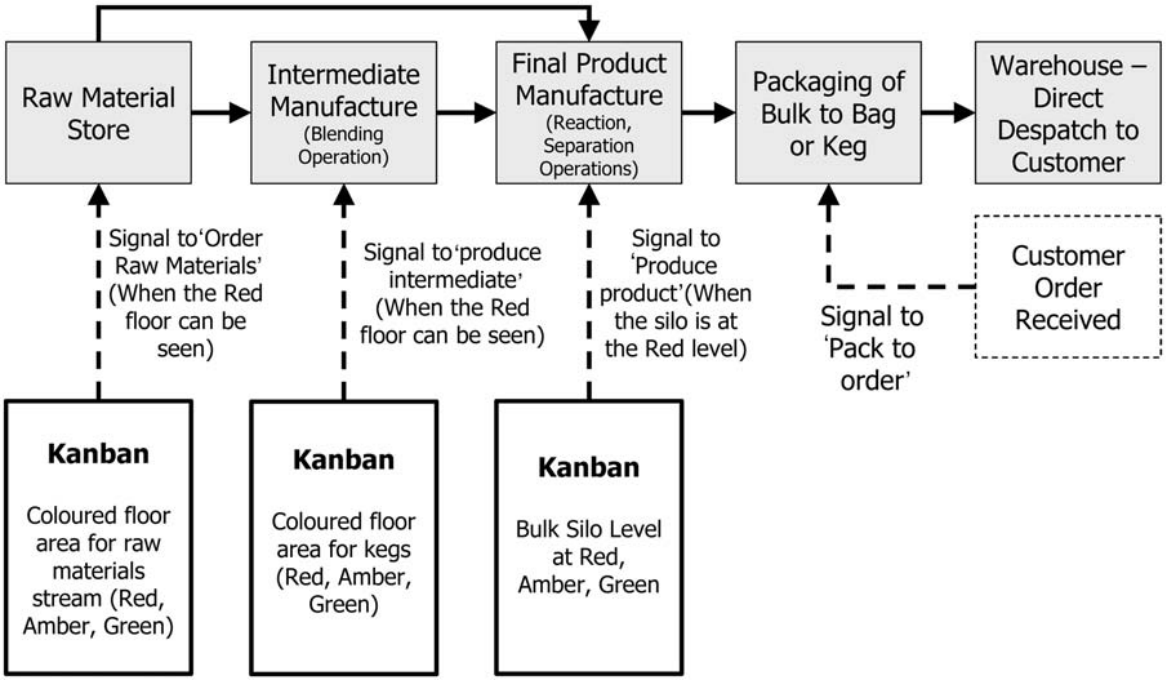

Figure 5. 'Pull' production example—using kanbans.

- Both of these are storage areas. Specific kegs are placed on a coloured floor. When enough kegs have been used so that the red area of the floor can be seen—this is a signal for the preceding operation to commence, i.e., intermediate manufacture or purchasing of raw materials.

The sizing of the kanbans and their operation to ensure FIFO (first in-first out) has to be thought through but this can be an effective method of:

- Implementing a 'pull' production system.
- Reducing lead-time to the customer.
- Reducing inventory at all stages in a process.

Knowledge Management

The knowledge we have in our systems and more importantly, our people, is fundamental to the implementation of lean.

The success of lean in some manufacturing organizations has been in part due to the reorganization of the teams at both operational and management level.

Example changes are:

- reorganization of all resources around value streams;
- multi-skilled or cross-functional teams with more responsibility for the day to day operation of a manufacturing unit.

Additionally, formally capturing knowledge of processes is necessary especially within a work environment where corporate knowledge is no longer defined by the large numbers of employees who have worked there all their lives. Some companies have used some form of IT solution to capture knowledge formally; for others a process of knowledge sharing spreads the knowledge wider than previously. A well-managed knowledge base is critical to the sustainability of change.

Continuous Improvement

Lean thinkers are aiming for 'perfection' and in doing so the improvement cycle is never ending. For many in the process industries this culture change is the hardest change of all.

However, for assured sustainability the organizations who are truly lean will invest the time and effort to support a change in culture—the way we do things around here. The case study attempts to highlight some of the ways in which culture can be impacted.

HOW TO START 'LEAN THINKING'

A data-rational, structured approach is needed if the key principles of value, waste and flow are to be rigorously applied along the supply chain.

