

# Going lean

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The Lean Processing Programme was designed to extend Lean Thinking into this particular group of firms and their associated customer base. Over a three year period it has sought to make radical and incremental change both within and between the firms as well as at a network level. Specific improvements have been made: better understanding of customer requirements, improved learning culture in the firms, faster reaction time, improved delivery performance, reduced new product time to market, better quality product, improved productivity and increased business opportunities.

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# Going lean

## A guide to implementation

Throughout our work at the Lean Enterprise Research Centre, we are often asked a number of searching questions about the application of Lean Thinking. Among the most frequently asked are:

- Where do I start?
- Is there a road map that I can follow?
- What does Lean Thinking involve?
- Who will I have to involve?
- Is it only applicable to the shop floor?
- Is it only for manufacturing firms?

To help answer these questions we have developed this simple step by step introductory guide to 'going lean'. It is designed to give you and your colleagues enough information to:

- see if going lean is for you
- develop an outline plan and
- point you in the direction of further sources of help.

We have designed this guide with plenty of space for you to write notes next to the text, and have also included a 'jargon-buster' at the back to explain the terms we use.

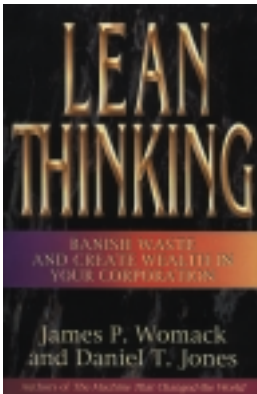
The chart below will help you through the guide as well as suggesting which type of employee is likely to be involved in which stage of the process.

Workbook focus ↓	Senior managers ↓	Line managers ↓	Wider workforce ↓
What is Lean?	Lean thinking		
	Understanding waste		
Focusing the Change	Setting the direction		
Mapping Things Out	Understanding the big picture		
		Detailed mapping	
		Getting suppliers & customers involved	
Will It Work?	Checking the plan fits the direction & ensuring buy-in		
Help!	Further sources of help		

We hope you enjoy reading the guide and wish you good fortune on your lean journey.

# The lean vision and the lean principles

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The characteristics of the lean company and the lean supply chain are described clearly in the book *Lean Thinking – Banish Waste and Create Wealth in Your Corporation* by Jim Womack and Dan Jones. This book provides a vision of a world transformed from mass production to lean enterprise. The authors highlight the huge amounts of waste that occur in most organisations and show that a systematic attack on waste, both within companies and along the supply chains, can have tremendous benefits to the short run profitability and long term prospects of companies and organisations.

Lean production methods were pioneered by Toyota in Japan. *Lean Thinking* distils the essence of the lean approach into five key principles and shows how the concepts can be extended beyond automotive production to any company or organisation, in any sector, in any country.

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## The five lean principles

- 1 Specify** what does and does not create **value** from the customer's perspective and not from the perspective of individual firms, functions and departments
- 2 Identify** all the steps necessary to design, order and produce the product across the **whole value stream** to highlight non value adding waste
- 3 Make** those actions that create value **flow** without interruption, detours, backflows, waiting or scrap
- 4 Only** make what is **pulled** by the customer.
- 5 Strive for perfection** by continually removing successive layers of waste as they are uncovered

These principles are fundamental to the elimination of waste. They are easy to remember (although not always easy to achieve!) and should be the guide for everyone in the organisation who becomes involved in the lean transformation.

If you are serious about going lean then the people in your organisation need to read *Lean Thinking* at the outset. If they haven't got enough time to do that they haven't got enough time for what follows!

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## Lean thinking

In order to go lean, you need to understand customers and what they value. To get your company focused on these needs you must define the value streams inside your company (all the activities which are needed to provide a particular product or service) and, later, the value streams in your wider supply chain as well. To satisfy customers you will need to eliminate or at least reduce the wasteful activities in your value streams that your customers would not wish to pay for.

Next you have to find a way of setting the direction, fixing targets and seeing whether or not change is actually occurring. You need an internal (and later external) framework to deliver **value** for your customers as well as a toolkit to make the change.

If you can do this effectively you won't need to benchmark competitors to set some arbitrary and often incomparable target; perfection or the complete elimination of waste should be your goal. Sounds good, but back to the real world – if it is so easy why doesn't everyone do it?

Sometimes we ask ourselves this question, and when we have gathered a few facts about a company, we ask the company's managers. The answer they give is usually something like 'yes, that makes a lot of sense, but we never saw it that way'. The difficulty is that firms often cannot get into this virtuous circle of improvement.

This book is here to help.

## How to go lean

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	1	2	3	4	5
<b>Objective</b> →	Understand customers and what they value	Define the internal value stream	Eliminate waste, make information & products flow, pulled by customer needs	Extend the definition of value outside your own company	Continually aim for perfection
	↓	↓	↓	↓	↓
<b>Method</b> →	Setting the direction, targets and checking results	An internal framework for delivering value	Appropriate methods to make necessary change	Externalise the value focus to the whole value stream	Strive for perfection in the product and in all processes and systems

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# Lean thinking

1 →

Understanding waste

- ↓
- Types of waste
- ↓
- The three types of activity

2 →

Setting the direction

- ↓
- Developing critical success factors
- ↓
- Reviewing or defining appropriate business measures
- ↓
- Targeting improvement for each business measure
- ↓
- Defining key business processes
- ↓
- Deciding which needs to deliver against each target area
- ↓
- Understanding which processes need detailed mapping

3 →

Understanding the big picture

- ↓
- Customer requirements
- ↓
- Information flows
- ↓
- Physical flows
- ↓
- Linking physical and information flows
- ↓
- Complete map

4 →

Detailed mapping

- ↓
- The detailed value stream mapping toolkit
- ↓
- Process activity mapping
- ↓
- Supply chain response matrix
- ↓
- Production variety funnel
- ↓
- Quality filter mapping
- ↓
- Demand amplification mapping
- ↓
- Value adding time profile

5 →

Getting suppliers & customers involved

- ↓
- Using the detailed mapping tools

6

Checking the plan fits the direction & ensuring buy-in

- ↓
- Assessing the projects
- ↓
- Catch-balling the change programme





# 1

## Understanding waste

The rationale behind going lean centres on waste removal both inside and between companies. This is fundamental to a lean value stream. Improved productivity leads to leaner operations, which in turn help to expose further waste and quality problems in the system. The systematic attack on waste is also a systematic assault on the factors underlying poor quality and fundamental management problems.

### The seven wastes



### Waste (*muda*)

Non value adding to product or service

### Types of waste

Seven wastes were identified by Shigeo Shingo as part of the Toyota Production System. You can use the following chart to make a note of any of these wastes that are present in your business.

Waste	Description	Examples in your organisation
1 Overproduction	Producing too much or too soon, resulting in poor flow of information or goods and excess inventory.	
2 Defects	Frequent errors in paperwork, product quality problems, or poor delivery performance.	
3 Unnecessary inventory	Excessive storage and delay of information or products, resulting in excessive cost and poor customer service.	
4 Inappropriate processing	Going about work processes using the wrong set of tools, procedures or systems, often when a simpler approach may be more effective.	
5 Excessive transportation	Excessive movement of people, information or goods resulting in wasted time, effort and cost.	
6 Waiting	Long periods of inactivity for people, information or goods, resulting in poor flow and long lead times.	
7 Unnecessary motion	Poor workplace organisation, resulting in poor ergonomics, eg excessive bending or stretching and frequently lost items.	

## The three types of activity

When thinking about waste, it is useful to define the three different types of activity within your organisation:

- 1 Value adding activity:** those activities that, in the eyes of the final customer, make a product or service more valuable. Examples would include converting iron ore (with other things!) into cars, or mending a broken down car on a motorway. A value adding activity is simple to define, just ask yourself if you as a customer would be happy to pay for it!
- 2 Non value adding activity:** those activities that, in the eyes of the final customer, do not make a product or service more valuable and are not necessary even under present circumstances. These activities are clearly 'waste' and should therefore be the target of immediate or short term removal. An example of non value adding activity would be transferring a product from one sized container to another so you can move it around your factory.
- 3 Necessary non value adding activity:** those activities that, in the eyes of the final customer, do not make a product or service more valuable but are necessary unless the existing supply process is radically changed. Such waste is more difficult to remove in the short term and should be a target for longer term or radical change. An example would be: inspecting every product at the end of a process because the process uses an old machine which is known to be unreliable.

In our past research at LERC we have developed a rough guide as to the proportions of these three types of activity that we might expect to find in a company before any lean improvements:

In a *physical product environment* (manufacturing or logistics flow), the ratio between the three for the total value stream time of a common (but not world class) company is around:

- 5% value adding activity
- 60% non value adding
- 35% necessary but non value adding.

This does not sound too good until the same figures are seen in an *information environment* (eg office, distribution or retail) where a common ratio of total value stream time is:

- 1% value adding
- 49% non value adding
- 50% necessary but non value adding.

These figures suggest that in most companies there is considerable scope for reducing waste.

### Waste removal tip:

Alert staff to the Seven Wastes by running a short seminar to explain these wastes. Choose groups of staff from the main areas of the business eg purchasing, production, distribution. Ask staff to note down their views of the specific wastes that occur in their section of the operation and to rank these wastes in terms of their relative importance. Ask for simple suggestions as to what could be done to reduce waste. Then task the staff, either individually or as a group, to change one thing each week that will reduce waste.

We talk about fitting people with '*muda* glasses' – once they are aware of the waste they become increasingly able to see it. The trick then is to create a culture that encourages them to eliminate waste once it has been identified.

### Service sector tip:

If we take the Toyota Production System's definition of waste, many activities carried out within a service provider such as a bank, insurance firm or retailer add no value. However, as many of these activities are useful, they might be referred to as service value adding even if strictly speaking they are reducing the (potential) cost to the customer rather than adding value. They could, therefore, be included within the necessary non value adding category. The reason why they should not be included as value adding activity is that this will direct attention away from their long term improvement or development.

# Lean thinking

1 →

Understanding waste

↓  
Types of waste  
↓  
The three types of activity

2 →

**Setting the direction**

↓  
Developing critical success factors  
↓  
Reviewing or defining appropriate business measures  
↓  
Targeting improvement for each business measure  
↓  
Defining key business processes  
↓  
Deciding which needs to deliver against each target area  
↓  
Understanding which processes need detailed mapping

3 →

Understanding the big picture

↓  
Customer requirements  
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Information flows  
↓  
Physical flows  
↓  
Linking physical and information flows  
↓  
Complete map

4 →

Detailed mapping

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The detailed value stream mapping toolkit  
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Process activity mapping  
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Supply chain response matrix  
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Production variety funnel  
↓  
Quality filter mapping  
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Demand amplification mapping  
↓  
Value adding time profile

5 →

Getting suppliers & customers involved

↓  
Using the detailed mapping tools

6

Checking the plan fits the direction & ensuring buy-in

↓  
Assessing the projects  
↓  
Catch-balling the change programme



One of the main difficulties we see when companies try to apply lean thinking is a lack of direction, a lack of planning and a lack of adequate project sequencing. Knowledge of particular tools and techniques is often not the problem. In many cases lean initiatives are killed because of a lack of senior management forethought.

For success, senior managers should:

- 1** develop critical success factors,
- 2** review or define appropriate business measures,
- 3** target improvement requirements over time for each business measure,
- 4** define key business processes,
- 5** decide which process needs to deliver against each target area, and
- 6** understand which process needs detailed mapping.

These preliminary steps are sometimes referred to as 'policy deployment'. We will take you through them before setting the scene for the top level and subsequent detailed mapping.

### 1 Developing critical success factors

Establish the key forces impacting your business or wider value streams. Divide them into categories, such as:

- general business environment
- industry specific
- customer specific
- company specific.

