

**GWYNNE RICHARDS**  
**SUSAN GRINSTED**

# 4TH EDITION

# THE LOGISTICS AND SUPPLY CHAIN TOOLKIT

# OVER 100 TOOLS FOR TRANSPORT, WAREHOUSING AND INVENTORY MANAGEMENT



# **PRAISE FOR *THE LOGISTICS AND SUPPLY CHAIN TOOLKIT* THIRD EDITION**

'A book that summarizes and explains many of the key techniques that make logistics the profession that it is. Certainly one that will not gather dust on a bookshelf, but will gather insight and understanding in the workplace.'

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**Carole Verry, Consultant, France**



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**Fourth Edition**

# **The Logistics and Supply Chain Toolkit**

Over 100 tools for transport,  
warehousing and inventory  
management

Gwynne Richards and Susan Grinsted



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A selection of tools are available at:

[www.koganpage.com/TLASCT4](http://www.koganpage.com/TLASCT4)

For a comprehensive set of tools go to:

<http://howtologistics.com>

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# Introduction

Today's logisticians are working in a fast-moving, ever-changing environment. The supply chain has become centre stage, providing competitive advantage to those who can master procurement, supplier management, inventory, warehouses and distribution. Getting the right product in the correct quantity to the right customer at the prescribed time in good condition at an acceptable cost is paramount to not only retaining but increasing sales and profitability. Supply chain and logistics managers are not only expected to be experts in their own field but also in human resource management, finance, customer service, supplier management and, at times, production. This book, written by supply chain and logistics practitioners, sets out to provide users with a handbook to enable them to keep pace with what's happening in this sector.

According to the *Collins English Dictionary*, a tool is 'anything that can be used as a means of performing an operation or achieving an end'. In this book we will introduce guides, frameworks, models, quick calculations and practical ideas, describing to the reader how to use the tools and under what circumstances. These guides and tools have been chosen to enable the reader to identify issues, produce solutions and thus improve operational efficiency and effectiveness. Some of these tools and spreadsheets can be downloaded from our website: <http://howtologistics.com>.

Have you ever wondered how you go about efficiently locating stock in your warehouse utilizing an ABC analysis, what is meant by the term 'slotting', or what your trucks' CO<sub>2</sub> emissions are? To answer these questions and more, we thought it was time to bring these tools and calculations together in an easy-to-understand format with specific examples that relate to the supply chain and logistics sector.

The aim of this book is to provide today's managers with a toolbox of practical guides, ideas and information to help them in their day-to-day work. It explains a number of the major management tools and suggests areas within supply chain and logistics where they can be applied. We don't expect you to use all the tools and data but hope that you will find a number of them useful in your work.

The introduction of advanced technologies into today's warehouses and fulfilment centres has gone a long way to assisting managers to become more efficient and cost effective. However, not all companies are able to afford sophisticated warehouse management systems, automation and robotics.

As a result of recent feedback from the third edition, we now compare some of these new technologies. However, the essence of the book remains – the provision of workable tools to assist managers in their day-to-day operations.

The tools have been put into chapters, including supply chain, warehousing, transport and inventory. The supply chain is a demanding and challenging area and managers require all the assistance they can get to satisfy both internal and external customers. Where we believe that the reader's experience will be enhanced by further information on the tools discussed, we have identified and provided details of websites, software packages and companies that can further assist. These are included at the end of each tool. Each chapter provides guides and tools that enable the reader to tackle most of the problems faced in the above areas and thus improve efficiency and effectiveness. The chapters provide guidelines and suggestions as to how each tool can be used and show logistics-related examples where needed, to explain the tools further.

The book is split into eight chapters:

- 1** Warehouse management tools and guides
- 2** Transport management tools
- 3** Inventory management tools
- 4** Supply chain management tools
- 5** Outsourcing tools
- 6** Performance management tools
- 7** Financial management tools and ratios
- 8** Problem-solving tools

The chapter on warehousing includes descriptions of the various types of item-pick methods, a comprehensive warehouse audit, how to use ABC analysis to lay out the warehouse and the factors that need to be taken into account when deciding on a new location for a distribution centre. We have also included a comparison of goods-to-person systems and a tool on how to produce a contingency plan for the warehouse.

The transport management chapter looks at areas such as carbon footprint measurement, fuel surcharge calculation and transport costs. We have also included a comparison of last mile delivery systems.

Within the inventory management chapter we discuss the various tools used in determining the optimum stock quantity, demand forecasting, how to calculate stock turn and carry out perpetual inventory counting.

The chapter on supply chain management looks at current tools such as SCOR®, factory gate pricing and supplier relationships. With the advancement in technology we have also included tools and information on Blockchain, Logistics 4.0 and Digital Twinning.

Chapter 5 provides a step-by-step guide to logistics outsourcing, while the performance management section provides a number of relevant logistics measures and details on how to measure performance.

The tools set out in the finance and problem-solving chapters can be used across the different logistics sectors.

Appendix 1 provides a list of useful websites while Appendix 2 provides useful measurements and conversions.

A glossary of terms and a list of useful acronyms can also be found, along with many of the tools in this book, on our website: <http://howtologistics.com>. A number of the examples and templates are free while others have been heavily discounted for purchasers of this book. The code to enable you to receive the discount is **lsct2024**.

As website addresses might change over time we have archived the information in a separate location. If you are provided with a company website address in the text, we also provide an alternative address should that location no longer be available.

This book is a quick reference guide for supply chain and logistics professionals who want immediate access to relevant tools and data to assist with their day-to-day work. We hope you enjoy it. This is the fourth edition of the book as we are constantly updating the tools. If you have any ideas for other logistics-related tools please let us know and we will endeavour to include them in the next edition and on our website.

Previous editions have been translated into Chinese and Russian.

# Warehouse management tools and guides

01

This chapter has a number of tools to assist you in operating your warehouse more efficiently. Tools include how to undertake an ABC analysis, which types of storage and materials handling equipment will enhance your operations, which is the best picking strategy for your type of operation and how to choose a warehouse management system.

At the end of the chapter we have included some general management tools and how they can be used to solve specific warehouse problems.

## 1.1 Warehouse audit

### *Introduction*

An internal audit is designed to monitor and improve an organization's business practices.

These are five reasons why internal auditing is important and should be carried out on a regular basis.

Audits:

- Provide objective insight
- Improve efficiency of operations
- Evaluate risks and protect assets
- Assess organizational controls
- Ensure legal compliance

This section provides an audit checklist for a warehouse and its operations. The list of questions is not exhaustive and can be added to by users to mirror their own operations.

Audits should be undertaken by an independent person from within the company or by an external consultant. The purpose of the audit should be explained to staff in advance. Results need to be shared with all the staff, and they need to take ownership of any improvements necessary.

The audits are based on what we see as best practice in a warehouse. A full set of audit forms in Excel format with over 100 questions can be purchased from <http://howtologistics.com>, discount code: **lsct2024**; an extract of the audit is shown in Table 1.1.

## **Further information**

Suggested reading to ensure safe and legal practices:

UK HSE – <http://www.hse.gov.uk> (archived at <https://perma.cc/U8CT-5ZGM>)

UK COMAH – <http://www.hse.gov.uk/comah/index.htm> (archived at <https://perma.cc/V26X-4NG7>)

UK SEMA – <http://www.sema.org.uk> (archived at <https://perma.cc/TQN3-2UR7/>)

USA OSHA – [www.osha.gov](http://www.osha.gov) (archived at <https://perma.cc/PE5B-TH7Z/>)

USA EPA – <https://www.epa.gov/laws-regulations> (archived at <https://perma.cc/8QX3-ACY3>)

European Safety and Health at Work – <https://osha.europa.eu/en/safety-and-health-legislation> (archived at <https://perma.cc/3SQB-JT2X>)

## **Further reading**

Ackerman, K (2003) *Auditing Warehouse Performance*, Ackerman Publications, Columbus, OH

Richards, G (2021) *Warehouse Management*, 4th edn, Kogan Page, London

United Kingdom Warehousing Association – [www.ukwa.org.uk](http://www.ukwa.org.uk) (archived at <https://perma.cc/ZMR8-QXFY>)

<https://kirkpatrickprice.com/blog/5-reasons-why-internal-audit-is-important> (archived at <https://perma.cc/D8GA-RRMZ>)



**Table 1.1** Warehouse audit checklists – example questions

Carried out by:			Location:			Date:
Item	No	Poor	Good	Excellent	N/A	Comments
Comprehensive signage for delivery drivers in multiple languages						
Stock adequately protected from theft and pilferage						
Escape routes clearly marked and obstruction free						
Is there disabled access into the building?						
Racking condition is checked regularly and reported						
Are there any overhanging pallets in the racks?						
Weight capacity visible on the end of the racks						
Are sufficient security measures in place for high-value items?						

(continued)

**Table 1.1** (Continued)

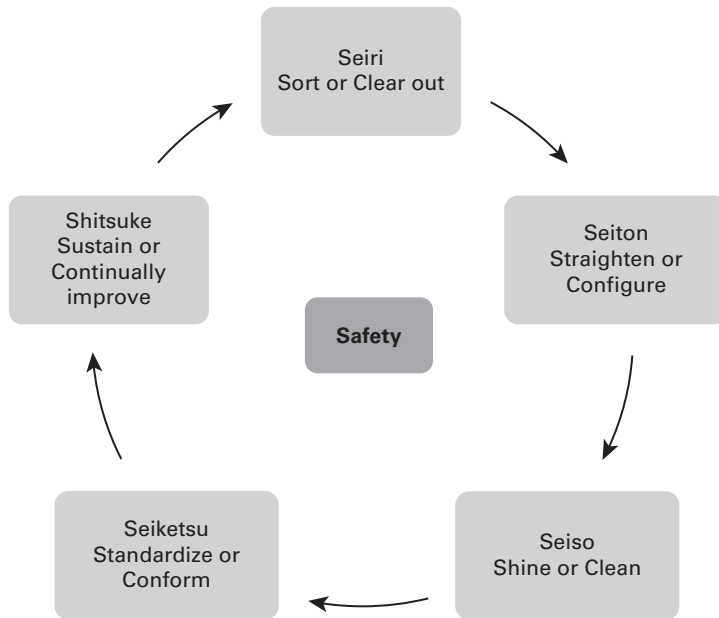
Carried out by:			Location:			Date:
Item	No	Poor	Good	Excellent	N/A	Comments
Are sufficient safety measures in place for hazardous items?						
All electrical items tested (UK PAT test)						
Staff have correct licence for type of truck operated						
Responsible staff trained to operate MHE						
Record of safety training kept up to date						

## 1.2 5S or 5C, also known as Gemba Kanri

### *Introduction*

5S, also known as 5C, has its origins in Japan. 5S focuses on organizing the workplace effectively and standardizing work procedures (see Figure 1.1). 5S simplifies processes and reduces waste and non-value-adding activities while improving quality, efficiency and productivity. Safety is sometimes included as a sixth S.

The tool is also effective in getting employees involved in the improvement process and ‘owning’ their area of work, taking pride in how it looks and performs.

**Figure 1.1** The steps of 5S

### ***When to use***

When a company is looking to improve efficiency within the warehouse and instil a culture of continuous improvement.

### ***How to use***

5S needs to be carried out in the correct order. You need to give individuals responsibility for each task and for their respective work areas within the warehouse:

- a** The first S (Sort or Seiri or Clear out) concentrates on removing any unnecessary items from the work area. This can include obsolete and damaged stock, over-stocks, defective equipment, broken pallets, waste packaging, etc. It can also refer to unnecessary movement within the warehouse. For example, the introduction of a cross-aisle within the picking area will reduce the amount of travel undertaken by the operators. Items marked for disposal can be put into a holding area until a consensus is reached as to what should be done with them.

**Figure 1.2** Shadow boards



**SOURCE** Courtesy of Fabufacture

- b** The second S (Straighten or Seiton or Configure) focuses on efficient and effective placement of items, for example, location labelling and putting frequently used items in easy-to-access locations. Shadow boards can be used to ensure equipment is returned to its correct locations (see Figure 1.2). Directional signs in the warehouse are also part of this, as they should reduce the amount of time taken to find items. Items such as tools, empty pallets and packaging should be placed in easily accessible areas close to the point of need. Finally, parking areas for handling equipment need to be set up, with reminders to staff to put the equipment on charge if required.
- c** The third S (Shine or Seiso or Clean) comes after you have cleared the area of any unnecessary items. Thoroughly clean the area and produce a

timetable for cleaning. This can be done at the end of each shift, with defects to equipment reported immediately. Staff take pride in a clean work area, they work better and from experience, clean warehouses tend to be more efficient! Suggestions include putting bins at the front of each aisle to capture waste paper, packaging and broken pallets and making brooms and dust pans easily accessible.

- d** The fourth S (Standardize or Seiketsu or Conform) is all about creating standards for each work area. Walk through each process with the relevant staff and then produce, document and display best practice procedures within the warehouse. Make them simple to read and understand. A photograph displaying the process with minimal text works well in this situation.
- e** The fifth S (Sustain or Shitsuke or Continually improve) ensures continuous improvement. Staff are encouraged not to return to previous work practices but to accept change and take things to a new level. Regular checks and audits need to be carried out, with the potential for bonus payments on achieving high performance scores.

More recently, companies have introduced a sixth S, which covers safety. It can be argued that safety is at the heart of the operation and therefore is a valuable addition to the 5S mentality.

An example of how to use the 5S tool is shown in Table 1.2. Companies that have instigated 5S have improved quality, increased efficiency, improved safety, reduced waste and given employees a sense of ownership.

Table 1.3 below shows an audit tool, which can be carried out in a work area, including offices. It can be adapted to work in most areas. An interactive version of this audit tool can be found at <https://www.adaptivebms.com/tools> (archived at <https://perma.cc/7ABV-R6UG>).

Allied to 5S are the 7 Muda (types of waste). These are as follows:

- 1** Inventory – waste of space, equipment, facilities, energy, administration and IT resources. It needs to be evaluated and adjusted as necessary.
- 2** Motion – any motion of a person or machine that does not add value needs to be removed.
- 3** Over-production – ‘just in case’ mentality. ‘More than’, ‘faster than’ or ‘sooner than needed’ have to stop.
- 4** Waiting – waiting is idle time, created by imbalances of machinery or people. This needs to be reduced or eradicated.

- 5** Re-work – reject, repair, re-work causes a great waste of resources: materials, manpower and machinery. Although capturing value in the warehouse it shouldn't occur in the first place.
- 6** Processing – non-logical flow in the wrong sequence that adds no value – needs to be regularly evaluated – walk through the process regularly.
- 7** Conveyance – essential but adds no value. Every time you move something it adds cost. Reduce these movements.

**Table 1.2** 5S tool

5S	Actions	Person/group responsible	Measurement	Checked by
Sort	Audit MHE and remove defective equipment	WM	Reduced maintenance costs, increased space	GM
	Identify obsolete stock and dispose of it	Inventory manager	Increased available locations, lower stock holding costs	GM
	Label locations. Introduce shadow boards	WM/external	No of locations labelled/total no of locations. All equipment in correct location	Put-away team. Housekeeping team
Straighten	ABC analysis	WM	Increased pick productivity rates, shorter travel distances	GM
	Slotting analysis	WM	Increased pick productivity rates, shorter travel distances	GM
	Reduce pick travel time	Picking team	Increased items picked per hour	WM

(continued)

**Table 1.2** (Continued)

5S	Actions	Person/group responsible	Measurement	Checked by
Shine	Identify and remove broken pallets	Housekeeping	Visual	WM
	Provide bins at the end of each aisle	WM	Visual	GM
Standardize	Produce new procedures for each section	Team leaders	Visual	WM
	Set up a communication cell for each team	WM/Team leaders	Visual	GM
Sustain	Set up regular review meetings between staff and team leaders	WM/Team leaders	No of improvement suggestions made per month. No of improvements introduced	WM

**Key**

WM = Warehouse Manager

GM = General Manager

MHE = Mechanical or Materials Handling Equipment

Companies need to carry out an audit to identify areas that can be improved based on the 7 Muda. Discuss the process/procedures and how any changes can benefit the organization.

The 7 Muda are also referred to at times by the mnemonic TIMWOOD:

T=Transportation

I=Inventory

M=Motion

W=Waiting

O=Over-processing

O=Overproduction

D=Defects

Some writers have also added an S which stands for Skills, or underutilization of worker capabilities.

**Table 1.3** 6S audit tool

<b>1S – SORT – ACTIVITY DESCRIPTIONS</b>		YES	NO
1	Only the required stock and packaging are present in the work area		
2	Only the required tools and equipment are present in the work area		
3	Only the required paperwork is present in the work area (signage)		
4	Unnecessary items have been removed from the general area		
<b>2S – STRAIGHTEN – ACTIVITY DESCRIPTIONS</b>			
5	Locations for all stock are clearly defined and labelled		
6	Equipment and tools are properly labelled and have a clearly defined storage location		
7	Paperwork/scanners/voice equipment is properly labelled and has a clearly defined location		
8	Walkways, access to equipment and work area boundaries are clearly defined and marked		
<b>3S – SHINE – ACTIVITY DESCRIPTIONS</b>			
9	Storage containers, shelving/racking and storage areas are clean and damage free		
10	Tools and equipment are clean, fully maintained and damage free		
11	Work surfaces are clean and damage free		
12	Walls and partitions are clean, uncluttered and damage free – no excessive signage		
13	Cleaning equipment available and neatly stored		

(continued)



**Table 1.3** (Continued)

<b>4S – STANDARDIZE – ACTIVITY DESCRIPTIONS</b>			
14	Displayed KPIs are correct, relevant for the department and up to date		
15	Tools, equipment, paperwork stored neatly and returned immediately after use		
16	Maintenance records for tools and material handling equipment are easily accessible and up to date		
17	Waste products (waste oil, rubbish) consistently cleaned up and removed from the work areas		
<b>5S – SUSTAIN – ACTIVITY DESCRIPTIONS</b>			
18	Is the 6S audit visible to all, up to date and shared with all staff?		
19	Recognition is given to teams who get involved in 6S activities		
20	Time and resources are continually allocated to 6S activities		
21	Has the team improved items that were not already identified on the previous audit?		
<b>6S – SAFETY – ACTIVITY DESCRIPTIONS</b>			
22	Are employees wearing suitable PPE required for their current work?		
23	Walkways and access to safety equipment are clearly identified and unobstructed (no hazards or obstacles in the way of fire extinguishers, emergency access doors)		
24	Is the working environment suitable for the work in hand (lighting, air quality, temperature)?		
25	Are the equipment and tools provided correctly for the current work activity?		

## ***Further information***

There is an abundance of literature on this topic and websites specifically for Six Sigma and Lean: [www.isixsigma.com](http://www.isixsigma.com) (archived at <https://perma.cc/EA5P-JGTX>)

## ***Further reading***

<https://www.adaptivebms.com/tools> (archived at <https://perma.cc/5PGA-SY7P>)

Toyota TPS system. <https://toyota-forklifts.co.uk/about-toyota/toyota-production-system> (archived at <https://perma.cc/59K3-38PQ/>)

## **1.2i Gemba Walk**

### ***Introduction***

A Gemba Walk is performed by management and is a tool that allows managers to witness first hand what is happening on the warehouse floor. It underpins initiatives such as Lean and TPM. It eliminates second-hand information; you are on the warehouse floor.

It is simply the C in the Plan Do Check Act (Tool 1.29) problem-solving model for sustainable improvement. It allows managers to go to the place of work, look at the processes and talk with the staff. It provides the opportunity to talk with the process owners and see the work done daily, understand the challenges faced, in order to improve efficiency through effective resolution of the problems and guide corrective actions.

In effect it gives management a close-up view of the operation.

It is important to note that the walk is not there to check up on people, more to have a presence and ask questions to understand what they need to do their job; ask guiding questions and let them identify their own problems. Use questions such as What, Why, What if and Why Not – pretty much in this order.

The key to a successful Gemba Walk is always to focus on process. When you get the process right, the results take care of themselves.

Performed correctly, the Gemba Walk is a much more powerful management approach than sitting at a desk looking at data. It requires some effort to get these walks right, but when you do it helps improve your organization.

Observations during Gemba Walk:

- Is the facility clean?
- Are employees engaged?
- Is the health and safety code followed?

- Are metrics updated?
- Is the operations status up to date e.g. picks per hour?
- Are documents updated?
- Are aisles clearly marked?
- Have MHE checklists and inspection sheets been completed?
- Are priority issues recorded and understood?
- Are the process flows clear?

Typical questions to ask:

#### Process

What is your priority for the day?

What is your biggest quality issue currently?

What is your quick Kaizen/CI (Continuous Improvement) for your area?

What are the things you feel are improving?

What would you change if you were given the opportunity?

How do you know if you are having a good or bad day?

What can I do to help you?

#### Safety

What's the number one hazard in your job?

What can we do to improve safety?

How do you report safety concerns?

Do you have a 'near miss' recording facility?

What recent safety improvements worked well?

Are our safety procedures easy to follow?

How are employees recognized for their safety contributions?

What else can we do to improve manual handling?

## 1.3 Pareto analysis, 80/20 rule, ABC analysis or the vital few analysis

### *Introduction*

Vilfredo Pareto was an Italian economist who calculated that 80 per cent of the land in Italy was owned by 20 per cent of the population and that 20 per cent of his pea plants produced 80 per cent of the crop. This idea was taken further by Joseph Juran, a US consultant in the 1940s, who demonstrated that 80 per cent of product defects were caused by 20 per cent of the problems in production methods. It is now used by companies to identify and separate best-selling products and profitable customers from slow-moving products and less-profitable customers.

The tool is used heavily within the warehouse environment. Examples are as follows:

- 20 per cent of the stock lines account for 80 per cent of sales;
- 20 per cent of the stock lines produce 80 per cent of the profit;
- 20 per cent of stock lines appear most frequently on orders;
- 20 per cent of the stock keeping units (SKU) account for 80 per cent of the stock value;
- 20 per cent of suppliers provide 80 per cent of the stock lines;
- 20 per cent of customers produce 80 per cent of turnover;
- 20 per cent of customers cause 80 per cent of the problems;
- 20 per cent of customers produce 80 per cent of the profit;
- 20 per cent of the staff produce 80 per cent of the output;
- 20 per cent of staff cause 80 per cent of problems.

These are all common rules of thumb used in business today. They may not be exact for every company, but most companies can relate to at least some of them. It is the 20 per cent figure (or the vital few) that we need to concentrate our efforts on; that is, our top 20 per cent of customers, suppliers, product lines and staff.

### *When to use*

One of the most time-consuming operations within a warehouse is the picking of orders. It can take up to 55 per cent of overall labour activity within

the warehouse and, of that, half can be accounted for by travel to, between and from the pick locations. Thus, to reduce travel in the warehouse we need to place our most popular items in terms of order frequency (not sales volume) as close to the dispatch area as possible. To do this, we need to analyse our data.

## ***How to use***

If we take a company's order profile, we can use Excel as a tool to list all of the products by sales frequency and use the 'Data Sort' function to list them from highest to lowest, as can be seen in Table 1.4. Once this analysis has been undertaken, you can revise the warehouse layout by having the top 20 per cent of popular stock lines (SKU), i.e. those that appear most often on orders, at the front of the warehouse closest to dispatch. Many companies use the total unit sales; however, this can provide a false picture in terms of warehouse layout as some items may sell in large quantities but only once a year, whereas others sell less but on a continuous basis.

As shown in Table 1.4, the first four items have by far the most appearances on orders during the period. These are classified as fast movers, the next six as medium movers, and the following eight as class 'C' or slow movers. They are also referred to as runners, repeaters and strangers. As a rule of thumb, 80 per cent of order frequency appearance tends to come from 20 per cent of the product lines (A items), 15 per cent from 35 per cent of the product lines (B items) and 5 per cent from 45 per cent of the product lines. The last two items have not sold at all during the period, and need to be assessed by sales, marketing, procurement and finance to determine whether they are likely to be sold in the future (note they could be new items), need to be put on special offer, returned to the suppliers or written off. In this example we have denoted them with an 'X' for further analysis.

This tool can also be used for perpetual inventory or cycle counting (see tool 3.5) and with activity-based costing (see tool 7.1) to determine which customers should be retained in terms of profitability and also how much sales time should be allocated to each customer. It is usually the case that the smaller customers demand more management time!

Provided that you have accurate information for each of these parameters, the 80/20 analysis can be a valuable tool in any company's armoury.

**Table 1.4** ABC analysis of pick list frequency

Product code	Ranking (by order frequency)	Frequency in period	Cumulative frequency	Cumulative % of total frequency	Cumulative % of number of stock lines	Category
123	1	300	300	30	5	A
235	2	225	525	52.5	10	A
127	3	150	675	67.5	15	A
134	4	125	800	80	20	A
167	5	40	840	84	25	B
222	6	30	870	87	30	B
361	7	25	895	89.5	35	B
363	8	25	920	92	40	B
221	9	17	937	93.7	45	B
344	10	15	952	95.2	50	B
345	11	10	962	96.2	55	C

(continued)

**Table 1.4** (Continued)

Product code	Ranking (by order frequency)	Frequency in period	Cumulative frequency	Cumulative % of total frequency	Cumulative % of number of stock lines	Category
166	12	8	970	97	60	C
177	13	6	976	97.6	65	C
189	14	6	982	98.2	70	C
190	15	6	988	98.8	75	C
111	16	4	992	99.2	80	C
1035	17	4	996	99.6	85	C
1037	18	4	1,000	100	90	C
126	19	0	1,000	100	95	X
135	20	0	1,000	100	100	X
Total		1,000				

CEPIEC

## Further information

There is a significant amount of information on the web for ABC analyses in logistics. The co-author's own book on warehouse management (Richards, 2021) has a section on the subject.

An Excel template can be downloaded from <http://howtologistics.com> (archived at <http://perma.cc/B94P-EKEP>); discount code: **lsct2024**.

## Reference

Richards, G (2021) *Warehouse Management*, 4th edn, Kogan Page, London

# 1.4 Choosing an order-picking strategy

## Introduction

Many warehouses continue to pick orders individually; however, in today's e-commerce environment, there is a requirement to speed up the picking process. We also find that there is confusion between the different pick strategies in terms of how they are described. Below is our interpretation.

### Pick by individual order

Line items are collected from all locations by an individual for a specific customer order. Once picked, the operator returns for the next order:

- Instructions can be via paper-based systems, scanners, voice or vision technology.
- It is normally a single-stage process unless every order is checked on dispatch.
- Handling equipment can range from a trolley to a forklift truck.
- It can be prone to error if using a paper-based system.
- It can be time-consuming.
- Training can be time-consuming for scanning and paper pick.

### Cluster picking

Operators take several individual orders out into the warehouse at the same time:

- Operation is as per individual order pick, although multiple orders are picked at the same time.



- Order sizes are lower than for individual order picks.
- Orders are clustered in a particular area.
- Normally a single-stage process unless every order is packed and checked on dispatch.
- Handling equipment can range from a trolley to a forklift truck but requires segregated sections in order to separate the orders.
- Reliant on operator being accurate in sorting.
- System assistance required to ensure orders are clustered efficiently and items are placed in the correct location. A put to light system or a vision-based system is ideal.
- Training can be very time-consuming.

### Pick by batch

Large quantities of items are collected for a large number of orders that have the same product lines. All orders are consolidated onto one pick request:

- Typical use in e-commerce applications.
- One to five lines per order maximum.
- Can pick exact amount from reserve storage and allocate to zero (pick to zero) or pick full cartons/pallets and return remainder to stock (pick by line) once allocation is completed.
- Handling equipment is mainly reach or forklift trucks for pallet quantities.
- Two/three-stage process – pick then sort and label. Possible return of unused stock.
- Requires additional space to sort and label.
- The use of a put wall with a put to light system is ideal for sortation.
- Reliant on system to consolidate orders.

### Pick by zone

Products are categorized into specific groups and located in defined areas within the warehouse:

- Reduces walking distance as operator looks after a small area.
- Picking can be simultaneous or sequential.
- Simultaneous orders require consolidation.
- Requires conveyors or automated mobile robots, sometimes referred to as cobots, to transport orders around the warehouse.

- Essential to ensure each zone has near-equal activity.
- Used with pick and put to light systems.
- High accuracy if combined with scanning or vision systems.
- Items are not individually identified unless using a more sophisticated system.
- Reliant on accurate put-away operation.

### Pick by waves

Large numbers of orders are picked during defined time periods:

- Any of the above pick methods can be used.
- Pick is associated with vehicle departures, shift changes, order deadlines, etc.

### Goods to picker

Large number of orders can be picked at the same time:

- Initial orders are batched together.
- Picker remains in one position.
- Products are brought to the picker by conveyor, robot or automated system.
- Operator uses put to light system, or a vision system, to allocate items to individual orders.
- Little training required.

### ***When to use***

When looking to improve both productivity and accuracy within the warehouse.

### ***How to use***

Table 1.5 compares the methods discussed above.

**Table 1.5** Order-picking strategies comparison chart

Pick method	Typical applications	Benefits	Disadvantages
Pick by individual order	Most operations	<ul style="list-style-type: none"><li>• Single-stage operation</li><li>• Flexible</li><li>• Quick implementation</li><li>• Ability to isolate urgent orders</li><li>• Picker able to decide pick path if using paper pick system</li><li>• Utilize manual or technology systems</li></ul>	<ul style="list-style-type: none"><li>• Low pick rate</li><li>• Very labour intensive</li><li>• Can result in bottlenecks at the pick face</li><li>• Training can take some time depending on the tools used</li></ul>
Cluster picking	Most operations with low cube items	<ul style="list-style-type: none"><li>• Multiple orders picked at the same time</li><li>• Reduce travel in the warehouse if orders clustered in a particular area</li><li>• Reduce overall pick time</li></ul>	<ul style="list-style-type: none"><li>• Training can take some time</li><li>• Accuracy can be an issue if no technology is used</li><li>• Urgent orders cannot be separated easily</li><li>• Requires equipment to hold multiple orders</li><li>• Requires low cube items in the main</li><li>• Requires system assistance to combine orders</li><li>• Can result in bottlenecks</li><li>• Needs sufficient orders to enable clustering</li><li>• May require second stage to pack orders</li></ul>

(continued)

**Table 1.5** (Continued)

Pick method	Typical applications	Benefits	Disadvantages
Batch pick to zero	e-commerce, retail store orders, TV shopping channels	<ul style="list-style-type: none"> <li>Multiple orders picked at the same time</li> <li>Very effective for e-commerce orders where 100s of orders for single line items are received</li> <li>Reduced travel</li> <li>Increased accuracy</li> <li>Can be used successfully in a cross-dock operation</li> </ul>	<ul style="list-style-type: none"> <li>Urgent orders cannot be separated easily</li> <li>Requires system assistance to combine orders</li> <li>Pick to zero initial pick likely to take longer than pick to line</li> <li>Requires sortation area and additional staff</li> <li>Repacking may be required</li> </ul>
Batch pick by line	e-commerce, retail store orders, TV shopping channels	<ul style="list-style-type: none"> <li>Multiple orders picked at the same time</li> <li>Increased accuracy</li> <li>Very effective for e-commerce and TV shopping orders with 100s of orders for single line items</li> <li>Reduced travel</li> </ul>	<ul style="list-style-type: none"> <li>Urgent orders cannot be separated easily</li> <li>With pick to line, excess products need to be returned to location</li> <li>Requires sortation area and additional staff</li> <li>Repacking may be required</li> </ul>
Zone pick	Situations where there are large numbers of SKUs and low number of items per order line. Also, where different families of products are located in different parts of the warehouse	<ul style="list-style-type: none"> <li>Less travel for operator</li> <li>Orders can be picked simultaneously or sequentially</li> <li>Can accommodate different families of items on orders such as hazardous, temperature controlled, ambient etc</li> <li>Less training if pick to light and put to light used</li> </ul>	<ul style="list-style-type: none"> <li>Normally requires conveyors or mobile robots</li> <li>Cost of equipment</li> <li>Normally combined with pick/put to light systems, which can be expensive</li> <li>Can lead to idle time if work is not balanced between zones</li> </ul>

(continued)

**Table 1.5** (Continued)

Pick method	Typical applications	Benefits	Disadvantages
Wave pick	When orders are released on a timed basis or to meet departing trucks	<ul style="list-style-type: none"> <li>• Ability to schedule work efficiently</li> <li>• Orders are picked in time for a production run or vehicle departure</li> </ul>	<ul style="list-style-type: none"> <li>• Urgent orders cannot be separated easily</li> <li>• Requires a WMS to manage the allocation</li> </ul>
Goods to picker	High-intensity pick operations	<ul style="list-style-type: none"> <li>• High pick rates</li> <li>• High accuracy</li> <li>• Equipment moves, operators stay in the same place</li> <li>• Reduced space requirement</li> <li>• Product security</li> <li>• Ergonomic workstations</li> <li>• Training is less intensive</li> </ul>	<ul style="list-style-type: none"> <li>• High equipment costs, although can be leased or rented</li> <li>• High energy costs if not self-charging</li> <li>• Potential system failure</li> <li>• High opportunity cost</li> <li>• Standardized unit loads required</li> <li>• Limited to smaller items in the main</li> <li>• Boredom for staff</li> </ul>

## Further information

There are a number of books and websites on the subject of picking:

Ackerman, K (2000) *Warehousing Profitably*, Ackerman Publications, Columbus, OH

Frazelle, E H (2016) *World Class Warehousing and Materials Handling*, McGraw-Hill, New York

Richards, G (2021) *Warehouse Management*, 4th edn, Kogan Page, London

Van den Berg, J P (2012) *Highly Competitive Warehouse Management*, Management Outlook Publishing, Utrecht, Netherlands

## 1.5 Choosing pick technology

### *Introduction*

The picking function in a warehouse can be up to 55 per cent of the operating cost, with travel to, between and from locations being up to 50 per cent of that labour involvement. It is therefore crucial to choose the most appropriate method of picking.

Many warehouses continue to use system-created paper pick lists to pick orders within the warehouse. There are a number of alternatives, the majority requiring some form of technology. Table 1.6 shows the advantages and disadvantages of each method. One thing to point out here is that many warehouses will use a combination of pick methods, depending on requirements such as velocity of movement, lead times, product identification, product size and accuracy requirements.

### *When to use*

When looking to improve both productivity and accuracy within the warehouse.

### *How to use*

Table 1.6 compares the different picking systems. A new picking method called 'vision pick' utilizing technology similar to Google glasses has been introduced by a number of companies recently.