The process of 'how to lean' (Figure 6) can be summarized as:

- Document current process performance—how do we do it now.
- Define value and then eliminate waste.
- Identify undesirable effects and determine their root cause in order to find the real problem.

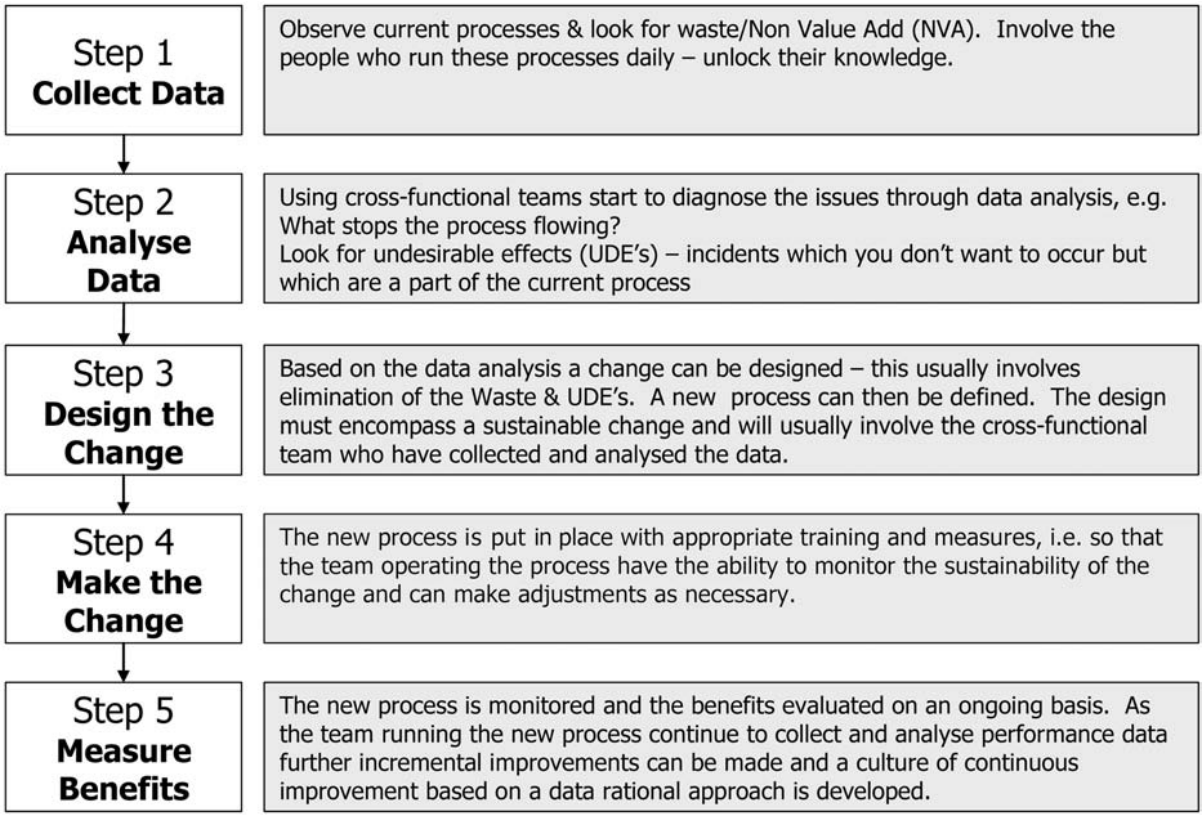

Figure 6. How to 'lean'.

- Solve the problem and re-design the process.
- Test and demonstrate that value is now flowing to the customer of that process.

There are many tools and techniques to support each step in the above process—they support implementation of the principles.

Table 4 shows a sample of the tools a 'lean thinker' would have in their toolkit. What surprises many skeptics is that the lean principles can be put into action using tools which are very familiar to those who have been involved in performance improvements.

What is different is the fact that they are used to ensure that:

- manufacturing processes deliver value to their customers;
- all activities which do not add value—waste—are eliminated or reduced;
- the manufacturing processes flow within a robust and 'lean' supply chain.

PRESENTING THE EVIDENCE: A CASE STUDY

The following case study is taken from a real situation—it aims to demonstrate the benefits from lean manufacturing and also lean supply chains—two facets of lean thinking which are revolutionising the parts of process industries in which they have been implemented.