Brainstorm using a flip chart or Post-It notes, facilitated by a team leader.

Develop critical success factors against these key forces. Critical success factors are a limited number of key areas where 'things must go right' for the business to succeed and flourish. They should be directly linked to, and influenced by, the specific factors impacting your company or value stream.

Examples are shown in the table below:

Key force	Examples of key specific factors	Possible critical success factors
General business environment	Recession	Turnover growth
Industry specific	New competitors	Maintain or grow market share
Customer specific	Main customer in decline	Find new customers
	High cost-down pressures	Dramatically reduce costs
	Severe quality improvement targets	Dramatically improve quality
	New product requirement targets	Develop new products
Company specific	A demanding holding company	Keep holding company happy

### 2 Reviewing or defining appropriate business measures

Most companies already have a set of top level (often finance-based) business measures. However, these may not be aligned to the critical success factors. This is very important as existing measures will drive aspirations and ultimately performance. You must check that they are compatible with what is critical in your business environment. Our example business measures are shown in the following table.

### Strategic level critical success factors

Key business measures	Turnover growth	Improve market share	Find new customers	Reduce costs	Improve quality	Develop new products	Keep holdings company happy
	Return on capital			maybe		negative (short term)	yes
	Net cash			yes (short term)			maybe
	Stock turn			yes			maybe
	Overall equipment effectiveness			yes	yes		maybe
	Total cost reduction	yes	yes	yes	yes	maybe	yes
	Total turnover	yes	maybe	maybe			maybe
	Market share	yes	yes	maybe			maybe
	Sales to new customers	yes	yes	yes			maybe
	Product quality	yes	maybe	maybe	maybe	yes	maybe
New product sales	yes	yes	yes	maybe	maybe	yes	maybe

This example shows a set of measures which will put you on the road to achieving your critical success factors. Each measure should correlate with at least one critical success factor, but it is to be expected that not every measure will correlate with every critical success factor. Although the measures may not be the absolute optimum set, they are good enough to pilot. It may be useful to review them, perhaps at the end of the first year.

### 3 Targeting improvement for each business measure

Targeting the improvement rate you need is the next stage, one that many companies fail to undertake. Where companies do this they usually only set one target, perhaps for six months time. However, for an effective lean conversion programme a more realistic timescale is 3 to 5 years within a long term vision, with staged targets for every 6 or 12 months. The table below shows examples of reasonable targets for each measure. Again, the first time you try this targeting exercise the result will probably not be the optimum, but it will point you in the right direction. You can adjust targets to suit your company's particular situation and they can be improved on an annual basis.

Measures	Now	Target end year 1	Target end year 2	Target end year 3	Target end year 5 vision	
	Return on capital	2.4%	4.4%	6.4%	8.4%	12.4%
	Net cash	(£2.4m)	(£2.2m)	(£1.8m)	(£1.2m)	£1.0m
	Stock turn	8.3	12	16	26	46
	Overall equipment effectiveness	43.4%	50.0%	60.0%	70.0%	85.0%
	Total cost reduction	(4.5%) last year	5.0%	5% additional	5% additional	5% additional
	Total turnover	£10.4m	£12m	£16m	£20m	£35m
	Market share	4.5%	5%	6%	8%	15%
	Sales to new customers	6.0%	10%	15%	20%	25%
	Product quality	8,300 ppm	4,000 ppm	1,000 ppm	400 ppm	50 ppm
New product sales	5.0%	5.0%	8.0%	13.0%	25.0%	

The targets set a broad direction for the company over the next three years. What we now need to work out is how are we going to achieve this. To achieve these targets you must understand your key business processes.

#### 4 Defining key business processes

A key business process can be defined as:

*Patterns of interconnected value-adding relationships designed to meet business goals and objectives.*

All business processes have a series of inputs and a number of steps, tasks or activities that convert these inputs into a number of outputs. They typically run across several departments in a business (or businesses) and encourage and support inter-departmental communication and co-operation throughout the company or value stream.

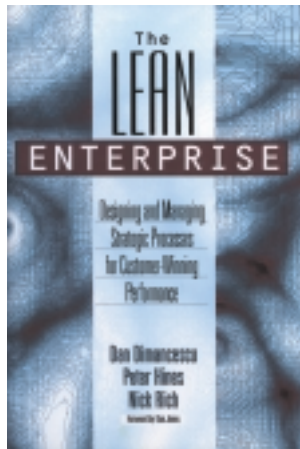
In our use of the term 'process' we are referring to a limited number of key activity groups that you need to deliver value to the business or value stream. The fewer you define the easier they will be to manage. Remember that these processes are not everything a company does, but they are the core activities it undertakes and must get right.

Don't fall into the trap of defining 100+ business processes (as you would for Business Process Reengineering). Brainstorm many, but settle on a few.

For a more detailed discussion of how to define processes, refer to *The Lean Enterprise* by Dimancescu *et al.*

Once you have agreed on between four and ten key processes make sure each have a definition. This will prevent confusion later.

In our example this brainstorming has defined the following processes:



Key business process	Definition
<b>1</b> Order fulfilment	Taking orders, processing the orders, production planning, production, delivery to customer and payment management.
<b>2</b> Sales acquisition	Winning new business with new or existing clients.
<b>3</b> Product lifecycle management	Managing customer needs for new products, developing new products, introducing them into the market and retiring old products.
<b>4</b> Technology, plant and equipment management	Developing, managing and maintaining operating equipment (including IT).
<b>5</b> Human resource development	Developing, managing and maintaining employees.
<b>6</b> Strategy and policy deployment	The strategic management of the company, focusing of change and managing critical success factors.
<b>7</b> Supplier integration	Integrating suppliers into the other key business processes.
<b>8</b> Continuous improvement	Continuous radical or incremental improvement of all other processes.

#### 5 Deciding which process needs to deliver against each target area

To decide which key business process area is likely to give us the targeted improvements, just ask if the business process is likely to yield benefit to each target area if improved. Record YES, MAYBE or NO. Do not answer YES unless there is a direct link. You will then know where you need to focus your improvement activity.

We will now do this for our example:



**Key business processes**

	Order fulfilment	Sales acquisition	Product lifecycle management	Technology, plant and equipment management	Human resource development	Strategy & policy deployment	Supplier integration	Continuous improvement
<b>Measures</b>	Return on capital	maybe	yes	maybe	yes	maybe	maybe	yes
	Net cash	yes	no	maybe	maybe	maybe	maybe	yes
	Stock turn	yes	maybe	maybe	maybe	maybe	maybe	yes
	Overall equipment effectiveness	maybe	no	no	yes	maybe	maybe	yes
	Total cost reduction	maybe	maybe	yes	yes	maybe	maybe	yes
	Total turnover	maybe	yes	yes	maybe	maybe	maybe	yes
	Market share	maybe	yes	yes	maybe	maybe	maybe	yes
	Sales to new customers	maybe	yes	maybe	no	maybe	maybe	yes
	Product quality	yes	no	yes	yes	maybe	maybe	yes
	New product sales	maybe	yes	yes	maybe	maybe	maybe	yes
<b>Total</b>	4 yes 6 maybe 0 no	5 yes 2 maybe 3 no	5 yes 4 maybe 1 no	4 yes 5 maybe 1 no	0 yes 10 maybe 0 no	0 yes 10 maybe 0 no	5 yes 5 maybe 0 no	10 yes 0 maybe 0 no

**6 Understanding which process needs detailed mapping**

We will explain how to map processes later on. First you have to decide which process or processes need detailed mapping. You have already identified which are likely to yield the greatest gains against the target areas; now identify which categories these processes belong to. In our case example, we divide the different processes into three categories:

- Processes focusing overall direction but not directly impacting on targets – strategic processes
- Processes directly impacting on targets – core processes
- Processes indirectly impacting on targets – support processes

In our example we have classified the processes as follows:

Strategic processes	Core processes	Support processes
Strategy and policy deployment	Order fulfilment	Human resource development
	Sales acquisition	Continuous improvement
	Product lifecycle management	
	Technology, plant and equipment management	
	Supplier integration	

Strategy and policy deployment sets the direction and the five core processes are required to deliver the targeted results, aided by the two support processes. At this point it is useful to estimate where the targeted improvements are likely to come from within the core processes. To keep things simple at this point, just pick one

time scale over which to target the required performance improvements. In this case we will take the five year horizon. Then estimate how much of the targeted gains should come from each core process area.

		Core processes					
		Total 5 year targeted improvement	Order fulfilment	Sales acquisition	Product lifecycle management	Technology, plant and equipment management	Supplier integration
Measures	Return on capital	10%		7%		3%	
	Net cash	£3.4m	£2.4m				£1m
	Stock turn	37.7	30				7.7
	Overall equipment effectiveness	41.6%				35%	6.6%
	Total cost reduction	25%	5%		10%	5%	5%
	Total turnover	£24.6m		£10m	£14.6m		
	Market share	10.5%		3%	7%		0.5%
	Sales to new customers	19%		19%			
	Product quality	8,250 ppm	1,250 ppm		2,000 ppm	2,000 ppm	3,000 ppm
	New product sales	20%		10%	10%		

Then decide in which order to map these processes. In many instances it is best to start with the order fulfilment process as it is easy for everyone to understand and is central to the operations of most companies and value streams. In other cases, and depending on the relationship with key customers, the sales acquisition process might be mapped first. However, inexperienced mappers should not work with a customer before piloting the approach internally.

In our example we would map:

- order fulfilment, then
- sales acquisition, then
- supplier integration, then
- product lifecycle management, and finally
- technology, plant and equipment management.

The following sections tell you how to go about mapping at the overview and detailed levels.

## Sum up

For effective policy deployment, take the following steps:

- develop critical success factors,
- review or define appropriate business measures,
- target improvement requirements over time for each business measure,
- define key business processes,
- decide which process needs to deliver against each target area, and
- understand which processes need detailed mapping.

Up to this point this is essentially a senior management process, perhaps involving line managers responsible for the key business processes.



# Lean thinking

1 →

Understanding waste

↓  
Types of waste  
↓  
The three types of activity

2 →

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**Understanding the big picture**

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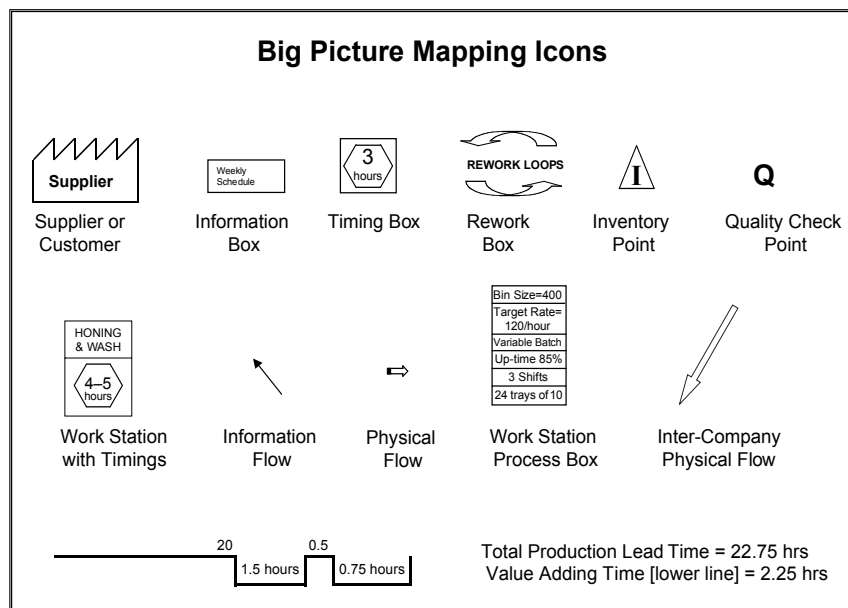
# 3 Understanding the big picture

Before starting detailed mapping of any core process it is useful to develop an overview of the key features of that entire process. This will:

- help you visualise the flows,
- help you see where waste is,
- pull together the lean thinking principles,
- help you decide who should be in the implementation teams,
- show relationships between information and physical flows, and
- create buy-in from the senior team undertaking the big picture mapping

To do this at a macro level we use 'Big Picture Mapping', a tool borrowed from Toyota. You can develop the big picture in five easy phases. We have used a set of generic icons to illustrate what happens within a process; you can copy these or use your own. But don't forget to record what actually happens. Don't bring the quality procedure manual into the workshop, it won't help. Map the reality of what actually happens, rather than what is supposed to happen.