### *Further information*

There is some excellent content at [https://www.inventoryops.com/order\\_picking.htm](https://www.inventoryops.com/order_picking.htm) (archived at <https://perma.cc/8X4J-ZCQ8>)

## 1.6 Cross-docking

### *Introduction*

Cross-docking is a technique utilized in distribution centres and warehouses to speed up the throughput of products. It eliminates the need to store

**Table 1.6** Pick technology comparison chart

	<b>Applications and pick rate</b>	<b>Benefits</b>	<b>Drawbacks</b>
Paper picking	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• Where there is very little systems support</li> <li>• Low cost areas</li> <li>• &lt;100 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Single-stage picking operation although two-stage update operation (key information into system)</li> <li>• Flexible</li> <li>• Quick implementation</li> <li>• Ability to isolate urgent orders</li> <li>• Picker able to decide pick path</li> <li>• Low maintenance</li> <li>• Suitable as part of a contingency plan</li> </ul>	<ul style="list-style-type: none"> <li>• Low pick rate</li> <li>• Not hands free</li> <li>• Low accuracy</li> <li>• Duplicated tasks</li> <li>• Not real time</li> <li>• Training can take some time</li> <li>• Requires manual update of system from written instructions</li> <li>• Requires return to desk for further instructions</li> </ul>
Pick by label	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• Where there is very little systems support</li> <li>• Low cost areas</li> <li>• &lt;100 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Reasonably accurate</li> <li>• Single-stage picking operation although two-stage update operation</li> <li>• Flexible</li> <li>• Quick implementation</li> <li>• Low maintenance</li> <li>• Ability to label product with dispatch details</li> </ul>	<ul style="list-style-type: none"> <li>• Low pick rate</li> <li>• Not hands free</li> <li>• Duplicated tasks</li> <li>• Need to print labels</li> <li>• Not real time</li> <li>• Training can take some time</li> <li>• Label information may be difficult to read</li> <li>• Can damage product if errors made</li> <li>• Requires return to desk for further instructions</li> </ul>

*(continued)*

**Table 1.6** (Continued)

	Applications and pick rate	Benefits	Drawbacks
Barcode scanning with gun	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• &lt;100 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Improved accuracy*</li> <li>• Paperless</li> <li>• Flexible</li> <li>• Real-time stock update**</li> <li>• Ability to deal with multi-SKU locations</li> </ul>	<ul style="list-style-type: none"> <li>• Low/medium pick rate</li> <li>• Not hands free</li> <li>• Can take longer than paper picking operationally</li> <li>• Cost of hardware</li> <li>• Requires barcode on every product</li> <li>• Issues with international bar code standards</li> <li>• Requires system interface</li> <li>• Requires maintenance</li> <li>• Real-time system requires wireless receivers throughout warehouse</li> </ul>
Wearable scanners	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• &lt;150 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Paperless</li> <li>• Flexible</li> <li>• Improved accuracy</li> <li>• Improved productivity compared to hand-held devices</li> <li>• Hands free</li> <li>• Less strain on operators</li> <li>• Damage reduction</li> <li>• Real-time stock update</li> <li>• Ability to deal with multi-SKU locations</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware</li> <li>• Requires bar code on product</li> <li>• Issues with international bar code standards</li> <li>• Requires system interface</li> <li>• Requires maintenance</li> </ul>

(continued)



**Table 1.6** (Continued)

	<b>Applications and pick rate</b>	<b>Benefits</b>	<b>Drawbacks</b>
Voice picking	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• Ideal for temperature-controlled areas, also heavy, awkward items</li> <li>• 100–250 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Paperless</li> <li>• Flexible</li> <li>• Fewer processes</li> <li>• Improved accuracy*</li> <li>• Improved productivity</li> <li>• Quick training</li> <li>• Hands free/eyes free</li> <li>• Improved safety</li> <li>• Less strain on operators</li> <li>• Damage reduction</li> <li>• Real-time stock update</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware</li> <li>• Difficult in very noisy environments</li> <li>• Requires system interface</li> <li>• Requires maintenance</li> <li>• Problem with multi-SKU location</li> <li>• Serial number capture is an issue – takes time – unless coupled with scanner</li> <li>• Accuracy issue if product in incorrect location</li> <li>• Unsure of long-term health issues</li> </ul>
Voice picking plus finger scanning	<ul style="list-style-type: none"> <li>• Most operations</li> <li>• Ideal for temperature-controlled areas</li> <li>• 125–250 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Paperless</li> <li>• High accuracy</li> <li>• Good productivity</li> <li>• Hands free</li> <li>• Less strain on operators</li> <li>• Damage reduction</li> <li>• Real-time stock update</li> <li>• Ability to deal with multi-SKU location</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware and software</li> <li>• Requires bar code</li> <li>• Requires system interface</li> <li>• Issues with international bar code standards</li> <li>• Unsure of long-term health issues</li> </ul>

(continued)

**Table 1.6** (Continued)

	<b>Applications and pick rate</b>	<b>Benefits</b>	<b>Drawbacks</b>
Pick to light	<ul style="list-style-type: none"> <li>• High no SKUs high frequency sales per individual item</li> <li>• Mail order/e-commerce, engineering stores</li> <li>• Approx 250–450 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• High accuracy*</li> <li>• High productivity</li> <li>• High pick rate</li> <li>• Easy to train staff</li> <li>• Staff can choose pick sequence</li> <li>• Real-time stock update</li> <li>• Hands free</li> <li>• Improved safety</li> <li>• Damage reduction</li> <li>• Simultaneous or sequential picking</li> <li>• Can be used for goods-to-person and person-to-goods picking (zone)</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware</li> <li>• Requires system interface</li> <li>• System failure</li> <li>• Cost of maintenance</li> <li>• Low flexibility</li> <li>• Long implementation time</li> <li>• Limited in terms of product types</li> <li>• Problem with multi-SKU locations</li> <li>• Difficulty with batched or clustered orders</li> </ul>
Put to light	<ul style="list-style-type: none"> <li>• Retail store operations</li> <li>• Goods-to-person operations</li> <li>• Sortation</li> </ul>	<ul style="list-style-type: none"> <li>• High accuracy</li> <li>• High productivity</li> <li>• Damage reduction</li> <li>• High pick rate</li> <li>• Easy to train</li> <li>• Real-time stock update</li> <li>• Can be used for goods-to-person picking</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware</li> <li>• System failure</li> <li>• Limited in terms of product types</li> <li>• Cost of maintenance</li> <li>• Can be a two-stage operation</li> </ul>

(continued)

**Table 1.6** (Continued)

	<b>Applications and pick rate</b>	<b>Benefits</b>	<b>Drawbacks</b>
RFID	<ul style="list-style-type: none"> <li>• High-value goods</li> <li>• Items requiring accurate traceability</li> <li>• 200–300 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Very high accuracy</li> <li>• High productivity</li> <li>• Real-time stock update</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of hardware</li> <li>• Cost of tags</li> <li>• Requires readers</li> <li>• Read distances very short</li> <li>• Requires international standards</li> <li>• Issues with certain types of products – metal and liquids</li> <li>• Requires system interface</li> <li>• Cost of maintenance</li> </ul>
Vision pick	<ul style="list-style-type: none"> <li>• Various goods</li> <li>• 230–350 lines per hour</li> </ul>	<ul style="list-style-type: none"> <li>• Hands free</li> <li>• Real-time verification</li> <li>• High accuracy</li> <li>• Capture serial numbers</li> <li>• Reasonable training time</li> </ul>	<ul style="list-style-type: none"> <li>• New technology</li> <li>• Some reports of neck ache/headache</li> <li>• Cost of hardware and software</li> <li>• Requires system interface</li> <li>• Issues with international bar code standards</li> </ul>

\* High accuracy is dependent on accurate put-away. Can be supplemented by reading out last four digits of barcode for voice picking.

\*\* Scanning can be real time or information can be downloaded once the tasks are completed.

product by consolidating items during the inbound process and taking them directly to the shipping or dispatch area.

Items are likely to remain on site for a maximum of 48 hours, with most leaving in a much shorter time. These can be dispatched separately or can be consolidated with product picked from stock. The costs of holding and handling inventory are significantly reduced. Walmart puts some of its success down to cross-docking as much as 85 per cent of its products through working closely with its suppliers and having sophisticated IT systems.

## ***When to use***

The pressure on companies to reduce order lead times requires products to move through the supply chain much faster. Cross-docking enables this to happen.

A variant of this is a sequencing centre where parts destined for a production line are consolidated and sorted so that they arrive at the production line only when they are required.

## ***How to use***

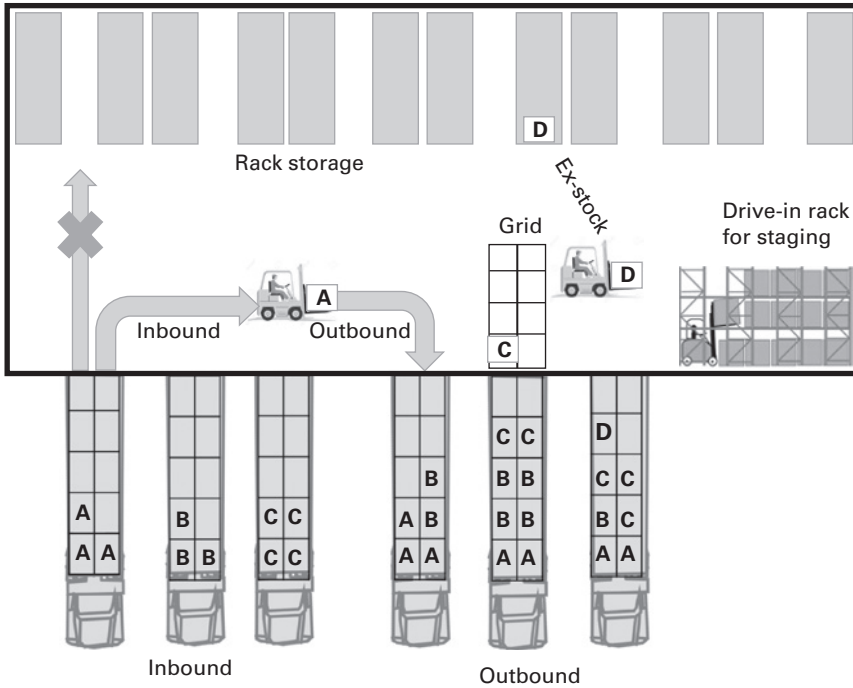
To operate an efficient cross-dock requires a good information technology system. Advanced shipping notifications (ASNs) are essential and goods need to be identified easily at the inbound stage to enable staff to move them directly to the dispatch or shipping area as opposed to the storage area. To enable this, barcodes or radio frequency identification (RFID) tags have to be aligned across suppliers and customers.

Suppliers can be requested to label the items with information that enables the goods-in team to identify the items quickly. Alternatively, the inbound team are alerted to the fact that a transfer of goods is required by an instruction on the paperwork, a voice message or a message on the barcode scanner. If the company is using scan technology, a message appears on screen as soon as the goods for cross-docking have been identified. Instructions as to where to move the product should also be given at this time.

Ideally a vehicle is already waiting on the loading dock for the items in question. This requires excellent coordination and planning. Alternatively, the pallets or cartons are placed in a section of the dispatch area that is marked out for outbound loads. If space is at a premium in the dispatch area, drive-in racking can be used to hold the products until the outbound vehicle arrives (see Figure 1.3).

The coordination of inbound and outbound movements is key to the system working effectively. An example of this is the hub operation for a parcel or pallet distribution operation where items arrive in time to meet a departing vehicle returning to its geographic area. A vehicle cannot depart until the last vehicle carrying goods destined for its area has arrived.

Finally, warehouse design plays its part in terms of where the inbound and outbound doors are located. If they are situated next to each other as in Figure 1.3, there is a need to ensure that congestion is not an issue.

**Figure 1.3** Example of cross-dock operation

Alternatively, doors can be situated at opposite sides of the building, with forklift trucks travelling the length of the building to load out the vehicles – less congestion but increased travel distances.

## 1.7 Slotting or item profiling

### *Introduction*

Inventory slotting or profiling is the process of identifying the most efficient placement for each stock item in a warehouse or distribution centre, taking into account item popularity, characteristics and safety aspects. Strategically placing the item in the optimum location allows workers to pick items efficiently, quickly and accurately, and reduces the risk of injuries.

## ***When to use***

To enable you to improve the efficiency of your picking operation within the warehouse.

## ***How to use***

Slotting can be done manually using standard spreadsheets, database programs or specifically designed slotting software. Slotting is a recent addition to many warehouse management systems (WMS).

There are several ways to increase picking productivity with slotting. Placing fast-moving items close to the dispatch area, conveyors and aisle ends minimizes picker travel time. Using easier-to-pick locations for high-activity items, such as the middle levels of shelving and carton flow racks, also facilitates quicker and more ergonomic picking.

Items that are often sold together should be stored together to reduce travel. This can also help distinguish between similar parts. For example, placing the same size nut and bolt together not only reduces travel but also separates one bolt size from another. Other potential pairings include dry pasta and pasta sauces. This is sometimes called product affinity.

From a safety point of view, frequently picked and moderate-weight items should be placed at a height between an average person's waist and shoulders to minimize the chance of injury to pickers and replenishment staff. In warehouses where there is a mix of heavy and fragile items, the heaviest items should be placed at the beginning of the pick path so that they are loaded at the bottom of a pallet, carton or tote.

Where items appear frequently on orders, these should not only be put close to dispatch but also into multiple locations in this area of the warehouse in order to balance the workload and avoid bottlenecks.

Note that if using zone picking, the most frequently ordered items should not be held in the same zone. They should be separated across all the zones to ensure that activity is equal across all zones.

Items can also be grouped within the warehouse based on vendor or product similarities. Vendor groupings can simplify merchandise put-away. Family groups can also be established to cluster items that are often sold together or items with specific storage or handling requirements. Retailers may use family groups to organize the warehouse logically so that the pick mirrors the layout in the stores.

Careful slotting can also ensure that items are placed in properly sized locations. The full cubic capacity of the location should be used, allowing for clearance height requirements. The location should hold a sufficient quantity of inventory to meet the restocking goals for the warehouse, for example a full shift's pick.

## How to start

The first step in any inventory slotting project is gathering the necessary information about the items, locations in the warehouse and product sales. Data may already be stored in the WMS or ERP (enterprise resource planning) system. Otherwise, items and cases need to be physically measured. The following information is typically needed for each SKU:

- item length, width, height and weight;
- case quantity and dimensions (length, width, height and weight) for items stored by the case;
- pallet quantity (or cases per tier and tiers per pallet – TiHi) for items stored by the pallet;
- vendor, if items are to be stored in vendor groupings;
- family group if items are to be stored by product groupings;
- special storage conditions, if applicable (flammable, refrigeration, high value, etc);
- maximum stacking height or crushability factor, if applicable;
- items that often appear together on an order;
- items that are very similar resulting in mis-picks or that can cause a chemical reaction should not be stored next to each other.

Each pick location in the warehouse needs to be defined. Information typically required for each slot is:

- location number;
- usable size (length, width, height);
- weight capacity;
- proximity to material handling equipment (MHE) and shipping;
- position within the pick path;
- types of items eligible to be stored here (hazard code, vendor or family group, batch code or lot number).

Item movement can be captured in terms of the number of times each item was sold (hits), the quantity sold, sales forecast (stocking level) and the on-hand quantity. Hits and quantity sold are most typically used because high-hit items should be placed in the most efficient locations and the optimal size location can be established using the quantity sold and the dimensions. Having two adjacent pallet locations (bays) is not an issue with fast-moving goods – this reduces the number of times the locations are replenished and can avoid replenishing during a pick cycle.

If items change frequently and do not have any historical movement figures, sales forecasts may be used instead of history. On-hand quantity data are important for warehouses that choose to size locations in slow pick areas to a typical on-hand inventory level, rather than a sales level.

## Slotting rules

Once the necessary data have been collected, slotting rules must be established by setting up constraints (rules that cannot be broken) and objectives (goals). Constraints include weight limits, hazardous material areas and vendor/family group areas. Objectives define factors such as the desired stock level, where faster-moving items are placed and how activity will be balanced. Examples of some typical rules include:

- Put the fast-moving items close to the shipping dock and on the lower pallet rack levels. Store slower-moving items on higher levels and further away from the dock.
- In the case pick area, locate taller cases and heavier cases at the beginning of the pick path. Put faster-moving cases on floor/lower levels.
- If using carousels, balance the activity among carousels in pods. Spread faster-moving items among the carousels and put them on the centre shelves.
- Place fast-moving items into carton flow racks, with the very fastest on the centre levels. Balance the workload among the flow rack units.
- Put slower-moving items into shelving.
- Put the faster-moving items closer to the take-away conveyor or end of aisle.
- Locate heavier items on the centre levels of shelving.

Proper slotting takes time to establish, and regular maintenance is required to keep items positioned efficiently; however, slotting software can ease the



burden of keeping items in proper locations. Slotting items properly increases picking productivity and makes order selection easier, safer and more accurate.

Trial re-slotting runs should be made to test the rules and refine them so that they will yield the desired results. You can opt to make the profile changes gradually during normal operations, rather than interrupting fulfilment activities to move hundreds of items. You can review item placement on a weekly basis and move items each night to relocate the most badly placed SKUs. Although it will take several months to achieve the optimal profile, picking productivity will increase with each set of moves.

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### ***Further information***

Details on specific slotting software can be found at <http://www.slot3d.com>, (archived at <https://perma.cc/6DCF-ZCHL>) <http://www.insight-holdings.com/dc-expert-45> (archived at <https://perma.cc/C82D-4FW5>)

<https://www.fortna.com/solutions/slotting/> (archived at <https://perma.cc/QSU4-9UAE>)

## **1.8 Resource planning**

### ***Introduction***

Labour is a significant cost within a warehouse operation. Warehouse managers are constantly required to optimize the number of staff employed and reduce overall headcount by increasing productivity. Planning work is therefore crucial to the running of a cost-effective warehouse.

Labour management enables warehouse managers to compare productivities between staff and engineered standards, and as a result identify opportunities for further training or possible redeployment. The system can also be used to introduce incentive schemes and be part of an appraisal system.

There are a number of labour management systems (LMSs) available on the market, some of which are listed at the end of this tool. Some WMSs also have a labour management module. However, it is possible to plan the resources required within a warehouse manually through the use of spreadsheets.

## ***When to use***

It is our contention that all warehouses should operate with some form of resource plan to ensure that the correct number of staff are deployed each day and therefore it should be part of daily operations. Resource planning enables the warehouse manager to reasonably calculate the number of staff required each day for each section of the warehouse and, when busy, to calculate how many additional staff may be required.

## ***How to use***

Table 1.7 details a number of warehouse tasks together with the volume of activity, productivity standards and the expected time to undertake these tasks. Forms such as this can be completed each day based on the activities planned for the coming days and weeks. It requires advanced information in terms of receipts and orders, whether forecast or actual. It also requires staff to undertake time-and-motion studies to calculate the time required to undertake each activity.

The data can be updated with actual figures once the task has been completed: this provides a more accurate picture for future similar work. Table 1.7 details an in-handling operation over the course of one day. Each activity is listed together with the expected volume and this, together with the engineered standards previously estimated, enables the warehouse manager to calculate the number of staff required and the equipment needed. By completing this form, the warehouse manager is able to calculate the number of people and equipment required for that particular day's operation.

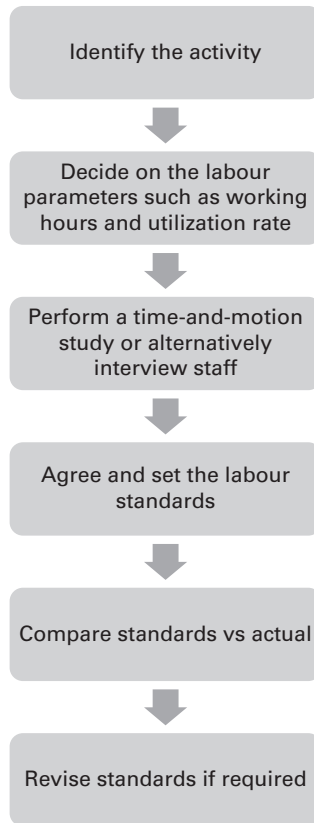
Utilizing an electronic LMS enables you to evaluate the productivity of individuals as well as the team as a whole. It measures the performance of each individual for completed tasks against existing labour standards to determine how the time spent performing each task compares with the expected task completion time. The system, if interfacing with voice or radio frequency, can more accurately measure the task in hand, taking into account idle time, delays and bottlenecks. The system is able to assign the operator an overall score. This enables the warehouse manager to compare performance against engineered standards and the operator's peers. The system is a great deal more sophisticated than a spreadsheet and will produce the data much faster. A number of steps are required to set up the system (see Figure 1.4).

The more sophisticated LMSs can also create a list of tasks for an operator and coordinate tasks. As Obal (2011) says: 'When you start interleaving and measuring people, you are driving out a lot of inefficiencies. You're maximizing your labour that is already there in the warehouse.'

**Table 1.7** In-handling resource plan

Activity description	Daily volume (average)		Productivity standard (units per hour)	Hours required	MHE Type 1	MHE Type 2	MHE Type 3	Other equipment e.g. radio frequency scanner
	Activity (units)	Unit of measure						
<b>Unloading</b>								
Unload palletized trailer	260	Pallets	52	5	PPT			RFS
Unload loose loaded containers & palletize	5000	Cases	200	25				RFS
Stretch-wrap pallets	100	Pallets	40	2.5				
<b>Put-away</b>								
Collect pallets, put away in wide aisle racking	210	Pallets	20	10.5		FLT		RFS
Collect pallets, put away in drive-in racking	124	Pallets	16	7.75		FLT		RFS
Collect pallets, put away in pick locations	26	Pallets	5	5.2	PPT			RFS

<b>Sub-total</b>				55.95				
Ancillary work (collect paperwork, equipment etc (15%))				8.39				
<b>Total hours required</b>				64.34	10.20	18.25		
Available productive hours per person/truck per day				7.2	8	8		
Approx number of staff required				<b>8.94</b>				
Approx number of equipment required					<b>1.28</b>	<b>2.28</b>		

**Figure 1.4** Setting up a labour management system

Although many WMSs have LMS as an option or even inbuilt, there are a large number of stand-alone systems that can be interfaced with both warehouse and transport management systems. A list of suppliers of LMS can be found at the website below.

### ***Further information***

<http://www.capterra.com/workforce-management-software?gclid=CMaxj8DF57UCFXDKtAodqxsAYA> (archived at <https://perma.cc/6MXG-E43M>)  
Shortcut – <http://bit.ly/2Jn7vim> (archived at <https://perma.cc/228U-AQ9Q>)

### ***Reference***

Obal, P (2011) cited in 2011 *Market Trends Report: Warehouse Management Programs*

## 1.9 Task interleaving

### *Introduction*

Minimal movement within a warehouse is key to efficiency and productivity. There are a number of ways of reducing the amount of travel undertaken in a warehouse.

As we have seen in the ABC/Pareto tool (tool 1.3), the notion of placing the most popular items as close to the dispatch area as possible reduces the amount of travel in the warehouse. Another method of movement reduction is task interleaving or dual cycling. Task interleaving is controlled by a WMS that allocates tasks to ensure an operator travels fully loaded, both ways. For example, an operator unloading a trailer on inbound and taking the pallet to reserve storage will be tasked with collecting a pallet for replenishment or possibly dispatch depending on the amount of travel required between locations. This can reduce equipment use by up to 30 per cent. The system works well with full pallet movements both inbound and outbound.

### *When to use*

When looking to increase efficiency and reduce travel within the warehouse.

### *How to use*

The idea is to combine work for a forklift truck or powered pallet truck. According to Tompkins (2003), task interleaving is especially good for tasks with the following characteristics:

- The same materials handling equipment can be used to undertake both types of moves.
- The end location for one type of move is relatively close to the collection point for the other move. This means that the operator and truck are utilized both ways rather than two separate single trips, which often happens. This is similar to the back-loading concept used in freight transport.
- The moves are pretty much equal both ways. Ensuring that the tasks are well matched needs an accurate set-up in the WMS.

Although put-away and replenishment may seem a good match, it is likely that interleaving these tasks can cause increased travel and delays for both processes. For task interleaving to be successful, it needs the support of an information technology system. Most modern WMSs have this capability.

This also works better when the doors are on the same side of the building and can be used for both inbound and shipping activities. It can also work reasonably well with doors on adjacent sides. It needs operations to be more flexible and not have dedicated inbound and outbound teams. The operators need to be free to undertake both put-away and dispatch activities. As a result, staff need to be able to multitask and move between operations.

Task interleaving will not be successful if inbound activities are undertaken in the morning, dispatch in the afternoon and replenishment overnight, for example. Task interleaving works best at larger facilities where more tasks can be queued up and staff will have continuous work.

The key is to manage the task allocation and not to disrupt urgent operations. The tasks have to be controlled sufficiently well and planned to coincide with other tasks. Releasing tasks too early or too late can have a devastating effect on productivity and on equipment and manpower usage.

## **Reference**

Tompkins (2003) <https://www.tompkinsinc.com/en-us/Insight/Articles/task-interleaving/> (archived at <https://perma.cc/5SUU-93KT>)

## **1.10 Selecting warehouse storage equipment**

### ***Introduction***

The selection of warehouse storage equipment is best carried out in conjunction with the equipment manufacturers. They are the experts and have experience of different types of warehouse operations. Ensure that you get a number of opinions and, if necessary, use a consultant to sense-check the options.

In this guide we look specifically at storage media. There are a number of different options when it comes to choosing the method of storage. The choice of how to store product will very much depend on the product size, its speed of throughput, the number of pallets per line item and the stock rotation policy (see Table 1.8).

There are, of course, many variables that will impact on the price. The main one is pallet size and type; for example, with drive-in racking there are different design options and alternative support rails available. On double-deep racking it would normally be the use of adjustable pallet racking (APR), but some trucks require a low-level beam to accommodate reach

**Table 1.8** Choosing a warehouse racking system

	Use of floor space	Use of cubic space	Speed of throughput	Access to individual pallets	Special MHE required	Rotation of stock	Pallets stored at ground level in 4,636 sq metres (50k sq ft)	Cost per location <sup>†</sup>
Adjustable pallet racking	**	**	***	****	No	FIFO	1,250	100
Very narrow aisle (VNA)	***	***	**	****	Yes	FIFO	1700	100 <sup>‡</sup>
VNA with articulated forklift	***	***	***	****	Yes	FIFO	1600	100
Drive-in racking	*****	***	**	*	No	FILO	2,120	200
Double-deep racking	***	***	**	**	Yes	FILO	1,650	120
Push-back racking	***	***	**	**	No	FILO	1,950	500
Gravity-fed racking	****	***	****	*	No	FIFO	2,500	700
Mobile racking	****	***	*	****	No	FIFO	2,325	500
Satellite racking	*****	****	***	*	Yes	FILO	2,500	500

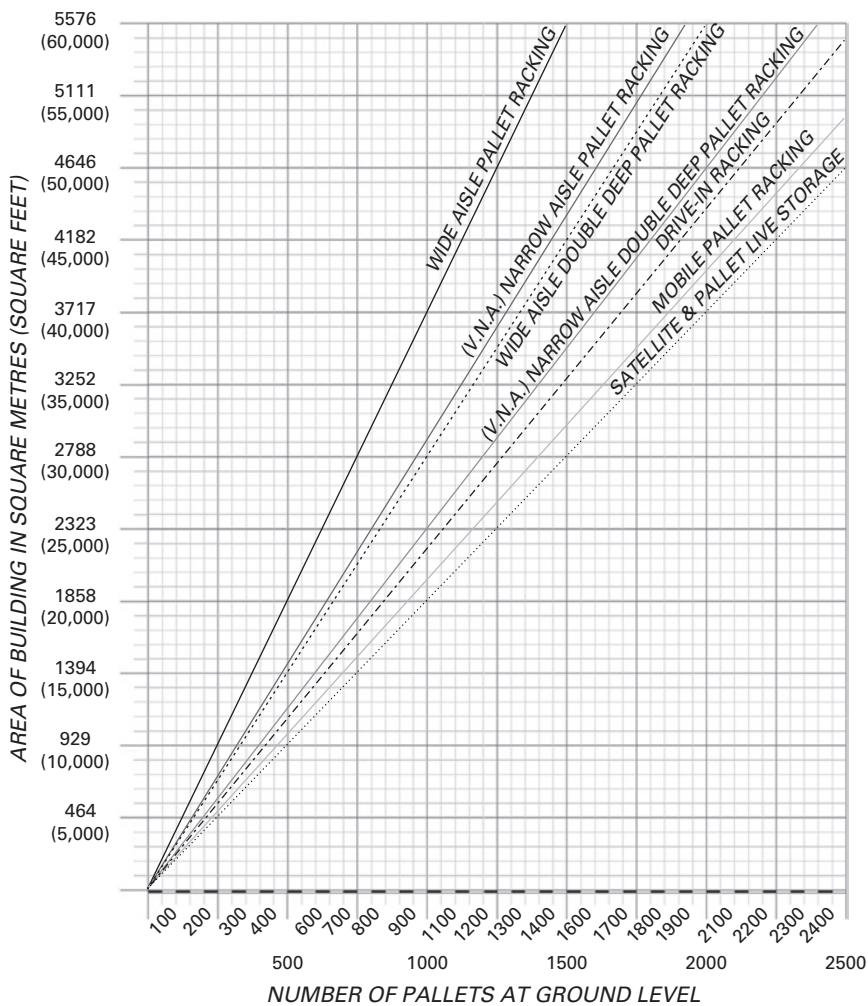
<sup>†</sup>The cost column assumes that standard adjustable pallet racking is given a base cost of 100.

<sup>‡</sup>This cost does not include any guidance wire or guidance rail that the VNA forklift may require to operate.

**SOURCE** information provided by Nene Ltd



Figure 1.5 Pallet rack capacity



SOURCE Reproduced by kind permission of Constructor Group

legs, which would increase the price, and very narrow aisle (VNA) operational costs will fluctuate depending on the guidance system used. In terms of special MHE required, we mean anything other than a counterbalance or reach truck.

Figure 1.5 provides an approximate figure in terms of how many pallets can be stored within a specific area utilizing the different types of racking.

## 1.11 Warehouse location numbering

### *Introduction*

When you enter the majority of warehouses you are faced with row upon row of storage racks. An interesting aspect from a consultancy viewpoint is how each row or aisle of racking is identified. This section suggests how to number rows of racking or shelving within a warehouse facility.

### *When to use*

If a company is looking to introduce greater efficiency into its picking operation and reduce travel time, it needs to consider carefully how it numbers its pick locations.

### *How to do it*

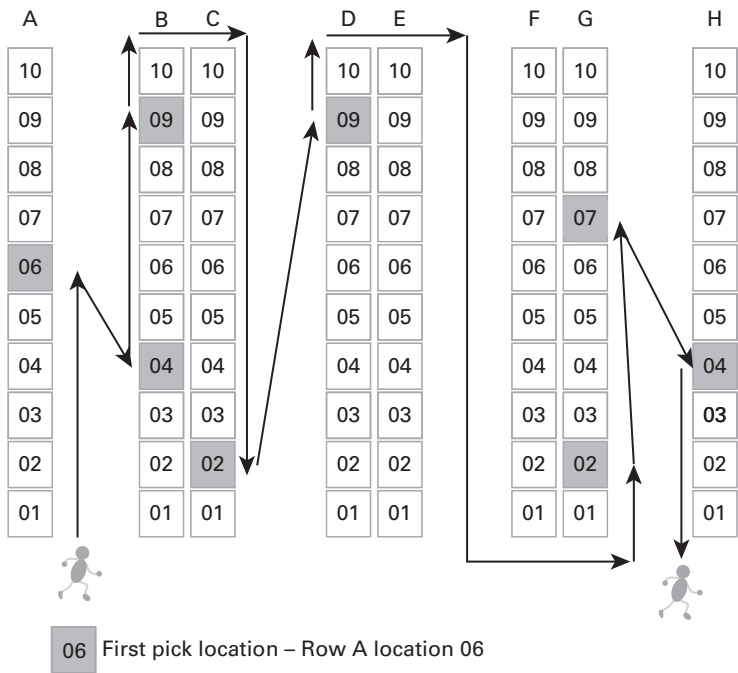
In Figure 1.6 we see that each row of racking is given a letter: A, B, C, etc. This results in one-sided picking as denoted by the arrows. The numbers denoted in the boxes are the pallet locations. The shaded area is an order pick location.

In this example the first pick location will have a location identification (ID) of A (row) 06 (bay) 01 (ground floor) – A0601, while the second location will be B0401. The pick list produced for the operator will automatically send him or her to the location in Row A. This can result in large walking distances as the order picker first visits the location on one side of the aisle and then returns to visit the locations on the other side. This method of identification can be utilized in very wide aisles; however, for narrow aisles and shelving it is more efficient to number the aisles as can be seen in Figure 1.7. However, note that there are warehouse management systems that can adapt to row numbers and configure the pick operation to follow the most efficient path.

In Figure 1.7 the aisles are given letters, as opposed to each row, which results in the picker traversing the aisle and thus picking from both sides at one pass. This will reduce the amount of travel significantly. In Figure 1.7 the first pick location is A0801 and the second becomes A1101. As a result, the pick travel has reduced significantly. This is referred to as snake path or S-shape picking.

It can also be noted in Figure 1.7 that the location numbers begin at the other end of the aisle for aisle B thus allowing the picker to travel less and

Figure 1.6 Pallet row numbering



SOURCE Adapted from and reproduced by kind permission of JP van den Berg

in sequence. Care should be taken in terms of which items are at the beginning of the pick sequence: heavier items should be picked first. The section on slotting (tool 1.7) gives further guidance on this subject.

Reference

van den Berg, J (2012) *Highly Competitive Warehouse Management*, Createspace

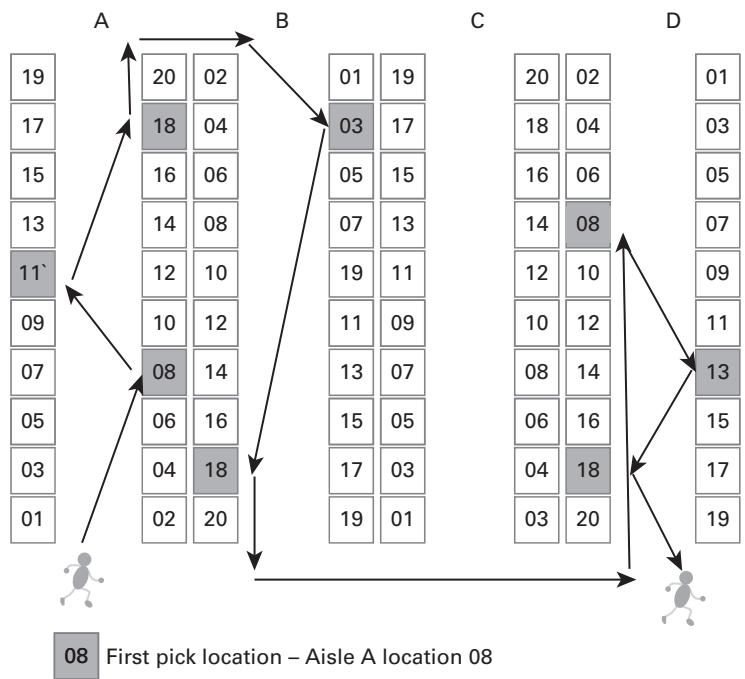
1.12 Selecting warehouse material handling equipment (MHE)

Introduction

The choice of MHE within a warehouse is closely linked to the choice of storage medium. It is therefore key to ensure that they are done simultaneously, taking into account the trade-off between additional space capacity



Figure 1.7 Aisle numbering



**SOURCE** Adapted from and reproduced by kind permission of JP van den Berg

and speed of throughput. In choosing the most appropriate equipment we are looking to:

- ensure staff safety;
- lower unit handling costs;
- reduce handling time;
- reduce travel time;
- maximize cubic space utilization;
- reduce energy consumption and emissions.