Making a Value Stream: The Design and Implementation of Lean

The following is a case study example taken from the process industries. It shows how the three principles of lean supported by the enabling principles, can deliver step change business benefits and ongoing incremental benefits.

A multi-product manufacturing process was taking 10 weeks from the introduction of raw materials to the completion of final product processing. The customers generally expected a lead-time of 6 weeks from order placement to receipt of the goods.

Table 4. A sample 'lean' toolkit.

Tool	Description	Typical Use
Force field diagramming	• A tool which allows analysis of the forces supporting or resisting a particular change	• When looking at a potential design • When looking at the implementation planning for a change following design
IPO diagramming	• A basic flowchart tool mapping inputs, processes and outputs. Based on the required outputs, the appropriate process can be defined and the required inputs specified	• To design a team session at any stage of the implementation of lean, e.g., data collection day, kaizen day (implement a change in one day), implementation planning
Process flow mapping	• A map showing each process step in the value stream	• A data collection activity • Also used to analyze the VA (value-add) and NVA (non value-add) steps and as a tool for redesign
Time-value mapping	• A map of the time taken for each process step in the value stream	• A data collection activity • Also used to analyze the VA and NVA steps and as a tool for redesign
Spaghetti diagramming	• A map of the physical path taken by a product as it passes down the value stream	• A data collection activity
Five whys	• Taiichi Ohno (Womack *et al.*, 1990) had a practice of asking why five times whenever a problem was found. In this way the root cause was solved rather than the symptom.	• As a part of the data analysis so that the root cause problem can be solved in the design phase
Five S's	• Five activities used to create a workplace suited for visual control and lean practices: • Seiri—separate required from unnecessary tools and remove the latter • Seiton—arrange tools for ease of use • Seiso—clean-up • Seiketsu—do the above regularly—maintain the system you've set up • Shitsuke—get into the habit of following the first four S's	• Can be used at the start of a lean induction to break down barriers and get a team to own their workspace • Often used during Kaizens as workplace layout and tidiness is often an issue which causes waste (unable to find the right equipment, use what's there, lose key paperwork, and so on)
Risk assessment	• A structured assessment of what could stop the achievement of specific objectives and how this can be mitigated	• Assessment of a design prior to implementation as a final challenge of the design • Assessment of the issues post-implementation—looking specifically at what would stop the sustainability of the change
Kaizen	• An improvement activity to create more value and remove waste. Commonly called a breakthrough kaizen	• Kaizen workshops are a common method to kick-off the start of a large step change within an area or value stream • Kaizens would actually start with data collection and continue to do some data analysis, design and even implementation
Kanban	• Japanese for 'signboard'. This is a 'visual' shop floor pull system which means that each supplying work centre does not make anything until the next work centre requests supply	• This is a design solution to materials flow problems within a process (examples within both manufacturing and lab situations have been seen)

As the *Manufacturing Time* > *Customer Lead-Time* all production was scheduled according to a sales forecast.

Sales forecasts within this particular organization, as with many others, were unreliable and the Production Manager had to build up significant stock of finished product to ensure that all eventual orders could be met.

The Site Director was faced with a set of key performance indicators (KPI) which showed a trend for late or incorrect customer orders, decreasing product quality, increasing manufacturing time and another request for an additional warehouse for all materials associated with the manufacturing process as well as finished product. Additionally, a new KPI was emerging: the amount of product which became unsaleable due to shelf life issues—indicating both a problem with the length of time product was being stored in warehouses and the process by which product was chosen for customer orders.

Initially a Kaizen was used to pull together a cross-section of all the operational teams that were involved in the manufacturing unit: Operators, Lab Analysts, Warehouse Staff, Customer Service Staff, Schedulers, MRP Data Handlers, Technical Support Scientists, and so on.

The aim of the Kaizen was twofold:

- to collect and analyse data to identify the REAL problem and design some solutions;
- to start to break down functional barriers and general skepticism about lean thinking.