Focus on a specific value stream or a specific product or product family, purchased by a specific customer or market segment. This avoids confusion over the different routes or process adopted for different products or different customers. Other value streams can be considered later to see if they differ significantly from the one studied. Choose a value stream that is important to the company, such as a key product line to a key customer or segment.



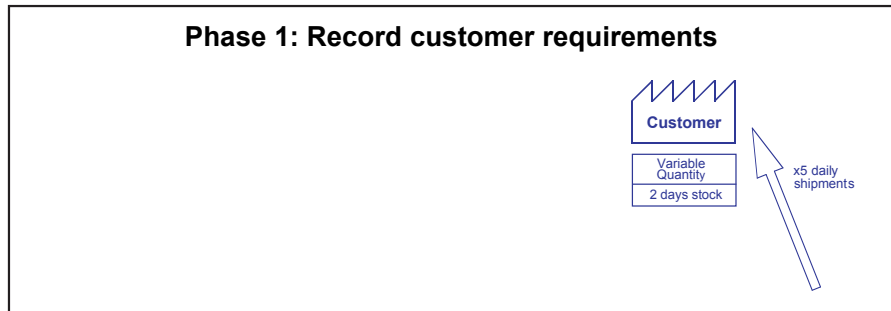
When doing this mapping exercise with a senior/line management team try using Post-It notes on a sheet of brown paper. This allows everyone to see what is going on as well as participating in moving things around! You can always record the data in a PowerPoint format later if you need to.

**Phase 1: Customer requirements**

Ask the following questions and record the answers in the top right hand corner of the paper:

- What is the product family or families to be mapped?
- What is the customer demand or how many products are wanted and when?
- How many different parts are made?
- How many products are delivered at a time?
- How often are deliveries required?
- What packaging is required?
- How much stock does the customer hold?
- Any special information eg multiple delivery points, delivery windows?

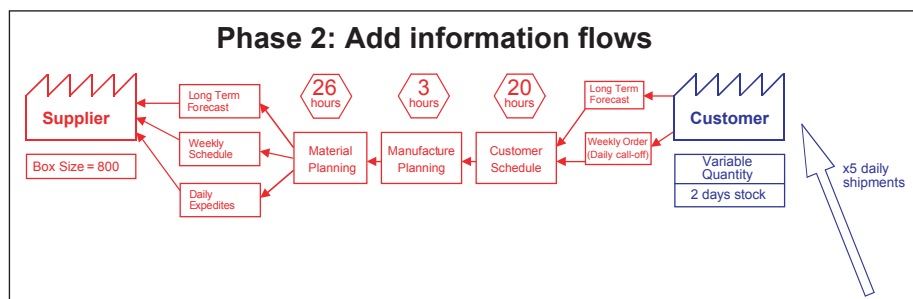
*In practice you may not be able to get all of this information immediately. Just record as much as you can.*



**Phase 2: Information flows**

Ask the following questions and record the answers from right to left along the top of the paper:

- What sort of forecast and call-off information is supplied by the customer?
- Who (or which department) does this information go to in your firm?
- How long does it stay there before being processed?
- Who do they pass it to as it moves towards suppliers? (we will cover the internal production planning in phase 4 so leave that for now)
- What sort of forecast and call-off information do you give your suppliers?
- What order quantities do you specify?



**Phase 3: Physical flows**

Ask the following questions and record the answers from left to right along the bottom of the paper:

For inbound flows of raw material and/or key components

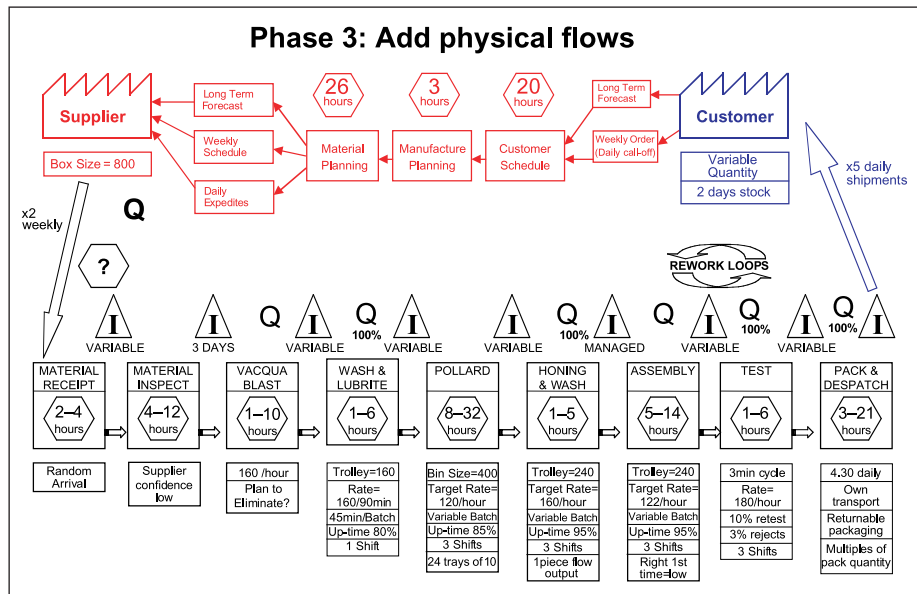
- What is your demand or how many products are wanted and when?
- How many different parts are required? (usually you would map the main or constraint part)
- How many products are delivered at a time?
- How often do deliveries occur?
- What packaging is used?
- How long does it take to deliver?
- Any special information eg more than one supplier for a given part number?

For internal processes

- What are the key steps in your company?
- How long do they typically take? (we often record maximum and minimum values here)
- At which points is inventory stored?
- At which points are there quality checks and what is the level of defects?
- Are there set rework loops?
- What is the cycle time at each point?
- How many products are made and moved in a batch at each point?
- What is the up-time of each operation?
- How much product is tested at each point?
- How many hours per day does each work station work?
- How many people work at each work station, is it variable?
- What is a typical changeover time at each work station?
- Where is inventory held and how much is there?
- What are the bottleneck points?

Understanding the big picture

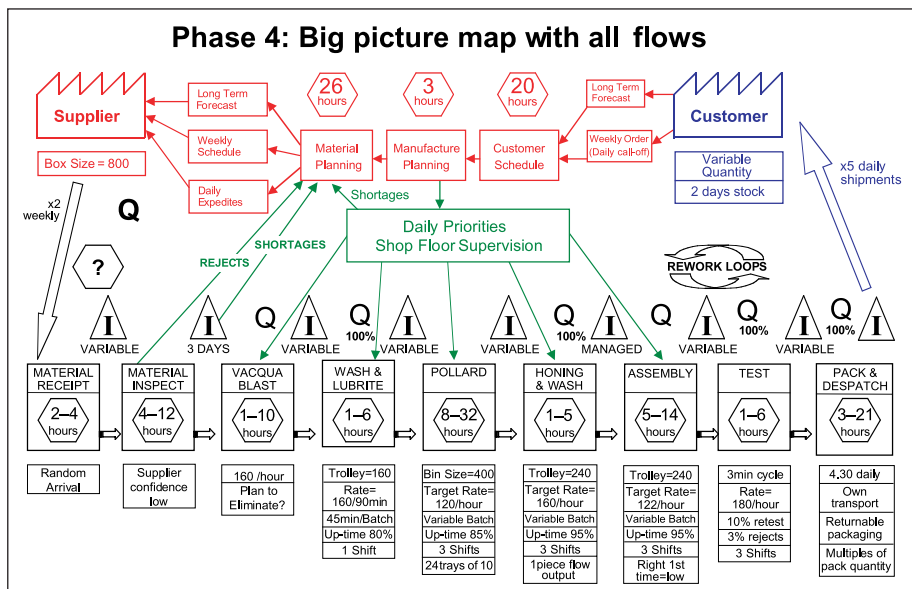
*If a group of senior and line managers can record this information accurately without going to look then you will already have a MANAGE BY FACT company. If not, then you will have learned what you don't know and can join the other 99.9% of firms!*



#### Phase 4: Linking physical and information flows

Ask how are the information flows and physical flows are related and draw on arrows to show the links.

- What sort of scheduling information is used?
- What sort of work instructions are produced?
- Where is the information and instruction sent from and to?
- What happens when there are problems in the physical flow?

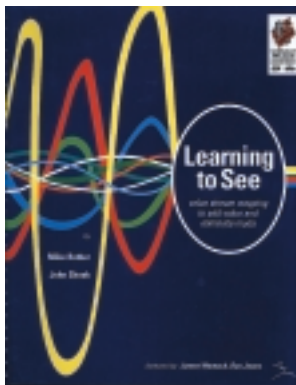
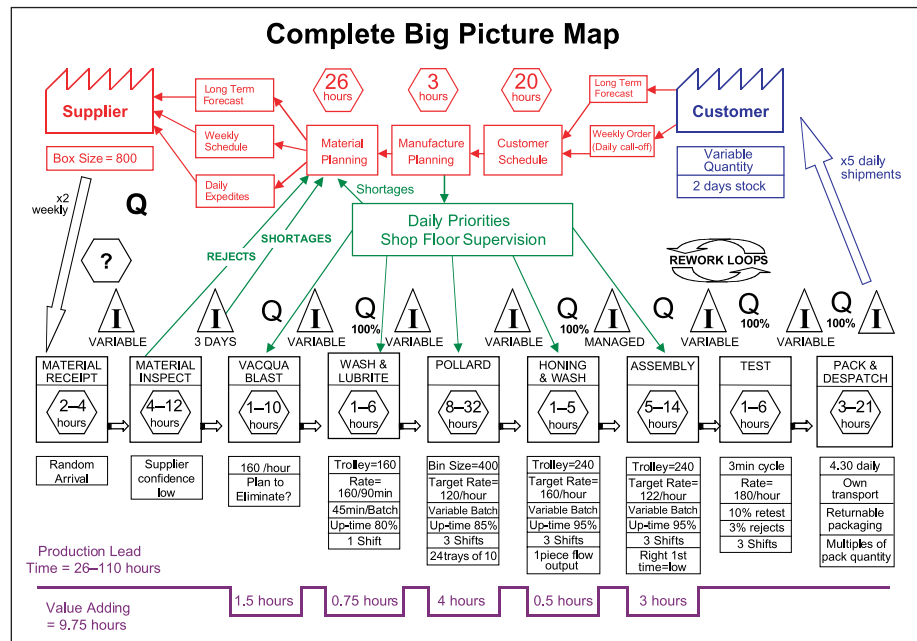


*You should now have linked the upper and lower parts of the figure.*



**Phase 5: Complete map**

To complete the map, add a time line at the very bottom recording the production lead time and value adding time. In the example we have only included the value adding time as the production lead time was so variable, although you can estimate an upper and lower limit.



You now have a complete big picture map. At this point some senior managers find it useful to brainstorm major issues, problems or opportunities. You can record these simply by using different coloured Post It notes. At this point some groups try to re-engineer the supply chain into a possible 'future state' map. We, however, prefer to collect more detailed information about the company by involving a team of line managers and members of the workforce. A future state map can be developed after this if necessary.