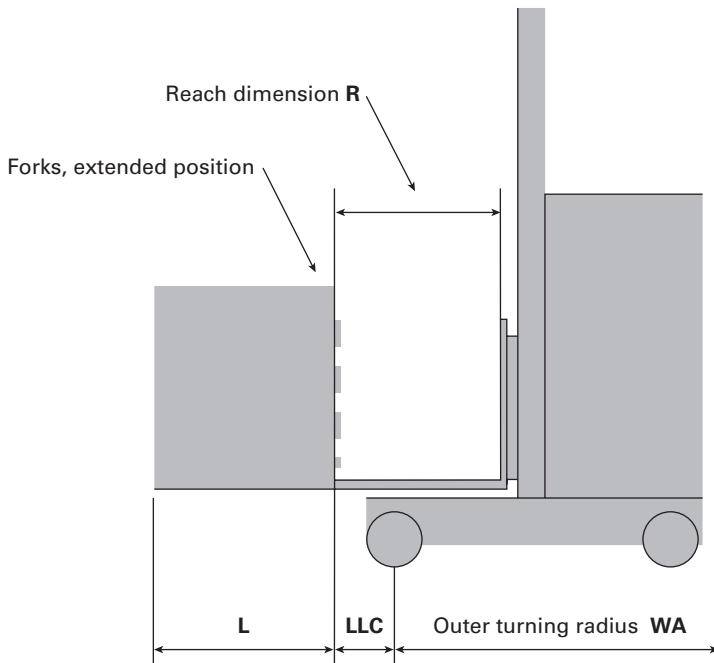
Table 1.9 compares different truck types working in a racked storage environment. We have taken a warehouse with the following storage area dimensions – 48 metres × 120 metres × 10 metres – to bring out the differences between the trucks. Note the lift height capability of the trucks together with the aisle space required. Also note that the VNA truck requires another truck to transport the product to and from the racked area.

**Table 1.9** Comparison chart for MHE

MHE type	Lift Height (mm)	Aisle width (mm)*	Lift capacity in kg from	To (kgs)
Hand pallet truck, pallet jack	200 mm	1525/1725	1000	2300
Hi-lifter	800 mm	2100 mm	1000	1000
Powered pallet truck	195 mm	2157/2265 mm	1300	2500
Pedestrian powered pallet stacker	3600 – 5400	2234/2216 mm	1000	2000
Platform powered pallet stacker	2500 – 6000	2990/2920 mm	1400	2000
Reach truck	7000 – 13000 mm	2687/2942 mm	1200	2500
Counter balance truck 3 wheel	7500 mm	3102/3440 mm	1500	2000
Counter balance truck 4 wheel	7060 mm	3327/3568 mm	1800	8000
Low-level order picker	800 mm	2813/3149	1200	1200
Medium-level order picker	1700/2500 mm	N/A	1000	1000
High-level order picker	10200/11200	1400/1250	1000	1200
Man up VNA	10500/16800	1698	750	1500
Man down VNA	6700/11000	1660	750	1500
Articulated forklift truck	15000	1800/1650	1500	2500

\* Aisle width – 1000 x 12000 crossways/800 x 1200 lengthways

**NOTE** These are guides only. Different manufacturers will have different capacities and lift heights.

**Figure 1.8** Reach truck aisle width calculation

Manufacturers of materials handling equipment have their own sophisticated systems with which to model operations within a warehouse. They are able to take your data and run a simulation to decide on the most appropriate equipment.

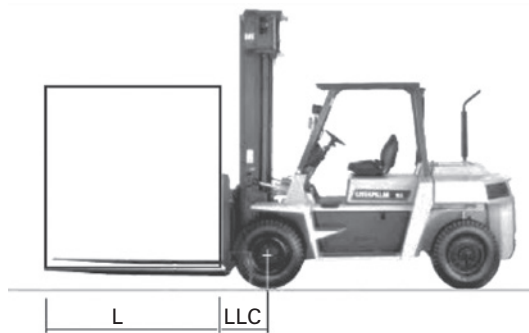
## 1.13 Calculating aisle width for a forklift truck

### *Introduction*

There is a correlation between the type of racking installed and the type of forklift required to operate within the racking. In order to ensure that the correct equipment is purchased we need to undertake a number of calculations. These are shown below.

### *When to use*

When deciding on the aisle width required for a certain type of racking and use of a forklift truck.

**Figure 1.9** Aisle width calculation, counterbalance truck

### How to use

In order to calculate the aisle width required for particular forklift trucks we need to use a formula that takes into account the size of load, the truck's outer turning radius and the truck's lost load centre, which is the horizontal distance from the centreline of the front axle to the front face of the forks. The formula should also include a margin for 'operator clearance'.

The official formula for working out the minimum 90-degree stacking aisleway dimension (known as Ast4 or Ast3) is shown as:

$$WA + LLC + L$$

where

WA = The forklift truck's outer turning radius

LLC = Forklift truck's lost load centre

L = Length of load

Tony Sellick from Forklift Training suggests adding a further 300 mm for operator clearance.

With regard to the reach truck the following formula applies:

$$WA + LLC + L - R \text{ plus } 200 \text{ mm (operator clearance)}$$

where

WA = The forklift truck's outer turning radius

LLC = Reach truck's lost load centre

R = The reach distance

L = Length of load

## ***Further information***

Note that the majority of racking and materials handling equipment companies will be happy to assist you with these calculations.

Another useful site is: <https://www.fork-lift-training.co.uk/buyersguide/forklift-aislway-turning-dimensions.html> (archived at <https://perma.cc/8Y82-LGQ7>)

## **1.14 Goods-to-person solutions – omnichannel operations**

### ***Introduction***

As mentioned in tool 1.5, the picking function in a warehouse can be up to 55 per cent of the warehouse operating cost, with travel to, between and from locations being up to 50 per cent of that labour involvement. It is therefore crucial to choose the most appropriate method of picking.

The shortage of labour coupled with increased labour costs, requirement for more flexible work hours and shorter order lead times has seen an increase in goods-to-person (G2P) systems.

In this section we examine the various types of G2P systems currently available.

There are four main types of systems: those which utilize mobile robots to convey items to static pickers at pick stations; those which are permanent fixtures, utilizing shuttles on rails; hybrid versions of the latter; and carousels/vertical lift modules.

The mobile robot systems convey shelving to a pick station where a picker will pick the required item and the mobile robot and shelving will return the shelves to the storage area.

These include AGVs (autonomous guided vehicles) and AMR shuttles (autonomous mobile robots).

AGVs/AMRs tend to convey shelving up to 1.8 metres in height while AMR shuttles can convey taller fixtures, up to 8 metres.

These robots move around a warehouse independently and take instructions from warehouse control/execution software (WCS/WES). The robots are fitted with sensors, scanners and 3D cameras. They navigate through



buildings using digital maps routing from point A to B. The robots can avoid obstacles and interact safely with humans. Robots can also navigate using 2D bar code labels positioned in strategic positions on the floors and in the racks.

Dynamic slotting takes place as orders are analysed. The WCS will monitor the movement rates of SKUs and units and will slot based on these rates.

Although floor space is utilized efficiently the cubic space is not, unless multiple floors are introduced. This is a significant downside of this system.

Major suppliers include Geek+, Mushiny, HIKRobot, GreyOrange, Quicktron, Swisslog.

Amazon, which has its own AMRs, states that fulfilment centres (FCs) with robots are three times more efficient and 20 per cent faster than traditional, less high-tech FCs.

Companies utilizing this system will tend to use put to and pick to light systems for put-away and picking.

In terms of static versions we have the cube AS/RS (Automated Storage and Retrieval Systems) provided by companies such as Autostore and utilized by Ocado and its clients. In this system, plastic totes are stacked one on top of the other in a grid system. An ABC analysis (see tool 1.3) is used to ensure the most popular items are as close to the surface as possible.

A similar system is provided by Cimcorp, but without the requirement of the superstructure. Each tote is stacked on top of another, and they are retrieved utilizing a gantry crane.

Static AS/RS systems provided by companies including Knapp, TGW, Dematic, SSI Schaefer, Opex, Honeywell etc. utilize a structure where shuttles move on rails to access the plastic totes. These totes can be located one or two deep in the 'racks'. Weight capacity tends to be in the region of <50 kg.

However, there are pallet AS/RS systems with a much greater capacity.

We can also include mini-load systems in this section. Shuttles retrieve items and bring them to the front of the structure where the required item is picked, and the remainder of the items returned to their location.

The hybrid version operates with a permanent fixture but utilizes mobile robots to access the totes in the racks and convey items to a picker. Each of these systems provides very dense storage. An example of this system is provided by Exotec and Hai Pick.

Although utilizing the cubic space of the warehouse, this system has its disadvantages – namely the permanency of the structure and the high capital

outlay. The cube AS/RS also requires the robots to ‘dig’ out the totes to access those items which are not located on top of the grid.

Another type of permanent structure includes carousels and vertical lift modules which have either shelves which rotate within the structure, called carousels – these can be vertical or horizontal – or a lift system at the back of the structure called a vertical lift module (VLM).

Another system is the pocket sorter which is very similar to a hanging garment system whereby pouches convey items to a pick station. This will usually require a separate storage location for storing items and a section for decanting into the pouches.

Another system, recently introduced to the market, is the Hive system where robots climb existing racking to retrieve items. This is still very much in its early development stage.

Selecting a G2P solution very much depends on the type of operation. You need to know what the inventory is in terms of size, stability of size, stock turnover, number and size of orders and order lead time, to name a few parameters.

As mentioned in the recent Stiq G2P report, ‘the higher the level of automation the higher the predictability must be for the future’.

## **When to use**

If you are a potential or existing user of G2P solutions, in the process of evaluating G2P solutions, constructing a new warehouse, having significant labour issues, looking to increase productivity and accuracy or just starting to think about the possibility of automating your warehouse.

## **How to use**

Table 1.10 shows the advantages and disadvantages of each type of automation. One thing to point out here is that many warehouses will use a combination of pick methods, depending on requirements such as velocity of movement, lead times, product identification, product size and accuracy requirements. This can be a combination of automation and manual processes.

The following table compares the different types of G2P systems.

The more stars the better the system for that parameter.

As can be seen from Table 1.10, there are advantages and disadvantages to each of the systems.

**Table 1.10** Different types of G2P systems

	AMRs/AGVs	Cube AS/RS	Static AS/RS	VLM/ Carousels	Collaborative Robots	Manual processes
<b>Implementation timescale</b>	****	**	*	**	****	*****
<b>Capital cost</b>	***	**	*	***	***	****
<b>Pay as you use</b>	****	*	*	*	****	*****
<b>ROI period</b>	****	**	**	**	****	***
<b>Labour cost</b>	***	***	***	***	**	*
<b>Space utilization</b>	**	***	*****	*****	**	**
<b>Complexity</b>	***	**	**	***	****	****
<b>Flexibility</b>	***	*	*	*	***	****
<b>Scalability</b>	****	****	****	****	****	***
<b>Accuracy</b>	***	****	****	***	***	**
<b>Productivity</b>	***	****	****	**	***	**
<b>Single point of failure</b>	****	****	****	**	****	****
<b>Fire risk</b>	***	**	**	**	***	****

With regard to the AMRs and the cobots, these can be acquired via rental or pay-as-you-use contracts, whereas the AS/RS systems will require a significant capital investment unless acquired through leasing.

## **Conclusion**

The type of system chosen has to be based on the following:

- size and type of products;
- speed of throughput required – based on the order types;
- number of SKUs;
- temperature storage requirements – ambient, chill or frozen?
- storage required and available space;
- capital available;
- labour availability;
- suitability of facility, e.g. floor loading and condition;
- failure/breakdown and how to get the system operational;
- insurance

## **References**

2023 G2P Solutions report by Stiq Ltd, [www.styleintelligence.com](http://www.styleintelligence.com) (archived at <https://perma.cc/2GGW-E3GJ>)

TH Logistics Blog <https://www.thlogisticsconsultant.com/blog/> (archived at <https://perma.cc/E7FE-RRZG>)

## **1.15 Warehouse space calculations**

### **Introduction**

For those companies that do not have access to warehouse design software there are a number of simple ways to calculate the space required for specific operations. In this tool we have included a calculation for dock space and racked pallet storage.

## How to do it

### 1. Calculation of dock space requirements

The formula for this is relatively simple, as follows:

$$\text{Dock space} = \{\text{Roundup} ((\text{Number of loads received} \times \text{hours per load}) / \text{hours per shift})\} \times (\text{Size of load} \times \text{pallet dimensions})$$

#### *Data*

Receiving 20 loads per day

Each load is 26 pallets

Each pallet is 1 m × 1.2 m

45 minutes per load to unload vehicle

30 minutes per load to stage prior to put-away

8 hours per day work shift

#### *Calculation*

$$\text{Roundup} ((20 \times 1.25)/8) \times (26 \times (1.2 \times 1.0))$$

$$= \text{roundup} (3.125) \times 31.2$$

$$= 4 \times 31.2$$

$$= 124.8 \text{ square metres}$$

$$\text{Dock space} = 124.80 \text{ square metres}$$

$$\text{Add double the space for working and travel area} = 249.60 \text{ square metres}$$

$$\text{Total space required} = 374.40 \text{ square metres}$$

### 2. Pallet storage calculation

This tool enables operators to calculate the number of pallets that can be stored within a particular cubic area. It works on the basis of calculating width, length and height modules within the warehouse.

A module width is calculated as follows:

$$\text{Module width} = \text{Width of aisle} + 2 \text{ Pallet lengths (short side)} + 100 \text{ mm}$$

*For example, given the following data:*

$$\text{Aisle} = 2,500 \text{ mm (variable with type of MHE used)}$$

$$\text{Pallet size} = 1,200 \text{ mm} \times 1,000 \text{ mm}$$

$$\text{Two pallets short side} = 2 \times 1,000 \text{ mm} = 2,000 \text{ mm}$$

Clearance = 100 mm between back-to-back pallets

*Therefore:*

Width of module = 4,600 mm (the sequence is pallet–aisle–pallet–clearance)

*A module length is calculated as follows:*

Module length = Width of upright + Clearance + 2 Pallets (long side)

Rack upright plus clearance = 420 mm (120 mm  $\times$  3  $\times$  100 mm)

Two pallets (long side) = 2  $\times$  1,200 mm = 2,400 mm

*Therefore:*

Length of module = 2,820 mm (the sequence is upright–clearance–pallet–clearance–pallet–clearance) (see Figure 1.11).

Module height = Height of pallet = 150 mm

Pallet height = 1,350 mm

Clearance above pallet = 150 mm

APR beam width of 140 mm

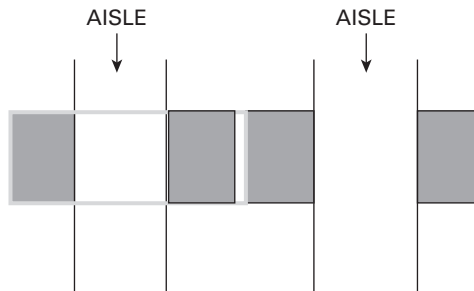
*Therefore:*

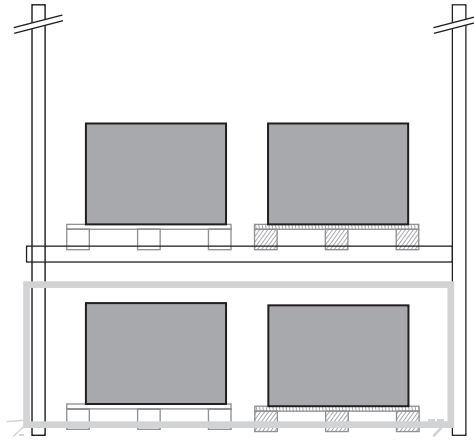
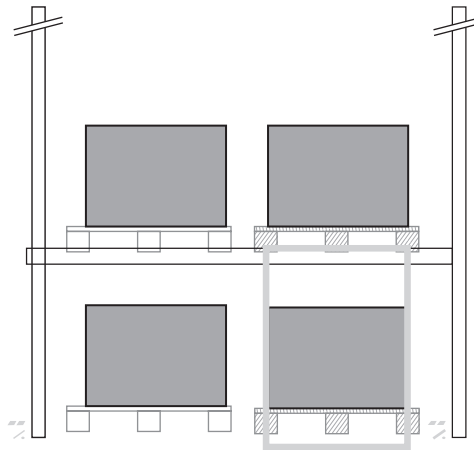
Height of module = 1,640 mm (sequence is pallet and goods–clearance–beam height) (see Figure 1.12).

Total pallets stored within cubic capacity of a warehouse section, excluding receiving and dispatch areas, gangways and other areas:

(No of width modules  $\times$  pallets in module width)  $\times$  (No of length modules  $\times$  pallets in module length)  $\times$  (No of height modules) = No of pallets into cube volume of warehouse.

**Figure 1.10** Width module calculation



**Figure 1.11** Length module calculation**Figure 1.12** Height module calculation

So, for a warehouse section with a width of 48 metres, a length of 120 metres and a height of 10 metres:

Width calculation =  $48 \text{ m} \div 4.6 \text{ m} = 10$  modules

Length calculation =  $120 \text{ m} \div 2.82 \text{ m} = 42$  modules

Height calculation =  $10 \text{ m} \div 1.64 \text{ m} = 6$  pallets

*Therefore:*

Total number of pallets =  $(10 \times 2) \times (42 \times 2) \times (6) = 10,080$  pallet locations in this warehouse storage area.

An alternative calculation to calculate space requirements is as follows:

$$S = (A/2 + W + 0.1 \text{ metres}) \times (L + 0.2 \text{ metres}) \times N/(h \times d)$$

where:

S = surface area required

A = aisle width, depends on building height

W = width of pallet

L = length of pallet

N = total number of pallets

h = stacking height in number of pallets high

d = stacking depth in number of pallets deep, d = 1 for traditional storage

Note that these calculations are 'rule of thumb' calculations and may not fit all operations.

## **Further information**

There are a number of free resources that can calculate the number of pallets that can be stored within a specific area or volume. These are supplied, in the main, by the material handling and storage equipment companies, for example <http://webtools.cisco-eagle.com/rack/> (archived at <https://perma.cc/E85U-2F7U>)

A simple pallet calculation sheet using Excel can be downloaded from <http://howtologistics.com> (archived at <https://perma.cc/YRW4-CNPM>)

## **1.16 Warehouse location**

### **Introduction**

Locating a warehouse strategically and in the most cost-effective geographic location is one of the most important decisions a company will make. The decision as to whether to operate the warehouse in-house or outsource is covered elsewhere in this book (see tool 5.1).

The selection of a warehouse location requires multiple criteria to be assessed, including both quantitative and qualitative data. Many companies will look at the location and size of customers which, although relevant, are



not as important as they would be when locating a retail outlet. Factors to take into account include the following:

- cost of land, rent, rates and local taxation;
- access to transport networks;
- availability of trained labour;
- transport links for staff;
- availability of funding, grants, etc;
- availability of existing buildings;
- availability and cost of utilities, including telecoms;
- availability of finance and resources;
- goods traffic flows;
- proximity to ports, including inland ports and airports;
- proximity to multi-modal facilities
- location of suppliers and manufacturing points;
- the potential neighbours, e.g. opportunities for co-loading or, negatively, hazardous storage facilities.

## ***When to use***

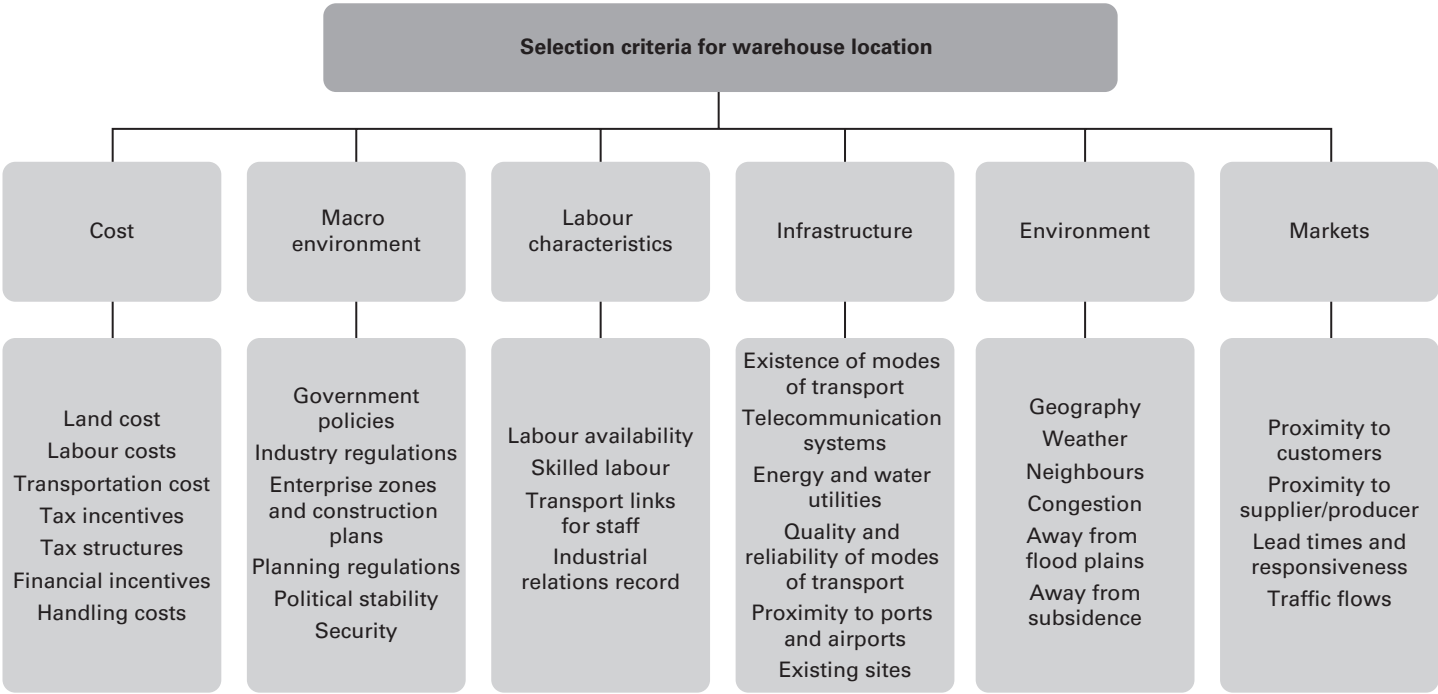
When the company is looking to locate or relocate a warehouse operation.

## ***How to use***

Figure 1.13 provides a list of criteria companies need to take into account when deciding on a new location for their warehouse. Fortunately, this does not have to be a totally manual decision as there are a number of software programs available that will take the majority of these criteria into account and produce a number of viable alternatives.

Route planning and optimization software will produce a viable location; however, supply chain optimization tools will further enhance this decision.

**Figure 1.13** Warehouse location criteria



## Further information

The websites for a number of providers of this software are:

Cirrus Logistics – <http://cirruslogistics.com/products/cost2serv-network-strategy/> (archived at <https://perma.cc/643B-4PDH>)

JDA – <http://www.blueyonder.com/solutions/> (archived at <https://perma.cc/YV58-CAMW>)

Llama Soft – <https://www.coupa.com/products/supply-chain-design> (archived at <https://perma.cc/DE6V-CK38>)

Plan LM – [www.solvoyo.com](http://www.solvoyo.com) (archived at <https://perma.cc/MP9X-KFBP>)

SCM Globe – [https://scmglobe.com/user\\_sessions/new](https://scmglobe.com/user_sessions/new) (archived at <https://perma.cc/RAW2-JG4P>)

## Further reading

Demirel, T, Demirel, N Ç and Kahraman, C (2010) Multi-criteria warehouse location selection using Choquet integral, *Expert Systems with Applications*, 37 (5), pp 3943–52

# 1.17 Justifying a warehouse management system (WMS)

## Introduction

A WMS has become essential to the smooth and efficient operation of complex warehousing and distribution environments around the world. Recognizing the need for a WMS is a reasonably straightforward exercise for many warehouse managers. Inaccurate inventories and pressure to continually reduce costs and improve service levels make the investment decision almost intuitive. Investments, however, are rarely made based on intuition. Fortunately, the benefits of a WMS can be identified and, to a great extent, quantified, to provide an accurate basis for justification.

## When to use

When contemplating the acquisition of a WMS.

## How to use

Red Prairie (now JDA) suggests a five-step plan to justify the introduction of a WMS.

### Step 1: Define the problem areas

Four principal benefits can be expected to arise from the implementation of a WMS. These benefits lie in the four areas that cause the majority of efficiency problems in warehouses: inventory accuracy, resource management, customer service and visibility. The first step is to identify the main problems currently experienced. Begin by creating a matrix using these four benefits as the primary categories. Next, list the facility's problems under each category.

Common problems occurring under inventory accuracy include excess inventory, lost product, incorrectly located items and mis-picks. Under resource management, problems may include wasting time looking for material, inefficient pick paths and no means of measuring performance. Customer service problems include ship errors and delayed shipments. Finally, information management problems may include stock-outs, false stock-outs, transaction update delays of hours and days, and data entry errors.

### Step 2: Estimate the costs

Once any warehousing problems have been documented, the next step is to estimate the costs associated with each. This step is critical to understanding the severity of any problems. A variety of equations and industry standards can be used to quickly estimate the costs. Four examples of typical costs are listed in Table 1.11. Having completed a quick estimate of the costs, it becomes easy to identify the most urgent problems – those problems that represent your biggest cost factors. The first example indicates the impact of ship errors. Two calculations are made: one assuming a ship accuracy of 98.5 per cent and one assuming 96 per cent. Ship accuracy above 95 per cent is often thought of as excellent, yet the cost of errors in these two cases is significant – \$44,250 and \$118,000 respectively. These figures are based on a survey by Honeywell, which estimated the cost of a picking error to be \$59.

**Table 1.11** Typical cost penalty if no WMS

	Error Occurrence (%)	Cost/Occurrence	Total cost
Ship errors	1.5	\$59	\$44,250
	4.0 (assume 50k orders pa)	\$59	\$118,000
Shrinkage	1.0	.01 × \$1m in invoicing	\$10,000
		.01 × \$7m in invoicing	\$70,000
Data entry errors	4.0 (assume 100k transactions pa)	\$10	\$40,000
Lost product	5.0	\$3.33	\$41,625
	7.0 (assume 50k orders × 5 lines per order)	(10 minutes searching × \$20/hour)	\$58,275

### Step 3: Identify the savings

The savings associated with the reduction of inventory levels may themselves justify investment in a WMS. Many companies have reported reducing inventory levels by as much as 30 per cent. This level of reduction greatly affects carrying costs, which typically equate to 25 to 35 per cent of the cost of inventory (see Table 1.12).

Realistically, during the few months of implementation, cost savings will not be maximized because of ‘learning curve’ issues such as training and a re-engineered warehouse culture. However, over time, users should expect near perfection in those areas that were once major problems. Estimated cost savings should take into consideration the fact that year two will return greater savings than year one. Minimizing the learning curve can be accomplished through training (commencing long before implementation) combined with good internal communication (change management).

### Step 4: Determine the cost of a WMS

At this point in the process, it will be reasonably clear how much money and time a good WMS product will be able to save. The next step is to determine how much will have to be spent to integrate the system. Although vendors

**Table 1.12** Potential cost savings from introducing a WMS

	Potential cost savings (%)
Labour utilization	10–35
Inventory reduction	5–30
Floor space utilization	10–30
Maintenance	0–10
Shrinkage	50–75
Rolling stock	10–20
Increase shipping accuracy to	99+
Increase data entry accuracy to	99+

use various pricing models, the components of their pricing proposals usually fall into five categories:

- 1** licence fees;
- 2** custom development (if applicable);
- 3** computer hardware;
- 4** radio frequency (RF) hardware; and
- 5** services such as design, implementation, training, testing and travel.

Your internal costs to implement the system should also be included when defining the total cost of the implementation, as well as the cost of maintenance over the time period for which you are calculating the ROI.

An alternative pricing and implementation model may also be considered. WMS systems are now available on a SaaS (Software as a Service) basis. In this model you typically pay a modest upfront implementation fee and then have a single monthly payment (including system and hardware costs and maintenance fees) for a specified period such as three or five years. Note some WMS suppliers charge on a transactional basis. Add the sum of the payments for the life of the contract and the implementation fee to determine total system costs.

## Step 5: Calculate the ROI

See tool 7.2. Once calculated and accepted by the board you can begin the process of supplier selection (see tool 1.18).

## Reference

<http://jda.com/knowledge-center/collateral/five-steps-for-cost-justifying-a-wms-white-paper/> (archived at <https://perma.cc/AX23-JFLL>)

# 1.18 Selecting a warehouse management system (WMS)

## Introduction

If I had to choose one tool to operate within a warehouse it would have to be a WMS, closely followed by ABC analysis (see tool 1.3). This tool describes how you should go about choosing a WMS.

A WMS can process data quicker and can coordinate movements within the warehouse. It can produce reports and handle large volumes of transactions, as seen in e-commerce operations. The potential benefits of having a WMS in place include the following:

- efficient and effective labour management;
- improvements in productivity and accuracy;
- stock visibility and traceability;
- accurate stock-takes;
- reduction in picking errors;
- reduction in returns;
- accurate reporting;
- improved responsiveness;
- remote data visibility;
- automatic replenishments;
- improved customer service; and
- minimized paperwork.

To embark on a WMS project you need to be certain that you are going to achieve significant business benefits. Such systems need capital investment, unless purchasing a SaaS system, plus there are some running costs involved; however, the main ‘cost’ is the drive, enthusiasm and commitment needed from the entire warehousing team and senior management to ensure that the system is set up correctly, used properly and regularly optimized. A WMS is not a ‘quick fix’ option. A WMS is more than a stock control and data collection tool. It is a system that helps you ‘automate’ your warehousing operations as much as possible.

IT projects arguably should be justified on the same basis as any other business investment. A WMS is very much a tactical ‘execution’ system and is therefore a lot easier to justify than many IT projects. It forms an important component for strategic business improvement but nevertheless is still tactical.

## ***When to use***

When you have decided on the purchase or rental of a WMS.

## ***How to use***

### **Step 1: Undertake a return on investment (ROI) calculation**

The justification process (see tool 1.17) is important because it helps you to set a budget for your project and also focus on the functional ‘must haves’ rather than the ‘nice to haves’ when selecting suppliers. The key areas to consider are:

- the potential for a WMS to give you improved stock accuracy – by reducing errors, providing real-time information and enabling perpetual inventory counting;
- the potential for increased productivity and cost savings – through improved labour, equipment and space utilization;
- the need for improved traceability – a WMS can give you two-way traceability, almost as a by-product of being in place;
- improved customer and client service – through overall improved warehouse control, improved pick and dispatch accuracy.

The more transactions per day (e.g. pallet moves, picks) and locations in the warehouse, the greater the potential for payback and the greater the



justification. In addition, warehouses use expensive equipment where optimization can bring significant savings – sometimes to such an extent that less equipment needs to be purchased and fewer staff employed.

Understand the cost methods used by WMS vendors. These can be broken down into four main components:

- 1 *Licences* – the software licence needed to run the system. Typically, this is charged by ‘user’, i.e. PC user or radio data terminal user, although different models are now being offered, including paying by transaction and/or paying monthly rather than outright purchase of the system.
- 2 *Professional services* – the costs for project management, training and go-live support.
- 3 *Development costs* for requirements not catered for in the package, including interfaces to third-party systems.
- 4 *Support costs* – typically an annual cost based on licence costs and often development costs; the scope of service and cost varies significantly from supplier to supplier.

Ensure that the suppliers you approach give you costs for all of the above. Ask them to indicate which prices are fixed and which are variable. Watch out for hidden costs such as travel costs, travel time and project management time. Summarize all the costs in a spreadsheet, showing the initial cost and then costs for years one to five with accumulated totals. You may be surprised by the results!

In addition, there are the hardware and infrastructure costs. These costs have to be considered in terms of project budget and ROI, of course, but in many cases can be managed as a separate project with interdependencies with the main project.

## Step 2: Decide on the process

Modern WMSs are highly configurable, normally by the end user, and should be capable of working in virtually any type of warehousing environment. In the past, the production of a large, detailed invitation to tender (ITT) was an important part of the WMS selection process. This reflected the limited functionality of most systems at that time. A major disadvantage of ITTs is that they cannot hope to take account of a company’s future requirements and are often over-prescriptive. The other disadvantage is that many WMS providers will often not respond to ITTs. They consume a vast amount of time, which the vendor might prefer to spend in other directions under its own control.

There are spreadsheet templates that are downloadable from the internet; however, many of these are, or were originally, prepared by WMS vendors and are slanted towards their products. Most WMS vendors therefore view such documents with suspicion.

### Step 3: Understand and analyse your existing systems

If your ERP/business system already has a WMS module, then you should examine and analyse this in the first place. The same due diligence applies to this selection as to any other system, but normally any small shortfalls in functionality are outweighed by reducing any risks of systems not interfacing with each other reliably and accurately.

Similarly, if your warehouse is highly automated, with cranes, conveyors or sortation systems, you may wish to focus on the WMS provided by the automation systems company. This will typically be known as a warehouse control system or WCS. Again, shortfalls in functionality are often outweighed by the avoidance of an interface to an external WMS. There are many papers available on this subject and some of these are mentioned below.

### Step 4: Is there an in-house development capability?

Owing to the ‘packaged’ nature of the WMS market nowadays, in-house development is very rarely viable as a typical WMS vendor will have perhaps 100+ clients over which it amortizes the continuous development costs; these same 100+ clients serve as a very valuable and thorough proving ground for the product in question. In-house development is sometimes viable if the overall requirements are particularly specialized or require specialized integration with existing in-house systems.

### Step 5: Request for information

Prepare a short RFI document (request for information); this should typically be no more than a few pages long. In this document you describe your business, your future business direction, your warehouse and your plans for the warehouse. Then talk in broad terms about what you want to achieve from the WMS.

By this stage you will have completed an operational specification for the warehouse to gain capital approval. The key elements from this specification are an ideal base for the RFI, for example number of loading bays, number and type of reserve locations, number of pick face locations, and pick-and-pack station details. Of particular relevance is the number of users, i.e.

administrative users, forklift truck drivers, pickers, packers and so on. Provide a guide to the number of transactions per day (receipts, put-aways, picks, dispatches) and indicate if there are any significant peaks across the day, week or month.