The data collection and data analysis phases yielded some key problems:

- *Process mapping*—the total number of steps both within and outside of the manufacturing process was 34; approximately 60% of these involved either travel or waiting, i.e., pure waste (see Figure 7).
  - — The process mapping was reviewed via closer observation after the kaizen and a number of variations came to light as well as a realisation that the discrete number of steps was nearly double!
  - — Typical variations were seen when urgent orders were expedited through the system and the teams worked closer together to naturally eliminate steps which didn't help get the product to the customer
- *Spaghetti mapping*—demonstrated the extent to which the product, its associated batch documentation, the operators, the samples and the support staff had to travel—it was miles!
- *Time-value mapping*—of the 10 weeks to produce a typical product from raw materials only 25% was value adding (Figure 8).
  - — The data collected during process mapping was converted into a time-value map (Figure 8). This type of analysis denotes value added activities as green and waste as red, i.e., the initial days are shown as waiting for the schedule.
  - — The Blend sample test (1 day) also has a 50% waste content as only 50% of the tests done on the sample ever fail.
  - — The space between each activity is the waiting time.
  - — This gives an excellent visual representation of the overall process—if all the red and 'white space' is removed then the process could theoretically be reduced from 10 weeks to 1 week!
- *Undesirable effects analysis*—the supply chain was managed via functional silos with little or no contact between them; the support functions did not behave as though they were actually producing a product for a

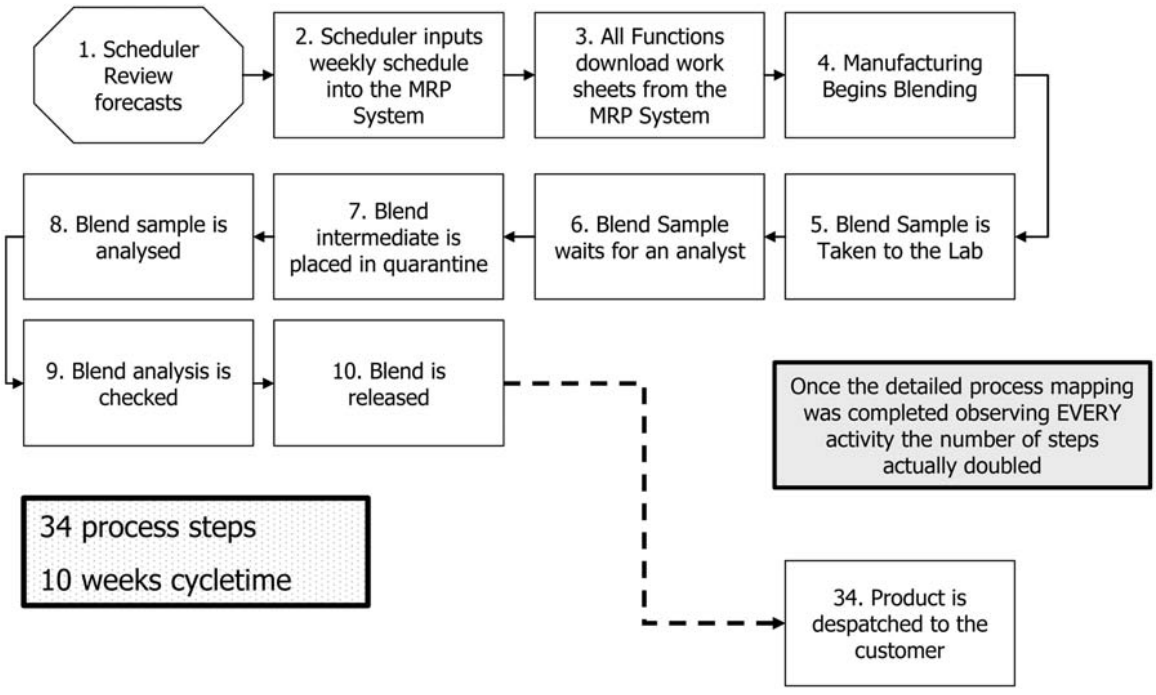

Figure 7. Process mapping—before.