For a more complete description of the procedures for Big Picture Mapping we suggest you refer to *Learning to See – value stream mapping to add value and eliminate muda* by Rother & Shook.

# Lean thinking

1 →

Understanding waste

↓  
Types of waste  
↓  
The three types of activity

2 →

Setting the direction

↓  
Developing critical success factors  
↓  
Reviewing or defining appropriate business measures  
↓  
Targeting improvement for each business measure  
↓  
Defining key business processes  
↓  
Deciding which needs to deliver against each target area  
↓  
Understanding which processes need detailed mapping

3 →

Understanding the big picture

↓  
Customer requirements  
↓  
Information flows  
↓  
Physical flows  
↓  
Linking physical and information flows  
↓  
Complete map

4 →

**Detailed mapping**

↓  
The detailed value stream mapping toolkit  
↓  
Process activity mapping  
↓  
Supply chain response matrix  
↓  
Production variety funnel  
↓  
Quality filter mapping  
↓  
Demand amplification mapping  
↓  
Value adding time profile

5 →

Getting suppliers & customers involved

↓  
Using the detailed mapping tools

6

Checking the plan fits the direction & ensuring buy-in

↓  
Assessing the projects  
↓  
Catch-balling the change programme



Up to this point we have only involved the senior or line managers, and lean change will not happen unless we involve the wider workforce. By this point the senior team will have a pretty good idea of the direction and possible areas that could be addressed. However, this information has not come from the 'doers' in the organisation. The bottom-up detailed mapping should, therefore, be done by a team of doers, led by a senior or line manager who has participated in the earlier activities.

There are two reasons for including those actually involved in the day to day information and physical flows:

- They are the only people likely to know what is actually going on, and
- When you use the detailed maps to develop action plans, you will ensure bottom up buy-in by developing bottom up plans from the wider team.

### The detailed value stream mapping toolkit

In our value stream mapping work we have used a large number of tools to fill in the gaps left by big picture mapping. Here, we will summarise six of the most useful tools. We have not invented all these tools. We have collected, modified or in some cases developed approaches when we have found gaps in what was already available.

#### Which are the best tools to use?

Before starting detailed mapping, the table below refers you back to the earlier discussion on wastes and provides an overview of which tool is good at detailing each particular waste. We have simply recorded YES, MAYBE OR NO.

	Process activity mapping	Supply chain response matrix	Production variety funnel	Quality filter mapping	Demand amplification mapping	Value analysis time profile
<b>Overproduction</b>	maybe	maybe	no	maybe	maybe	yes
<b>Waiting</b>	yes	yes	maybe	no	maybe	maybe
<b>Excessive transportation</b>	yes	no	no	no	no	maybe
<b>Inappropriate processing</b>	yes	no	maybe	maybe	no	maybe
<b>Unnecessary inventory</b>	maybe	yes	maybe	no	yes	maybe
<b>Unnecessary motions</b>	yes	maybe	no	no	no	no
<b>Defects</b>	maybe	no	no	yes	no	maybe

### Process activity mapping

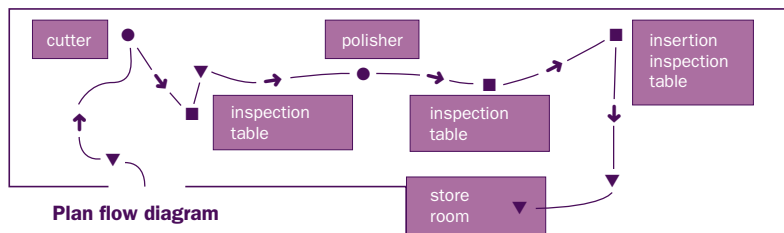
This is the key tool for the detailed mapping of the order fulfilment process. It is an engineering-derived approach that has traditionally only been used for the shop floor of manufacturing companies. However, we use it more widely to identify lead time and productivity opportunities for both physical product flows and information flows, not only in the factory but also in other areas of the supply chain.

**Pin manufacturing (before improvement)**

Step	Flow	Machine/ tool	Distance (metres)	Time (minutes)	People	Chart symbol			
						●	→	■	▼
1 Cut and chamfer pins	●	Cutter		60	1				
2 Transportation	→	Crane	20	5	2				
3 Measure length inspect chamfering	■	Calipers		10	2				
4 Set aside	▼	Bag		70	2				
5 Transportation	→	Crane	10	3	2				
6 Polish exterior surface	●	Polisher		15	1				
7 Transportation	→	Crane	20	5	2				
8 Measure outer diameter	■	Calipers		5	2				
9 Transportation	→	Crane	20	5	2				
10 Inspect pin insertion into socket	■			10	2				
11 Transportation	→	Crane	15	4	2				
12 Set aside	▼			10	2				
13 Storage	▼			50					
<b>Total</b>	<b>13 steps</b>		<b>85 metres</b>	<b>252 minutes</b>	<b>22</b>	<b>2 times</b>	<b>5 times</b>	<b>3 times</b>	<b>3 times</b>
						<b>75 min</b>	<b>22 min</b>	<b>25 min</b>	<b>130 min</b>

**Key**

- Operation
- Transport
- Inspection
- ▼ Storage



The idea is to map out every step of activity that occurs throughout the order fulfilment process. In the example above this has been done for the shop floor of a pin factory with an illustrative plan of the flow. But remember: there may be more waste in the information flow than on the shop floor, so map the information flows as well as the physical product flow.

Before looking at the method in detail, work through the following completed example of a process activity map for a simple activity with which we are all familiar – filling a car with petrol.

**Step 1: Fill in the main body of chart as shown (everything except flows):**

Starting with a trigger point (or start of process) record all activities, areas where they occur, distances moved, time taken, number of people involved in each step and any relevant comments. Then sum the columns for distance, time and people.

#	Activity	Flow	Area	Distance (metres)	Time (minutes)	People	Comments
<b>Trigger</b>	Arrive at garage		Roadside	0.00	0.00	0	Arrive at 08:30
<b>1</b>	Queue to enter forecourt		Roadside	0.00	0.75	1	Early morning congestion, (usually none)
<b>2</b>	Drive to free pump		Forecourt	25.00	0.20	1	
<b>3</b>	Queue for pump to become free		Forecourt	0.00	5.00	1	Cars parked at pump whilst paying (usually none)
<b>4</b>	Drive to free pump		Forecourt	3.00	0.10	1	
<b>5</b>	Open car door and exit car		Forecourt	0.50	0.10	1	
<b>6</b>	Walk to petrol cap on car		Forecourt	2.00	0.10	1	
<b>7</b>	Unlock petrol cap on car		Forecourt	0.00	1.00	1	Cap is faulty and regularly gives problems
<b>8</b>	Walk to petrol pump nozzle		Forecourt	1.50	0.10	1	
<b>9</b>	Retract nozzle		Forecourt	0.00	0.10	1	
<b>10</b>	Walk to petrol cap on car		Forecourt	1.50	0.10	1	
<b>11</b>	Insert nozzle into petrol tank		Forecourt	0.00	0.10	1	
<b>12</b>	Dispense petrol into tank		Forecourt	0.00	3.00	1	50 litre tank, always fill to top
<b>13</b>	Round up value to nearest £1		Forecourt	0.00	0.50	1	
<b>14</b>	Retract nozzle from petrol tank		Forecourt	0.00	0.10	1	
<b>15</b>	Walk to petrol pump		Forecourt	1.50	0.10	1	
<b>16</b>	Replace nozzle		Forecourt	0.00	0.10	1	
<b>17</b>	Close car door and lock car		Forecourt	0.00	0.10	1	Rule I have set myself
<b>18</b>	Walk to shop		Shop	35.00	0.50	1	
<b>19</b>	Queue for cashier		Shop	0.00	3.00	1	Two people in queue
<b>20</b>	Hand petrol card to cashier		Shop	0.00	0.10	2	Collecting air miles!
<b>21</b>	Hand payment card to cashier		Shop	0.00	0.10	2	Payment by card to manage finances more easily
<b>22</b>	Cashier swipes petrol card		Shop	0.00	0.10	1	
<b>23</b>	Cashier swipes payment card		Shop	0.00	0.10	1	
<b>24</b>	Cashier hands payment slip		Shop	0.00	0.30	1	
<b>25</b>	Check slip		Shop	0.00	0.20	1	Past errors at this garage
<b>26</b>	Sign slip		Shop	0.00	0.10	1	
<b>27</b>	Hand slip back to cashier		Shop	0.00	0.10	2	
<b>28</b>	Cashier returns cards and receipt		Shop	0.00	0.20	2	Hand them back in one go
<b>29</b>	Return to car		Forecourt	35.00	0.50	1	
<b>Total</b>				105 metres	16.85 minutes	33 people	

It is surprising how complex even apparently simple tasks actually are.

### Step 2: Assign flows

There are four types of flows:

- Operation = O
- Transport = T
- Inspection = I
- Delay (or storage) = D

As a guide assume that:

- operations are value adding steps that you are willing to pay for, or a set rule eg shut guard before starting machine
- transports are where there is movement around the plant or between sites but you would prefer to avoid paying for this
- inspections are checks of the quality or quantity of product or information
- delay (or storage) is where a product or information is waiting and there is no activity.

Petrol station answers
1 = D
2 = T
3 = D
4 = T
5 = T
6 = T
7 = T
8 = T
9 = T
10 = T
11 = T
12 = O
13 = I
14 = T
15 = T
16 = T
17 = T
18 = T
19 = D
20 = T
21 = T
22 = I
23 = I
24 = T
25 = I
26 = I
27 = T
28 = T
29 = T

Note: when mapping information flows you may find it useful to add another category:

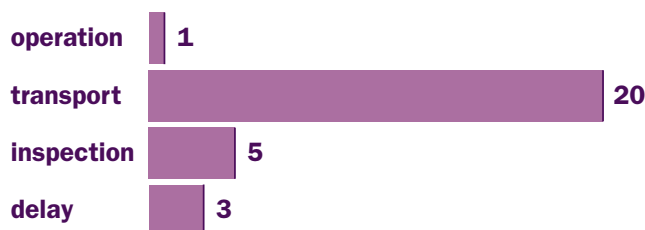
- Communications – this refers to movement or transmission of information. It may involve a time and a distance, for example if people carry documents around the plant, or it may involve no time or distance if data is transmitted electronically.

Now go back to page 29 and assign flows to the petrol station example by completing Column 3. A model answer is shown on the left, but remember there are no hard and fast right answers. It is the debate and discussion that is most important.

### Step 3: Analyse

You will notice in this example that most of the activities involved transport, inspection or delay. This is normal, as surprisingly there is often not much going on that you would really want to pay for.

Number of activity types



Total time for each activity (minutes)



Now use the data for analysis and action planning. You can do this by identifying the major problems or concerns, understanding the causes of these concerns and developing possible countermeasures.

Concern	Cause	Countermeasure
Queue for pump position	Not enough pumps available	Provide more pumps or spread peak usage throughout day
Long time to dispense petrol	Small nozzle	Larger nozzle, but may be safety risk
Many small transport steps to fill car	Filling procedure not customer friendly	Make customer friendly by redesign to car and/or forecourt
Many small transport steps and delay steps to pay	Paying procedure not customer friendly as garage wants to get you into the shop to buy other goods	Credit card payment system at pump

Clearly there are a large number of other things that you could do. However, if you could address just the few areas suggested in the table above then you could probably cut the distance moved, time and number of people and steps by about 80%.

Why not see how the countermeasures work? Redraw the process activity map with these changes.