Do not try to describe how the system should work – in fact it can be dangerous to be too specific at this point, as there may be faster, better, cheaper ways of doing things and part of the selection process is to see how potential suppliers can guide you in this regard. You could use the services of a specialist consultant to help you.

Within the RFI, ask the vendor for budget costs and implementation timescales. You should ask for supplier information, including:

- company history;
- financial history and status;
- number of sites using its current WMS product;
- who owns the IP (intellectual property – source code) for the WMS;
- client list, especially those companies operating in your marketplace;
- daily rates and support charges;
- support cover;
- development plans;
- track record.

We suggest that you send this RFI to 6 to 10 suppliers initially. Focus on suppliers that have experience in your market – this is particularly the case if you are a third-party logistics provider; WMS vendors with no experience in this sector are unlikely to have the functionality and importantly the expertise to help you. Focus on suppliers that have a track record linking to any business or ERP system you are operating.

At this stage you will need to decide whether to purchase the software and hardware outright or to rent the software and operate it on a third-party server platform. A SaaS (Software as a Service) WMS is an internet-based application that is developed, hosted and maintained by a third-party software provider on secure servers. The vendor rents out the system to a number of different clients. These clients, in turn, will choose the various modules within the software they require and pay for them as they use them. The advantages are:

- lower cost of entry;
- reduced start-up costs;

- instant upgrades;
- user-driven innovation;
- ability to turn on and off as required, e.g. to run a temporary warehouse operation.

Such a system will be attractive to start-up companies and small and medium-sized enterprises (SMEs), although it could benefit larger companies that are looking for a temporary fix. Potential disadvantages include the possibility of poor internet links between the companies and worries over data security.

## Step 6: Short list

Produce a short list of three to five suppliers. Price, of course, is not the main criterion at this stage but can be used to rule out suppliers that will exceed your budget. Get the suppliers to visit you for an informal meeting. This will help you get a feel for their company – how professional they are, how carefully they listen and respond to your needs, how well they answer your questions.

Before you get into the detailed demonstration stage, do a little more checking on each of the suppliers; this will help you to reject unsuitable suppliers at an early stage. A good way of doing this is to telephone-interview at least six reference sites, preferably sites you choose from a longer list. These calls should all be made with the knowledge of the supplier – unless you have contacts with their clients already.

Get the short-listed suppliers to provide you with a tailored demonstration. Get them to focus on what you believe is especially important for your operation – for instance, pick face replenishment, or kitting and assembly. At some time during the selection process you should also get them to give you an overview of their company, products and people and of their strategy – in terms of both company and product.

Visit their head office to get a better understanding of their culture, management style and team working. It is very important to get a good ‘people’ fit with any organization you select. It is always worth asking the suppliers why they think they should be selected for your project.

The reference site visit/s is often the crux of supplier selection. Make sure you are given a choice of sites, not just ‘the one’, and make sure it is similar in terms of size and processes to yours – or preferably slightly larger and slightly more complex.

If you have identified any gaps in functionality, now is the time to get these specified and costed. The supplier should be asked to provide an accurate project cost, clearly identifying any variable costs. This is where the contacts you have developed with the suppliers' reference sites will pay off, as you can talk to them about how well the supplier worked to budget and time.

## Step 7: Final choice

Choose the most appropriate supplier. Utilize a decision matrix, taking into account the criteria mentioned above (see tool 5.8).

## Summary

Here are 20 tips for choosing a WMS:

- 1 Have a clear long-term vision of what your warehouse could look like in the future – this will help you ensure that you choose a solution that is sufficiently scalable, flexible and functional.
- 2 Ensure complete 'buy-in' from senior management.
- 3 Keep an open mind about how your WMS will operate – let the WMS vendors listen to your needs and show you different ways of using their solution.
- 4 Ensure that your processes are working efficiently before introducing a WMS.
- 5 Look for a supplier that is warehouse and logistics focused; more generalist companies will often change strategy and reduce their focus on warehousing as their fortunes change.
- 6 Look for a supplier with a strong team of warehousing specialists, otherwise you will be training the supplier in warehousing or at best will be reliant on one or two individuals.
- 7 Choose a WMS vendor that you get along with – it is about partnership.
- 8 Make sure that help desk and support cover is available during your working hours – 24/7 if necessary.
- 9 Look for a WMS that has been specified by warehouse and logistics professionals, rather than by programmers and analysts.
- 10 Make sure that the product is relatively new but with a sound track record, and uses the latest software technology.

- 11** Make sure that the product is being developed on an ongoing basis to meet future warehousing and supply chain needs. Historically, WMS vendors have made their money by charging their customers significant amounts of money for development work. This has several major disadvantages: it invariably costs more than functionality provided as a package, it extends the project time, and it introduces risk (bespoke software often fails to perform due to both technical issues and differences in interpretation of the specification). A further disadvantage is that custom software often makes software upgrades cumbersome, risky and expensive.
- 12** Choose a WMS vendor that can demonstrate a significant track record in your type of warehousing operation; get them to take you to customer sites to see the WMS in action, and make sure that you talk to the users and the management team at each site.
- 13** Look for a WMS that is an end-user-configurable package. Nowadays it is impossible to predict future WMS needs, particularly in a third-party environment, so flexibility is the name of the game.
- 14** Where small but important changes are needed to make the system meet your very specific needs, ensure that these changes do not compromise the package upgrade route.
- 15** Look for relevant reference sites. Look for a vendor with a good, active user group, and ensure that this group has real influence on the product strategy and support services.
- 16** Ensure that the vendor is of the right size – not so small that it has insufficient resource and not so large that you have no influence on product development and service levels.
- 17** Ensure that the vendor will help and support you in commercial and technical discussions with suppliers, customers and clients.
- 18** Have an in-depth demonstration of the WMS. Make sure that potential users of the system go along. Ensure that the WMS is easy to use and related closely to your operation.
- 19** Make sure that you involve your IT team in ensuring that the WMS vendor can work with you to provide solid interfaces with your other business systems. Do not let them dominate the project – a WMS is a tactical, operational solution and, as such, in most cases the project should be managed and run by logistics people.

- 20** Make sure that you identify a project champion in your organization, build a team around him or her and get the champion to own the WMS implementation.

(This tool is adapted from a white paper written by Stephen Cross and reproduced with his permission. The original paper can be found at <http://www.cenglobal.com/atms/wp-content/uploads/2015/04/chapter-12-systems.pdf> Shortcut – <http://bit.ly/2S1DnMm>)

### ***Further information***

A comprehensive list of WMSs can be found at <http://www.capterra.com/warehouse-management-software> (archived at <https://perma.cc/2ZE3-2EEK>)

An example of a WMS Request for Proposal (RFP) template can be found here: <https://www.koerber-supplychain-software.com/en/knowledge-center/supply-chain-resources/wms-rfp-template-for-enterprise-businesses> (archived at <https://perma.cc/5DHX-QVGF>)

## **1.19 Choosing between a best-of-breed warehouse management system (WMS) and an enterprise resource planning (ERP) WMS module**

### ***Introduction***

For omnichannel retailers and those with complex operations, up until very recently, choosing a best-of-breed warehouse management system (WMS) over an enterprise resource planning (ERP) WMS module was quite common. However, according to enVista, ‘the functionality of ERP WMS systems has continued to evolve, leaving companies with a tough choice – which WMS is best for our company and our needs?’

Many businesses are already using an enterprise resource planning (ERP) system of some sort such as Infor, Oracle, SAP, Sage and Microsoft – and these solutions also offer warehouse management capabilities. Some are rudimentary and very basic, whereas others are more feature rich. Depending on the type of business and complexity of your warehouse processes, you may find the functionality offered as standard within your ERP is perfectly

adequate – this may well be the case for SMEs. ERP vendors have been slowly replicating best-of-breed functionality.

Best-of-breed systems have interfaces to integrate with the host ERP; however, companies can remove any integration concerns by going with an ERP WMS. In the past companies found that the value they received in a best-of-breed WMS and its complementary products far outweighed integration and increased licence costs.

A significant increase in order volumes, together with a competitive labour market where salaries have increased significantly and labour shortages are commonplace, has heralded an increase in the use of automation and robotics. As a result we are now also seeing the introduction of more sophisticated and comprehensive warehouse execution systems and warehouse control systems.

With the evolution of warehouse control and warehouse execution systems and their ability to interface with ERP systems, companies are finding that they are less dependent on best-of-breed WMS and more likely to utilize the WMS module in their ERP solution.

## ***When to use***

When deciding to purchase a new WMS, replace an existing WMS, or when purchasing a new ERP system.

## ***How to use***

One of the main issues in determining which system to go with is that companies are made up of departments and people that often have differing, or even conflicting priorities.

The operations team will be looking for a comprehensive suite of functionalities, while finance will be concerned with cost, and the IT team with having to deal with multiple systems.

The WMS you select must ultimately align with your company's short- and long-term performance goals while providing a competitive advantage. This is a decision for the long term, so it should be treated as such! There are some essential questions to ask when deciding whether to implement a dedicated WMS solution or choose a module from your ERP vendor. These are as follows:

- How will improved warehouse efficiency from buying a separate WMS contribute towards your business goals – both now and longer term?



- To what extent can the ERP's WMS record and manage KPIs in the warehouse?
- How easily can the following key metrics be tracked?
  - time required to complete routine stock movements;
  - goods receiving and put-away processing times;
  - stock replenishment time frames;
  - 'On Time In Full' order-picking trends, pick accuracy levels and operator productivity;
  - stock accuracy and stock audit discrepancies.
- How easily can the ERP solution be adapted to reflect changing warehouse operations? Can these be implemented without incurring extra costs?
- Does the ERP vendor have the real-world warehouse management expertise to help refine existing processes during the implementation programme?
- How well does the ERP's functionality fit your current business processes and are compromises required? Can custom functionality be easily added?
- Does the ERP module support wave picking for e-commerce, perpetual inventory counting, value add packing, allergen management, customs and excise reporting, compliance procedures or track and trace?
- Can the WMS vendor support you with in-house integration capabilities, to ensure all systems can communicate in real time?

While ERP WMS systems are fully integrated with the ERP suite, the lack of autonomy between the two systems can cause unforeseen enhancements to obtain comparable functionality.

Many of the best-of-breed WMS software providers have complementary software solutions for complete fulfilment execution that span several channels including retail, wholesale, e-commerce and marketplaces such as Amazon.

## ***Example***

An example of the benefits of a dedicated WMS is provided by Indigo software.

A best-of-breed WMS integrated with their existing ERP system delivered their client the following benefits:

- more efficient raw materials delivery to production and improved replenishments in the manufacturing area;
- real-time inventory accuracy at every location – no searching for available put-away spaces;
- optimized picking with pre-allocated travel paths to minimize time between locations;
- no time delays between inventory transactions and system updates;
- accurate cycle counting and improved stock auditing.

‘Overall, the client’s WMS investment generated significant cost savings and they quickly recouped their initial capital expenditure in reduced labour hours required.’

## **Conclusion**

The WMS you select must ultimately align with your short- and long-term performance goals while providing a competitive advantage. This is a decision for the long term, so it should be treated as such!

Invest in the WMS that creates a competitive advantage for your supply chain by enabling impactful service and cost benefits.

## **Further information**

<https://logisticsvoices.co.uk/2022/07/best-of-breed-wms-or-erp-bolt-on-how-to-evaluate-what-your-warehouse-needs/> (archived at <https://perma.cc/R3TZ-QRW4>)

Indigo Software – <https://indigo.co.uk/> (archived at <https://perma.cc/Z8D3-37FQ>)

<https://envistacorp.com/blog/5-considerations-when-evaluating-best-of-breed-wms-vs-erp-wms/#:~:text=5%20Considerations%20When%20Choosing%20Between%20Best-of-Breed%20WMS%20vs.,Technology%20Complimentary%20Software%20Products%20Total%20Cost%20of%20Ownership> (archived at <https://perma.cc/KT3K-7YCL>)

[https://www.msasys.com/wp-content/uploads/2013/03/ERP\\_vs\\_Best\\_of\\_Breed\\_WMS\\_White\\_Paper\\_MSA.pdf](https://www.msasys.com/wp-content/uploads/2013/03/ERP_vs_Best_of_Breed_WMS_White_Paper_MSA.pdf) (archived at <https://perma.cc/YQ9J-D8NX>)

## 1.20 How to implement a WMS

### *Introduction*

Once you have decided you really need a WMS, and you have selected a WMS vendor, the hard work begins. There is no substitute for good and robust project management, alongside the selection of a good team. The WMS project must be owned from the top of the organization to the bottom. A project sponsor is an invaluable member of the project team – someone who ensures that the focus is maintained on delivering business benefits with minimal disruption.

A project champion needs to be appointed to effectively take charge of the project and this person will often come from a warehousing rather than an IT background. Crucial to this is having project management experience. IT staff should also be represented on the team, but increasingly IT is seen as a business support function as opposed to the main ‘drivers’ of a WMS project. Too many projects have failed when the project manager has not been experienced or has not been able to concentrate fully on the project itself.

Use the guidance and support of your WMS vendor as much as possible; a major part of your selection process should have been to identify a vendor that adds value during the implementation process. This guidance needs to be paid for, of course, so make sure that you have budgeted for it.

Methodology before technology is the key reminder for virtually all IT projects, particularly WMS projects. Ensure that your warehouse is running in an optimal manner with tried-and-tested processes before trying to implement a WMS: otherwise expect failure! That is not to say you cannot introduce new and better processes while implementing a WMS – this is often the case – but if your warehouse is disorganized, tackle that problem before doing anything else. Do not automate a bad process: you just get to the wrong result faster.

In the case of a greenfield operation, methodology before technology is not normally possible as timescales are tight. Here it is vital to have a strong and experienced management team with a logistics background. In addition, you may want to use the services of a specialist consultant or an interim manager. Interim management can be a very cost-effective way of providing the extra resource needed in this change management process.

The scope of the project should be documented. The scope is just building on the WMS description you wrote for your RFI, i.e. what you want the

system to do for your business. This need not be an arduous or tedious task, but it is important to focus on top-level business requirements and warehouse processes rather than being prescriptive as to how the WMS should function in detail at this stage. This top-level approach is particularly relevant where a well-established packaged solution has been purchased – in the final analysis, such a solution should be highly flexible and configurable.

Interfaces to external systems, including ERP systems, transport management systems, warehouse control and automation systems and parcel carriers all have to be thought about and specified. This is a specialist area and can be one of the riskiest areas of a WMS project if not managed properly.

A project plan should be drawn up – often the WMS vendor will have a template available (see Table 1.13). The plan will detail all the tasks required, responsibilities and timescales. Regular review meetings will monitor progress against the plan and make corrective actions as required. Make sure that there is no project creep: learn to say no! Start as simply as possible and get some quick wins.

## The contract

A contract should be drawn up between you and the vendor. This should be done before you commit any major finances, but far enough into the initial stages of the project that you can have it scoped, planned and costed.

Your RFI and scope document form a key part of this contract, as does all documentation received from the vendor. An outline plan should have been produced by this stage, showing key milestones and deliverables. This plan also forms part of the contract.

The contract should as far as possible be in plain English. It does not necessarily need to be produced by a lawyer, but you should get appropriate legal advice. The contract needs to be produced by someone with knowledge of the principles of contract law.

## Infrastructures

The IT infrastructure needs to be planned around the WMS. Your internal IT department can help with this, assuming they have the skills and resources. Alternatively, you can contract it out or in certain cases the WMS vendor will take on complete responsibility.

The IT infrastructure will consist of servers to run the applications, PC workstations, network infrastructure and printers. In some cases you will also use radio data terminals (RDTs) or a voice- or vision-enabled technology for the system. Both are mini-projects in their own right that need to be

**Table 1.13** Generic project plan

<b>Generic Project Plan – Warehouse Management System Implementation Plan for FZ Company</b>			
<b>Task</b>	<b>Detail</b>	<b>Duration</b>	<b>Resource &amp; responsibility</b>
<b>Project planning</b>		5 days	
	Internal project kick-off		WMSS* Projects, WMSS Sales
	Identify project teams & responsibilities		Customer, WMSS Projects
	Identify scope & boundaries		Customer, WMSS Projects
	Identify server & PC requirements		Customer, WMSS Projects
	Identify any additional RF requirement		WMSS Projects, Customer
	Identify printer/print server requirements		Customer, WMSS Projects
	Understand existing network		WMSS Projects, Customer
	Sourcing server		WMSS Projects
	Source progress		WMSS Projects
<b>Project management</b>		7 weeks	
	Project meetings		WMSS Projects, Customer
	Update meetings		WMSS Projects
	Document and diarize		WMSS Projects
	Action		WMSS Projects, Customer

\*warehouse management systems staff

(continued)

**Table 1.13** (Continued)

<b>Generic Project Plan – Warehouse Management System Implementation Plan for FZ Company</b>			
<b>Task</b>	<b>Detail</b>	<b>Duration</b>	<b>Resource &amp; responsibility</b>
<b>Identify RF Hardware</b>		2 days	
	RF survey		Hardware vendor
	Design overall hardware configuration		Customer, WMSS Projects
	Order equipment		Customer
<b>Configuration/ consultancy</b>		3 days	
	Identify existing/ proposed business processes		WMSS Projects, Customer
	Business process document		WMSS Projects, Customer
	Present – process overview		WMSS Projects, Customer
	Acceptance/gap analysis		WMSS Projects, Customer
	Configuration		WMSS Projects
<b>Interface (if any)</b>		2 days	
	Specify & agree interface requirements		WMSS Projects
<b>Installation &amp; commission</b>		7 days	
	Server available		Customer
	Remote access implemented		WMSS Technical/ Customer

(continued)

**Table 1.13** (Continued)

<b>Generic Project Plan – Warehouse Management System Implementation Plan for FZ Company</b>			
<b>Task</b>	<b>Detail</b>	<b>Duration</b>	<b>Resource &amp; responsibility</b>
	Install progress		WMSS Deployment
	Deploy standard WMS		WMSS Deployment
	Application, data, menus, scripts		WMSS Deployment
	Shutdown, truncate, back-up etc		WMSS Deployment
	Create deployment document for support		WMSS Deployment
	Data collection sheet		Customer
<b>Interface (if any)</b>		3 days	
	Develop & test interface		WMSS Devt, WMSS Projects
	Install		WMSS Deployment
<b>Training</b>		15 days	
	Training on full system		WMSS Trainer, Customer
	General guides – WMSS & Warehousing		WMSS Projects, Customer
	STP & datahub overview		WMSS Projects, Customer
	Basic data set-up		WMSS Projects, Customer
	Inbound processes		WMSS Projects, Customer
	Outbound processes		WMSS Projects, Customer

(continued)

**Table 1.13** (Continued)

<b>Generic Project Plan – Warehouse Management System Implementation Plan for FZ Company</b>			
<b>Task</b>	<b>Detail</b>	<b>Duration</b>	<b>Resource &amp; responsibility</b>
	In-house processes		WMSS Projects, Customer
	Train the users		Customer
	Change management		Customer
<b>Go-live preparation</b>		2 days	
	Create implementation plan		WMSS Projects, Customer
	Resourcing		WMSS Projects, Customer
	Determine & source necessary consumables		WMSS Projects, Customer
<b>Data entry support</b>		10 days	
	Locate and harvest static data		Customer
	Preliminary dynamic data		WMSS Projects, Customer
	Full data take-on		WMSS Projects, Customer
	Stock take pre go live		Customer
<b>Documentation</b>		1 day	
	Document revisions to user manual		WMSS Projects
<b>System live</b>		3 days	
	Go-live support		WMSS Projects

(continued)



**Table 1.13** (Continued)

Generic Project Plan – Warehouse Management System Implementation Plan for FZ Company			
Task	Detail	Duration	Resource & responsibility
	Project summary meeting		WMSS Projects, Customer
Project review meeting		1 day	WMSS Projects, Customer
Total project days		54 days*	WMSS Projects

\*The project management (49 days) simultaneously runs alongside these 54 days.

planned and specified. Often the WMS vendor can provide the subsystem, or you may prefer your IT supplier to provide the wireless network backbone and then the WMS vendor or hardware vendor provides the necessary equipment. Note that if you are considering a SaaS, the software will be run on the vendor’s server to which you will have remote access.

Pilot project

Set up a pilot project, either as a conference room pilot or ideally in the warehouse itself. Focus on one customer, one product group or one function, such as receiving. Create a test plan and continue to test to ensure that the system is operating as required and that operatives understand the system and are working optimally.

Start working out how you are going to do a ‘data take-on’, i.e. all the data you need to start and run the system, including locations, location maps, product codes, product details, pallet sizes and configurations. A lot of these data can come from your ERP system if present. You can construct spreadsheet templates to compile them. You also need to start planning the ‘rules’ within the warehouse, for example put-away rules, replenishment rules, FIFO, LIFO, etc. If you are moving into a warehouse with existing stock, consider how you are going to label and record this stock.

Remember that you are testing for failure as well as testing for success. This is an ideal opportunity to test the interfaces to external systems; interface testing invariably takes longer than planned.



Ensure that you train the trainers or super users and then cascade the training down to the users; this way, you will build your own in-house expertise.

## Going live

The go-live stage needs to be planned carefully. Go live can be a ‘big bang’ or can be phased, according to the nature of your operation. You are likely to need extra personnel during this period. Budget very carefully for the on-site support you may need from the WMS vendor; costs can escalate in this area, particularly for out-of-hours, evening and weekend support. It is likely that your performance levels will be low to start with until the operation has moved up the learning curve; for this reason it is best to go live during a quiet period if possible, although ensure that your key personnel are not on holiday at this time.

## *In summary*

As with all system projects, and indeed projects in general, the more you plan and prepare, the better your results will be. The old adage is ‘Fail to plan, plan to fail’. Supplier selection is the crux of a successful project, along with good project management and good project ownership. Obal (2007) says that during implementation the following have to be avoided:

- establishing an unrealistic implementation schedule;
- buying a low-end system and expecting high-end results;
- failing to track vendor progress;
- failing to develop a contingency plan;
- overselling the system to users;
- lack of system integration training;
- providing the software vendor with faulty, incomplete or out-of-date data;
- thinking a newly integrated WMS will eliminate all inefficiencies within the operation;
- blaming the WMS provider for glitches that occur during the software’s initial launch;
- failing to audit the results to see if the system is working as efficiently as possible.

(Adapted from JDA and a white paper written by Stephen Cross and reproduced with his permission.)

## Further information

For additional information visit [www.blueyonder.com](http://www.blueyonder.com) (archived at <https://perma.cc/82HA-V95K>)

## Reference

Obal, P (2007) *Selecting Warehouse Software from WMS & ERP Providers – Expanded Edition: Find the best warehouse module or warehouse management system*, 2nd edn, Industrial Data & Information Inc. IDII

# 1.21 Warehouse maturity scan, by Jeroen van den Berg

## Introduction

This tool enables companies to assess the maturity of their warehouse operations (an introduction to maturity models is given in tool 4.7). The model comes from *Highly Competitive Warehouse Management* by Jeroen van den Berg (2012). In his book he makes a distinction between four phases of warehouse maturity:

- Phase 1 – *Reactive*. The warehouse is not well structured.
- Phase 2 – *Effective*. Processes are streamlined with more transparency in the operation.
- Phase 3 – *Responsive*. Processes are better planned and controlled by the use of intelligent IT.
- Phase 4 – *Collaborative*. The warehouse is an equal partner in the supply chain and generates more added value.

## When to use

The scan can be used to assess the maturity of a distribution centre.

## How to use

The assessment requires answers to 18 specific questions about your current warehouse operation. The four answers to each question represent an increasing level of sophistication. If you believe that your operation ranks in between two answers, you should select the lowest answer; for example, if your distribution centre almost meets the requirements of answer c but not completely, then choose answer b.

### Example question

Are the processes in the distribution centre formally specified?

- a** No, we do not have standard operating procedures.
- b** Somewhat, we have specified our processes, but they are somewhere in a drawer and/or outdated.
- c** Yes, we do have up-to-date standard operating procedures, which are being actively followed by operators.
- d** Yes, we do have up-to-date standard operating procedures, which we use for process analysis and for the instruction and operational management of operators. A comprehensive maturity model can be completed online at <https://www.jvdbconsulting.com/en/warehouse-maturity-scan/>. A full supply chain maturity scan can be completed at <https://www.jvdbconsulting.com/en/supply-chain-maturity-scan/>

## Reference

van den Berg, J P (2012) *Highly Competitive Warehouse Management: An action plan for best-in-class performance*, Management Outlook Publishing, Utrecht, Netherlands

## 1.22 Warehouse risk assessments

### Introduction

Warehouses, like any industrial facility, can be dangerous places to work in, especially with the movement of forklift trucks, the risk of slips and trips, and people working at height. So, to ensure a safe and secure environment,

companies need to undertake risk assessments regularly. (A full description of risk assessment is included in tool 4.12.) Note that:

- a *hazard* can be anything – whether work materials, equipment, work methods or practices – that has the potential to cause harm;
- a *risk* is the chance, high or low, that somebody may be harmed by the hazard.

The following are potential risk areas:

- falls from height;
- slips, trips and falls;
- manual handling;
- falling objects;
- operation of MHE;
- operation of other machinery;
- traffic movements;
- portable electrical equipment;
- lighting;
- hazardous substances; and
- fire.

## ***When to use***

To ensure the safety of all visitors to, and staff working in, a warehouse.

## ***How to use***

The guiding principles that should be considered throughout the risk assessment process can be broken down into a series of steps:

- Step 1: Identifying hazards and those at risk.
- Step 2: Evaluating and prioritizing risks.
- Step 3: Deciding on preventive action.
- Step 4: Taking action.
- Step 5: Monitoring and reviewing.

As can be seen in the risk assessment form in Table 1.14, it is essential that there is a suitable person responsible for the action to be taken, and that a

**Table 1.14** Example risk assessment for the warehouse

Location		Date:		Assessor:		
What are the hazards?	Who might be harmed and how?	What are you already doing?	What further action is necessary?	Action by whom?	Action by when?	Completed?
Falls from height	Staff can suffer severe or even fatal injuries if they fall while climbing racking	All staff are given instructions never to climb racking – monitored by supervisors	Signage put in place to reiterate the point	Warehouse manager	01/03/20–	Yes 01/03/20–
	Staff or contractor could suffer severe or fatal injuries falling through fragile roof lights when effecting repairs	No controls in place	<ul style="list-style-type: none"> <li>Put up ‘fragile roof’ signs on each side of the building and at access points</li> <li>Only trained contractors to access the roof</li> <li>Full risk assessment to be undertaken by contractor</li> </ul>	Facilities manager (FM)  FM  FM/ Contractor	01/03/20–  02/04/20–  As required	Yes 8/02/20–  No
Slips, trips and falls	All staff may suffer sprains or fractures if they trip over debris or slip on spillages	<ul style="list-style-type: none"> <li>Flooring kept dry and quality maintained</li> <li>All staff trained to maintain good housekeeping standards</li> </ul>	<ul style="list-style-type: none"> <li>Suitable absorber to be made available for liquid spills</li> <li>Extra bins provided for waste</li> </ul>	FM	25/02/20–	24/02/20–
				FM	25/02/20–	24/02/20–

target date is set for completion. We have completed part of the form as an example. The form can be downloaded from <http://howtologistics.com>, discount code **lsct2024**.

### ***Further information***

<https://osha.europa.eu/en/tools-and-publications/oira> (archived at <https://perma.cc/KG72-U48B>)

<http://www.hse.gov.uk/risk/> (archived at <https://perma.cc/4K6F-KB5E>)

<http://www.hse.gov.uk/toolbox/index.htm> (archived at <https://perma.cc/NVN6-7DEJ>)

[https://www.osha.gov/Publications/3220\\_Warehouse.pdf](https://www.osha.gov/Publications/3220_Warehouse.pdf) (archived at <https://perma.cc/E3Z7-BW3P>)

## **1.23 Contingency planning for the warehouse**

The Covid-19 pandemic highlighted the need for a contingency plan or business continuity plan.

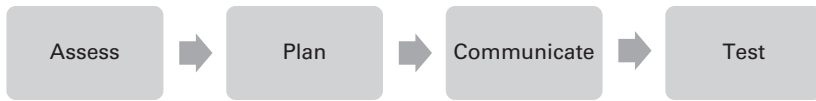
Many companies will have plans in place for certain eventualities; however, you cannot cover everything. The Covid pandemic was an example of this.

Natural disasters such as hurricanes, tornadoes, floods etc together with labour issues, system failures and supplier problems can all have a significant impact on your warehouse operation.

Contingency planning assists companies to minimize the impact of these disruptions in order to maintain operational continuity and recover more quickly.

An explosion close to an ASOS warehouse resulted in the company being out of action for six weeks. A fire at another of their warehouses a few years later resulted in a quicker recovery, having instigated a robust contingency plan.

According to Kyle Krug from Legacy Supply Chain there are three steps to creating a robust warehouse contingency plan. I have added a fourth – Test.

**Figure 1.14** Contingency Plan Steps

## ***When to use***

Contingency plans should be in place for an existing warehouse operation and need to be reviewed regularly. New warehouses should also be risk assessed and a contingency plan drawn up.

## ***How to use***

### **Step 1 - Assess**

The first step to create an effective contingency plan is to perform a risk assessment within your warehouse (see tool 1.22).

Start by mapping out business-critical processes, procedures, technologies and personnel to create a foundation for the plan. Next imagine various worst-case scenarios and formulate a response for each.

Ensure you have an up-to-date contact list for emergency services and other stakeholders.

### **Step 2 – Plan**

Once the risk assessments have been completed the contingency plan can be formed. Irrespective of the likely disruption, every warehouse contingency plan should outline the following:

- **Specific triggers.** These dictate what will set your plan in motion.
- **Response strategy.** Your plan should include a brief overview of how your warehouse staff should respond to the situation at hand.
- **Key roles and responsibilities.** Clearly define who is responsible for enacting different parts of the plan and what is expected of them. Include a substitute to cover for absence.
- **Leadership depth and training.** Continuous training and cross-training efforts within the warehouse will prove an invaluable time investment should disaster strike.



**Table 1.15** Emergency contacts

Position	Name/Company	Phone	Email
Plan coordinator			
Emergency services			
Power company			
Telecoms provider			
Water company			
IT systems provider			
MHE supplier			
Suppliers (planned inbound deliveries)*			
Customers (planned outbound deliveries)*			
Transport companies (planned inbound/outbound deliveries)			
Other			
Insurance company			

\***NOTE** You will need access to those customers and suppliers who will be affected in the immediate future

- **Technology.** One of the most critical elements of any warehouse contingency plan is a thorough schematic of all technology systems such as warehouse management systems, warehouse control systems, labour management and timekeeping systems, enterprise resource planning systems and transportation management systems – as well as the systems they connect to.
- **Labour.** Another critical element of a warehouse contingency plan is to have labour providers and staffing agencies able to react quickly to your call.
- **Timeline.** Explain to your employees when each step of your contingency plan should take place – for example, whether an action needs to occur within the first hour of the plan being implemented or the first day.

- **Alternative work schedules.** Certain emergency scenarios, such as Covid-19, will require you to drastically reduce the number of on-site employees. Build alternative work schedules into your warehouse contingency plan to ensure that all of your business-critical operations are completed, even with a reduced workforce.
- **Remote work arrangements.** If there's anything the Covid pandemic has taught us, it's that every business – even warehousing – needs to have a plan in place for remote work arrangements. Your warehouse contingency plan should detail which workers are considered essential and which ones can work from home; be sure to provide the necessary resources and equipment to help remote workers get set up.
- **Attendance requirements.** When creating your warehouse contingency plan, be sure to include information about attendance requirements and expectations, and policies to address these concerns.
- **Payment and benefits information.** Similar to attendance, depending on the nature of the emergency, your employees may have concerns about payment and benefits. Take care to include specific information about both in your warehouse contingency plan.
- **Corporate responsibility.** For more high-risk scenarios, it's important that you demonstrate to your staff that your organization is taking the necessary precautions to ensure their safety. Provide detailed explanations of workplace safety protocol, as well as offering a point of contact who can field employee questions or concerns.
- **Evacuation plans.** In some situations – say, a flood or a fire – it may be necessary to evacuate your staff from the warehouse. To accommodate for this possibility, your contingency plan should include specific instructions on how to proceed, as well as clearly outline an evacuation route.
- **Communication models.** It's important that your contingency plan maps out a structured flow of communication, and that you have prepared message templates. This is imperative not only for internal communications, but also for potential external communication should the situation attract media attention. Having someone who has had media training is also a good idea.

## Step 3 – Communication

You need to clearly communicate your plan to all levels of your business.

The best way to do this is to start by determining the different groups within your warehouse. For example, your site leadership team might consist of a facility manager, an HR manager, an operations manager and various supervisors. This group should be separate from your senior leadership team, which might consist of VPs and C-suite executives and your warehouse staff.

The next step is to create a tiered chain of communication so that individuals in leadership positions have a clear understanding of whom they're responsible for delivering information to.

There needs to be documentation that your employees can easily access and can refer to for guidance. An employee FAQ that your staff can refer to if they have additional questions about your contingency plan is a good idea.

Ensure that all new employees are aware of the plans.

Copies of the plan should be stored in various places including off-site.

Ideally, your warehouse contingency plan communication effort should be multi-faceted so that messaging is consistently reinforced. This can also include face-to-face meetings and videoconferencing.

An important note: these should be considered living documents and regularly updated with new information to ensure accuracy, e.g. changes in contact details etc.

Having an established business continuity committee that meets at least annually to review and update plans and responsibilities is advised.

You should communicate your organization's contingency plan to warehouse staff well in advance of an actual emergency. There's really no way to accurately predict when disaster might strike, so it's important that your employees are prepared, no matter what.

## Step 4 – Test

Contingency planning and business continuity are all about preparation and diligence. Creating mock scenarios in which key staff are required to activate certain elements of your contingency plan can prove invaluable should you ever have to actually enact it. From practising technology fails, to being able to pick and process orders manually, to moving large groups of people to a safe area, there are any number of ways to practise your warehouse contingency plan ahead of time in a controlled environment.

Finally, having a qualified third party to evaluate your plan is also advised.

## Further information

Thanks to Kyle Krug, Director of Corporate Solutions for Legacy Supply Chain for this tool.

A warehouse contingency plan template can be downloaded from <https://legacyscs.com/warehouse-contingency-plan-template/> (archived at <https://perma.cc/7QW9-K9C6>)

## 1.24 How to 'green' your warehouse and save energy

### Introduction

In recent years environmental issues have come to the fore, both at home and at work, with corporate social responsibility (CSR) initiatives concentrating on the environment, waste, health and safety, and the local community. The introduction of these initiatives does not have to cost the earth. In the majority of cases there are grants and significant opportunities for cost saving as well as the resulting reduction of the company's impact on the environment.