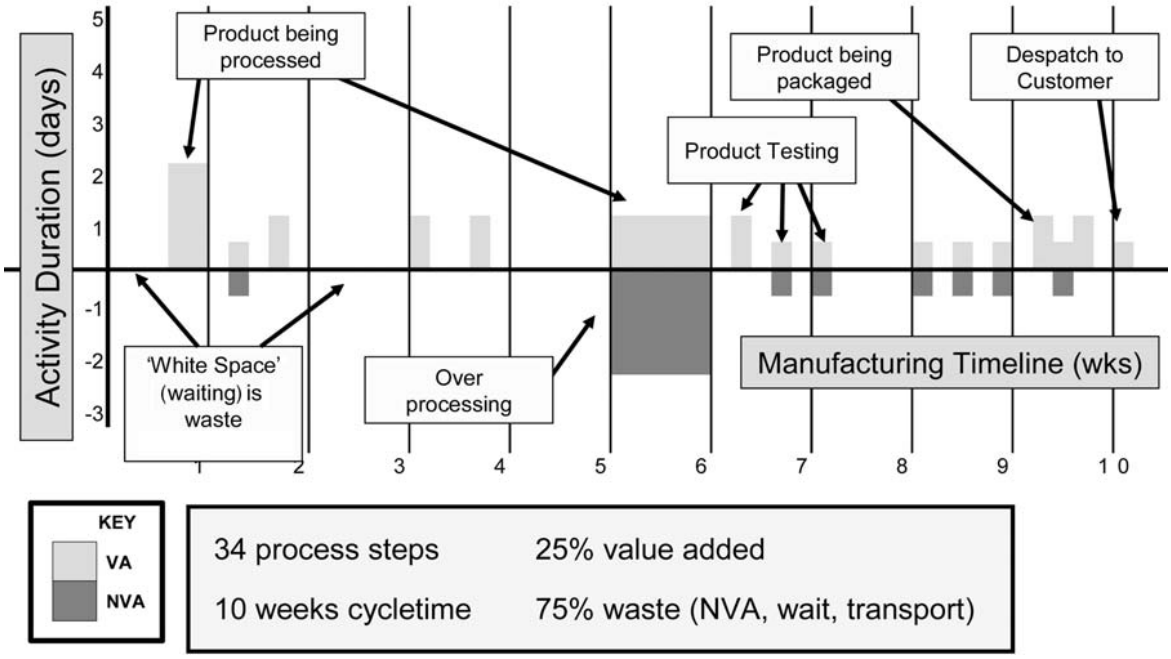

Figure 8. Time-value mapping—before...

customer—just a lab analysis or a signed batch record; the financial systems pushed all parts of the supply chain to large supply purchases in order to reap supplier discounts

- *Root cause analysis*—the symptoms revealed by the data analysis were root caused with a major issue being the lack of flow in the process and another being the functional behaviour of the various parts of the supply chain. The real problems were identified as:
  - — Lack of flow and functional behaviour—lack of connectivity of the supply chain; each step was operated as a distinct entity; functional teams were praised for functional efficiency even when customer orders were not being filled.
  - — Lack of flow—the system was literally too full. The warehouse was full of work in progress; the lab was overflowing with samples; the production area contained kegs of raw materials and intermediates waiting to be processed.
  - — Functional behaviour—no one person in the supply chain was accountable for the delivery of customer orders apart from the site director who had no direct influence on this. Functional effort was seemingly better whilst overall cycletime got worse.

As a result of the Kaizen event a number of quick changes were able to take place:

- *Communication*—the Kaizen team could see that it made no sense NOT to communicate with each other more often—formal agreements were made (and subsequently kept!):
  - — Production operators were going to speak to the warehouse each morning to check on key materials.
  - — Lab analysts were going to speak to the production area each day to check on the volume of samples likely that day.
- *Production and lab stoppages*—both the production area and the lab had a culture of 'team breaks' which effectively stopped value adding activities and reduced the capacity of the plant; i.e., parts of the supply chain were identified as the bottleneck (lab) or a near-bottleneck (packaging)
  - — The lab agreed to stagger break times for analysts so that the processing of samples could continue without stoppage.
  - — The production areas agreed to review the system of breaks and to ensure that 'cover' was provided to the near bottleneck process during break periods (this area was highly automated and did not have a large team even through it was one of the most unreliable areas in the supply chain from an equipment perspective).

The design phase for the main change project took some time as it extended to all parts of the supply chain:

- *Value streams* were formed—these were dedicated to a family of products with similar manufacturing processes and with similar customer requirements.
  - — This impacted the manufacturing, laboratory and warehouse layout.
  - — It changes the whole organization of resources associated with the product.
- *Kanbans* were introduced—these were only at key stages in the overall process but they visually signaled when production was required—no signal = no production.
  - — Laboratory—analysts worked in cells dedicated to the value stream and within the lab a kanban system was set up to ensure that all materials were available for the anticipated volume of samples. The system was very visual.
  - — Manufacturing area—earlier stages in the manufacturing process were signaled to commence if they

received a visual signal from the kanban (a storage based visual system as per Figure 5); this was important as they had a capacity far greater than the packaging step.