## Mapping your order fulfilment process

In your own order fulfilment process you will have a number of different steps or stages. These may be natural breaks by department or they may be due to different physical locations. Split your process into these natural stages and map the process step by step. Only by seeing the whole can you prioritise which part of the process to attack first. Here is a real example of a process activity map of an order fulfilment process for a plastic moulding company.

Bearing in mind that value adding operations are the only part your customer might want to pay for, there is certainly a lot of waste to tackle!

**Process activity mapping** – order fulfilment process example (time in minutes)

Process activity	Operation	Transport	Inspection	Delay
Customer forecast processing	0.0	2.1	0.0	7200.0
Production planning	3.7	51.9	12.0	1035.4
Material planning/purchasing	3.3	38.0	18.0	8192.1
Stock replenishment process	0.1	1.5	5.0	8.0
Goods receiving/inspection	0.1	19.2	10.5	158.2
Raw material store	0.1	30.5	0.0	15162.0
Moulding shop store & drying	240.0	38.3	9.5	1549.0
Moulding/packing	15.1	602.6	3.1	15921.4
Stock transfer	2.0	13.1	1.0	14502.1
Finished goods despatch	0.1	176.6	0.0	7317.0
Tool room	5.0	20.0	15.0	150.0
Invoicing	1.0	5.0	20.0	480.0
Inspection activities	15.0	31.7	46.1	74.1
	<b>285.5</b>	<b>1030.5</b>	<b>140.2</b>	<b>71749.3</b>
	<b>0.39%</b>	<b>1.41%</b>	<b>0.19%</b>	<b>98.01%</b>

### Tips:

- 1 Always record *where* the activity is occurring, *when* it is occurring and who is involved.
- 2 When mapping information flows: attach yourself to an order or forecast at the point it enters the company and follow it through all stages of order processing and production scheduling
- 3 When mapping material flows: attach yourself to a product at the start of your process and follow it through to the point of despatch to the customer
- 4 The level of detail required will depend on what you need the data for. If it is time compression and you want to reduce a lead time from 4 weeks to 1 week, recording to the nearest second is not very useful. However, if you want to reduce time in a particular production cell then minutes will probably be appropriate. Record very small time periods as 0.1 minutes.
- 5 Don't get your units mixed up: never mix metres and kilometres or minutes with hours or days.
- 6 Check that nothing unusual is happening; find out what usually happens, but don't be fooled if you are continually being told 'it's usually much better than this'.
- 7 When analysing the data always start with the steps with the longest distances, longest times and most people involved. These are likely to yield the greatest gain.

## Supply chain response matrix

This is a mapping technique used to evaluate the inventory and lead times incurred by a supply chain in maintaining a given level of customer service. It is used to identify large sectors of time and inventory and allows the manager to assess the need to hold stocks within the context of short lead-time replenishments. Any improvement, or decrease, in the level of inventory or time compression in these



areas of the supply chain will release savings or simplify the management of the entire chain. The objective of this mapping is to improve, or maintain, the service level of the entire chain but with fewer costs.



### The map

The vertical axis represents the cumulative inventory held at each stage of the supply chain. In this simple case, there is a supplier, a customer warehouse and a retail store. The total amount of cumulative inventory is 46 days with the warehouse accounting for 30 days of this total. The horizontal axis represents the cumulative lead-time to plan and move the products through the chain. In the example, this totals 26.5 days, with 25 days needed by the supplier to make the product and send it to the customer warehouse. In total, there is 72.5 days worth of stock and movement time which may yield a customer service level of 100%. The larger blocks in the diagram are therefore investigated for savings.

#### Method

Create a simple xy chart and for each stage of the supply chain calculate the amount of inventory that is stored at the point and the lead time required to plan, produce and move the materials to the next operation. Note the cumulative amount of time and inventory.

Analyse the chart for lengthy delays (long horizontal lines within and between the elements of the chain) and high amounts of inventory storage (long vertical lines within each element of the chain). Investigate the reasons for these delays and inventory patterns, and then look for potential solutions to eliminate these costs or streamline the supply chain.

#### Tips

- 1** Ensure that the units of measurement for both the horizontal axis and vertical axis are the same and have equal spacing.
- 2** Often inventory holdings or lead times can be variable, so take averages.
- 3** Investigators should attempt to break down lead times into their basic elements (planning and production) so those improvement projects can be targeted with greater effect.
- 4** It is important to analyse the very small inventory levels (often in transit) with very short transit times as this suggests that quick delivery may not need to be supported by high inventory levels.

Always look for the greatest improvements first rather than targeting many small improvements.

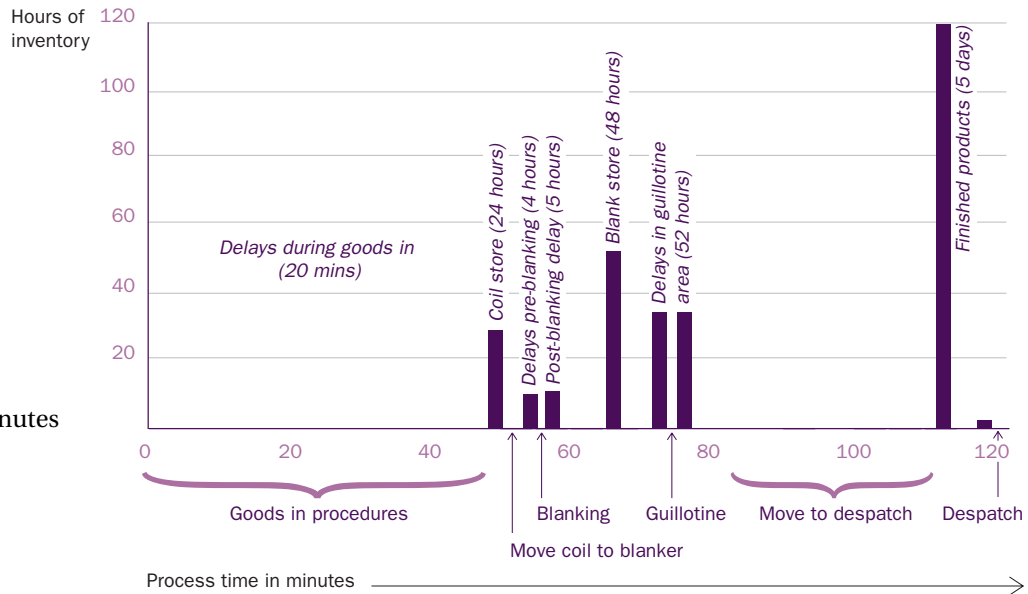
## Logistics pipeline map

This is a complement to the supply chain response matrix. It shows the accumulation of process time on the horizontal axis and of inventory levels on the vertical axis. It shows exactly where inventory and time accumulate *within* each organisation. It highlights the greatest opportunities to compress process time and reduce inventory. The pipeline map is particularly useful for identifying the duplications of inventories that often occur on either side of corporate or functional boundaries. The example here is a pipeline map of the internal operations of a steel processing company.

### Summary

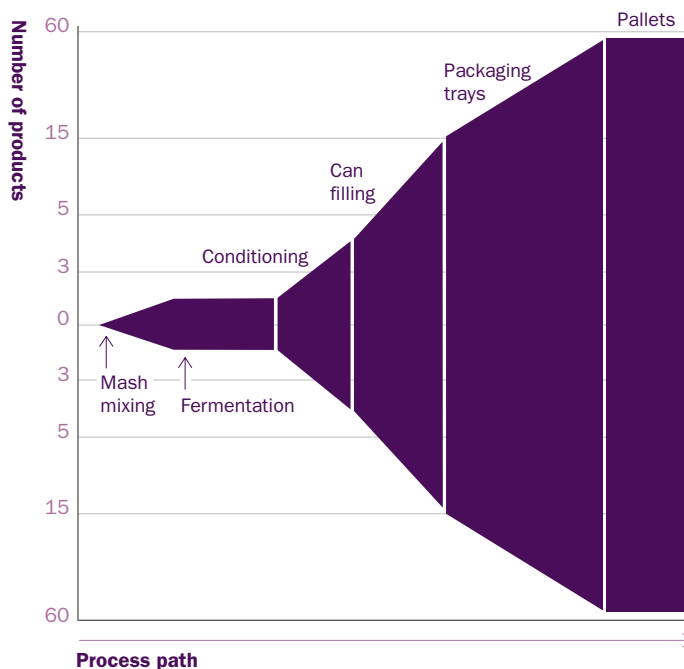
Total operating time = 9 minutes  
 Total transport time = 106 minutes  
 Total inspection time = 3 minutes  
 Total storage time = 192 hours (11 days)  
 Total delay time = 63 hours

**Note:**  
 vertical axis in hours  
 horizontal axis in minutes



## Production variety funnel

This is a visual mapping technique that plots the number of product variants at each stage of the manufacturing process. This technique is used to identify the point at which a generic product becomes either increasingly or totally customer specific. The risks of holding 'specific' stock is that it will not sell and the company will be left holding inventory costs. The map also provides some insights into possible factory inventory policies, in terms of combining the flexibility of the plant with short lead time.



To illustrate the use of this technique, brewing companies often produce a high gravity 9% beer during the initial process of fermentation. This 'mother brew' is not sold at this alcohol content but is 'cut' during the conditioning process into many different products through a process of lowering the alcohol content, say to a 5% brew, a 4.2% brew and a 3% brew. These products are then packed into different can volumes (such as 500 ml and other volumes) before being placed into a tray. The tray itself is used to pack the cans into 24 single cans, 2 packs of 12 cans, 6 packs of 4 cans, 4 packs of 6 cans as well as promotional packages. This means the single product entering the process has multiple points at which that single product divides.

This technique also generates a series of questions relating to the logical reasons for product diversity and the need to maintain such complexity for the supply chain. The map also suggests the logical point at which buffer stocks may be held prior to customisation. The technique is useful when analysing the ability to postpone the manufacturing process rather than maintaining stocks of production output at each stage of the production process. The point at which the product variety rises (expands) rapidly is of key concern and it is the buffer (prior to this point) that creates flexibility from the production system. In short, with favourable manufacturing and demand characteristics, this buffer point can be used to create high levels of customer service without incurring the penalty costs of stock holding further downstream. The map also provides useful data for potential product and inventory rationalisation.

#### Method

- 1** Take a piece of graph paper and create the horizontal (process path) axis and vertical (number of products) axis.
- 2** Select each product, or generic family group of products, and identify the process path through the manufacturing facility. The key item of the bill of materials is likely to be one which follows the entire length of the production sequence. Examples of these products would include water (the primary element of soft drink manufacturing), yarn or fibre for textiles, or the 'body in white' element of vehicle assembly.
- 3** At each stage of the conversion process, identify the number of products that are created. As each process is analysed, plot the final number of 'outputs' produced from each stage on the chart.

#### Tips

- 1** Select the component to be mapped carefully. It must be an element that is integral and significant to the finished product, not a screw or piece of packaging.
- 2** Look for subtle changes in the product at each stage of the process, for example the colour matching, piercing holes in the product, and any other activity which changes the component into a new product.
- 3** Accuracy is always important and therefore it does pay to cross-reference the numbers of outputs, at each stage of the conversion process, with the bill of materials code for that product. The collection of these codes is important when secondary analyses are undertaken to find out the actual stock levels of each identified output.

## Quality filter mapping

The quality filter mapping approach is a new tool designed to identify quality problems in the order fulfilment process or the wider supply chain. The map shows where three different types of quality defects occur in the value stream:

- 1** Product defects: defects in physical goods that are not caught by in-line or end-of-line inspection and are therefore passed on to customers. In a few cases we have found faulty product that was detected but still passed to customers; this would also fall in this category.
- 2** Scrap defects: defects that have been caught by in-line or end-of-line inspection. The in-line inspection methods will vary and can consist of traditional product inspection, statistical process control or through poke yoke devices.