The following list provides warehouse managers with ideas on how to reduce their impact on the environment and thus help companies achieve their CSR targets and save energy:

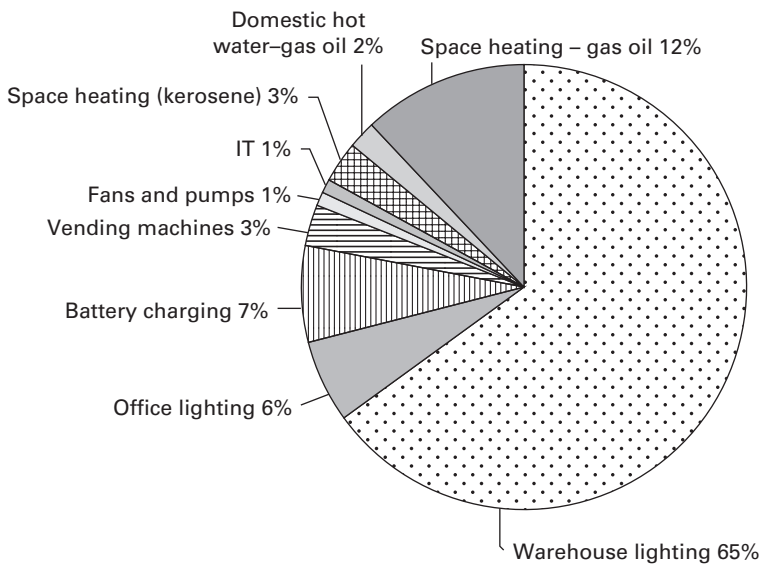
- Lighting in a non-automated warehouse can be up to 70 per cent of the total energy costs. Ways to reduce lighting costs are as follows:
  - introduce energy-efficient lighting;
  - switch off all non-essential lighting out of business hours;
  - install movement sensors and timers;
  - introduce and regularly clean skylights and clerestory windows to increase the use of natural light;
  - switch off lights when daylight is sufficient;
  - turn off external lights when daylight is sufficient;
  - switch off office lights on exit or introduce motion sensors.
- Use of alternative energy production methods:
  - solar panels;
  - wind turbines;
  - biomass boilers.

- Heating/air conditioning can make up 15 per cent of a warehouse's energy costs:
  - use zoned and time-controlled thermostats that are set accurately (a 1 per cent reduction in temperature on the thermostat can reduce heating bills by 8 per cent);
  - experiment with switch-on times for heating and air conditioning and switch off well before close of business;
  - ensure hot water supply is sized in relation to site occupancy.
- Install time controls on equipment that is not required after close of business, such as vending machines.
- Use of natural ventilation systems:
  - use ventilation stacks;
  - use atria and automatic window openings combined with automatic control systems;
  - use passive cooling such as breathable walls;
  - use the effective thermal mass of buildings to reduce cooling and ventilation energy.
- Cooling the warehouse can also increase energy costs:
  - introduce sunlight reflectors;
  - use mobile air handling units;
  - switch off equipment when not in use;
  - ensure all doors have sufficient seals to prevent air and water entry.
- Make better use of resources:
  - rainwater collection for reuse in vehicle washing, flushing toilets, etc;
  - low water use in sanitary appliances;
  - check insulation levels and increase where practical and cost-effective;
  - reuse or recycle where feasible and cost-effective;
  - move to utilizing plastic totes/bins in place of cardboard;
  - utilize plastic or aluminium pallets;
  - use of gas, electric or hybrid forklift trucks;
  - in-rack charging for narrow aisle trucks and shuttle systems.
- Movement reduction within the warehouse to reduce energy consumption:
  - use of ABC analysis (see tool 1.3) to ensure that popular items are placed close to the dispatch area.

- Kinetic-energy plates positioned on the access road to produce power from vehicles entering and leaving the site.
- Introduce car-sharing schemes for staff.
- Encourage staff to walk or cycle to work or take public transport.
- Introduce training in green initiatives such as fuel-efficient driving.
- Source materials locally, such as packaging, paper, MHE, etc.
- Continually assess the situation by walking around the warehouse at various times during operating hours.
- Plant trees and shrubs to assist with the removal of emissions.
- Finally, ensure that your warehouse is operating effectively – no unnecessary movements, accurate picking and dispatch and effective utilization of space and packaging materials.

In the UK, the Carbon Trust Implementation Services provide expert support to warehouse and logistics companies that are looking to cut energy costs by implementing new lighting or heating equipment (see Figure 1.15 for its figures on energy usage in an SME warehouse). The new service introduces warehouses to established suppliers of energy-efficient equipment that are accredited by the Carbon Trust. It helps warehouse companies

**Figure 1.15** Energy usage in an SME warehouse



**SOURCE** Carbon Trust 2013. Reproduced with permission

obtain a set of high-quality proposals and competitive quotes for an energy efficiency project. The Carbon Trust delivers value to warehouses through energy efficiency:

- It helps warehouses develop a compelling business case for an energy efficiency project – demonstrating a proven ROI. <https://www.carbontrust.com/news/2012/08/making-the-business-case-for-energy-efficiency/>
- The Carbon Trust provides affordable financing packages for new equipment and projects that are designed to pay for themselves. <https://www.carbontrust.com/client-services/programmes/finance/>
- The Carbon Trust also provides tools for measuring, managing and reducing carbon emissions and energy costs. <https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/>

## ***Further information***

Other initiatives include being part of Voluntary Sustainable Building Award schemes such as:

- BREEAM (Building Research Establishment Environmental Assessment) – UK: [www.breeam.com](http://www.breeam.com) (archived at <https://perma.cc/8TSH-K8XV>)
- LEED (Leadership in Energy and Environment Design) – United States: [www.usgbc.org](http://www.usgbc.org) (archived at <https://perma.cc/PBP8-CYJ7>)
- Greenstar – Australia <https://new.gbca.org.au/> (archived at <https://perma.cc/B9EA-UMLG>)
- CASBEE (Comprehensive Assessment System for Built Environment Efficiency) – Japan: <http://www.ibec.or.jp/CASBEE/english/index.htm> (archived at <https://perma.cc/4Z5E-UQL2>)

## ***References***

<http://www.carbontrust.com/> (archived at <https://perma.cc/79JE-9KUL>)  
[www.ukwa.org.uk](http://www.ukwa.org.uk) (archived at <https://perma.cc/H8SR-2TVZ>)

## **1.25 Hazardous packaging and labelling**

The consignor/supplier is responsible for ensuring that packaging of hazardous items conforms to the regulations for the product. The packaging can

vary from a cardboard box or paper bag for low-risk powders in small quantities to very sophisticated double-skinned stainless-steel packages for more complex high-risk products.

To promote the safe storage and transportation of dangerous goods, an international system of classification has been introduced (the UN Classification System). Examples are:

- UN1263: Paint or paint-related materials
- UN1498: Sodium nitrate
- UN1500: Sodium nitrite

An up-to-date list can be found at <https://bit.ly/3K3KMXu>

The system divides the different types of dangerous goods into classified groups, each group identified by a code marking. There are nine classes, some with divisions, as shown in Table 1.16.

In general, the package needs to be UN approved and compatible with the product. For every UN number there is a list of packaging options available to the packer.

All over the world there are different laws on how to identify the hazardous properties of chemicals (called ‘classification’) and how information about these hazards is then passed to users (through labels and safety data sheets for workers). This can be confusing because the same chemical can have different hazard descriptions in different countries; for example, a chemical could be labelled as ‘toxic’ in one country but not in another. This also acts as a barrier to international trade.

Given the expanding international market in chemical substances and mixtures, to help protect people and the environment and to facilitate trade, the United Nations has developed a Globally Harmonized System (GHS) on classification and labelling. The GHS is a single worldwide system for classifying and communicating the hazardous properties of industrial and consumer chemicals. GHS sits alongside the UN Transport of Dangerous Goods system. The GHS is not a law – it’s an international agreement. To make the GHS legally apply, each country or bloc of countries must adopt the GHS through legislation. EU Member States agreed to adopt the GHS across the EU through a direct-acting Regulation, the European Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of substances and mixtures. This is also known as the CLP Regulation or just CLP. This will finally lead to a reduction in the regulatory burden on manufacturers, which currently have to struggle with many different systems of classification depending on the countries they manufacture in and export to. Figure 1.16 shows the new pictograms.












**Table 1.16** Hazardous classes

Class	Type of material
1	Explosive substances and articles
1.1	Mass explosion hazard
1.2	Projection hazard only
1.3	Fire hazard and minor blast or minor projection hazard
1.4	Minimal hazard
1.5	Blasting agents
1.6	Very insensitive detonating articles
2	Gases
2.1	Flammable gas (e.g. butane)
2.2	Non-flammable and non-toxic gases that could cause asphyxiation (e.g. nitrogen, helium, carbon dioxide) or oxidizers (e.g. oxygen)
2.3	Toxic gases (e.g. chlorine, phosgene)
3	Flammable liquids (e.g. lighter fluid, petrol)
4.1	Flammable solids, self-reactive substances and solid desensitized explosives
4.2	Substances liable to spontaneous combustion
4.3	Substances which, in contact with water, emit flammable gases
5.1	Oxidizing substances
5.2	Organic peroxides
6.1	Toxic substances
6.2	Infectious substances
7	Radioactive material
8	Corrosive substances
9	Miscellaneous dangerous substances and articles

## Further information

- UK – <http://www.hse.gov.uk/chemical-classification/legal/background-directives-ghs.htm> (archived at <https://perma.cc/PX3T-2XY6>)
- United States – <https://www.osha.gov/dsg/hazcom/pictograms/index.html> (archived at <https://perma.cc/T4SS-YR8Y>)
- EU – [https://ec.europa.eu/growth/sectors/chemicals/classification-labelling\\_en](https://ec.europa.eu/growth/sectors/chemicals/classification-labelling_en) (archived at <https://perma.cc/75ZG-ZJ5F>)

**Figure 1.16** GHS pictograms

GHS Pictograms and Hazard Classes		
		
<ul style="list-style-type: none"> <li>• Oxidizers</li> </ul>	<ul style="list-style-type: none"> <li>• Flammables</li> <li>• Self Reactives</li> <li>• Pyrophorics</li> <li>• Self-Heating</li> <li>• Emits Flammable Gas</li> <li>• Organic Peroxides</li> </ul>	<ul style="list-style-type: none"> <li>• Explosives</li> <li>• Self Reactives</li> <li>• Organic Peroxides</li> </ul>
		
<ul style="list-style-type: none"> <li>• Acute toxicity (severe)</li> </ul>	<ul style="list-style-type: none"> <li>• Corrosives</li> </ul>	<ul style="list-style-type: none"> <li>• Gases Under Pressure</li> </ul>
		
<ul style="list-style-type: none"> <li>• Carcinogen</li> <li>• Respiratory Sensitizer</li> <li>• Reproductive Toxicity</li> <li>• Target Organ Toxicity</li> <li>• Mutagenicity</li> <li>• Aspiration Toxicity</li> </ul>	<ul style="list-style-type: none"> <li>• Environmental Toxicity</li> </ul>	<ul style="list-style-type: none"> <li>• Irritant</li> <li>• Dermal Sensitizer</li> <li>• Acute toxicity (harmful)</li> <li>• Narcotic Effects</li> <li>• Respiratory Tract</li> <li>• Irritation</li> </ul>

**SOURCE** reproduced from United States Department of Labor (nd)

Reproduced from <https://www.osha.gov/dsg/hazcom/index.html> (archived at <https://perma.cc/SLV7-28EN>)

- Details regarding hazardous goods transportation can be found in tool 2.11.
- <https://www.uk.dsv.com/air-freight/hazardous-air-cargo/The-9-Classes-of-Dangerous-Goods> (archived at <https://perma.cc/PZY9-LVXY>)

## Reference

United States Department of Labor (nd) *A Guide to The Globally Harmonized System of Classification and Labelling of Chemicals (GHS)*, Occupational Safety and Health Administration, Washington, DC, <https://www.osha.gov/dsg/hazcom/ghsguideoct05.pdf> (archived at <https://perma.cc/3S7N-YT33>)

## 1.26 Automatic identification (autoID)

### Introduction

Automatic identification methods have made a great difference to accurate visibility of inventory in the supply chain. The most common methods in use in supply chains are 1D (one-dimensional) and 2D (two-dimensional) barcodes, and radio frequency identification (RFID).

Clearly, it is much quicker to read a barcode or RFID tag than to enter a 10- to 20-digit product identity on a keyboard. However, it is the accuracy of such an operation that makes the big difference. Studies indicate that a trained keyboard operator will make an average of one mistake per 300 keystrokes. In contrast, the worst accuracy rate for barcode reading is approximately one error per 300,000 readings, but may be as low as one error per 10 million operations for certain types of barcode.

Since barcode labels are easily affixed or can be directly printed onto virtually any material (mailing tubes, envelopes, boxes, cans, bottles, packages, books and more), they are the most cost-effective and accurate solution for capturing data.

### When to use

Barcodes and RFID systems are used to allocate identities to materials and products with a unique identity per SKU. Anybody can implement a barcoding or RFID system in their own operation for items in the warehouse

or to track production orders through the factory, for example. Note, however, that if you want these identities to be recognized outside your business, they must be registered with a national body, thus ensuring that the identity is unique in the world.

## ***How to use***

The first stage of an autoID project is to be clear about why you want to implement barcodes, and what benefits you are expecting. Different barcoding and RFID systems exist. In this section we will concentrate on 1D and 2D barcodes.

When barcodes are used on a widespread public basis, such as printed on an internationally sold item, it is important to register the symbology to protect the data, especially from product/code copiers. However, if the barcode is for in-house use, it does not need to be registered. Registering a barcode is a simple process that can be performed through third-party online sites or through barcode global organizations such as GS1.

All symbologies have some limitations on the number (size) and type of characters that can be encoded (set). Barcodes can encode numeric only, alphabetical only or alphanumeric character sets. The values of these digits are determined by standards managed by GS1, Global Standards One, formerly known as the Uniform Code Council (UCC) in the United States and EAN International in the rest of the world. GS1 is now the single worldwide origination point for UPC and EAN numbers. Table 1.17 lists the different types of barcodes and their typical applications.

Two-dimensional (2D) barcode symbologies contain information in both the X and Y axes of the symbol. In other words, there are different data encoded in the horizontal and vertical dimensions of the code. To properly decode the data, a scanner must read the entire symbol, in both dimensions simultaneously. This can be done by sweeping the scan line (in the case of a laser or linear imaging scanner) over the symbol, or by using a 2D-array-equipped scanner, which acts as a camera. Since the data can be stored in two dimensions, 2D barcode symbologies allow vast amounts of data to be stored.

There are two kinds of 2D barcode symbologies: stacked codes and matrix codes. Stacked codes consist of multiple layers of linear barcodes and matrix codes encode data using cells within a matrix. Examples of stacked codes are shown in Table 1.18 and matrix codes in Table 1.19.

**Table 1.17** Types of barcode and application

Barcode	Application
EAN – 13	Character Set: Numeric only; Character Size: 13 fixed-length; Fault Tolerance: High; Application: International retail and grocery standard (Europe)
UPC – A	Character Set: Numeric only; Character Size: 12 fixed-length; Fault Tolerance: High; Application: Retail and grocery standard (United States)
AN – 8	Character Set: Numeric only; Character Size: 8 fixed-length; Fault Tolerance: High; Application: Small packages in retail (Europe)
UPC – E	Character Set: Numeric only; Character Size: 6 fixed-length; Fault Tolerance: High; Application: Small packages in retail (United States)
Code 128	Character Set: Alphanumeric (uppercase/lowercase), punctuation, controls; Character Size: Any; Fault Tolerance: High; Application: Best for full ASCII character set
Code 39	Character Set: Alphanumeric (uppercase only), punctuation; Character Size: Limited by reader; Fault Tolerance: High; Application: Military, government
GS1 DataBar Omnidirectional	Character Set: Numeric only; Character Size: 14 fixed-length; Fault Tolerance: High; Application: GTIN in small format
GS1 DataBar Expanded	Character Set: Numeric only; Character Size: Variable-length; Fault Tolerance: High; Application: GTIN, applications in ID fields
GS1 – 128	Character Set: Alphanumeric; Character Size: Variable-length; Fault Tolerance: High; Application: Many uses in supply chain: lots, containers, batches, retail
MSI/Plessey	Character Set: Numeric only; Character Size: 3–16 fixed-length; Fault Tolerance: High; Application: Grocery
Code 32	Character Set: Numeric only; Character Size: 8 digit (plus one check character) fixed-length; Fault Tolerance: High; Application: Pharmaceutical industry (Italy)

**Table 1.18** Stack codes

Stack codes	Application
PDF 417	Character Set: Alphanumeric (uppercase/lowercase), punctuation, controls; Character Size: Variable-length; Fault Tolerance: High; Application: Driver licences, transportation, inventory management, government
Codablock F	Character Set: Numeric only; Character Size: Up to 5,450 characters variable-length; Fault Tolerance: High; Application: Healthcare

**Table 1.19** Matrix codes

Matrix codes	Application
Data Matrix	Character Set: Alphanumeric, uppercase/lowercase letters, punctuation, controls; Character Size: Up to 2,335 characters fixed-length; Fault Tolerance: High; Application: Marking small items, printed on labels and letters, industrial engineering for marketing components
QR Code	Character Set: Alphanumeric, uppercase/lowercase letters, punctuation, controls, includes Kanji characters; Character Size: Up to 7,000 numeric characters or 4,296 alpha characters variable-length; Fault Tolerance: High; Application: Automobile manufacturing, mobile phone codes

## Further information

AIM Global – [www.aimglobal.org](http://www.aimglobal.org) (archived at <https://perma.cc/KB3X-Y2W6>)

GS1 The Global Language of Business – <http://www.gs1.org/> (archived at <https://perma.cc/9U6Z-4PGA>)

Ten Steps to Barcode Implementation – <http://www.gs1.org/barcodes/implementation> (archived at <https://perma.cc/GPR4-AL3M>)

Global Electronic Party Information Register (GEPIR). GEPIR is a distributed database that contains basic information on over 1,000,000 companies in over 100 countries. You can search by GTIN (includes

UPC and EAN –13), SSCC and GLN numbers or by company name in some countries – <http://gepir.gs1.org> (archived at <https://perma.cc/9FK3-KAFQ>)

Barcoding for beginners and barcode FAQ – <https://www.barcodefaq.com/barcoding-for-beginners/#barcode-Accuracy> (archived at <https://perma.cc/29XH-XCUK>)

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## 1.27 Setting up ‘Go / No Go’ decision criteria in logistics projects

### *Introduction*

Confusingly, some of the most common reasons for failure in logistics change projects are a lack of clarity among stakeholders about what constitutes success, but also a failure to agree which elements of the project are critical to a successful outcome, and an understanding of what must happen if key milestones are not achieved.

In any major project, there may be many steps where a planned completion date is built into the overall project plan, but no key performance indicator (KPI) agreed for delivery of the action to be considered a success, and no agreement on what happens if that step is not successfully delivered in full and on time.

This is risky for the project team. Expectations will be high for a successful implementation of the project and any delay is unwelcome and difficult to explain internally unless the potential for, and implications of delay are discussed in advance. Most importantly, in many projects, there will be clear steps towards ramping up operations, often connected with changes elsewhere in the organization, such as transfer of suppliers to a new location, allocation of orders to the new location, starting a new delivery schedule.

All these changes (and many other examples depending upon the complexity of the project) impact on other areas of the organization and may have wider implications for those areas. An unexpected delay to a previously agreed plan may be met with anger and hostility, perhaps even with demands to continue with the plan irrespective of the issues that may cause

for the project. The ‘Go / No Go’ decision criteria is a tool to build understanding and consensus when critical elements do not go according to plan.

Not every line in a project plan requires a KPI to be agreed – the focus of this tool is primarily based upon a few ‘operational’ steps that are most important, or even critical, to the success of the project (although some other key areas are also listed below, under ‘Typical examples’).

This tool helps to identify and define those few steps in the project where ‘success’ criteria must be clearly delineated, fully understood and communicated widely. Equally importantly, if success criteria are not achieved, the implications for the next steps in the project are also clear and agreed in advance.

Let us take a specific operational example: ‘January 1st 20xx = First inbound receipt’. Assuming there is agreement in the project team that this is a critical milestone (see ‘How to use’ below), what constitutes success? Is it the actual arrival of a vehicle at the new facility? Is it the successful unloading of the cargo, or the completion of the process to check the received items, or the successful placing of stock into storage locations or the availability of the stock in the Warehouse Management system... clearly, there are many options.

The project team must consider which outcome is required to enable the project to move forward by understanding the impact of the milestone on the succeeding steps of the project. In our example, the target may not be achieved for a variety of reasons: the checking process for the received stock takes much longer than expected due to unfamiliarity; the storage locations for the received stock allocated by the system are not available; scanning of labels does not work; the system is not updated by the receipt process; communication between the WMS and the host system does not work; and so on – but the critical issue is that the milestone is not achieved and this has already been agreed as a requirement for further investigation and a potential delay in the plan.

Therefore, for each milestone to be considered a complete ‘Go / No Go’ indicator, the target for the milestone must be fully defined – so success of ‘First inbound receipt’ could be defined as the stock delivered on an inbound vehicle is successfully unloaded, put into storage and is available on the warehouse management system (WMS) within four hours of arrival.

For this example, a ‘Green’ outcome would be that the target is achieved as the stock received from an arriving vehicle is all available on the WMS within four hours of arrival.



An 'Orange' outcome is that the target is mostly achieved (for example, there is an issue with one item on a multi-item load, or the target is achieved after six hours rather than four) and the indications are that the issue can be fixed or there is an agreed 'workaround' for the problem (Note: 'workarounds' are a temporary fix to an issue – a full solution must be in preparation).

On the other hand, a 'Red' outcome identifies that the process is not working – and, crucially, that the project cannot continue until a 'fix' for the problem is found and tested. In this example, a 'Red' outcome could be that none of the stock was available on the WMS within four hours of arrival because the scanners did not function or there was stock in locations that were expected to be empty.

With either an 'Orange' or a 'Red' outcome, the project team needs to investigate the root cause and assess next steps and a realistic time scale for rectification – and achievement of the 'Green' outcome. No further critical steps should be activated until this investigation is complete and key stakeholders briefed.

## ***When to use***

The 'Go / No Go' tool should be used at four stages of a project:

- 1** After completing the overall project plan, select key points where the 'Green / Orange / Red' traffic light system can be used to define achievement of acceptable performance. Agree those key decision points at this early stage with the project Steering Committee.
- 2** Before operational activities start, define 'Green / Orange / Red' performance for each of the selected decision points and reach agreement on the implications of a 'red' or 'orange' outcome on the next project steps.
- 3** Shortly before each decision point is reached, review the criteria and revisit the implications of 'Red' and 'Orange' performance with the Steering Committee and key internal stakeholders.
- 4** After each decision point, update the Steering Committee and key stakeholders with news of the outcome and the agreed next steps. For an 'Orange' or 'Red' outcome, further communication will need to be planned.

## ***How to use***

- 1** Select key criteria for project (the template lists some common criteria, but these will need to be customized for every project – see next section for more examples).
- 2** Agree key criteria with Steering Committee and key stakeholders.
- 3** Create ‘Green / Orange / Red’ performance levels for each criterion.
- 4** Agree performance levels and outcomes with Steering Committee.
- 5** Re-brief before each decision point is reached.
- 6** Communicate the outcome of each decision point – including remediation activities and timescales if necessary.

## ***Typical examples of key criteria in different parts of a project***

- Building / construction (may be significant implications on overall timeline if building stages are not delivered on time).
- Approvals and permits; construction stage completions, building handover by developer; arrival of key materials for building fit out (e.g. steel for racking).
- Equipment (if lead times for equipment supply are not met, this may cause delay to overall project timeline).
- Arrival on site of equipment (mechanical handling, automation, robotics, IT hardware).
- Operational / functional testing of all new equipment on site.
- IT systems (there may be a complex ecosystem of interconnected systems that need to be tested in isolation but also in combination and from end to end):
  - Delivery and testing of hardware, including wireless network and servers.
  - Testing of external system connections (examples include connections from on-site servers with host ERP (enterprise resource planning) systems).
  - Testing of internal IT connections (such as middleware, servers, and warehouse execution systems (WES) for specific pieces of automation such as robots or shuttles).

- Health and safety:
  - Confirm that all safety processes are in place, tested and trained before new equipment or activity starts in any given area. Examples include ‘Working at Height’ training, training on use of forklift trucks, use of lorry / container immobilization tools before loading or unloading.
- Human resources (having insufficient or improperly trained staff may cause subsequent steps to be delayed):
  - Recruitment plan written identifying what people are needed at each project stage.
  - Training matrix written by roles and delivered according to agreed timetable.
  - Process mapping and ‘One Point Lessons’ available for all key tasks.
- Operational issues and delays (the most common area for critical failures at a late stage in any project – require clear agreement on what constitutes Green, Orange and Red performance levels).

Each physical process step from goods receipt, through put-away, to storage, to stock management, to order assembly, despatch and returns management (in the case of traditional warehouse activity), needs to be tested against the expected performance levels.

For example, if the operation is designed to receive orders by 17.00 for next day delivery (but orders are actually received by 19.00), or to assemble orders within an average of 5 minutes per item (but is actually taking 12 minutes), or is expected to retrieve 15 units per forklift per hour (but is actually retrieving 7 units per hour), it is not acceptable to proceed according to plan if the difference between achieved and expected parameters is neither understood nor fixable within a short time frame.

## Conclusion

A key benefit of this tool is for key stakeholders to acknowledge that, potentially, not everything in a project plan will go smoothly. Many operational elements in a project plan cannot be tested fully before they are deployed and a single line in a project plan (such as ‘receive first orders into WMS’ or ‘start storage automation’ or ‘commence inbound receipts’) hides a complex and not-fully tested interrelationship of systems, equipment and individuals. The key purpose of this tool is to enable achievement of agreed performance levels to drive project progress and for the implications of failure to achieve

**Table 1.20** Example of Go/No Go decision criteria

Description	Metric	Performance levels			Note: all figures are for indicative purposes only.
		Good. Continue with plan	Improvement plan required	Stop! Remedial plan required!	Explanation/Comments
Inbound	% of inbound receipts pre-advised to Warehouse Management System	>95%	80–95%	<80%	
Inbound	% of inbound pallets correctly labelled and readable by scanners	>75%	60–75%	<60%	
Inbound	% of receipts checked and on WMS within 2 hours of unloading	>95%	80–95%	<80%	
Putaway	% of received items placed into storage within 4 hours of arrival	>95%	90–95%	<90%	
Putaway	% of allocated putaway locations actually available	>99.5%	99–99.5%	<99%	
Storage	Number of damaged items as percentage of total items in stock	<0.1%	0.1–0.5%	>0.5%	
Storage	Number of inventory errors as percentage of total inventory checks	<1%	1.0–1.5%	>1.5%	

(continued)

**Table 1.20** (Continued)

Description	Metric	Performance levels			Note: all figures are for indicative purposes only.
		Good. Continue with plan	Improvement plan required	Stop! Remedial plan required!	Explanation/Comments
Automation	% of inbound items meeting automation conformance criteria	>90%	75–90%	<75%	
Automation	Max throughput of units per hour achieved by storage automation as % of design capacity	>99%	90–99%	<90%	
Order Assembly	Number of lines assembled per hour versus target	>95%	90–95%	<90%	
Order Assembly	Number of items assembled in error as % of total items assembled	<0.5%	0.5–1.0%	>1.0%	
Despatch	% of items loaded onto correct outbound delivery	>99%	95–99%	<95%	
Health and safety	Number of H&S incidents as % of total hours worked on site	<0.5%	0.5–1.0%	>1.0%	
Recruitment	% of target workforce employed and available	>99%	90–99%	<90%	
Sickness	% of total hours paid lost to sickness	<0.5%	0.5–1.0%	>1.0%	

a critical performance level to be understood and agreed by stakeholders in advance.

A failure to prepare for things to go wrong or to take longer than planned, followed by an expansion of activities according to the previously agreed plan, is a significant root cause of poor outcomes in logistics projects. Having an agreed 'fall back' position can provide breathing space for the project team to get things back on track by reducing pressure to keep to the original timeline.

Remember that there is no 'list' of the project steps to be chosen as 'Go / No Go' indicators. The list will vary from project to project. Some examples are given in the previous section. The focus should be on construction, procurement, operational and process steps that lead to a step change in the activities performed at the new site.

Equally, it is vital that the 'Go / No Go' indicators are chosen and agreed with the relevant stakeholders well before the relevant activities are about to take place. It is critical that the 'Red' and 'Orange' outcomes are communicated to, and understood by, stakeholders well in advance – when the discussion is theoretical – and not in the middle of a 'real life' issue.

## **Further information**

More details on using the template can be found in *Delivering Change: The art and science of successful change management in logistics* by Rod Turner, available on Amazon.

Rod Turner can be contacted via [www.rodturnerlogistics.co.uk](http://www.rodturnerlogistics.co.uk) (archived at <https://perma.cc/WM9H-6B43>)

## **1.28 Flow charts**

### **Introduction**

Flow charting is a method of recording work or business processes, or for explaining how to navigate through a series of decisions. There are many other methods for doing this, including techniques from method study, information systems analysis and business process re-engineering, to name a few. However, standard flow charting can be powerful and useful for improving work or business processes.

The basic flow-charting method uses symbols for operation or activity, decisions, the start and end points, and links to the next stage, either following immediately or elsewhere on the chart (see Table 1.21).



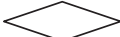


### When to use

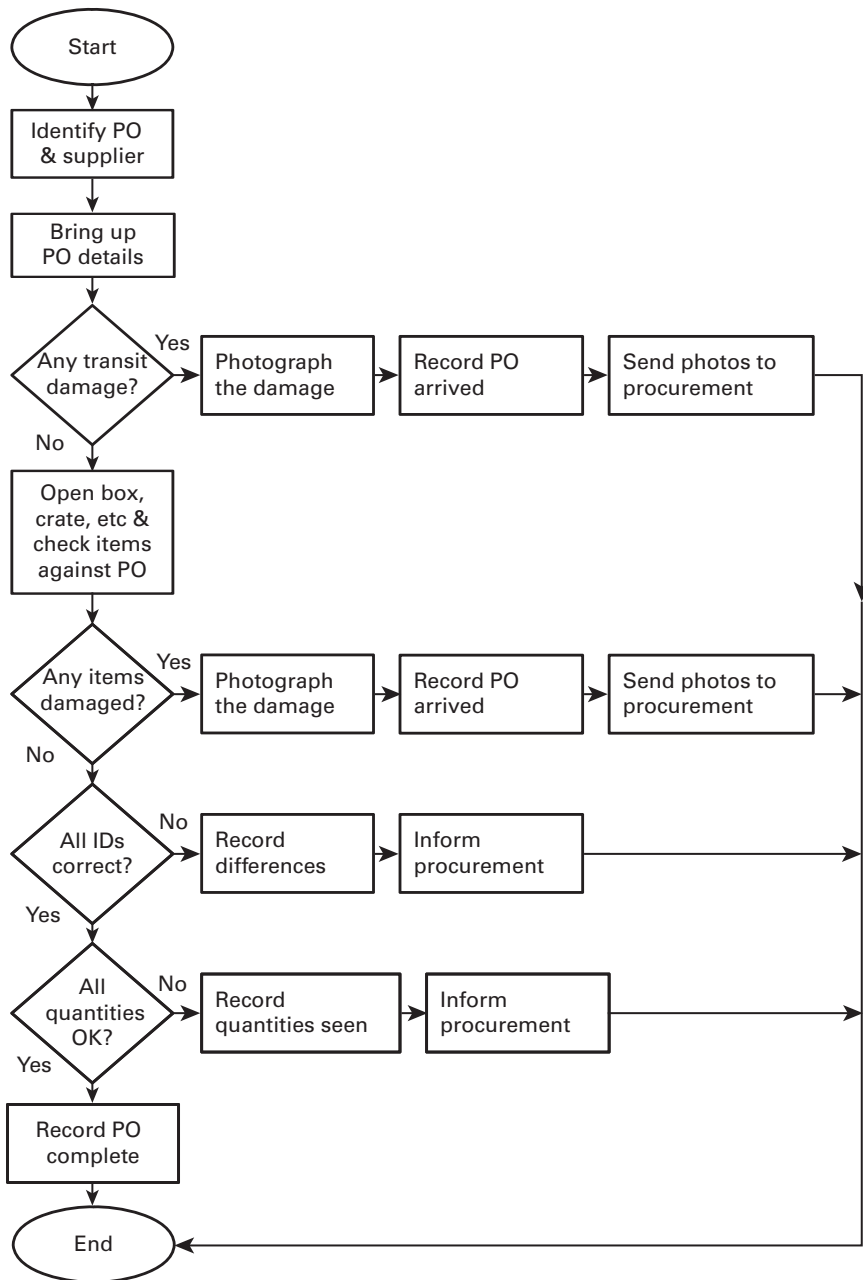
Flow charts are a good means of recording a current business process or ‘as-is’ situation that you want to analyse and streamline. When the new process is designed, the ‘to-be’ process, it can also be communicated as a flow chart. A flow chart can therefore be used as a communication tool for discussion leading to redesign, or for presenting or formalizing a work procedure.

### How to use

The most common method of creating a flow chart of a business process is for the person creating the chart to interview the person carrying out the business process. The interviewer makes notes or may sketch the activities as they are described. Later, the interviewer constructs the flow chart. Actually drawing out the flow chart can give rise to questions about the logic of the procedure or the sequence of activities, and it is often necessary to go back to the person carrying out the process to check the details. The process of constructing the final flow chart often offers ideas for improvement. The

**Table 1.21** Flow chart symbols

Symbol	Meaning	Rule for use
	Start or end	Make sure that there is only one start point and one end point in the diagram
	Operation (rectangle)	Multiple inputs are possible, but only one output
	Decision (diamond)	One input, multiple outputs (which must cover all eventualities, and with no overlapping between options)
	Arrow to next stage	Check that the arrow shows direction of flow
	Link to another part of the chart	Ensure that the link continues elsewhere, i.e. if there is an ‘A’ end point, there is also one ‘A’ start point somewhere else

**Figure 1.17** Flow chart for goods receiving



process chart can be shown to all involved and used as the basis for a discussion about potential improvements. Eventually, a 'to-be' process can be developed, tested and implemented. The flow chart thus becomes the reference document of 'what should happen' and for future checking of 'conformance to process'.

### **Example**

Figure 1.17 shows a flow chart for goods receiving. Note how the links ensure that there is only one start point and one end point, and a clear way through the chart ('PO' is purchase order).

### **Further information**

Obolensky, N (1996) *Practical Business Re-engineering*, Kogan Page, London

## **1.29 The PDCA tool**

### **Introduction**

The PDCA tool (Plan, Do, Check, Act) or Deming Cycle, named after W Edwards Deming, a business improvement and quality guru, is an approach to change and problem solving. The four phases in the cycle involve:

*Plan*: identifying and analysing the problem.