- *Visual factory* was introduced—this ensured that value stream KPIs were aligned along the value stream and were available either in the production area, the lab or the warehouse.
  - — As soon as you entered each area it was clear how the area was performing; how many samples were being processed in the lab; what level of order fulfillment to target lead-time had been achieved in the warehouse; the throughput of the value chain.
  - — Functional measures were no longer used.

Overall the benefits for the organization can be measured in 'hard' terms:

- Approximately 50% reduction in overall supply chain cycle time (see Figure 9).
- Approximately 25% increase in customer order accuracy (delivery and quality).
- Approximately 30% reduction in inventory (including safety stock kept due to the inherent inaccuracy in sales forecasts).

There are also softer benefits and these should not be forgotten:

- Breakdown of in-company functional barriers.
- Joint development of value stream KPIs with all functions buy-in.

Changing the Manufacturing Culture: Sustaining Lean

Following the completion of the change project it was critical that key sustainability measures were tracked:

- Were the new processes being followed?
- Was the layout being kept as per the design?
- Was the visual performance board being used?

A process of 'hot tagging' was used within the value stream to consolidate the culture. This process involved all the team members highlighting when a part of the value stream was not in alignment, e.g., kanbans being overfilled; sloppy housekeeping not in line with the 5 S's (see Table 4).

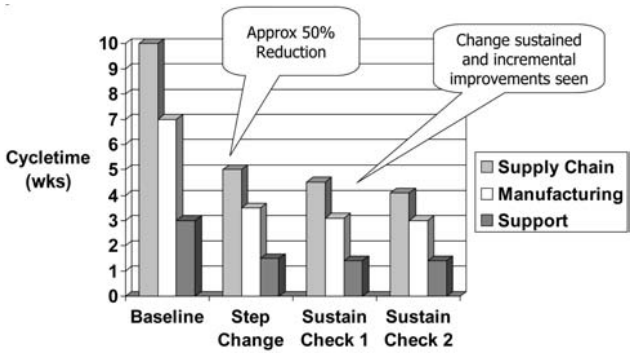

Figure 9. Cycle time reduction results.

LOOKING AHEAD: APPLICATION WITHIN THE PROCESS INDUSTRIES

Clearly lean manufacturing has, and could be further, applied within the process industries. The tools and techniques described in previous sections can and have been used within chemicals and pharmaceuticals manufacturing in the UK.

For some parts of the process industries the revolution has yet to begin—for others it is a case of expanding lean thinking into all parts of the supply chain.

- To start the implementation of lean thinking:
  - — start on a manufacturing process;
  - — build a small cross-functional team;
  - — ensure senior management demonstrate their support;
  - — ensure that all change is based on a structured data rational process;
  - — communicate success effectively.
- To develop lean thinking further within your organization:
  - — communicate the sustainable successes from the implementation within manufacturing;
  - — review the value chain for a specific customer or set of customers;
  - — review the business processes as well as the physical processes and apply the same structured data rational process, based on using cross-functional teams empowered to implement change;
  - — keep looking for waste, keep checking up on the value you deliver to customers, keep controlling the flow—make it a part of your business culture.

CONCLUSIONS

It is clear that the climate for change within the process industries over the last couple of years has been an 'open door' to lean thinkers. We are seeing, and hearing of, more and more examples of how manufacturing processes within the chemicals and pharmaceuticals industries are being improved through the use of relatively simple techniques.

It is obvious what 'lean' has to offer the process industries:

- Performance improvements across the whole supply chain supporting increased business performance.

Ultimately 'lean' will enable UK based manufacturing operations to compete more globally—but only if the time, expertise and senior management backing is available.

Implementing lean is a revolution but one that the process industries should be welcoming with open arms. The leaders of this revolution will have to continue to show by example the financial, cultural and organizational benefits of starting down a route of REAL continuous improvement—this is not an initiative, not a fad, it's a philosophy which has the potential to transform your business. The data can speak for itself:

- Release of working capital.
- Increased supply chain speed.
- Reduced manufacturing costs.

Lean manufacturing has been applied within the process industries, most notably chemicals and pharmaceuticals sectors, to great effect. The wider use is increasingly likely, but more than that it is required!

Lean thinking is applicable to all business processes within the process industries. The challenge, if we decide we want to be lean, is whether we know enough about our ways of working, what customers of the business processes truly value, and how our businesses operate and need to operate.

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