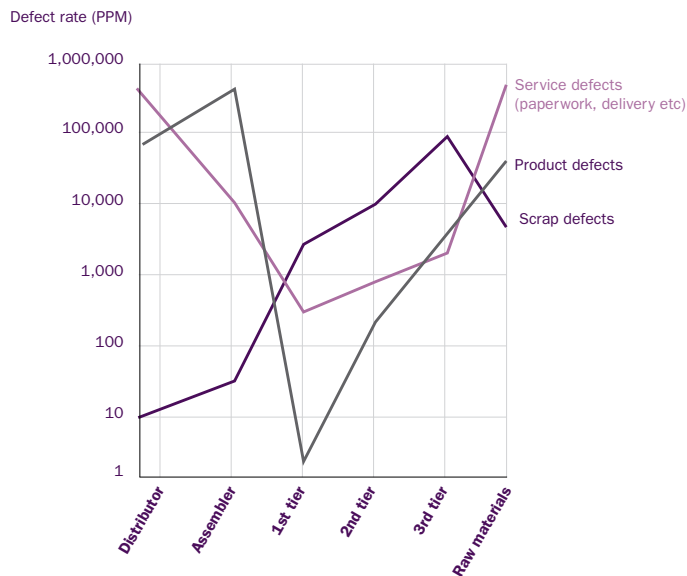
**3** Service defects: problems given to a customer that are not directly related to the goods themselves, but due to the accompanying level of service. The most important of these service defects is inappropriate delivery (late or early). Others include incorrect paperwork or documentation, incorrect packaging or labelling, incorrect quantity and incorrect invoicing.

The approach integrates quality and logistics performance measures. It is designed to establish both internal and external quality levels as well as levels of customer service.

#### Method

**1** Map the three types of defect along the various stages of the value stream, using a parts per million (PPM) scale. If appropriate, plot with a logarithmic scale. Usually the data used to collate the graph is already being collected by the company or companies involved.

**2** The example represents an automotive value stream, stretching from distributor (or car dealer) back through the car assembler, first, second and third tier suppliers and back to raw material producers.



**3** In this case the quality filter map directs attention to:

- the generally high level of scrap (and wasted cost) at the lower component manufacturer tiers,
- the relatively high level of product defects at the car assembler,
- the high levels of service defects at distributor and lower components tiers, and
- the generally poor performance on all measures of raw material producers.

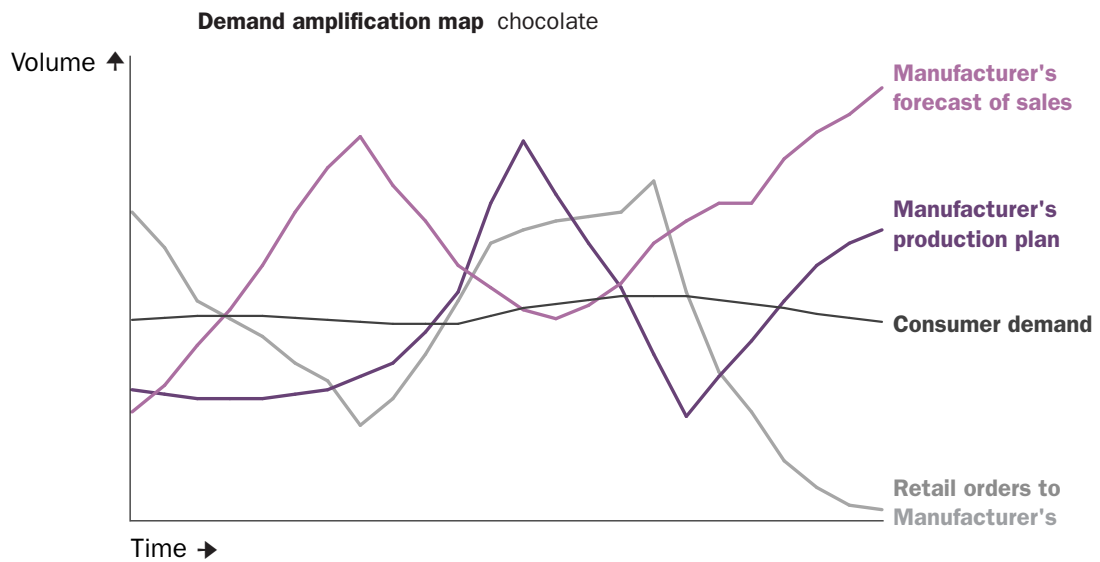
**4** If the tool is being used inside a company, use individual departments or work areas instead of different companies as in the above example. In that case, record product defects where they are passed on to an internal customer or the next department. Service defects would similarly refer to non-product defects passed on to internal customers. Scrap defects would simply refer to any scrap within each particular work area or department.

#### Tips

You may find that data is not presently being collected by the firm or firms involved. If you have time, start recording the data yourself or set up a scheme to do this. If this is not possible, the resulting graph may have some gaps. However, this result is illuminating in itself. It shows that little or no attention is being placed on the quality and service area and that improvements in these areas are very likely to be needed. Without the data though, improvement is almost impossible.

## Demand amplification mapping

This is a graph of quantity against time, showing the batch sizes of a product at various stages of the production process. This may be plotted both within a company and along a supply chain. It can also be used to show inventory holdings at various stages along a supply chain through time. A 'snapshot' of one month's data is often adequate, although a four to six month period gives a clearer picture. An important result of the demand amplification map is to show the 'bullwhip' or 'Forrester effect', where demand changes amplify the further one gets away from the original demand source. The map is also useful to examine scheduling and batch sizing policies, and inventory decisions. The chart below shows the demand amplification effect for a well-known chocolate bar.



Use this map to:

- 1 see the extent of amplification as orders are passed upstream. The greater the amplification, the more difficult it is to encourage flow. The ideal, of course, is that all stages of production work at the customer's rate of demand, bringing uninterrupted flow.
- 2 gain an insight into detailed batch sizing and scheduling policies, looking at both quantity and timing. The reasons for excessive batches or lack of synchronisation may then be explored.
- 3 check inventory decisions. Inventory is the buffer between demand and supply; inventories should be low if there is synchronisation between demand and supply.

### Method

- 1 Identify the stages at which data will be collected. The first stage will usually be actual demands made by the customer. Subsequent stages are at major production stages or cells. Look out for inventory storage and record data at and after each inventory location.
- 2 Identify the products or parts to be studied. If you have already collected data for other maps, use the same part. Otherwise select a representative part.
- 3 Decide on the time horizon for data collection. The period should include a minimum of three batches at the longest manufacturing cycle. For instance, if fortnightly batches are made at a press stage, but assembly takes place every two days, then record data for three press batches over a time horizon of four weeks.
- 4 Decide on the period for analysis. This should be a 'typical' period. Avoid 'rush' and 'quiet' periods, if possible. You may be constrained by the company's record keeping system.
- 5 Collect data on batch sizes and inventories. Take care on this: be aware that a batch may take more than one day to produce. Inventory data may or may not be available, but it can be derived from batch sizes as long as just one accurate snapshot of inventory can be made.
- 6 Plot the data on a graph.

## Analysis

The demand amplification map is a very powerful tool for looking at scheduling and inventory policies and decisions. Rather than asking schedulers how they make up schedules (and getting a theoretical answer!), the map allows discussion around what actually happens, and how it can be improved.

Distinguish between amplification due to changeovers and amplification due to inventory or safety stock policies. Changeovers lead to batching, but are the batch sizes appropriate? Look at this in relation to available capacity. Examine amplification due to inventory policies by asking what the policies are, if any.

Look for variation in batch sizes. What is the consistency of the ratio of batch size to customer demand? Then ask about batch sizing policies. Look out for the temptation to overproduce whilst the set-up is in place.

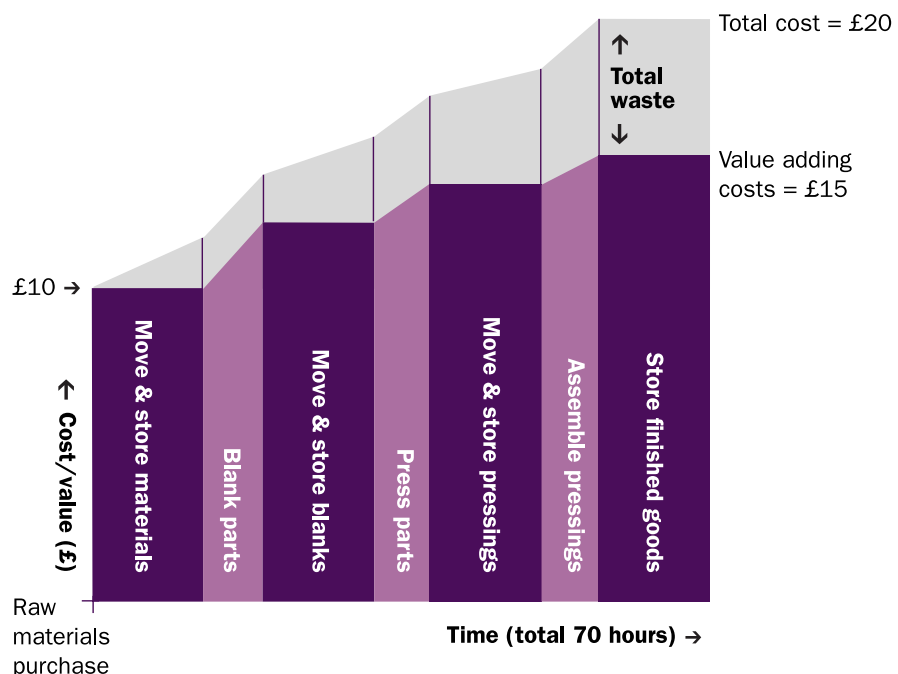
Look out for regularity of batches. A lean operation should be attempting not only to run products as frequently as possible, but as regularly as possible – say the same day each week.

## Tips

- 1 Make sure you use appropriate units of measurement. For instance, if you are producing plastic moulding with a shot (raw material) weight of 50g then measure raw material purchases so that 50g is equal to 1 unit.
- 2 In some firms it is possible to collect data from more than a dozen points, but be selective, three or four well chosen points will give you 99% of the information with far less work and analysis time.

## Value adding time profile

The value adding time profile plots the accumulation of both value adding and non value adding costs against time. It is an excellent tool for looking at time compression or mapping out where money is being wasted.



The difference between the total cost line and the value adding line represents the cost of the wastes. The area under the total cost line represents the amount of money tied up in a unit of inventory. Differences between various types of waste can be easily seen. Plateaux represent storage and delay wastes, and sharp increases in the distance between the value adding line and the total cost line represent waste due to non value adding operations.

**Value adding time profile.  
Required base cost data 1**

Raw materials	
Cost per unit of finished product (pence)	100
Facilities space cost	
Rent £pa	50000
Rates £pa	30000
Light/heat £pa	10000
Total cost £pa	90000
Total m <sup>2</sup>	10000
Cost/m <sup>2</sup> £	9
Cost/m <sup>2</sup> pence	900
Cost/m <sup>2</sup> /min (pence)	0.002068
Fork lift truck	
Depreciation £pa	10000
Maintenance £pa	1000
Driver £pa	16000
Total FLT cost £pa	27000
Total FLT cost/min (pence)	6.21
Plant No.	
Depreciation £pa	1000
Maintenance £pa	250
Direct labour £pa	12000
Floor space £pa	50
Total cost £pa	13300
Total cost pa (pence)	1330000
% Plant utilisation	70
Effective mins pa	304584
Cost/effective min (pence) of plant no.	4.37
% Stock holding cost	
% Opportunity cost of capital pa	20
% Insurance pa	3
% Damage pa	3
% Obsolescence pa	4
% Total pa	30
% Cost/min	6.89E-05
Other direct labour	
Cost/min pence	3.68

As you can see from the example certain activities such as storage are not value adding but they do contribute to cost. In contrast, activities like blanking or pressing do add value. However, they add value at a lower rate than they add to costs. This is because they incur non value adding costs such as set-up or scrap costs. You can easily see the seriousness of these costs compared to the costs of non value adding tasks such as storage.