*Do*: producing and trying a potential solution.

*Check*: measuring how successful the test solution is and analysing whether it can be improved in any way.

*Act*: implementing the improved solution fully.

### **When to use**

The Deming Cycle or PDCA is an excellent, well-ordered, precise method for problem solving. It can be utilized in a number of areas such as:

- assisting in the implementation of Kaizen or continuous improvement practices, enabling the cycle to be repeated over and over as new areas for improvement are discovered and resolved;

- pinpointing new resolutions and improvements to processes and practices that are repetitive;
- investigating a range of possible new solutions to problems, evaluating and improving them before selecting the most appropriate for full implementation;
- avoiding the waste of resources that accompanies full-scale implementation of an average or deficient solution.

PDCA is a proven method for removing waste or inefficient cost in an operation, resulting in increased value. In our example below, Nissan Motor Parts (NMPC) uses PDCA as part of its continuous improvement process. It is in a competitive environment and needs to have high performance levels.

Nissan uses PDCA when examining larger change events that require more time and perhaps investment but are critical for the business performance. These are not in the gift of any one team, so require senior managers' support through active participation. They rely on data for objective root-cause analysis and for testing possible solutions before implementation. Projects tend to be more data intensive.

According to Nissan, the use of PDCA supports the development of leaders and team members by providing a place for people to work together and grow their skills for continuous improvement. It not only increases confidence in individuals but also develops a good spirit in the workplace. It becomes a place to apply individual expertise and a place to learn about the expertise of others by working cross-functionally in the supply chain.

Nissan uses it as a training opportunity and it becomes a place of ownership, i.e. when a group of people make a change for the better in their part of the business, they will implement the change and follow the standard operating procedure, which is the written record of the changed procedure.

A mutual respect grows among colleagues: 'If your colleague made the change you support that change when you are deployed in that task because you need your colleague to reciprocate.'

## ***How to use it***

The following is a case study example from Nissan Motor Parts UK. Figure 1.18 shows the model that Nissan uses.

Project title: Physical Picking Claims Improvement Project

**Problem:** NMPC receives dealer orders and then processes them in a manual picking process. When carrying out this task there is the risk of a team member in the supply process making a physical error resulting in a dealer claim and loss of value for the part. This is at a cost of £563,869 per year.

**Target:** A reduction of physical errors by 10 per cent equating to a reduction in claims value of £56,386 in total. This is equal to 1,007 physical error claims.

**Approach:** Use of PDCA and DMAIC (see tool 6.8).

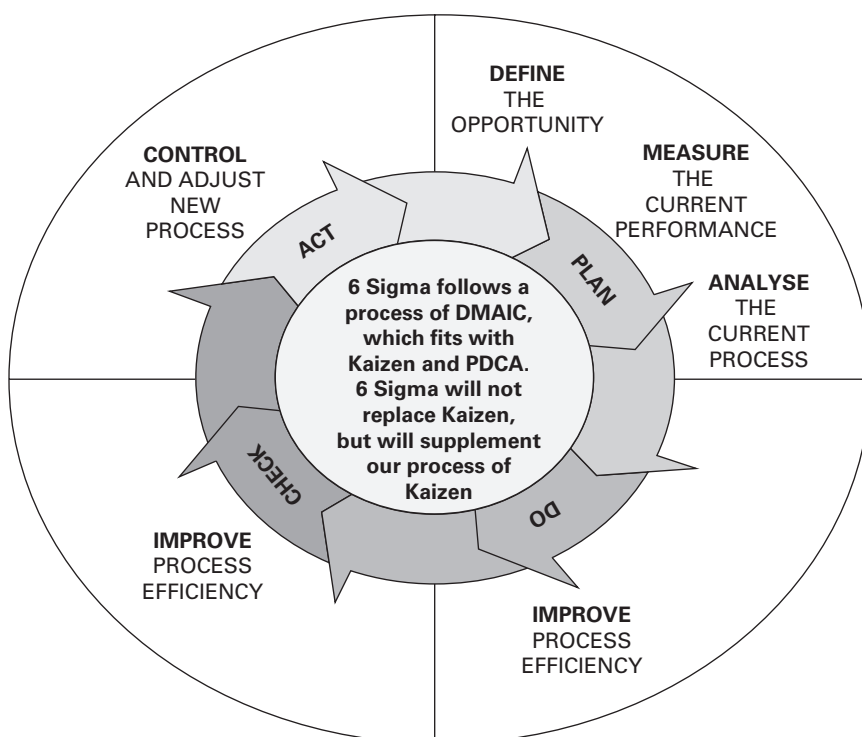
### Step 1. Plan (Define, Measure, Analyse)

Define the opportunity and set up a project team.

Undertake a stakeholder analysis (see Table 1.22).

Produce a communication plan (see Table 1.23).

**Figure 1.18** PDCA/DMAIC model produced by Nissan



**SOURCE** Reproduced by kind permission of Bruce Taylor, Nissan

**Table 1.22** Stakeholder analysis

Stakeholders' name and group	Project impact on stakeholder (SH) H/M/L	SH level of influence on success H/M/L	SH current attitude+ /0/-	Explanation of current SH attitude	SH score H=3, M=2, L=1, +=1,0=2, -=3	Action plan for SH
<b>Pickers</b>	H	H	+	Monetary reward and self-worth	7	Consult and involve at each step using skills
<b>TL</b>	H	H	+	Time back, morale of team, monetary reward, self-worth	7	Consult and involve at each step using skills
<b>Management</b>	H	H	+	KPI uplift, morale of team, monetary reward, self-worth	7	Consult and involve at each step for approval at gateway review
<b>Gatekeeper</b>	H	H	+	Time to focus elsewhere	7	Consult and involve at each step using skills
<b>Dealers</b>	H	L	+	Service improvement	5	Dealer conference

Key: SH – Stakeholder

TL – Team leader

H/M/L – High/Medium/Low

**Table 1.23**    Communication plan

Audience/to who	Media	Purpose	Topic of discussion/key message	Owner	Frequency	Notes/Status
Pickers	Visit teams in person to brief progress	Engage and prepare audience for coming changes gaining input	Intentions and plan to utilize skills of pickers	Team	25/03 then as required	Detail to be discussed to ensure ownership and involvement
TL	Face to face	Inform and encourage feedback	Intention and current status	Team	Launch and post gateway review	
Management	Face to face	Inform and encourage feedback	Intention and current status	Team	Launch and post gateway review	
Gatekeeper	Face to face	Recognize role	As per picker	Team	As all above	
Dealers	Conference/ intranet	Inform	Relay result of better service	Team	At finish	



The stakeholder analysis and the communication plan together form the engagement plan.

The group discussed the best methods to engage the stakeholders effectively and maintained this approach throughout the project. It was decided that the critical group of ‘pickers’ would be communicated to via a ‘road-show’ type of presentation. The use of the same presenting team and the opportunity to ask questions provide consistency and transparency.

This technique was employed from start to finish for both this project and the sub-projects that came from it:

- Produce process maps to assess the current situation.
- Measure and validate the data for the current situation.
- Determine the influencing factors of below-par performance and chart them (see Figure 1.19).

At the next stage, which is the Analysis stage in DMAIC, the team looked to identify the root cause or causes of the problem or opportunity. Using the data produced, the problem is analysed and ‘drilled down’ to gain a better understanding of what and where the root causes are.

## Step 2. Do (Improve)

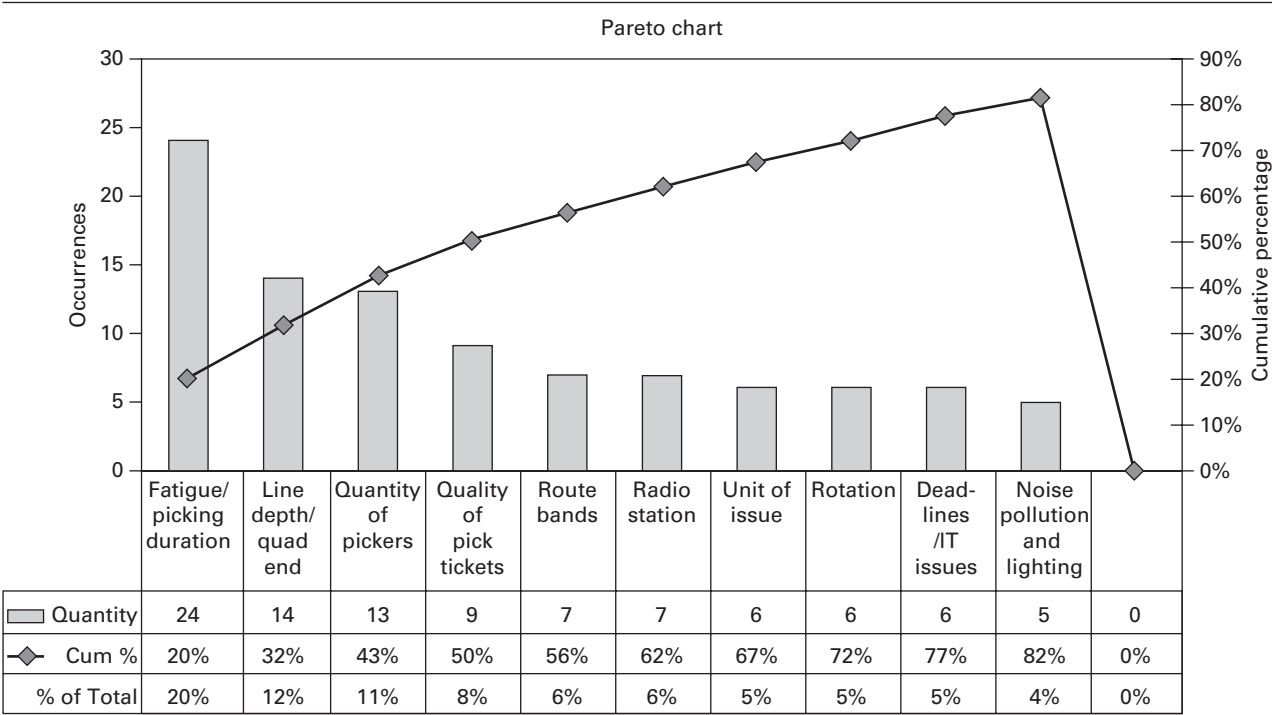
A ‘quick win’ was identified that saw Nissan provide its pickers with the opportunity of a free eye test. Out of 77 who took the test, 33 required glasses. A number of people were not aware they needed them. Everyone was given the option to have free glasses up to a cost of £50 and everyone was able to choose from a variety of styles.

Other solutions were identified, scored and ranked by effectiveness, feasibility, cost and duration. The top five ideas were evaluated and a risk analysis carried out. The ideas were later either implemented or a separate project team was set up to look at return on investment and feasibility.

## Step 3. Check

The group identified a loophole in the way that the existing claims tracker calculated overall claims scores for operatives. The existing tracker allowed operatives to score points towards merit-based pay reviews even when they were performing poorly in key areas. This was due to the way that the tracker took a percentage of the overall score for each area and enabled one good performance to guarantee a minimum score.

Figure 1.19 Performance chart



A new tracker with a new calculation was developed to remove this loop-hole and enable like-for-like comparison between operatives. This ensures that the operatives who need the most assistance get the most coaching and in good time.

#### **Step 4. Act (Control)**

Many of the new processes have been introduced and others are currently being fully evaluated in terms of feasibility and cost, with the project teams due to report back on the results.

### **Result**

The 10 per cent reduction was equivalent to a drop of 1,007 claims over the year. Nissan achieved a reduction of 582 claims in four months. If this is maintained it is forecasting an annual saving of 1,746 physical error claims. This equates to a 23 per cent reduction in physical errors.

At an average of £55.97 a claim, it has so far saved £32,574 in four months. If this continues, the projected saving over a 12-month period will be £97,723. Implementation resource costs were approximately circa 300 hours at £15.15 per hour = £4,650 = net saving in first year of £93,073.

The introduction of tools such as PDCA and DMAIC has resulted in staff working together in teams to ensure continuous improvement and in many instances exceed the targets initially set.

### **Further information**

Further information can be found at: [http://www.mindtools.com/pages/article/newPPM\\_89.htm](http://www.mindtools.com/pages/article/newPPM_89.htm) (archived at <https://perma.cc/7FXE-CCGP>)

(With thanks to Bruce Taylor from Nissan UK for his input.)



02

Transport  
management  
tools

In this section we have included tools to assist you in your day-to-day freight transport operations.

There are certain tools that have not been included such as drivers’ hours regulations due to the differences across countries. As a result we have included useful website addresses at the end of the chapter.

2.1 Transport audit checklists

This section provides audit checklists for a road freight transport operation; an extract is shown in Table 2.1. The questions are not exhaustive and can be added to by users to mirror their own operations.

Audits should be undertaken by an independent person, either an outside consultant or someone from another department within the company. The purpose of the audit should be explained to the staff. Results should be shared with all staff, who should take ownership of the results and the improvements necessary. A timescale should be agreed to undertake the improvements.

A full set of audit forms can be purchased from <http://howtologistics.com>; discount code: **lsct2024**.

**Table 2.1** Transport audit checklists

Transport audit (Part 1)				
Carried out by:	Location:		Date:	
Item:	No	Yes	NA	Comments

(continued)



Table 2.1 (Continued)

Transport audit (Part 1)				
Transport yard				
Sufficient space for goods vehicle parking				
Comprehensive signage for drivers in multiple languages				
Comprehensive signage for visitors				
Staff cars parked away from freight vehicles				
Perimeter fencing in good order				
Security gates/barriers in good working order				
External ground in good condition, no potholes, etc				
LPG and diesel kept in suitably safe and secure area				
Vehicle and trailer wash facilities available				

## 2.2 Calculating emissions in freight transport

### Introduction

Companies worldwide are being encouraged to lessen their impact on the environment and many governments are likely to introduce taxation based on greenhouse gas emissions so as to meet their own targets. This section provides information on how to measure these emissions in a freight transport environment.

Another reason for transport operators to calculate their emissions is to provide information to their customers. For most transport operators, this will mean calculating their total emissions, and then using an appropriate method to fairly ‘allocate’ an appropriate share of those emissions to each of their customers.

Greenhouse gases (GHGs) can be measured by recording emissions at source by continuous emissions monitoring or by estimating the amount

emitted by multiplying activity data by relevant emissions conversion factors. These conversion factors allow activity data (e.g. litres of fuel used, number of miles/kilometres driven, tonnes of freight carried, tonnes of waste sent to landfill) to be converted into kilograms of carbon dioxide equivalent (CO<sub>2</sub>e). CO<sub>2</sub>e is a universal unit of measurement that allows the global warming potential of different GHGs to be compared. There are seven main GHGs that contribute to climate change, as covered by the Kyoto Protocol: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF<sub>6</sub>) and nitrogen trifluoride (NF<sub>3</sub>). Different activities emit different gases and companies need to report on the Kyoto Protocol GHG gases produced by their particular activities.

Values for methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are presented as carbon dioxide equivalents (CO<sub>2</sub>e) using global warming potential (GWP) factors, consistent with reporting under the Kyoto Protocol and the second assessment report of the Intergovernmental Panel on Climate Change (IPCC).

This tool provides calculations for each mode of freight transport.

## How to use it

The following examples illustrate how to calculate kgCO<sub>2</sub>e for diesel with an average biofuel blend:

Total fuel used by company road freight vehicles per annum = 150,000 litres

UK emission factor for diesel is 2.51 kgCO<sub>2</sub>e/litre

Therefore total kgCO<sub>2</sub>e = 376,500 kgCO<sub>2</sub>e.

If the company does not have details of fuel consumed it is possible to use the following formula based on DEFRA emission factors.

This is based on an average for all HGVs between 3.5 tonnes and 44 tonnes gross vehicle weight:

Total emissions = distance × emission factor

= 377,015 × 0.64258

= 242,262 kgCO<sub>2</sub>e

Table 2.2 provides the calculation for the different gases based on distance travelled in miles and kilometres and by tonne kilometre. It is based on average loaded vehicles.

**Table 2.2** Gas and particulate emissions by truck type

Type	Unit	kg CO <sub>2</sub> e
Rigid (>3.5 – 7.5 tonnes)	tonne.km	0.51228
	km	0.48562
	miles	0.78152
Rigid (>7.5 – 17 tonnes)	tonne.km	0.35412
	km	0.59277
	miles	0.95398
Rigid (>17 tonnes)	tonne.km	0.15375
	km	0.97436
	miles	1.56808
All rigids	tonne.km	0.17819
	km	0.82313
	miles	1.3247
Articulated (>3.5 – 33t)	tonne.km	0.11578
	km	0.76647
	miles	1.2335
Articulated (>33t)	tonne.km	0.07421
	km	0.91265
	miles	1.46876
All artics	tonne.km	0.07518
	km	0.90644
	miles	1.45877
All HGVs	tonne.km	0.09696
	km	0.87205
	miles	1.40341

The website shown at the end of this tool provides spreadsheets to enable the user to calculate these figures automatically. For those working in miles as opposed to kilometres the following formula provided by the UK Road Haulage Association (RHA) can suffice. The calculation is as follows:

To convert miles per gallon to kilometres per litre, multiply by 0.354.

To obtain litres per kilometre, divide 1 by the kilometre/litre figure above.

To convert miles per US gallon to kilometres per litre multiply by 0.425144.

To obtain CO<sub>2</sub> in kilograms per kilometre, multiply by 2.51.

To obtain CO<sub>2</sub> in grams per kilometre (the accepted measure), multiply by 1,000.

*Example: carbon footprint calculation:*

Assume a 44-tonne articulated vehicle returning 8 miles per gallon:

8.0 multiplied by 0.354 gives 2.832 kilometres/litre;

1 divided by 2.832 gives 0.3531 litres/kilometre;

0.3531 multiplied by 2.51 gives 0.886281 kilograms of CO<sub>2</sub>/kilometre;

That figure multiplied by 1,000 gives 886.281 g of CO<sub>2</sub>/kilometre.

## Other modes

### Freight flights

Short haul to/from UK = 1.668155 kgCO<sub>2</sub>e per tonne kilometre

Long haul to/from UK = 1.099032 kgCO<sub>2</sub>e per tonne kilometre

### Railfreight

Railfreight (UK) = 0.02779 kgCO<sub>2</sub>e per tonne kilometre

### Sea freight

Crude tanker (≥ 200,000 + dwt) = 0.00294 kgCO<sub>2</sub>e per tonne kilometre

Container ship (≥ 8,000 + TEU) = 0.01266 kgCO<sub>2</sub>e per tonne kilometre

Bulk carrier (≥ 200,000 + dwt) = 0.00253

RoRo Ferry [≥ 2000 + LM – (lanes in metres)] = 0.05012

## ***Further information***

<https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023> (archived at <https://perma.cc/8WE4-2LXR>)

## **2.3 Fuel adjustment factor formula**

### ***Introduction***

Fluctuations in the price of fuel have a significant impact on the rates paid for the transportation of goods. To enable companies to pass on the increase (or decrease) in the cost of fuel to their customers, a mathematical formula can be used to calculate the percentage increase/decrease. Not only does the transport supplier need to understand the mechanism but so does the customer in terms of how it has been calculated.

Over recent years the cost of fuel as a percentage of total transport costs for UK hauliers has been in the region of 30 per cent. The 2022 RHA cost tables show a figure of 28.95 per cent.

### ***How to use***

At the beginning of the contract a base price for the fuel needs to be agreed between both parties. This needs to be written into the contract. The contract should also state the review frequency. If the haulier is undertaking a large number of jobs for the customer and the price of fuel is continually rising or falling, then maybe a weekly adjustment is required. Other contracts can be set up on a quarterly or six-monthly basis.

A further calculation is the cost of fuel as a percentage of the total cost or revenue for the transport company at the time of the fuel increase. Any fuel taxation such as value added tax needs to be excluded from the price of fuel.

Once these figures have been calculated, the formula shown in the example below can be used to calculate the overall increase/decrease in price for the work undertaken. The figure is illustrative only. Figure 2.1 covers a situation where fuel has increased in price. Note there will be situations where fuel has gone down in price and the haulier will need to adjust the cost accordingly.

In terms of container shipping there is a fuel adjustment factor called BAF or bunker adjustment factor.

**Figure 2.1** Fuel adjustment – specimen agreement and calculations

This Agreement dated [Enter date] is between [Enter name of haulier] and [Enter name of company].

It is agreed that:

- (a) the base price of diesel for the purpose of this Agreement is [Enter amount] pence per litre, exclusive of VAT
- (b) the haulier may adjust the price(s) for work undertaken for the customer by reference to the following formula:
  - (i) a change in the average price of fuel in the period shall be determined as a percentage of the base price as in (a) above
  - (ii) the cost of fuel to the haulier shall be determined as a percentage of the haulier's total revenue, as recorded
  - (iii) the adjustment to be applied (by way of either increase or decrease in price) shall be the product of (i)  $\times$  (ii)
  - (iv) an adjustment will be triggered when the change in cost is + / – % (to be agreed)
- (c) such adjustments shall be calculated at [Enter frequency, e.g. weekly, monthly] intervals.

### EXAMPLE

1	<b>Vehicle type</b>		44 tonne artic	
2	<b>kms in period</b>		120,675	
3	<b>Mpg / kms per litre</b>		8.3 mpg / 2.94 kms per litre	
4	<b>Litres in period</b>		41,070	
5	<b>Fuel at base price</b>	Date	£	-
	<b>1.40</b>	25/9/22		
6	<b>Fuel at av. price for period</b>	Date	£	-
	<b>1.18</b>	30/9/23		
7	<b>Increase/ (decrease)</b>		<b>(9,208)</b>	
8	<b>Costs in period</b>	A	£201,326	-
9	<b>Fuel as % of revenue at av</b>	B	24.71	
10	<b>Fuel % at base price</b>	C	30.11	
11	<b>INCREASE/(DECREASE)</b>		<b>(5.4%)</b>	
	<b>(B—C)</b>			

If the trigger is + / – 2% there is no adjustment required (this depends on the actual contract agreed).

**NOTES:** A) Period revenue as recorded; B) Line 6  $\div$  line 8  $\times$  100; C) Line 5  $\div$  line 8  $\times$  100

The appropriate adjustment is shown in line 11.

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The BAF tariff is designed to recover fuel-related costs and it is charged separately from basic ocean freight as the fuel cost is a very significant and volatile part of shipping costs. The BAF consists of a trade factor and the fuel price.

The fuel price is calculated as the average fuel price in key bunkering ports around the world, while the trade factor reflects the average fuel consumption on a given trade route as a result of variables such as transit time, fuel efficiency and trade imbalance. Currently there is no standardization across the shipping companies.

Depending on volumes shipped, BAF can be fixed, locked in or floating (variable).

## 2.4 How to improve fuel efficiency

### *Introduction*

Fuel represents approximately 28.95 per cent of transport costs within a distribution operation in the UK today, based on September 2022 fuel prices. It is therefore vital that companies look to reduce the amount of fuel consumed and improve metrics such as miles per gallon or kilometres per 100 litres.

The following is a list produced by Goodyear Dunlop on how to improve fuel efficiency. It has been supplemented by further advice from Freight Best Practice.

### **Driver training**

Driver behaviour is the biggest factor affecting fuel consumption. Investing in driver training will therefore quickly pay off and cut costs.

### **Work with equipment manufacturers**

A key aspect of driver training will often be working with the vehicle manufacturers, which can offer advice on how to get the most from their vehicles. This relationship should be extended across all equipment manufacturers. Tyre, trailer and aerodynamics suppliers can advise you on how best to use their equipment and provide ongoing maintenance to ensure fuel consumption stays as low as possible.



## Make fuel efficiency a key consideration for vehicle procurement

Truck manufacturers are increasingly offering vehicles with improved fuel efficiency. The upfront cost of investing in these vehicles will be more than outweighed by the future savings from reduced fuel consumption.

## Invest in cost-effective tyres

The cheapest tyres are not always the most cost-effective. Tyres should be selected on the basis of what offers best value – this means selecting a tyre that offers optimal safety, longevity and fuel efficiency, even if it may be more expensive upfront. Tyre pressure monitoring systems (TPMS) can also help maximize the cost-effectiveness of tyres in the long term.

## Aerodynamic improvement

Investing in aerodynamic improvements to vehicles can pay big dividends. Aerodynamic drag is a major factor in fuel consumption and retro-fitted improvements such as side skirts can offer a quick return on investment (ROI).

## Perform regular and thorough maintenance

There is little point in spending money on fuel-efficient trucks, tyres and aerodynamic improvements if this equipment is not well maintained. It is necessary to keep all of this equipment in good condition if it is to deliver the desired savings in fuel consumption.

## Improve your logistics

Better route planning and journey organization can cut journey times, avoid congestion and reduce empty running, saving fuel.

## Work with your customers

Customers are increasingly asking for more environmentally friendly freight services. Cooperating with them can help reduce fuel consumption by making deliveries easier and journeys shorter. Customers can be encouraged to place depots out of urban centres to avoid congestion, to reorganize deliveries to reduce empty running and to organize distribution to ensure trucks run full rather than half loads, improving fuel efficiency.

## Use telematics to track fuel consumption

Using telematics software can allow fleets to track their fuel consumption. It can be used to identify drivers who are wasting fuel and routes plagued by congestion, allowing fleets to act on these issues.

## All of the above

Improving fuel efficiency requires a holistic approach – improving in only one area is not enough and the investment may not be recouped if other areas are neglected. Fleets need to identify a reduction target, devise a fuel management plan that covers all areas and then measure how successful it is. This kind of thorough plan may be more expensive, but it will also save much more money in the long run.

## Best-practice advice to drivers

- 1** Always drive the truck with as low an engine speed as is practicable. This means using as high a gear as possible and monitoring the speedometer to ensure that the needle is always in the green band. Remember, the higher the gear, the lower the engine revs.
- 2** Make full use of the engine exhaust brake or engine brake, if fitted.
- 3** Avoid double-declutching on a synchromesh gearbox.
- 4** Do not use every single gear in the gearbox when shifting up or down. Make use of block changing/forward shift techniques where it is safe to do so, for example: 2–4–6–8. Where a splitter gearbox is fitted, use this facility to your best advantage. Again, do not use it automatically on each gear, but rather in the top range only as a 1/2 gear step. It helps to keep optimum speed up and engine revs down.
- 5** Safety checks and prompt defect reporting should be carried out before, during and at the end of every shift.
- 6** Let the engine work for you and ‘lug’ (i.e. work within the green band) on gradients. Remember, use maximum engine torque and thus pulling power. Use the engine’s ‘sweet spot’.
- 7** Make sure tyre pressures are correct. Incorrect pressure accelerates tyre wear, may jeopardize safety and affects fuel consumption. Fill tyres with nitrogen as opposed to air.
- 8** Use cruise control, whenever safe and practicable.
- 9** When filling fuel tanks, take care not to fill to the brim. Never leave a fuel nozzle unattended.

By undertaking a combination of the above, the result will be:

- lower fuel consumption;
- better tractive effort;
- reduced engine and transmission wear;
- reduced wear on brake components;
- reduced tyre wear;
- optimum speeds and journey time;
- reduced environmental impact;
- less driver fatigue;
- safer vehicles on the road;
- fewer road accidents;
- fewer prohibition notices and driver convictions;
- less fuel spillage (both in the depot and on the road).

## ***Reference***

[https://www.goodyear.eu/en\\_gb/consumer/learn/choosing-the-right-tire.html](https://www.goodyear.eu/en_gb/consumer/learn/choosing-the-right-tire.html) (archived at <https://perma.cc/YTS5-4EDB>)

## **2.5 Incoterms® 2020**

### ***Introduction***

Incoterms® are a set of uniform rules produced by the International Chambers of Commerce for the interpretation of international commercial terms. They define and set out the obligations of both consignors and consignees of goods in relation to the risks and costs that relate to each party during the movement of the goods between the seller's premises and those of the buyer.

Incoterms® are internationally accepted definitions and rules of interpretation for most common commercial terms. Incoterms® rules are recognized by UNCITRAL as the global standard for the interpretation of the most common terms in foreign trade.

A major consideration when selecting the correct Incoterms® rule is that sellers and buyers should not use a term that imposes risks and obligations

beyond their control. One point to note here is that under an ex-works agreement it is the responsibility of the buyer to load the vehicle, yet in the majority of cases it is the seller's staff who tend to load the vehicle on departure. The question is: 'Who is responsible if the goods are damaged while being loaded?'

Technically the seller should make the goods available but not load the goods on collecting vehicles and the seller is not responsible for clearing them for export. If the seller does load the goods, it does so at the buyer's risk and cost. If the parties want the seller to be responsible for the loading of the goods on departure and to bear the costs and risk of such loading, this must be made clear by adding explicit wording to this effect in the contract of sale and any other specific documentation.

It is imperative that precise delivery points are identified, especially with regard to port or terminal areas. The typical functions and responsibilities identified by Incoterms® 2020 are listed below. It notes who is responsible for:

- packing and marking of the goods (packing in cases, etc for contract and mode of transport – not loading items in, or on containers);
- providing and paying for the goods;
- preparing documentation, whether in hard copy or electronically;
- arranging dispatch of the goods to specific delivery points;
- sorting out (and paying for) export and import clearances;
- ensuring import and export licensing is in order;
- ensuring security requirements are met;
- loading and unloading of cargo at the agreed delivery points;
- pre-shipment inspection (always the buyer for UK exports);
- obtaining documents or their equivalent electronic messages (online documentary considerations);
- insuring the goods – this is for additional cargo insurance, not carriers' liability insurance;
- paying duties and taxes, usually at the point of import.

According to 512 Sheffield, a UK-based freight forwarder, the way to avoid problems is to do the following:

- ALWAYS quote the specific three-letter abbreviation.
- ALWAYS mention a PRECISE place of delivery.

- ALWAYS add the phrase ‘as per Incoterms® 2020’ – in the contract, the quotation, order, order confirmation – and on the invoice.
- ALWAYS ensure that all parties understand that they are working to the terms qualified in Incoterms® 2020 and not a perception of what they think a term means.
- ALWAYS ensure that any contractual issues that may cause deviation from Incoterms® 2020 are clarified and resolved before the contract is agreed and signed.

The following is a list of the 11 Incoterms® used.

When transporting goods by any mode of transport, be it air, sea, inland waterways, rail or road:

EXW – Ex Works – (named place of delivery)

FCA – Free Carrier – (named place of delivery)

CPT – Carriage Paid To – (named place of destination)

CIP – Carriage and Insurance Paid to (named place of destination)

DPU – Delivered at Place Unloaded (insert place of destination)

DAP – Delivered at Place – (named place of destination)

DDP – Delivered Duty Paid – (named place of destination)

When transporting by sea and inland waterways only:

FAS – Free Alongside Ship (named port of loading/shipment)

FOB – Free on Board (named port of loading/shipment)

CFR – Cost and Freight (named port of destination)

CIF – Cost, Insurance and Freight (named port of destination)

As can be seen from Table 2.3, the majority of terms specifically show whether it is the buyer or supplier who is responsible for the cost and risk involved. However, there are situations where risk and cost will be determined by the named place of destination; these are denoted by B/S on the chart. Table 2.3 details the responsible party based on the Incoterms® agreed. The chart is for guidance only. A copy of the Incoterms® 2020 can be found at <https://iccwbo.org/resources-for-business/incoterms-rules/incoterms-2020/> (archived at <https://perma.cc/36GW-N845>).

**Table 2.3** Incoterms® 2020 responsibilities

INCOTERMS® 2020	EXW		FCA		FAS		FOB		CFR		CIF		CPT		CIP		DPU		DAP		DDP	
	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST	RISK	COST
Loading onto collection vehicle	B	B	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Export Customs formalities	B	B	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Carriage to point/ place of export	B	B	B	B	S	S	S	S	S	S	S	S	S B	S B	S B	S B	S	S	S	S	S	S
Unloading of vehicle at point/ place of export	B	B	B	B	S	S	S	S	S	S	S	S	S B	S B	S B	S B	S	S	S	S	S	S
Loading on main mode of transport	B	B	B	B	B	B	S	S	S	S	S	S	S B	S B	S B	S B	S	S	S	S	S	S
Delivery to point/ place of import	B	B	B	B	B	B	B	B	B	S	B	S	B	S	B	S	S	S	S	S	S	S
Unloading from main carriage at place of import it final delivery point	B	B	B	B	B	B	B	B	B	B	B	B	S B	S B	S B	S B	S B	S B	S B	S B	S	S

(continued)

**Table 2.3** (Continued)

Import customs clearance	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	S	S
Loading onto vehicle at the place of import to final delivery point	B	B	B	B	B	B	B	B	B	B	B	B	S B	S B	S B	S B	S	S	S	S	S	S
Carriage to named place of destination it final delivery point	B	B	B	B	B	B	B	B	B	B	B	B	S B	S B	S B	S B	S B	S B	S B	S	S	S
Insurance for cargo in transit	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	N/O	S	S	N/O	N/O	S	S	N/O	N/O	N/O	N/O	N/O	N/O
Import duties and taxes	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	S	S
S represents SELLER, B represents BUYER and S/B represents SELLER OR BUYER determined by named place.  N/O represents NO OBLIGATION for the SELLER or the BUYER This guide is meant as a representation of Incoterms®2020 Rules –all traders are advised to study the official Incoterms®2020Rules as issued by the ICC				ANY MODE OR MODES OF TRANSPORT  EXW – ex works (... named place of delivery) FCA – free carrier (... named place of delivery) CPT – carriage paid to (... named place of destination) CIP – carriage and insurance paid to (... named place of destination) DPU – delivery at place unloaded (... named place of destination) DAP – delivery at place (... named place of destination) DDP – delivery duty paid (... named place of destination)										SEA AND INLAND WATERWAY TRANSPORT  FAS – free alongside ship (... named port of shipment) FOB – free on board (... named port of shipment) CFR – cost and freight (... named port of destination) CIF – cost, insurance and freight (... named port of destination)								

Key:

R – Risk

B – Buyer

N/O – Represents no obligation for the buyer or the seller

C – Cost

S – Seller

**SOURCE** Reproduced by kind permission of 512 Sheffield, www.5-1-2.com

## Further information

UK: [www.5-1-2.com](http://www.5-1-2.com) (archived at <https://perma.cc/Z5SK-XG6N>)

United States: [http://export.gov/faq/eg\\_main\\_023922.asp](http://export.gov/faq/eg_main_023922.asp) (archived at <https://perma.cc/XJ28-H2DT>)

## 2.6 Load and pallet configuration

### Introduction

The efficient loading of containers and trailers is crucial in today's environment of rising transport costs. Unused space is inefficient and can cost a company a great deal of money.

Efficient loading of vehicles and containers begins with the initial packaging of the products. Companies need to ensure that the outer packaging of their products is designed to fit perfectly onto the pallets used for both transportation and storage. The ideal is to ensure no overhang whatsoever, with a reduction in unused space.