Where a profile is drawn along a complete supply chain, the relative importance of issues along the chain becomes very clear. For instance, storage delays may be shown up as the dominant problem in one segment, and rework in another. A Pareto analysis can then be drawn to show these problems.

**Method**

The value adding time profile is a very useful tool, especially for justifying projects back to the senior managers. Compared to the other tools, it is also harder to map out. We suggest you leave it to last to see whether you really need it! We have added some example data to the left and on the following pages to illustrate the method.

- 1** Begin by collecting process activity chart data but in addition to the activity description, flow type and times, you will need the number of operators involved (if any), the machine type, inventory, and space occupied. Also note the length of the working day for that particular operation (the number of shifts and the shift length).
- 2** Obtain the unit costs, per minute, of all the resources used, including an estimate of the costs of floor space.
- 3** Obtain the unit cost of the material used in making the part, and the costs of all subsequently added components.
- 4** Obtain an estimate of the inventory holding cost per minute, expressed in percentage terms. This should include capital, storage, and insurance. In annual terms this will probably be at least 20%, but converted to the rate per working minute this will be a small figure.
- 5** Set up the data on a spreadsheet. For practical purposes this is essential, since any revisions result in all subsequent step costs having to be recalculated.
- 6** A typical set of spreadsheet columns is: step number, step description, step category, time, inventory, space used, machine used, number of people, step cost, cumulative value added cost, cumulative total cost. You can add extra columns for costs and times by category.
- 7** Calculate unit component costs for each step. Each step will add to the total cost, but not necessarily to the value adding cost. To do this, multiply the step time by the cost of all the resources used. Most operations involve both human operator costs and machine costs. Storage and delay do not usually involve people costs.
- 8** Where there is storage or delay, calculate the cost of holding one unit of the part for the storage or delay period. Multiply the holding cost rate per minute by the accumulated total cost of the product up to this point.
- 9** Where there is machine processing or a value adding operation involved, base the cost on the number of units that are processed together during that step. This is usually one unit but may be more where, for instance, two pressings are made simultaneously.
- 10** Where there is transport involved, base the cost on the number of units that are moved together (ie divide the step cost by the move quantity).
- 11** To calculate the costs of space used, divide the unit cost of space (£ per minute per square metre x space used x time) by the number of units involved, typically one in the case of a machine and the batch size in the case of storage and delay.

## Developing the Value adding time profile from the process activity map

### Required base cost data 2

Raw material cost per unit	Facilities space cost / metre <sup>2</sup> /min	FLT cost including driver / minute	Plant cost including direct labour /minute	Stock holding cost/minute as %
100 pence	0.0021 pence	6.21 pence	4.37 pence	6.89E-05%

### Required base time data

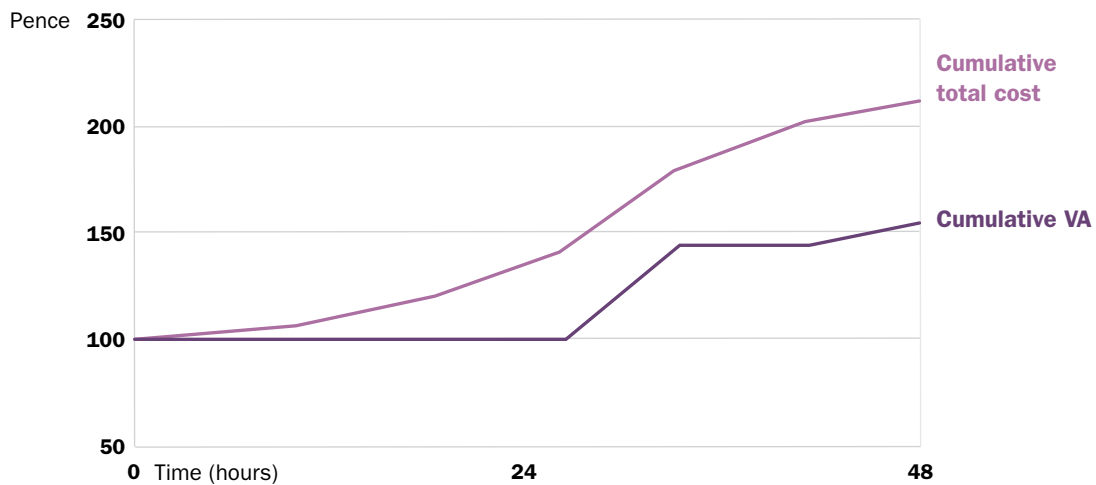
Weeks pa	Shifts per week	Hours per shift	Hours per week	Max minutes per week	Max minutes pa
49	18.5	8	148	880	435120

### VATP spreadsheet (see page 38 and above for required base data)

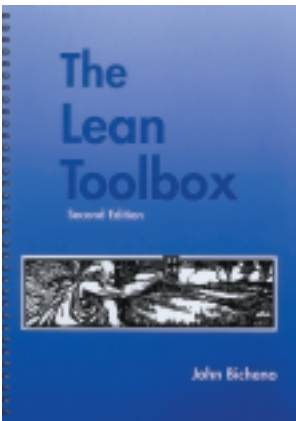
	Raw material cost	Unload truck	Store raw materials (for 1 day – space used 1 metre <sup>2</sup> )	Move to operation 1	Process at operation 1	Store finished product	Pack & despatch
<b>Flow type</b>		Transport	Store	Transport	Operation	Store	Operation
<b>Distance (metres)</b>		10		50			
<b>Duration (minutes)</b>		1	1440	3	10	1440	10
<b>People (no.)</b>		1		1	2		1
<b>Value added ops</b>					1		
<b>Non value added ops</b>		1	1				
<b>Fork lift truck cost</b>		6.21		18.63			
<b>Space cost</b>			3.02			3.02	
<b>Inventory cost</b>		0.00	9.93			18.02	
<b>Operation cost</b>		0.00			43.70		10.00
<b>Total step cost</b>		6.21	12.95	18.63	43.70	21.04	10.00
<b>Cumulative value added</b>	100.00	100.00	100.00	100.00	143.70	143.70	153.70
<b>Cumulative total cost</b>	100.00	106.21	119.16	137.79	181.49	202.53	212.53
<b>Cumulative time</b>	0	1	1441	1444	1454	2894	2904

Detailed mapping

VATP chart from above sample data







### Tips

- 1** The service variant of this tool helps you to understand where service value is added, and where service wastes such as delays and lack of responsiveness occur, as well as the more general types of waste such as inspection, rework or warranty problems, and inventory. In many service environments there is little value added (in the engineering sense). So instead of recording total costs and value adding costs, try plotting total costs, service value adding (necessary but non value adding tasks) and value added costs.
- 2** Base unit costs (cost per minute) on the length of the working day, not 24 hours, unless full shifts are being worked.
- 3** In the case of storage and delay times, which may run across non working weekends and nights, the recorded times should exclude these non-working periods. This ensures that the costs are correct, but cumulative times shown on the value added time profile may appear misleading unless it made clear that times are working times only.
- 4** Add the costs of raw materials at the start of the time profile. Unless you have data which show otherwise, assume these costs are all value added. Add the costs of all bought in or sub components added at the point at which they are actually added. This will result in steps in the profile.
- 5** Since the operation times are typically very much less than the times for storage and delay, a typical value adding time profile will show apparent vertical jumps in cost at operation stages. This is to be expected.
- 6** If you have set up the calculation on a spreadsheet, you can easily evaluate the potential savings due to (a) cutting delay and storage time and (b) cutting inventory levels.

For more details on the application of each of the mapping tools described in this section and other mapping tools, see *The Lean Tool Box* by John Bicheno.

# Lean thinking

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Understanding waste

- ↓  
Types of waste
- ↓  
The three types of activity

2 →

Setting the direction

- ↓  
Developing critical success factors
- ↓  
Reviewing or defining appropriate business measures
- ↓  
Targeting improvement for each business measure
- ↓  
Defining key business processes
- ↓  
Deciding which needs to deliver against each target area
- ↓  
Understanding which processes need detailed mapping

3 →

Understanding the big picture

- ↓  
Customer requirements
- ↓  
Information flows
- ↓  
Physical flows
- ↓  
Linking physical and information flows
- ↓  
Complete map

4 →

Detailed mapping

- ↓  
The detailed value stream mapping toolkit
- ↓  
Process activity mapping
- ↓  
Supply chain response matrix
- ↓  
Production variety funnel
- ↓  
Quality filter mapping
- ↓  
Demand amplification mapping
- ↓  
Value adding time profile

5 →

Getting suppliers & customers involved

- ↓  
Using the detailed mapping tools

6

Checking the plan fits the direction & ensuring buy-in

- ↓  
Assessing the projects
- ↓  
Catch-balling the change programme



Every organisation requires inputs to convert materials and information into products and services that are attractive to customers. Traditionally, businesses sought to control the supply chain through vertical integration (ownership) but more recently this trend has reversed and companies now engage in a high level of outsourcing.

It is, therefore, highly beneficial to extend the order fulfilment mapping to customers and suppliers as we have done in some of our examples. However, care and diplomacy are needed when involving people outside your own organisation. In general the methods are the same but with a wider team involvement.

When mapping with external companies bear in mind that there are likely to be two types of waste (or opportunities):

*Supply chain co-ordination*, which looks at inefficiencies and wastes between companies. This type of co-ordination would involve areas such as working to common quality standards, using the same paperwork system, shared transport and employing inter-company communication methods such as EDI.

*Supply chain development*, which looks at inefficiencies inside certain companies within the supply chain. This type of development would include the dissemination of customer strategies, so that suppliers could plan their processes more effectively, as well as one firm or firms offering specific assistance to other firms in areas such as factory layout, set-up time reduction and the operation of internal kanban systems.

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### Using the detailed mapping tools

Select the most appropriate and 'rewarding' tools to use when conducting the detailed analysis. It is important to use maps that highlight the problems and opportunities both within the individual firms and in the linkages and relationships between firms along the supply chain.

Our experience suggests that the following are the best tools to use at the outset.

A process activity map of the selected key parts through each factory and the information systems that trigger the procurement or replenishment activities. You can then discuss the nature and performance of the activities that comprise the relationship between the companies using real evidence. Then you can seek ways of improving the supply chain in order to improve the system.

The demand amplification map is essential as it exposes the fluctuations in demand that impact on the supply chain to create unlevelled and interrupted schedules. Here the mapping team will reveal mismatches in order quantities and the real impact of poor inventory control routines.

The quality filter map will provide valuable data relating to the type of defects present, and where in the supply chain these tend to occur. These data can then be used to ask for modifications to the processing activities of the firm(s) involved. The data also highlight the need to assure perfect quality of supply before modifications of the inventory system can take place.

At a later point, when improvement activities have been undertaken with the supply chain, the supply chain response matrix and production variety funnel can be used to highlight areas of 'low hanging fruit' and short term gains. The value adding time profile can also be used. As a detailed level of cost data sharing is required this tool is often not appropriate until relationships between firms have developed.

The table summarises the benefits of tools suitable for use in the wider supply chain.