Pallet loads need to be configured to ensure that product damage is minimized, cubic capacity is fully utilized, load stability is ensured and the configuration is acceptable to the receiving location. Fortunately, there is software available to assist not only with pallet loading but also container and trailer loading. The software can also optimize packing within an individual carton.

The pallet configuration software works on the basis of TiHi (tier × high), which determines how many cartons should be placed on a layer or tier, in which configuration and how many layers in total (see Figure 2.2).

In the figure on the left there are 12 cartons per layer and four layers, giving a carton total of 48. Utilizing pallet configuration software, Able Plastics was able to increase the number of cartons to 52 by changing the layout of the cartons. This can lead to significant savings in transport costs.

Many retailers insist on products being delivered in a certain way so that they conform to their storage mediums. For example, a retailer could ask for the goods delivered to its distribution centre (DC) to conform to the list shown in Table 2.4. The same can be achieved in terms of efficient container and trailer loading.

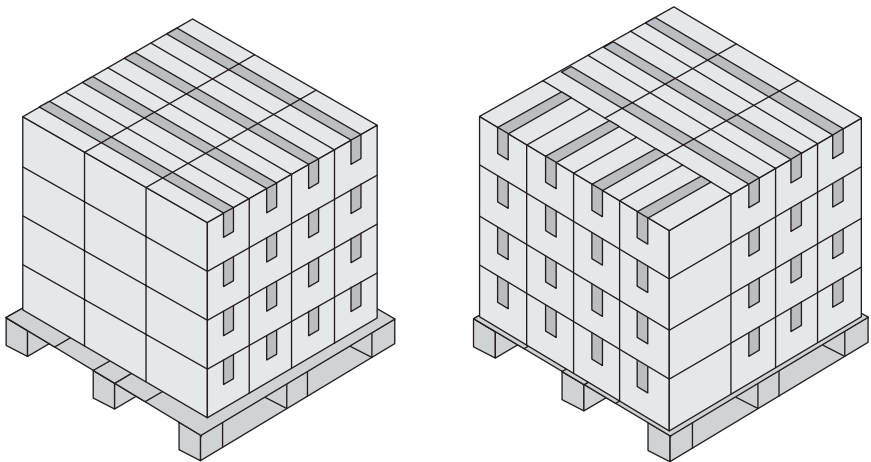
Sophisticated software optimization can not only take into account the cube of the products but also their weight, load-bearing strength and location within the container. This ensures ease of offloading at the receiver, with



all the cartons from the same product line being located together. The software also ensures that lighter items are packed on top of the heavier ones.

Many websites provide software to enable operators to calculate the most efficient way of loading containers and trailers, and also configuring boxes on different pallet sizes and items within cartons.

**Figure 2.2** Comparison between manual planning and load configuration software



**SOURCE** Reproduced from Able Plastics

**Table 2.4** Retail DC requirement

Overall pallet height	1,500 mm
Pallet width	1,000 mm
Pallet length	1,200 mm
Cartons per layer	13
Layers per pallet	4
Total number of cartons	52
Total gross weight	780 kg
Weight per carton	15 kg

(continued)

Table 2.4 (Continued)

Type of pallet	Chep/White/Red
Pallet exchange	Yes/No
Special instructions	Product label on all four corners
Ability to block stack	Yes/No
If yes, how high	3

Further information

Load configuration websites:

- www.onpallet.com (archived at <https://perma.cc/Z8QT-3XQJ>)
- www.cubedesigner.net (archived at <https://perma.cc/4RJR-4VVF>)
- www.cubemaster.net (archived at <https://perma.cc/7VCN-MCTR>)
- www.exds.co.uk/cubiscan.htm (archived at <https://perma.cc/C3LP-G9KL>)
- www.koona.com/qpm/ (archived at <https://perma.cc/GX2X-26TF>)
- www.softtruck.com/ (archived at <https://perma.cc/7KJL-BY86>)
- www.topseng.com/TOPS\_Pallet\_Configuration.html (archived at <https://perma.cc/27QS-YSFW>)

2.7 ISO containers, weight volume ratios and pallets

Introduction

ISO containers enable companies to ship product via a number of different transport modes, including deep sea, short sea, inland waterways, road and rail. There are several basic types of ISO containers, including flat racks, open-top, dry freight, insulated, refrigerated and tank containers.

ISO 6346 requires a visual identification system for every container, including a unique 11-character serial code used for container tracking that defines the owner (three letters), container category (one letter), a unique owner identifier (six numbers) and a check digit (one number), e.g. MSCU 123456 7. There are four possible category identifiers:

- U for all freight containers;
- J for detachable freight container-related equipment;



- Z for trailers and chassis;
- R for refrigerated containers.

A further four characters denote the size and type of container:

- character 1 denotes the length;
- character 2 denotes the width and height;
- characters 3 and 4 denote the type.

Table 2.5 provides data regarding the dimensions and capacities of ISO containers in use worldwide. The dimensions will vary between different shipping companies and therefore it is wise to check with them or your freight forwarder before ordering a particular container for collection.

Other points to note are as follows:

- The floor of a container should be able to carry a forklift truck with a maximum axle load of 5,460 kg providing that the contact area per wheel is at least 142 cm<sup>2</sup>.
- The figures quoted are based on ISO 668 and ISO 1496-1, which provide the standard dimensions for ISO containers. Some 10 ft and 30 ft containers remain in use and in the United States containers can also be operated at 48 ft and 53 ft lengths.
- Container capacity tends to be expressed in 20-foot equivalent units (TEU). An equivalent unit is a measure of containerized cargo capacity equal to one standard 20-foot (length) × 8-foot (width) container.

**Table 2.5** Standard ISO container dimensions

	Length		Width		Height	
Dimensions	6,058 mm	12,192 mm	13,716 mm	2,438 mm	2,591 mm	2,896 mm
	20'	40'	45'	8'	8'6"	9'6"HC
Minimum internal dimensions	5,867 mm	11,998 mm	13,532 mm	2,330 mm	2,350 mm	2,655 mm
	19'3"	39'438"	44'4¾"	7'7¾"	7'8½"	8'8½"
Minimum door opening dimensions	–	–	–	2,286 mm	2,261 mm	2,566 mm
	–	–	–	7'6"	7'5"	8'5"



Effective 1 July 2016, any container leaving from any port in the world must be accompanied by a shipping document signed either electronically or in hard copy by the shipper on the bill of lading listing the verified gross mass of a container in order to be loaded onto a ship. The mandate from the International Maritime Organization under the Safety of Life at Sea (SOLAS) convention comes after mis-declared weights contributed to a number of maritime casualties.

# Weight/volume ratios

In terms of freight costs shipped by different modes of transport, there are conventions that need to be understood. One of the main conventions is the weight to volume ratio.

The following provides a guide to charging for air, sea and road freight. Weight versus volume charges are based on weight but calculations switch to volume over a certain threshold:

6 m<sup>3</sup> / 1000 kg = Air freight

1 m<sup>3</sup> / 1000 kg = Sea freight

3 m<sup>3</sup> / 1000 kg = Road Trailer freight

# Pallets

The use of pallets or skids to move and store product is familiar the world over. The only problem is that there is very little uniformity in terms of the sizes and types of pallets. Table 2.6 is a guide to the sizes of pallets used in different countries. Other specialist pallet sizes for the storage and movement of paper, drums, etc also exist.

**Table 2.6** Pallet sizes (length × width)

Dimensions	Geographic area of use
1219 × 1016 mm (48 × 40 inches)	North America
1219 × 1219 mm (48 × 48 inches)	North America
1000 × 1200 mm (39.37 × 47.24 inches)	Europe, Asia
1165 × 1165 mm (44.88 × 44.88 inches)	Australia

(continued)

**Table 2.6** (Continued)

Dimensions	Geographic area of use
1067 × 1067 mm (42.00 × 42.00 inches)	North America, Europe, Asia
1100 × 1100 mm (43.30 × 43.30 inches)	Asia
800 × 1200 mm (31.50 × 47.24 inches)	Europe

Note there are two-way and four-way entry pallets. Pallets are sometimes known as block pallets or Stringers.

Pallets can be purchased or they can be rented. Both wooden and plastic pallets are available for rental. Pallet suppliers and rental companies include the following:

- [www.chep.com](http://www.chep.com) (archived at <https://perma.cc/E545-FT9L>)
- [www.ifco.com](http://www.ifco.com) (archived at <https://perma.cc/3QCU-X5XR>)
- [www.igps.net](http://www.igps.net) (archived at <https://perma.cc/5ZFK-L7UZ>)
- [www.loscam.com](http://www.loscam.com) (archived at <https://perma.cc/VHF2-BFVM>)
- [www.lpr.eu](http://www.lpr.eu) (archived at <https://perma.cc/3GQ7-HTF9>)
- [www.pecopallet.com](http://www.pecopallet.com) (archived at <https://perma.cc/B8WS-VU5V>)
- <https://www.pallite.co.uk/> (archived at <https://perma.cc/4EAV-5CJY>)
- [www.goplasticpallets.com](http://www.goplasticpallets.com) (archived at <https://perma.cc/PW8E-36YP>)

**Further information**

Further information on pallets can be found at: [www.napd.co.uk](http://www.napd.co.uk) (archived at <https://perma.cc/2VZL-AE2V>), [www.palletcentral.com](http://www.palletcentral.com) (archived at <https://perma.cc/GCM5-A3EG>) and [www.palletlink.com](http://www.palletlink.com) (archived at <https://perma.cc/2YDE-UYJ9>).

Further information on containers can be found at: [http://www.iso.org/iso/home/store/catalogue\\_tc/catalogue\\_tc\\_browse.htm?commid=51156](http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=51156) (archived at <https://perma.cc/R73Q-RB6X>) and [https://www.hapag-lloyd.com/content/dam/website/downloads/press\\_and\\_media/publications/15211\\_Container\\_Specification\\_engl\\_Gesamt\\_web.pdf](https://www.hapag-lloyd.com/content/dam/website/downloads/press_and_media/publications/15211_Container_Specification_engl_Gesamt_web.pdf) (archived at <https://perma.cc/2R24-U7M9>) Shortcut – <http://bit.ly/30tyYoj> (archived at <https://perma.cc/E75G-E57Z>)



# 2.8 Calculating road freight transport charges and rates

## Introduction

As a haulier or trucker, one of the most difficult aspects of running a business, alongside keeping costs as low as possible and attracting clients, is calculating charges for freight deliveries. To do this accurately you need to understand the total costs within your business, both fixed and variable.

For each particular delivery or collection, you need to fully assess both the time required to complete a job and the number of miles/km covered. You must then apply to the time element the cost per day, including overheads, add any specific bonuses, extra hours, subsistence and sundries (tolls) and miles/km at the appropriate cost.

This will give you a fair cost for the job for which you are quoting. To this you must add a percentage for profit. In today's market this is extremely difficult because, on many occasions, you will find the costs as properly determined from the cost categories below are greater than the revenue likely to be derived from the rates being charged by your competitors.

Notwithstanding this, you must aim for a reasonable profit margin. In the case of fuel you should always attempt to negotiate a clause into all rate schedules and contracts allowing fuel price increases to be passed on to the customer as they occur (see tool 2.3).

You must then decide whether you can accept a job at less than the rate calculated and, even more crucially, whether you can accept it at less than the true cost of undertaking it. In anything but the shortest run you cannot afford to do the latter, except perhaps for casual or special jobs that fit into the pattern of your overall work.

## How to use

The following template (Table 2.8) allows you to calculate the costs involved and the rates required. Example costs for a 44-tonne gross (6 × 2 + tri-axle trailer) combination are shown in Table 2.7. Note that bonuses, excess hours, subsistence and similar are not included. These should be added to costs as they are incurred, by job (Table 2.8).

NB The chargeable rate = time cost + mileage cost + job-specific cost + profit.



**Table 2.7** Example costs for articulated truck and trailer (based on 2023 prices)

Costs for a 6 x 2 44 tonne GVW articulated unit + tri-axle trailer	Average figures	Your figures
Vehicle price	£121,822	
Average depreciation period (years)	6	
Average miles per annum	75,000	
Average days worked per annum	240	
Average miles per gallon	8.3	
COSTS (Fixed)		
Driver employment costs	£55,059	
Depreciation	£20,304	
Licences	£560	
Vehicle insurance	£5,015	
Interest on capital (6%)	£3,655	
Overhead per vehicle	£33,195	
Ownership of one trailer	£4,358	
Total time costs	£122,145	
Cost per working day	£508.94	
VEHICLE COSTS (variable)	PPM	
Fuel @ 139.95 ppl	76.65	
Additive @ 49.5 ppl	3.06	
Tyres (pence per mile)	2.60	
Repairs and maintenance (pence per mile)	11.59	
TRAILER COSTS (variable)		
Tyres (pence per mile)	3.24	
Repairs and maintenance (pence per mile)	4.77	
Total cost per mile	101.91	

**Table 2.8** RHA template for haulage rate quotation

<b>TEMPLATE FOR RATE QUOTATION</b> <b>1 NAME OF CUSTOMER.....</b> <b>2 DETAILS OF JOB.....</b>		
3	Size of truck required	
4	Estimated days/hours for job	
5	Estimated trip miles/km	
6	Details of market competitor (if known) & likely charge	
7	Anticipated time cost for job	
8	Anticipated distance cost of job	
9	Job-specific costs Subsistence Bonus Tolls Ferry Other	
10	Total cost of job	
11	Target profit margin	
12	Target revenue	
13	Target rate	
14	Agreed rate	
15	Return load time cost	
16	Return load distance cost	
17	Return load specific cost	
18	Total return load costs	
19	Total round trip cost (10 + 18)	
20	Return load revenue	
21	Minimum required outward revenue (19 – 20)	
22	Actual revenue	

(continued)



**Table 2.8** (Continued)

<b>TEMPLATE FOR RATE QUOTATION</b> <b>1 NAME OF CUSTOMER.....</b> <b>2 DETAILS OF JOB.....</b>		
23	Actual time costs	
24	Actual mileage cost	
25	Actual specific costs	
26	Actual profit/loss	

**NOTES:**

- (a) You will often find that a job will be completed with some hours in the day 'left over'. These hours will be costing you. You will need to decide whether you can use them for something else. If not, can those hours be charged to the job without making you uncompetitive?
- (b) Where a return load is involved, it is important that you cost the whole round trip, allowing for the revenue you are likely to earn for the return and deciding how much to allow against the outward job for which you are quoting.
- (c) When you are allocating costs in lines 7, 8, 15, 16, don't forget when using the appropriate figures from Table 2.7, if possible, to substitute YOUR costs where they are different.
- (d) Rate = time cost + mileage cost + job cost + profit.

### Rates and charges – example

You are asked to give a quotation for loading a 26-pallet load weighing 24 tonnes at a shipper's factory, delivering to a nominated address and returning to base with a full load of empty pallets. You are using a 44-tonne gross vehicle weight (gvw) articulated unit and tri-axle trailer.

You decide from your experience that this task will occupy two full working days, and you ascertain that the total distance to be covered will be 480 miles. Referring to the cost tables below, you derive the standard costs and estimate other items as shown in Table 2.9. Substitute your own figures for those shown.

**Table 2.9** Standard costs

	£	Your figures
2 standard days at £508.94	1,017.88	
480 miles at 101.91 pence per mile	489.17	
Driver's subsistence	30	
Driver's bonus and any additional overtime	25	

(continued)

**Table 2.9** (Continued)

	£	Your figures
Bridge toll	10	
Total cost	1,572.05	
Target margin (say 5%)	78.60	
Desired rate and quotation	1,650.65	

If possible, and before submitting this quotation, try to determine what the ‘going rate’ or market rate for these movements is. Decide whether, or to what extent, the gap between approximately £1,650 and the market rate can be bridged. Negotiate as strongly as possible to ‘educate’ the customer about realistic figures.

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(These templates can be downloaded for free from <http://howtologistics.com>)

## 2.9 Transport management system (TMS) selection process

### *Introduction*

Many companies continue to utilize whiteboards and spreadsheets and rely on transport planner experience to manage the routing and allocation of their vehicle fleets. This is fine, but there are systems on the market that can optimize transport movements and introduce greater efficiency. This can lead to an improvement in vehicle utilization and a reduction in total cost.

If you are operating your own vehicles there are two routes to implementing a TMS – license the TMS from a software provider and manage the software in-house or get the TMS provider to host the system for you. Own-account operators and third-party logistics companies will have different

requirements. The model from Capgemini (see ‘References and further reading’) outlines the potential features of a TMS.

## ***When to use***

When you are looking to improve both the efficiency and effectiveness of your transport fleet through introducing a TMS.

## ***How to use***

First, you have to fully understand your needs and the key business requirements, not only today but some time into the future so that you select the solution that best matches your business objectives. You also need to calculate the ROI on the purchase and ongoing support of the TMS (see tool 7.2).

The choice of a TMS roughly follows the same lines as that of any software acquisition and implementation. To ensure that the system you choose is the right one for your operation, here are some best-practice guidelines courtesy of BASDA and Sage:

- 1** Ensure full commitment from the board of directors and the IT department.
- 2** Form a project team:
  - Assemble a team of people capable of logical thinking who will decide what your company needs from a TMS, what functionalities it must have and those it will be nice to have. Members of the team should include a member from finance, sales, operations/production (if applicable), IT and of course the transport department.
  - Ensure the availability of all key staff throughout the project.
- 3** Define, record, review and improve current processes:
  - Ensure that your processes are working properly before introducing a TMS. Do not make the error of automating poor processes.
  - Understand how the transport department communicates both internally with other departments and externally with customers and suppliers.
- 4** Create a list of key functions required of the new system:
  - Each project team member needs to compile a list of the key functions required of a system and rank them by importance, for example 1, 2 or 3, or essential, greatly desired or nice to have.

- There are a number of templates that can be downloaded from the internet to help you. A website for these can be found at the end of this section.
- 5** Produce a current base cost for the operation.
- 6** Incorporate any future growth plans in your specification:
  - Although difficult to forecast, you need to take into account likely future events when specifying a TMS.
- 7** List the benefits of a TMS to your company:
  - The right TMS can maximize the efficiency of your fleet, the productivity of your labour and aid with network design. All of these need to be quantified and presented alongside the ROI report.
- 8** Research and approach a select number of vendors and produce a list of companies with experience of providing solutions in your market sector.
- 9** Visit reference sites to look at operational effectiveness and discuss the benefits the TMS has brought about since implementation:
  - This is very important. Try to visit a cross-section of companies and speak to the operators, not just the managers who chose the software in the first place.
- 10** Produce a ROI report:
  - This is vital if you want to convince the board to spend some money (see tool 8.3).

This is not the type of purchase you make through an e-auction. As with many large service offerings such as outsourcing, the likely success of the project will ultimately come down to your relationship with the people at the software vendor. As a previous manager of mine told me, ‘people buy people’, therefore it is very important to meet the vendors, not only the sales staff but also the operations and support staff.

The main aspects to look for in a partner include the following:

- Look for providers that employ staff with significant operational experience as well as staff with the ability to produce a best-in-class TMS.
- Not only will the operational staff have had input into the TMS but they will also be able to understand your own requirements better. Choose a vendor that listens effectively and understands your organization fully.
- Check how long the company has been in business and what its credit-worthiness is like – it will certainly check yours!

- Choose a vendor that emphasizes the benefits of the software, not just the features.
- Choose a provider that has already installed TMS with clients in your industry.
- Ensure that the vendor can supply not only the system but also the installation, training, maintenance and help desk service.
- Verify that your prospective TMS provider is reinvesting significant capital into research and development, and future product enhancements.
- Choose a vendor you are comfortable working with. Try to find a vendor that is culturally similar to yourselves, is professional and well respected in the industry.
- Ask for a large list of customers and visit the customer sites of your choice.
- Choose a partner that has reasonable modification rates and is willing to set up a realistic budget, based on your needs assessment, prior to formalizing the relationship. Alternatively, look to set up an agreement where your own IT staff are able to introduce certain modifications.
- Make sure that the TMS provider can fully support you during the implementation phase.
- Select a partner that has an adequately staffed help desk and that the help desk is available during your company's hours of operation. Time zones can cause innumerable problems if they are not taken into account at the outset.
- Select a partner that has established partnerships with hardware providers.
- A final decision is whether to purchase the software and hardware outright or to rent the software and operate it on a third-party server platform (see tool 1.18 on selecting a WMS).

## ***Further information***

A comprehensive list of transport management software can be found at:  
<http://www.capterra.com/transportation-management-software/> (archived at <https://perma.cc/35YT-8AUE>)

Example TMS RFP templates: <http://www.technologyevaluation.com/store/rfp-template/Transportation-Management-System-TMS-RFI-RFP-Template.html> (archived at <https://perma.cc/8MS2-WNXU>)

## References and further reading

BASDA (2009) *Logistics and Supply Chain Best Practice Handbook*, available at <http://www.basda.org/> (archived at <https://perma.cc/N72H-HHU9>)

<https://www.capgemini.com/resources/transportation-management-report-2011> (archived at <https://perma.cc/KXX8-EJ62>)

## 2.10 Vendor assurance of transport logistics service providers

### Introduction

When outsourcing logistics and supply chain services, it is vital that companies understand the risk profile of the suppliers they are using if they are to protect their brand and reputation as well as their service levels. A company outsourcing its logistics may congratulate itself that it is no longer responsible for the headache of safety and compliance management; however, if there is a serious accident or breach of health and safety legislation, publicity will normally focus more on any connection with a branded goods manufacturer or retailer than on the typically less well-known logistics service provider. Similarly, any interruption in service associated with the loss of a facility, bankruptcy or loss of key personnel will have a dramatic and serious impact on the outsourcing company, particularly when the service includes warehousing or e-commerce activities.

### When to use

Outsourcing companies need to include an audit of vendor risk profiles. Ideally this is done during the tender process and repeated at appropriate intervals throughout the life of the contract. The frequency and depth of such audits will depend on the criticality of the service being outsourced.

Where more than one company is audited, or a company is audited more than once over a period of time, it is best to use a standard list of questions that reflect the risks that are relevant for that contract, with standardized scoring for the responses. Scores may then be compared to see relative risk and to assess progress over time. However, the main value of the audit tool is to identify and track actions to reduce or mitigate risk.

## How to use

The questions shown in Table 2.10 should be asked and the answers recorded and analysed.

**Table 2.10** Vendor assurance questionnaire

Area	Typical questions
Health and safety	<p>Is the supplier aware of their general safety responsibilities in line with current legislation?</p> <p>What is the supplier's approach to the safety of operations and transport on site?</p> <p>What processes does the supplier have in place?</p>
Compliance (with legal operating requirements)	Can the supplier demonstrate compliance with Operator Licence legislation?
Financial	<p>What is the credit rating of the supplier?</p> <p>Have the supplier's latest published accounts been examined by a financial expert?</p>
Performance	Does the supplier issue a regular performance report to the client and to other clients?
Contractual	<p>Is there a record of the agreement between the client and the supplier?</p> <p>Who has the controlling interest in the supplier and how does this affect the contract (are there parent company guarantees in place)?</p>
Dependency	<p>Is the supplier performance dependent upon one or two key individuals?</p> <p>How dependent is the supplier upon their largest other customer? Could loss of this contract threaten the supplier's viability?</p>
Systems	<p>Does the supplier measure and report on their systems performance, and what is the performance?</p> <p>What steps has the supplier taken to protect against systems failure? Is there a disaster recovery plan in place?</p> <p>How widely used is the main software package?</p>
Food safety or dangerous goods	Is the supplier meeting the specific safety or quality requirements related to the products carried for this contract?

### Who should audit?

Auditors should have an operational logistics background and have been trained in national health and safety and professional competency standards for road transport and logistics operations. They should also have received training in quality auditing skills and techniques.

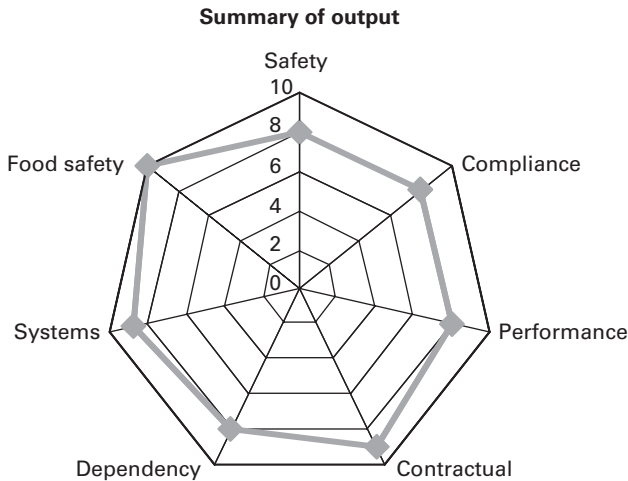
### Where is the audit carried out?

Typically, an audit will be carried out at the premises where the contract is operated from or at a similar site for such services. Health and safety, training and monitoring records should be available to the auditor on request.

### Output and follow-up

At the end of the visit the supplier is given a score out of 10 for each area (see Figure 2.3 for an example of a graphical representation of the results), with any significant risks being highlighted. A report is written for each audit, with details of all the areas audited and suggested actions to improve performance. The outsourcing company should then put in place checks to ensure that the actions are carried out by the next audit at the latest, preferably earlier, depending on the risk attached to non-compliance.

**Figure 2.3** Example of radar chart summarizing how well the supplier meets the criteria



**NOTE** Information on how to produce a radar chart can be found in tool 6.6.  
Reference: Ruth Waring, Jo Godsmark Big Change Ltd [www.bigchange.com](http://www.bigchange.com)



## 2.11 Transportation of hazardous products

In terms of the movement of hazardous goods the carrier's duties are far less complicated than the consignor's duties in that there is far less need for interpretation. The following is expected of the carrier:

- The carrier must decide, from the information provided by the consignor's dangerous goods note, as to whether it has a dangerous goods load under the carriage of dangerous goods by road regulations.
- The carrier's obligations have thresholds at which the regulations become relevant and these thresholds are based on the packing group of the goods to be carried.
- The carrier must appoint a DGSA (dangerous goods safety adviser).
- The carrier must ensure the vehicle is roadworthy and not overloaded.
- Drivers must hold vocational training certificates and be trained in emergency action procedures.
- Drivers must carry a photographic identification card.
- Drivers must not carry matches or lighters, or smoke in close vicinity of the load.

Additional requirements include the completion of a security plan that all participants are made aware of. Note that different regulations apply to the different modes of transport utilized. Note also that there are certain hazardous items that cannot be transported together. Each mode of transport will have a dangerous goods segregation chart detailing what can and cannot be transported together.

The carriage of dangerous goods by sea is governed by the International Maritime Dangerous Goods Regulations (IMDG) (<https://www.imo.org/en/OurWork/Safety/Pages/DangerousGoods-default.aspx> (archived at <https://perma.cc/HUR7-EE9C>)).

Transporting goods around the globe, by air, is governed by two sets of Regulations: International Civil Aviation Organization (ICAO) and International Air Transport Association (IATA) Dangerous Goods Regulations (<http://www.iata.org/publications/dgr/Pages/index.aspx> (archived at <https://perma.cc/LKG2-PBSK>)).

In the UK, the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (CDG) and the European agreement 'Accord européen relatif au transport international des marchandises dangereuses par

route' (ADR) together regulate the carriage of dangerous goods by road (<http://www.hse.gov.uk/cdg/index.htm> (archived at <https://perma.cc/CG2G-WD5F>)).

Other countries will have their own specific regulations. For example, in the United States it is covered by the Federal Motor Carrier Safety Administration (FMCSA) (<http://www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm> (archived at <https://perma.cc/3RA7-BJF3>)).

Separate pictograms are to be used for labelling hazardous goods in transport. As these are colour coded, we have not included them here but they can be accessed at <http://www.unece.org/trans/danger/danger.html> (archived at <https://perma.cc/C59G-9V9B>) where there is also further information.

## 2.12 Calculating customs duties

### *Introduction*

To be able to calculate the customs duties to be paid when trading goods, three factors have to be taken into consideration:

- 1 the value of the goods;
- 2 the customs tariff to be applied;
- 3 the origin of the goods.

Customs valuation is the determination of the economic value of goods declared for importation. Having a standard set of rules for establishing these goods' value is of great importance for several reasons. Customs duties and value added tax (VAT) are calculated as a percentage of the goods' value. Economic operators and customs authorities need to have clear rules on how to perform this task.

Having a commonly agreed and accurate measuring standard is vital for the purposes of:

- economic and commercial policy analysis;
- application of commercial policy measures;
- proper collection of import duties and taxes; and
- import and export statistics.

The value of imported goods is also one of the three ‘elements of taxation’ that provides the basis for assessment of the customs debt, which is the technical term for the amount of duty that has to be paid, the other ones being the origin of the goods and the customs tariff.

Once the value of the goods is determined, customs duties can be calculated.

## ***When to use***

When importing or exporting goods.

## ***How to use***

The importer or exporter needs to understand all the criteria involved in calculating customs duty and taxes. The three main elements are as follows.

### **1. The value of the goods is normally calculated from the commercial invoice**

The price actually paid or payable shall be the total payment made or to be made by the buyer to the seller or by the buyer to a third party for the benefit of the seller for the imported goods and include all payments made or to be made as a condition of sale of the imported goods.

These payments include such things as loading, handling, transportation (not within customs territory of the European Union), packing, insurance, brokerage, royalties and licences plus many others if relevant.

### **2. Customs tariff**

All imports or exports must be declared to customs authorities using a commodity code.

Each commodity code is made up of a number of different elements such as the type of product, the material used to make it, and even the production method. You must be able to accurately describe your item to search the tool. Utilizing the Trade Tariff tool (<https://www.trade-tariff.service.gov.uk/> (archived at <https://perma.cc/FT69-YKWZ>)) sections, the following steps will help you find the right code:

- Enter the search term you want to use – remember an item may not be listed by name; it may be shown under what it’s used for or made from.

- The tool will suggest a section/number of sections, divided into chapters.
- The headings in each chapter describe a particular product; only select a sub-heading if your item is accurately described.
- If your item is not accurately described, check further down the list – if none of the sub-headings match your item use the ‘other’ heading.
- When you find the correct item type you will be shown the import and export codes, and any important information connected to the code – such as whether you need a licence to import or export items under this code.

NB You’re legally responsible for the correct tariff classification of your goods.

Use the following tool to calculate the duty and tax payable in the EU: [https://ec.europa.eu/taxation\\_customs/dds2/taric/taric\\_consultation.jsp?Lang=en&Expand=true&SimDate=20190724](https://ec.europa.eu/taxation_customs/dds2/taric/taric_consultation.jsp?Lang=en&Expand=true&SimDate=20190724) (archived at <https://perma.cc/UB8A-JEQY>)

### 3. Origin of the goods

‘Rules of origin’ are the criteria used to define where a product was made. They are an essential part of trade rules because a number of policies discriminate between exporting countries: quotas, preferential tariffs, anti-dumping actions, countervailing duty (charged to counter export subsidies), and more. Rules of origin are also used to compile trade statistics, and for ‘made in...’ labels that are attached to products. This is complicated by globalization and the way a product can be processed in several countries before it is ready for the market.

Goods, the production of which involves more than one country or territory, shall be deemed to originate in the country or territory where they underwent their last, substantial, economically justified processing or working, in an undertaking equipped for that purpose, resulting in the manufacture of a new product or representing an important stage of manufacture.

### ***Useful websites***

US Department of Transportation: <https://www.transportation.gov/> (archived at <https://perma.cc/MM5T-32G5>)

World Trade Organization: [https://www.wto.org/english/Tratop\\_e/cusval\\_e/cusval\\_info\\_e.htm](https://www.wto.org/english/Tratop_e/cusval_e/cusval_info_e.htm) (archived at <https://perma.cc/H33Q-G7B4>)

EU Commission: <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1521191466211&uri=CELEX:02013R0952-20161224> (archived at <https://perma.cc/ZCR3-KDY5>)

## 2.13 How to become an Authorized Economic Operator (AEO)

### *Introduction*

Authorized Economic Operator status is an internationally recognized quality mark that shows the holder's role in international supply chains is secure and that they operate customs control procedures that meet AEO standards and criteria according to the UK government.

There are two types of status:

AEOC – Authorized Economic Operator Customs Simplification

AEOS – Authorized Economic Operator Security and Safety

Companies can apply for either or both.

### Authorized Economic Operator Customs Simplification

If you hold this status and are based in Great Britain (England, Scotland and Wales), you could benefit from:

- a faster application process for customs simplifications and authorizations;
- a lower risk score which may reduce the number of checks customs carry out on your documents and goods;
- a guarantee waiver up to the level of your deferment account.

If you hold this status and are a Northern Ireland trader, you could benefit from:

- a faster application process for customs simplifications and authorizations;
- your consignments receiving priority treatment for customs controls;
- a lower risk score which may reduce the number of checks customs carry out on your documents and goods;
- a reduction or waiver of comprehensive guarantees;
- a 70 per cent reduction in a business's deferment account guarantee;

- a notification waiver when making entries into a declarant's records;
- moving goods in temporary storage between different member states.

## Authorized Economic Operator Security and Safety

If you hold this status, you could benefit from:

- a lower risk score which may reduce the number of checks customs carry out on your documents and goods;
- your consignments receiving priority treatment for customs controls;
- reduced declaration requirements for entry summary declarations and exit summary declarations;
- reciprocal arrangements and mutual recognition.

If you have Authorized Economic Operator Security and Safety status, you can benefit from Mutual Recognition Arrangements (MRAs). The UK negotiates MRAs with other customs authorities.

The UK has negotiated arrangements with:

the European Union

Japan

the People's Republic of China

the United States of America

Switzerland

New Zealand

Republic of Singapore

The AEO programme is open to all operators, including small and medium-sized enterprises and regardless of their role in the international supply chain. There is no legal obligation for operators to become an AEO; it is a matter of the operator's own choice based on their specific situation. Nor is there any legal obligation for AEOs to require their business partners to obtain the AEO status.

AEOs can be manufacturers, exporters, importers, freight forwarders, customs brokers, warehouse keepers, importers, port operators, airline loaders, secure freight parking operatives or carriers.

The AEO concept is based on the Customs-to-Business partnership introduced by the World Customs Organization (WCO). Traders who voluntarily meet a wide range of criteria work in close cooperation with customs authorities to assure the common objective of supply chain security.

## ***When to use***

When companies would like to benefit from the various simplifications specifically provided for under the customs legislation.

## ***How to apply***

A responsible person, for example a Director, within the business should apply for the status. You'll need to give up-to-date evidence of the person's role, responsibilities and competences.

To meet the criteria, you must have evidence of your business procedure and processes.

Approval for Authorized Economic Operator status involves audit visits from HMRC staff.

For a close cooperation between customs and the applicant/AEO it is recommended to get in contact with the Issuing Customs Authority (ICA) at an early stage and to keep that contact even beyond the application process. This can help to avoid misunderstandings on both sides and gives support if any questions arise.