Tool	Benefit
Process activity mapping	This is a useful tool for highlighting the 'low hanging fruit' and for prompting 'why?' questions.
Demand amplification mapping	This and the process activity mapping technique are the most powerful techniques. The demand amplification chart shows why inventory exists and highlights the problems of inventory and batch size policies adopted by either the customer or supplier.
Quality filter mapping	This technique is useful in identifying the nature of quality losses to the supplier and customer. It can highlight problems with purchase specifications and tolerance. This technique does focus the short term improvements of both companies where quality losses exist.
Supply chain response mapping Logistics pipeline mapping	This is an essential technique and demonstrates the amount of inventory held by both organisations. The chart also highlights the areas of the supply chain where products are stagnant or delayed. The map is also good for demonstrating the progress made from one year to the next.
Production variety funnel	This technique can be used to highlight the diversification of a single element of raw material through the supplier and customer processes. It is useful in determining opportunities for postponement ie the amount and extent of last minute configuration that can take place. It can also be used to highlight bottleneck areas of design.
Value adding time profile	The costs and wastes associated with production are necessary in order to justify any improvement effort, but often there is little that either the integration team or supplier can do about customer costs, although there may be opportunities for insourcing to suppliers.

# Lean thinking

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Reviewing or defining appropriate business measures  
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Targeting improvement for each business measure  
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Understanding the big picture

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Customer requirements  
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Detailed mapping

↓  
The detailed value stream mapping toolkit  
↓  
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↓  
Supply chain response matrix  
↓  
Production variety funnel  
↓  
Quality filter mapping  
↓  
Demand amplification mapping  
↓  
Value adding time profile

5 →

Getting suppliers & customers involved

↓  
Using the detailed mapping tools

6

Checking the plan fits the direction & ensuring buy-in

↓  
Assessing the projects  
↓  
Catch-balling the change programme



## 6

# Checking the plan fits the direction and ensuring buy-in

Once the detailed maps are complete, go back to the original target setting exercise. At this point the team will have gathered a great deal of information. They will then need to turn this into a workable plan over a sensible time frame. In other words, are the means for improvement (projects and resources) going to meet the set targets?

Set up teams for the various implementation projects, for each business process. However, to illustrate the method, we will again just focus on the order fulfilment process.

### Assessing the projects

The mapping team, consulting other process experts if necessary, must assess how much each of the projects is likely to contribute towards the key business measures. Using the case example we first encountered in *Setting the direction*, this has been done for potential projects within the order fulfilment area:

**Order fulfilment target and means**

	Target end year 5 vision	Project A: 5S	Project B: Visual management	Project C: Pull	Project D: Small lot production	Project E: Standard work	Total projection
<b>Return on capital</b>							
<b>Net cash</b>	£2.4m	£0.5m	£0.2m	£1m	£0.5m	£0.1m	£2.3m
<b>Stock turn</b>	30	3	3	10	10	4	30
<b>Overall equipment effectiveness</b>							
<b>Total cost reduction</b>	5%	1%	1%	3%	2%		7.0%
<b>Total turnover</b>							
<b>Market share</b>							
<b>Sales to new customers</b>							
<b>Product quality</b>	1,250 ppm	1,000 ppm	500 ppm	200 ppm	200 ppm	200 ppm	2,100 ppm
<b>New product sales</b>							
<b>Timing</b>		Year 1	Year 1	Year 1&2	Year 2	Year 2&3	
<b>Human resource</b>		2 FTE*	0.5 FTE*	3 FTE*	2 FTE*	2 FTE*	9.5 man years
<b>Capital resource</b>		£5K	£2K	£20K	£10K	£20K	£57K

\*FTE = full-time equivalent staff



At this point we also need to ask a few questions:

- Are all the projects likely to deliver?
- Are the projects within each process correctly sequenced?
- Are the project hand-overs within and between process areas sensible?
- Do we believe the figures?
- Is there any double counting?
- Do we think it is going to work?
- Can we afford the time and cost?
- Are there too many projects at any one time wanting the same people?
- Are there enough project team leaders?
- Are there enough project team members?
- Are there bottleneck people and/or skills areas?
- Are we happy to accept any short-falls?
- Will they be made up by other process teams?
- Is the plan so far off that it needs reworking?

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### **Catch-balling the change programme**

This checking process will help identify potential problems and irregularities. What we have been doing is starting a 'catch-ball' process or feedback from the order fulfilment process team to the senior management team. This process has been about making sure the plan is sensible, realistic and will take the business in the direction that the senior managers have set. It has also showed us where some failings exist and where we will encounter capital, project or human bottlenecks.

The catch-ball process may go through a number of iterations before the 'optimum' plan is agreed. We have found the more experienced the senior management team are at guiding the process, the less iterations will be necessary. But we have never seen anyone get it completely right first time round, including ourselves at the research centre!

A lean transformation will take time and commitment to achieve, but it will be worth the effort. Adopting this planning process described here and implementing its results will give you and your organisation a chance to go lean.

*Good luck in your lean journey!*

# Further sources of help

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## Research assistance

At LERC we have a number of ongoing research programmes in both the manufacturing and the service environment, either on a group or individual basis. If you would like to discuss your specific requirement please contact:

Professor Peter Hines, Co-Director  
Lean Enterprise Research Centre  
Aberconway Building  
Colum Drive, Cardiff, CF10 3EU, UK

e-mail: [hinespa@cardiff.ac.uk](mailto:hinespa@cardiff.ac.uk) or visit: [www.cf.ac.uk/uwc/carbs/lerc](http://www.cf.ac.uk/uwc/carbs/lerc)

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## Educational assistance

A range of educational courses are run at LERC including: MBA in Supply Chain Management; MSc in Lean Operations; the Automotive Retail Management Programme and a number of tailored short and specialist courses. For further information please contact:

Claire Gardner, Education Manager  
Lean Enterprise Research Centre  
Aberconway Building  
Colum Drive, Cardiff, CF10 3EU, UK

e-mail: [gardnerca@cardiff.ac.uk](mailto:gardnerca@cardiff.ac.uk) or visit: [www.cf.ac.uk/uwc/carbs/lerc](http://www.cf.ac.uk/uwc/carbs/lerc)

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## Publications

### Companion books to this publication:

Peter Hines, John Bicheno & Nick Rich, *End to End Lean* (Portland, Oregon, Productivity Press, 2000)

A more in-depth text on how to apply lean thinking.

David Taylor and David Brunt (eds), *Manufacturing operations and supply chain management – the lean approach* (International Thompson Business Press, 2000)

A case book detailing the application of lean thinking within the LEAP programme

### Other useful texts:

John Bicheno, *The Lean Toolbox*, 2nd edn (Buckingham, Picsie Books, 2000)

Available from Picsie Books: tel. +44 (0)1280 815023 or visit:

[www.axiom.co.uk/picsie/](http://www.axiom.co.uk/picsie/)

Dan Dimancescu, Peter Hines & Nick Rich, *The Lean Enterprise: Designing & Managing Strategic Processes for Customer Winning Performance* (New York, Amacon, 1997)

Peter Hines, Richard Lamming, Daniel Jones, Paul Cousins & Nick Rich (eds), *Value Stream Management: strategy and excellence in the supply chain* (Harlow, Financial Times Prentice Hall, 2000)

Mike Rother & John Shook, *Learning to See* (Brookline, Mass, The Lean Enterprise Institute, 1998)

Direct e-mail to: [info@lean.org](mailto:info@lean.org) or visit: [www.lean.org](http://www.lean.org)

James Womack & Daniel Jones, *Lean Thinking: Banish Waste and Create Wealth in your Corporation* (New York, Simon & Schuster, 1996)

Available from most booksellers

James Womack, Daniel Jones and Daniel Roos, *The Machine that Changed the World* (New York, Rawson Associates, 1996)

Available from most booksellers

# Jargonbuster

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**Big picture mapping** A specific visual approach designed to display at a high level a major part or whole *Lean enterprise*.

**BPR** Business process re-engineering, where minute activity sets are defined as processes and improvement generally takes the form of a complete redesign.

**Catch-balling** The feedback and agreement process for plans with *Policy deployment*.

**Core processes** Those central processes that directly deliver results against targets. See also *Key business processes, Strategic processes and Support processes*.

**Critical success factors** Those key external or internal elements that a business needs to focus on for success, such as market growth or employee involvement.

**Current state map** A visual method of succinctly recording the key aspects of the current structure and processes in the whole or any part of a supply chain. See *Big picture mapping*.

**Flow** All activities being undertaken within the *Lean enterprise* at an even rate without delays, interruptions or other batching.

**Future state map** A vision of a lean system which is used as the guide for the change process.

**Hoshin Kanri** See *Policy deployment*.

**Key business process** Patterns of interconnected value-adding relationships designed to meet business goals and objectives, or the main cross-functional activities required in a business for success. See also *Strategic processes, Core processes and Support processes*.

**Lean** A consumer focused approach to the provision of effective solutions involving the consumption of a minimum of resources.

**Lean enterprise** The extended supply chain responsible for effectively satisfying consumer requirements using a minimum of resources.

**Lean thinking** The process by which individuals can understand the need for, create and implement a *Lean enterprise*.

**Mapping** The use of a appropriate tools and technique to analyse the current situation in any process.

**Muda** The Japanese term for *Waste*. Any activity which consumes resources but adds no value.

**Necessary non value adding** Non value adding activities which are necessary under the present operating system or equipment. They are likely to be difficult to remove in the short term but may be possible to eliminate in the medium term by changing equipment or processes.

**Non value adding** Those activities within a company or supply chain that do not directly contribute to satisfying end consumers' requirements. Useful to think of these as activities which consumers would not be happy to pay for.

**Overall equipment effectiveness** A composite measure of the ability of a machine or process to carry out value adding activity.

$$OEE = \% \text{ time machine available} \times \% \text{ of maximum output achieved} \times \% \text{ perfect output}$$

It measures the degree to which machines are adding value by not being wastefully employed due to planned or unplanned downtime or in producing defects.

**Overall supply chain effectiveness** A composite measure of supply chain performance.

OSCE = % orders delivered on time × % Order completeness × % On time delivery.

**Pareto analysis** Sometimes referred to as the '80 : 20 rule'. The tendency in many business situations for a small number of factors to account for a large proportion of events. For example 80% of total sales volume might be attributable to 20% of customers and to 20% of the product range. In terms of quality, 80% of defects might be attributable to 20% of causes. The 20% is sometimes referred to as 'The vital few.'

**Perfection** The complete elimination of *muda* so that all activities along a value stream create value.

**Poke-yoke** A mistake-proofing device or procedure to prevent a defect during order intake or manufacturing.

**Policy deployment** A strategic decision making tool that focuses resources on the critical initiatives necessary to accomplish the *Critical success factors* of the firm. The term usually also encompasses the cascading of this by *Key business process* together with the control, measurement and feedback of results. Also known as *Hoshin Kanri*.

**Pull** All activities being undertaken within the *Lean enterprise* according to and at the rate of the actual demand requirements of the end consumer.

**Seven wastes** A framework of seven types of activity that do not add value, originally defined by the Toyota company.

**Strategic processes** Those processes that help focus overall direction but do not directly impact on targets. See also *Key business processes*, *Core processes* and *Support processes*.

**Support processes** Those processes only indirectly impacting on targets but providing support to the *Core Processes* that do. See also *Key business processes*, *Strategic processes* and *Core processes*.

**Uptime** The % of time that a machine is available for productive work.

**Value adding** Those activities within a company or supply chain that directly contribute to satisfying end consumers, or those activities consumers would be happy to pay for.

**Value stream** The specific activities within a supply chain required to design, order and provide a specific product or service.

**Value stream mapping** The process of charting out or visually displaying a *Value stream* so that improvement activity can be effectively planned. See *Mapping*.

**Waste** All those activities that occur within a company or wider supply chain that do not add to the value of a product or service supplied to a final consumer. Sometimes called *Muda*. See also *Seven wastes*.

# Notes

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