The company should have in place appropriate organizational measures in the fields related to the AEO criteria, aiming at ensuring that risks linked to their customs activities may be identified and avoided and/or minimized.

You'll need to show evidence that you have:

- procedures that identify and report any customs irregularities or errors;
- taken appropriate action to deal with any irregularities;
- procedures that report any customs business changes;
- clear procedures for handling controlled goods;
- customs record keeping.

When applying for the status you'll need to provide evidence that you have:

- a well-maintained logistics system with a full audit trail;
- methods to allow HMRC to access your customs records;
- a logical administrative system;
- documented procedures to manage the flow of goods;
- internal controls that detect illegal or irregular transactions;
- procedures to handle licences and authorizations;
- archive and retrieval procedures in place;

- trained staff to tell HMRC of any system errors;
- procedures for checking customs declarations submitted by third parties on your behalf;
- information technology security measures in place.

If you make declarations on behalf of others, you'll need to provide evidence that you have:

- understood your contractual responsibilities and obtained written instructions from business partners;
- understood your legal responsibilities if acting in the capacity of an indirect or direct representative;
- processes for choosing business partners;
- documented procedures to validate the valuation, classification and origin of goods;
- procedures to manage or review relationships with clients who are non-compliant.

A comprehensive list of requirements can be found at the website shown below.

The status can take up to 120 days to approve.

You can check if a business holds Authorized Economic Operator status at <https://www.gov.uk/government/publications/check-if-a-business-holds-authorised-economic-operator-status>

There's also information on the World Customs Organization website. [https://www.coomd.org/en/topics/facilitation/instrument-and-tools/frameworks-of-standards/safe\\_package.aspx](https://www.coomd.org/en/topics/facilitation/instrument-and-tools/frameworks-of-standards/safe_package.aspx)

## ***Useful websites***

<https://www.gov.uk/guidance/authorised-economic-operator-certification>  
(archived at <https://perma.cc/7P87-2ZSX>)

## **2.14 Last mile and micro delivery options**

### ***Introduction***

'Last Mile' is typically a delivery from the last staging post, such as a local delivery depot, distribution or sorting centre to the customer or to a customer collection point.



As technology advances and even more customers' preferences shift in this direction, the last leg of delivery is one of the most challenging and important parts of supply chain management.

The goal of a last mile carrier is to deliver the item as quickly and cost-effectively as possible.

According to the latest research from Style Intelligence, the market for autonomous delivery vehicles and the wider use of autonomous vehicles in last mile situations is still emerging.

Business models continue to evolve as vendors seek commercial partners and different routes to scale. Trials are frequently approved, but rarely lead to scaled-up solutions with significant commercial objectives and service improvements.

There are, also, issues with the regulatory environment, congestion in cities, infrastructure problems (condition of pavements/sidewalks and delivery points (space for drone landing) among others).

Parcels make up the bulk of deliveries, but online grocery orders have increased recently together with fast-food deliveries.

According to ShipBob, last mile delivery is one of the most expensive aspects of retail logistics. They believe that 28 per cent of an online brand's bottom line comes from last mile delivery costs and on average, businesses spend approximately \$10.10 per order on last mile delivery. Given that most retailers offer free delivery and returns this may prove to be unsustainable in the future.

Last mile deliveries include the following:

- Couriers – vans, cars, motorbikes, bicycles, pedestrian.
- Pavement robots such as Starship.
- Lockers – static and dynamic (in terms of space); ambient and temperature controlled.
- Autonomous delivery vehicles.
- Drones.
- Legged robots.

## **When to use**

If you are considering the various options for last mile delivery of your products.

# How to use

Table 2.11 shows the advantages and disadvantages of each type of last mile delivery. One thing to point out here is that many companies will use a combination of delivery methods, depending on size of products to be delivered, delivery lead time, location of customers.

Where there are stars (\*) in the table, the more stars, the better the option.

**Table 2.11** Comparison of last mile and micro mile delivery methods

	Courier van	Lockers	Pavement robots	Drones	Legged robots	Autonomous road robots
Speed	Local speed limit e.g. 20 mph	N/A	Circa 4 mph	Up to 30 mph	Circa 2–4 mph	Local speed limit e.g. 20 mph
Payload	Up to 1500 kgs	<30kgs	<30kgs	<5kgs	<20 kgs	Up to 1500 kgs
Safety	****	*****	***	**	***	*****
No. of deliveries	100+	Collection only	1–5	1	1	Depends on capacity
Customer handover capability	Yes	No	No	No	Possibly	No
Door to door	Yes	No	Partially	Partially	Yes	Partially
POD	Yes	No	No	No	Possibly	No
Additional customer actions required	No	Yes	Yes	Yes	Possibly	Yes
Customer convenience	Average	Good	Average	Average	Average	Average

## Conclusion

As can be seen from Table 2.11, there are advantages and disadvantages to each of the systems.

However, many of the technologies shown above are still in their early stages and therefore it is difficult to compare on a like-for-like basis.

There remains significant competition from courier companies operating traditional deliveries direct to homes or via lockers located at high-frequency, convenient, strategic locations.

The novelty of pavement robots, drones, legged robots and ARRAs has seen growth in these areas; however, it is difficult to see how these technologies will evolve sufficiently to take the place of courier deliveries in the near future.

## References

*Autonomous delivery vehicles 2022* published by Stiq Ltd [www.styleintelligence.com](http://www.styleintelligence.com) (archived at <https://perma.cc/6PWC-PKZC>)

ShipBob – <https://www.shipbob.com/uk/blog/how-last-mile-delivery-works/> (archived at <https://perma.cc/E2SJ-TKSX>)

# Inventory management tools

03

## 3.1 Inventory management audit

### *Introduction*

This audit aims to measure the extent to which the inventory is managed against known best practices. It is not an exhaustive list of questions and should be tailored to individual companies, sectors or environments. Nevertheless it will give you a good start in understanding where improvement could be made and will enable you to compare operations at different sites.

### *When to use*

This is a good tool to use when you want to improve inventory management in your business, start a supply chain implementation project or when taking up a new job to understand how well inventory is managed in your new company.

### *How to use*

Table 3.1 shows the first five sections of the audit. The full audit can be purchased from <http://howtologistics.com>; discount code: **lsct2024**.

The full audit contains over 50 questions arranged into nine sections (inventory analysis, inventory reporting, inventory management parameters, inventory accuracy, data management, demand management, supply management, operating efficiency and process management).

**Table 3.1** Inventory management audit

Inventory Management Audit				
Carried out by:			Location:	
Date:				
Item	No	Yes	N/A*	Comments
<i>Inventory analysis</i>				
Are inventory families identified?				
Is ABC/Pareto analysis using average usage value carried out by family?				
Is ABC/Pareto analysis using average usage value carried out by item?				
Is ABC/Pareto analysis using average usage rate carried out by family (to identify fast/medium/slow movers)?				
Is ABC/Pareto analysis using average usage rate carried out by item (to identify fast/medium/slow movers)?				
Is the number of ABC/Pareto classes appropriate for the inventory? (Maybe 4, 5 or 6 classes would be more suitable.)				
Are stock-outs systematically recorded and investigated?				
Is demand variation measured using statistical methods?				
Is stock cover calculated and reviewed regularly by item and family?				
Is stock turn calculated and reviewed regularly by item and family?				
Is a non-mover analysis carried out?				
Is a back order analysis carried out?				
Are 'special' items (one-off purchases, not to be reordered) clearly identified?				
Are non-standard stock (e.g., seasonal items, check before reordering) items clearly identified?				
<i>Inventory reporting</i>				
Is the inventory value recalculated daily/weekly/monthly? (Choose appropriate time period.)				

(continued)

Table 3.1 (Continued)

Inventory Management Audit				
Carried out by:			Location:	
Date:				
Item	No	Yes	N/A*	Comments
Is a variety of customer service measures employed?				
Is the level of immediate availability of all items measured daily/weekly/monthly?				
Is the fill rate measured daily/weekly/monthly?				
Is the percentage of orders delivered on time and in full measured?				
Is an inventory performance report issued daily/weekly/monthly?				
Is the number of back orders days/weeks overdue monitored closely to ensure fulfilment as soon as possible (and to prevent 'unreal' back orders when customers forget to cancel)?				
Inventory management parameters				
Is an inventory management strategy (replenishment method) identified for each item/family/class?				
Is somebody responsible for setting inventory management parameters for each replenishment method (reorder points, safety stock levels, reorder quantities, etc)?				
Are inventory parameters reviewed at regular intervals?				
Are replenishment lead times checked and adjusted at appropriate regular intervals?				
Is stock cover reviewed at appropriate intervals?				
Does a disposal policy group exist, including representatives of users, finance, warehousing, procurement and inventory management functions?				
Does a disposal policy exist?				
Is the disposal policy clearly described and workable?				

(continued)

**Table 3.1** (Continued)

Inventory Management Audit				
Carried out by:			Location:	
Date:				
Item	No	Yes	N/A*	Comments
Are candidate items for disposal reviewed regularly?				
Is Kanban used for fast-moving, medium- or high-value items?				
Is VMI/CMI (vendor-managed inventory/co-managed inventory) used for high-usage/low-value items?				
Are safety stock levels reviewed at appropriate regular intervals?				
Are stock cover targets set for each family/item?				
<i>Inventory accuracy</i>				
Is quantity accuracy measured regularly?				
Is cycle or perpetual counting used?				
Is location accuracy measured regularly?				
Is condition/quality measured regularly?				
Is labelling accuracy measured regularly?				
Is a full stock count carried out at least once per year?				
Are random audits carried out in between formal counting?				
<i>Data management</i>				
Is the ability to change inventory management parameters restricted to a specific individual/group (i.e. restricted access)?				
Is there a procedure for creating new items/codes (to prevent duplicate identities for the same item)?				
Is the new item procedure followed?				
Is the coding system for new items logical and intuitive?				
When adding a new item to the system, is it easy to check if similar items exist already?				
* N/A = not applicable				

## 3.2 ABC Pareto analysis for inventory management

### *Introduction*

ABC analysis or Pareto analysis has been described as a general tool for distinguishing ‘the important few from the insignificant many’. This is especially useful in inventory management. Because of the high cost of holding inventory, it is critical to know which items are capable of generating the greatest holding cost so that we can focus our effort on managing these most important items carefully. ABC analysis for inventory management and procurement depends on item ‘usage value’, where usage value is the product of usage over a period of time and some indicative item value. By ranking usage value from highest to lowest, the few most important items can be identified. This calculation is essential because there may be a small number of very expensive items that must still be managed carefully, or there could be very high usage of low-value items, e.g. fasteners, to which it may not be worth dedicating a lot of our precious management effort (see VMI, tool 3.17).

We tend to calculate ‘usage value’ over a year but it could be calculated over other time periods, e.g. a week or a month. Usage value has several other applications in inventory management, including setting the limits of the ABC classes, in order to find an appropriate balance between administrative effort (to raise orders and plan replenishment) and replenishment quantity (which influences the average level of cycle stock and hence the average level of inventory and inventory holding costs).

### *When to use*

Item values and quantities consumed change over time and so it is useful to repeat the ABC analysis periodically to ensure that the class allocations are still appropriate, for example every 6 or 12 months.

The Pareto class of an item is used in inventory management to allocate the most appropriate inventory replenishment method, e.g. Kanban, MRP or classical inventory management methods for dependent items, or to understand the strategic importance of the item when applying the Kraljic matrix in procurement (see tool 4.6).



## How to use

Most inventory management systems have an ABC analysis function. If this is not the case, the data can be downloaded into Excel and manipulated using the data 'sort' function. There are five main steps:

- 1 Calculate the annual usage value for each item under consideration (formula 1), using some indicative item value (e.g. most recent price, or average item value):

$$\text{Annual usage value} = \text{annual quantity sold or used} \times \text{indicative item value} \quad (1)$$

- 2 Rank the annual usage values from highest to lowest.
- 3 Starting with the highest usage value, calculate the cumulative usage value.
- 4 Express the cumulative usage value as a percentage of the total annual usage value.
- 5 Identify the ABC class of each item.

Note that according to the data, it may be more appropriate to change the class limits, or even have more than three classes. Typical limits for a three-class system are:

- A** Up to and including 80% of total annual usage value ( $x \leq 80.0$ )
- B** Greater than 80% and up to and including 95% ( $80.0 < x \leq 95.0$ )
- C** Greater than 95% of total annual usage value ( $95.0 < x \leq 100.0$ )

Where there are a very large number of B or C items, some companies have identified four or five classes, by splitting B items into B1 and B2, C items into C1 and C2, or introducing a D class to have more precise control.

## Example

This example uses just 10 items to demonstrate the method. Clearly, there will be thousands of items in practice! Table 3.2 shows the starting data of average annual usage and indicative unit cost.

The items are then ranked in order of annual usage value (AUV), starting with the highest AUV. Cumulative AUV is then found and this is expressed as a percentage of the total (see Table 3.3). The class of each item can then be identified, using the limits stated earlier.

(This example can be downloaded for free from <http://howtologistics.com>)

**Table 3.2** Calculating the annual usage value

Item no.	Average annual usage	Unit cost (£)	Annual usage value (£)
1	10	295.00	2,950.00
2	5,270	0.40	2,108.00
3	22	18.00	396.00
4	185	320.00	59,200.00
5	43	118.00	5,074.00
6	780	12.80	9,984.00
7	550	0.50	275.00
8	365	0.50	182.50
9	150	13.25	1,987.50
10	225	10.35	2,328.75
		Total	84,485.75

### Further information

Ralph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London  
 Wild, T (2005) *Best Practice in Inventory Management*, 2nd edn, Butterworth-Heinemann, Oxford

## 3.3 Ballou's inventory-throughput curve

### Introduction

Ronald Ballou is one of the early writers who integrated inventory, warehousing, transport and location into a coherent and modern concept of customer service-oriented logistics management. His research has contributed greatly to the development of the field over the years. One of the many tools that he developed from empirical research is a method for using current and historical data to understand the relationship between the level of business

**Table 3.3** Calculating the cumulative percentage annual usage value

Item number	Annual usage quantity	Unit cost (£)	Annual usage value (AUV) in £	Cumulative annual usage value (£)	Cumulative percentage of annual usage value (%)	ABC class	
4	185	320	59,200.00	59,200.00	70.07	A	≤80.0%
6	780	12.8	9,984.00	69,184.00	81.89	B	
5	43	118	5,074.00	74,258.00	87.89	B	
1	10	295	2,950.00	77,208.00	91.39	B	
10	225	10.35	2,328.75	79,536.75	91.14	B	
2	5,270	0.4	2,108.00	81,644.75	96.64	C	>95.0%
9	150	13.25	1,987.50	83,632.25	98.99	C	
3	22	18	396.00	84,028.25	99.46	C	
7	550	0.5	275.00	84,303.25	99.78	C	
8	365	0.5	182.50	84,485.75	100.00	C	

carried out by a warehouse and the overall level of inventory required to support that level of business.

Ballou makes the point that warehouses are often planned to have a certain number of stock turns per year. Although this may be the target, it is worth analysing data on existing activities to find out the actual relationship.

## ***When to use***

Periodically, owing to changes in law such as the drivers' hours regulations or changes in markets and demand, it is necessary to review the structure of the distribution network. This review includes the location and size of warehouses and distribution centres relative to the customers and markets they are serving. Alternatively, a new warehouse may be planned to serve a new market. Ballou's inventory-throughput curve gives a first approximation of the total amount of inventory required to support a certain level of business.

## ***How to use***

The aim is to plot a graph of the value of the average inventory level against the value of annual throughput or sales. Most warehouses produce a weekly or monthly report of value of inventory and value of shipments made. The average value of inventory can be found by averaging the month-end inventory values from a number of reports. The annual value of shipments can be found by summing shipments across the last 12 months or extrapolating values from the last three or six months.

If this data is plotted for each warehouse in the network, a graph can be built up (see Figure 3.1). The best fit curve is found. If it is proposed to reorganize the network or to open a warehouse in a new market with an estimated volume of business, the total amount of inventory required for a given level of business can be found (Figure 3.1).

## ***Example***

A distribution network expanded from four to six warehouses between 20xx and 20xy. Throughput and inventory data are shown in Table 3.4. All of these points can be used and are plotted on a graph (see Figure 3.1). The best curve has been fitted. This can be done in Excel by selecting scatter plot,

Figure 3.1 Inventory-throughput curve

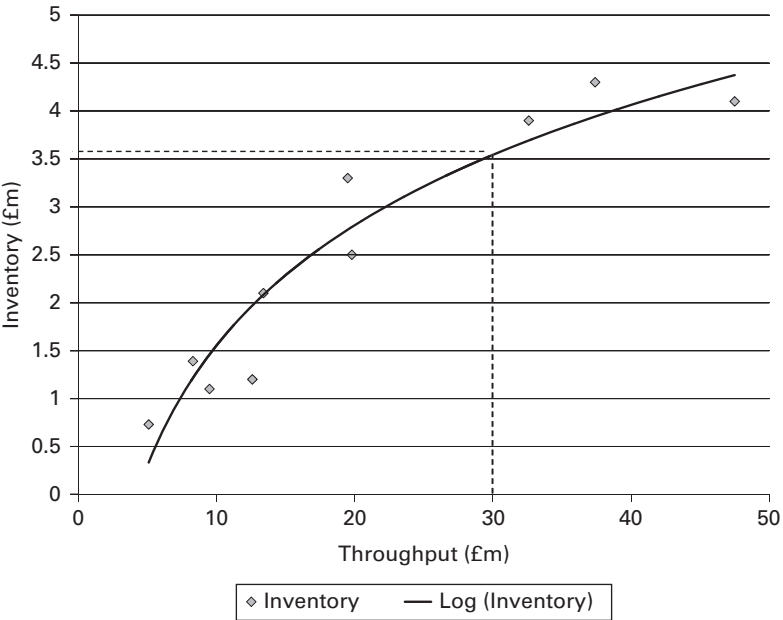


Table 3.4 Network data

Year	Warehouse	Throughput (£m)	Inventory (£m)
20xx	1	32.6	3.9
	2	8.3	1.39
	3	12.6	1.2
	4	19.5	3.3
20xy	1	37.4	4.3
	2	9.5	1.1
	3	13.4	2.1
	4	19.8	2.5
	5	5.1	0.73
	6	47.5	4.1

and then adding the best fit logarithmic curve. A new warehouse is being planned, which is expected to have a throughput of around £30 million. It can be seen from the graph that following previous practice it can be expected that inventory with a value of approximately £3.6 million will be required to support this level of business.

Note that the method assumes that systems and working practices in the new warehouse will be the same as in the other warehouses, but this may not necessarily be the case. (This example can be downloaded for free from <http://howtologistics.com>)

## Further information

See Ronald Ballou's *Business Logistics Management* or his 1981 paper that described the origins of this curve.

## References

- Ballou, R H (1981) Estimating and auditing aggregate inventory levels at multiple stocking points, *Journal of Operations Management*, 1 (3), February, pp 143–53
- Ballou, R H (2000) Evaluating inventory management performance using a turnover curve, *International Journal of Physical Distribution & Logistics Management*, 30 (1), pp 72–85
- Ballou, R H (2004) *Business Logistics Management: Planning, organizing, and controlling the supply chain*, 5th edn, Prentice Hall, Upper Saddle River, NJ

## 3.4 Consignment stock

### Introduction

The term comes from the old phrase 'on consignment', where something is supplied to a customer before payment on the basis that the customer will only pay for what has been sold on or used and can return any unsold stock. Consignment stock therefore refers to inventory that has been delivered to your warehouse, but for which you have not yet paid or even issued a

purchase order. When that material is taken out of stock for use, a purchase order is sent to the supplier and payment is made. Ownership of the, as yet, unused material still in the warehouse rests with the supplier and is transferred to the customer at the moment of withdrawal for use. The consignment agreement should specify:

- responsibility for any damage before use;
- the grounds under which either the customer can return the product, or the supplier can reclaim the product;
- who pays for the return transport; and
- whose insurance covers its presence in the warehouse.

It is common for a period of time to be specified, after which the goods are returned to the supplier.

There is a particular application of consignment stock in the retail sector where the supplier may use a consignment agreement to propose new products to a retailer, or high-end products the retailer would not normally stock. By this means the associated financial risk is shared between both parties and sales are equally beneficial to both.

Consignment stock can be part of an ongoing VMI/CMI arrangement where ownership of the stock rests with the supplier, and the customer pays only for what has been used (see tool 3.17). The advantages and disadvantages for each party are summarized in Table 3.5.

**Table 3.5** Advantages and disadvantages of consignment stock for each party

	Advantages	Disadvantages
Supplier	Customer will choose your material over a competitor's material because it is available. Can plan your deliveries such that you anticipate future requirements and may be able to reduce the number of deliveries. Shared financial risk for products that might not have been ordered otherwise.	This material is no longer available to send to another customer who may have an unplanned urgent requirement. There may be a long wait before payment. Risk of damage in the customer's warehouse. Increased inventory in the supply chain.

(continued)

**Table 3.5** (Continued)

	Advantages	Disadvantages
Customer	<p>Can obtain favourable financial terms in a buyer's market.</p> <p>Payment terms can be advantageous for the customer since payment is due at some time after use, rather than some period after delivery.</p> <p>Material is available if there is a sudden increase in demand.</p> <p>Ability to offer/use products that might not have been stocked otherwise.</p>	<p>Stockholding cost of items supplied that do not have immediate use.</p> <p>Increased space requirement for stock and associated stockholding cost.</p> <p>Increased inventory in the supply chain.</p>

### ***When to use***

Although consignment stock looks financially attractive to the customer, it must be remembered that the customer is holding this stock until the time of use. If this time is not imminent, the stock is simply adding to the inventory that must be managed (allocated space, counted, looked after, etc). In general, supply chain thinking states that we do not want extra inventory at any point in the chain, and that any stock on consignment, rather than delivered against a production or supply schedule, is causing a delay in the flow through the chain.

Consignment stock as part of a VMI agreement is more acceptable since the VMI agreement will have taken into account the stock profile of the different items and set up maximum and minimum stock levels using historical data and a plan of future requirements.

In summary, consignment stock without VMI should only be used for fast-moving items likely to be used in the very short term. In this instance, the flow is hardly limited, the financial effect is primarily a delay to payment, and the customer has received what they were going to order anyway.

### ***How to use***

Draw up an agreement taking into account the range of items concerned, methods/timing of supply, payment terms, maximum stock levels, returns at



the request of the supplier or customer, return transport cost, insurance and damage. Specify the liabilities and responsibilities of each party.

Check the VAT rules. The application of VAT to consignment stocks depends as much on 'control' (who has the right to withdraw stock) as ownership and it is therefore worth checking liabilities with the accounting function before setting up any agreement, particularly if material is being supplied across borders.

### **Example**

A manufacturer is developing a new product and is refining the specification through trialling various thicknesses of polymer sheeting. Market research has been very positive and the supplier has been engaged to supply material as required on consignment, essentially sharing some of the financial risk of the development process, on condition that its product(s) will be specified for a minimum of the first 100,000 units of production, or one year, whichever event occurs first.

### **Further information**

Wild, T (2005) *Best Practice in Inventory Management*, 2nd edn, Butterworth-Heinemann, Oxford

## **3.5 Cycle counting or perpetual inventory counting**

### **Introduction**

In order to have usable inventory data, it is vital to maintain the integrity of the stock records. This requires user discipline but also a good counting discipline. The primary purpose of stock checking is to count the items and check the quantities found against the quantities recorded in the inventory management system. Sometimes it is useful to take advantage of the stock-checking process to check the location of each item, that it is labelled correctly and is still in usable condition. The traditional approach to stock checking is to set up an annual stock count, usually at the beginning of January, or near the end of the company's tax year. This requires hiring

temporary personnel or using existing personnel, which may halt activities or prevent sales while the count takes place.

Another approach is to count a proportion of items regularly throughout the year using normal stores or warehouse personnel. This is known as cycle counting or, sometimes, perpetual inventory counting. There are two approaches to cycle counting: 1) count each item at least once during each replenishment cycle (where the replenishment cycle time is the average time between replenishments); and 2) use ABC analysis to set up a counting plan (sometimes called a periodic counting plan).

## ***When to use***

Cycle counting or perpetual inventory counting is used as an efficient alternative to the annual stock count by spreading the counting effort through the year, counting higher-value items and fast movers more often than lower-value or slower-moving items.

## ***How to use***

### **1. Counting each item at least once during the replenishment cycle**

The most efficient way to do this is to count the number of items just as the replenishment arrives, i.e. count the amount remaining just before the new stock is added. At this point, one might expect there to be the least stock to count. Since Pareto class A items should be replenished more frequently than B items, this will result in counting A items more frequently. However, some weeks may see more deliveries than others, so the counting workload could see peaks and troughs.

### **2. Setting up a periodic counting plan**

An alternative to counting just before replenishment is to count a certain number of items every week and thus spread the counting workload evenly across the year (although there may be more stock to count at times since the count will not necessarily take place when the stock level is lowest). For example, if the business works 52 weeks of the year and there are 1,560 different items in inventory, we would plan to count  $1,560/52 = 30$  different items each week. Clearly we could count more than  $1/52$  of all items each

week if we wanted to count the stock more than once per year. For example, we could count 60 items each week if we thought it necessary to count all items twice per year.

Let us say that we are planning to count all the items once per year and this means counting 30 items each week. How should we choose what to count each week? One method is to choose these 30 items at random from the stock list, and allocate them to week 1, remove those items from the list of items waiting to be allocated, choose another 30 items at random and allocate them to week 2, and so on. This ensures that the person(s) counting will visit the whole of the stores area and may spot any other problems as they carry out the count. Another method is to choose 30 items that are co-located since there is more chance of finding any misplaced items in this way, and the area can be left well organized after counting.

Data about the 30 chosen items are then transferred to a list, either on paper or on a handheld terminal. The data required are:

- item code;
- item description;
- item location.

The person carrying out the stock count would normally be somebody familiar with the stock, for example a person who usually works in the stores. It is important to estimate how long counting takes each week so that enough stores people are employed and that this task is not forgotten in the daily list of tasks and other priorities. In some large warehouses, automotive spare parts for example, some people are employed full-time as stock checkers.

## **Example**

A good approach is to use ABC analysis to determine the frequency of counting. First, decide the frequency at which you wish to count each category of item; for example, to count A items four times per year, B items twice per year, and C items once per year. Table 3.6 shows how to determine what proportion of the total items will appear on the weekly list. Using the frequencies proposed, a weekly list of 1/13 of all A items, 1/26 of all B items and 1/52 of all C items would be created.

**Table 3.6** Derivation of ABC cycle counting frequencies

ABC class	Desired number of counts (cycles or periods) per year	Fraction of items to be counted in each period	Period of counting	Proportion of items on the weekly list
A	4	$\frac{1}{4}$	$\frac{1}{4} \times 12$ months = 3 months = 13 weeks	$\frac{1}{13}$
B	2	$\frac{1}{2}$	$\frac{1}{2} \times 12$ months = 6 months = 26 weeks	$\frac{1}{26}$
C	1	$1/1 = \text{All}$	$1 \times 12$ months = 12 months = 52 weeks	$\frac{1}{52}$

### Further information

If you are having a problem with inventory accuracy, you may find it helpful to read David Piasecki's 2003 book, which contains a wealth of experience on improving inventory management: *Inventory Accuracy: People, processes, and technology*, OPS Publishing, Kenosha, WI.

### Further reading

Relp, G J and Milner, C Z (2019), *The Inventory Toolkit*, Kogan Page, London

## 3.6 Strategic positioning of inventory

### Introduction

For centuries, holding stock has been used to offer reduced lead times to customers. Finished goods stock has time value since it is available immediately. Work in progress can be finished quickly. Raw materials stock means that we do not have to wait for the procurement lead times to elapse before we can start to manufacture. Downstream activities are thus decoupled from

upstream activities. Since the 1970s, however, we regard inventory as a liability and not as an asset. There is, therefore, a balance between the level of stock and its associated stockholding cost (see tool 4.19) and risk of obsolescence and the financial opportunity it potentially represents in terms of avoiding lost sales.

Strategic positioning decisions aim to optimize the location of the inventory in order to increase sales without unnecessarily increasing the stockholding cost and associated risk. These stocks are often called decoupling buffers. They can be used to reduce the lead times in a bill of materials and thus compress the overall planning time in the material requirements planning (MRP) calculations.

## ***When to use***

Stock levels are reviewed as part of an inventory reduction programme or as part of a regular reassessment of investment in inventory. Positioning of decoupling buffers is reviewed as part of a demand-driven material requirements planning implementation (see tool 4.17 on DDMRP).

## ***How to use***

For finished goods stock, the questions are:

- What lead time will our customers tolerate? If we cannot achieve this lead time, will we lose business?
- If we can reduce this lead time by holding stock, will we gain more business?
- How much demand variation do we want to be able to absorb?

For work in progress, the questions are:

- Where are the bottlenecks? Can we protect continuity of production by placing strategic stock before the bottleneck (it must never be starved)?
- Where are the long lead times? Can we reduce the lead time to deliver the product to finished inventory by placing a strategic stock of part-finished items to decouple the finishing processes from the supply processes (procurement and initial production)?
- How much demand variation do we want to be able to absorb?

For stocks of raw materials, components and purchased sub-assemblies, the questions are:

- Which are the longest lead time items? Would holding stock to decouple the procurement lead time from the production lead time enable a more rapid response to customer orders?
- Which are the riskiest items in terms of supplier reliability? Would raw materials stock ensure continuity of supply to production?
- How much demand variation do we want to be able to absorb?

## **Example**

Sometimes offering a reduced lead time can win the order. Other times, there are industry-accepted lead times at certain points in the supply chain which schedulers plan into their build programmes or lead times are already very short. In this case, there is no advantage in offering reduced lead times to these customers unless you want to respond to the rare urgent demand when the planner gets it wrong.

A company based in the United Kingdom supplying laminated flat glass products to the building industry was reviewing levels of its finished goods stocks. The industry-accepted lead time for simple laminates to common specifications was next day delivery, thus requiring finished goods stock. Failure to deliver one stock item risked losing the customer to a competitor who could deliver all the required stock items. The question here is to determine which are the common specifications and ensure finished goods stocks of those specifications. Finished goods stock could be replenished within 24–48 hours from production, but raw materials were subject to occasional delays of 48–72 hours, when glass was not allowed onto the cross-channel ferries from mainland Europe due to bad weather. Clearly, it is cheaper to hold a stock of raw materials than finished goods. Further, those raw materials can be made into several different products offering better reactivity and flexibility to changing demand. It was decided to hold enough raw material inventory of common glass sheets to cover production for 96 hours as a decoupling buffer from the unreliability of supply as well as allowing reactivity to demand variation.

An example of strategic positioning of inventory in demand-driven MRP can be downloaded for free from <http://howtologistics.com>

## Further information

See *Orlicky's Material Requirements Planning or Demand-Driven MRP*, both by Carol Ptak and Chad Smith, published by McGraw Hill.

## 3.7 Measuring demand variation

### Introduction

Coping with variation in supply and demand is one of the inventory manager's biggest challenges. As deliveries from suppliers become gradually more reliable due to improvements in on-time delivery performance, the spotlight is shifting to the demand side. While we try to obtain better forecasts from customers and better demand data (such as point of sale data), many companies are still forced to manage finished goods inventory using historical data only.

It is therefore important to be able to measure variation in historical demand so as to set safety stock levels (see tool 3.14) to meet future demand with a certain level of confidence. We shall consider two methods of measuring variation in demand: mean absolute deviation and standard deviation.

### When to use

A measure of demand variation is necessary to be able to set safety stock levels for a given level of availability of finished goods stock (see tool 3.14).

### How to use

#### Method 1: Mean absolute deviation (MAD)

The MAD is defined as:

$$\text{MAD} = (\sum |x - x'|) / n \quad (1)$$

where  $x'$  is the mean demand,  $x$  is the demand in a particular time period and  $n$  is the number of time periods being taken into account.

#### Method 2: Standard deviation (SD)

The standard deviation is found from:

$$\text{SD} = \sqrt{[\sum (x - x')^2 / (n - 1)]} \quad (2)$$

where  $\bar{x}$  is the mean demand,  $x$  is the demand in a particular time period,  $n$  is the number of time periods being taken into account, and  $\Sigma$  means ‘sum of’.

### Example

Let us consider the demand data for just one item as shown in Table 3.7. The final column shows that total demand is 500 units over the 10-week period. Hence, we can say that the average weekly demand is 50 units per week ( $500/10 = 50$ ). In preparation for calculating both MAD and SD, data are entered into Table 3.8.

**Table 3.7** Weekly demand for blocks of soap from weeks 20 to 29

Week	20	21	22	23	24	25	26	27	28	29	Total
Demand	48	54	57	49	51	50	46	47	53	45	500

**Table 3.8** Calculations for weekly demand for bars of soap

1	2	3	4
Week	Demand	$ x - \bar{x} $	$ x - \bar{x} ^2$
20	48	2	4
21	54	4	16
22	57	7	49
23	49	1	1
24	51	1	1
25	50	0	0
26	46	4	16
27	47	3	9
28	53	3	9
29	45	5	25
		30	130



## Method 1: MAD

Column 3 in Table 3.8 shows the absolute differences between the weekly demand and the average weekly demand (which we know is 50 per week). For example, the demand in week 20 is 48. The difference between 48 and the mean demand of 50 is 2. Thus we see the value 2 in column 3. The two vertical lines either side of  $x - \bar{x}$  mean 'magnitude'. This means that it does not matter if the actual demand is two units higher or two units lower than the average. We are simply interested in how far apart the two figures are. The sum (symbol  $\Sigma$ ) of all these differences over the 10 weeks is found to be 30, shown at the bottom of column 3.

The final stage of the calculation is to divide 30 by the number of weeks being considered, which is 10. We conclude that MAD for blocks of soap from weeks 20 to 29 is  $30/10 = 3$ .

The bigger the variability in demand, the bigger the MAD. We therefore now have a means of measuring and expressing variability in demand.

## Method 2: SD

Standard deviation of demand is a more accurate measure but is a bit more difficult to calculate. In column 4 in Table 3.8, we can see that the absolute difference between demand and mean demand found in the MAD calculation has been squared. To find the standard deviation, we sum all the figures in column 4, divide by  $n - 1$  ( $10 - 1 = 9$ ) and then find the square root. The bigger the value found for SD, the bigger the variation in demand.

$$SD = \sqrt{\left[ \sum (x - \bar{x})^2 / (n - 1) \right]} = \sqrt{[130 / 9]} = 3.8$$

It is worthwhile mentioning that there is a rough relationship between MAD and SD where SD is approximately 1.25 times the MAD value. For example, for blocks of soap, we found that SD is 3.8 and MAD is 3.0, so here SD is 1.27 times the value of MAD. Although SD is more complicated to calculate, it is a more accurate measure of spread than MAD and should be used if possible.

(This example can be downloaded for free from <http://howtologistics.com>)

## Further information

Any introductory statistics textbook will provide a thorough explanation of the two methods. See also: Relph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London

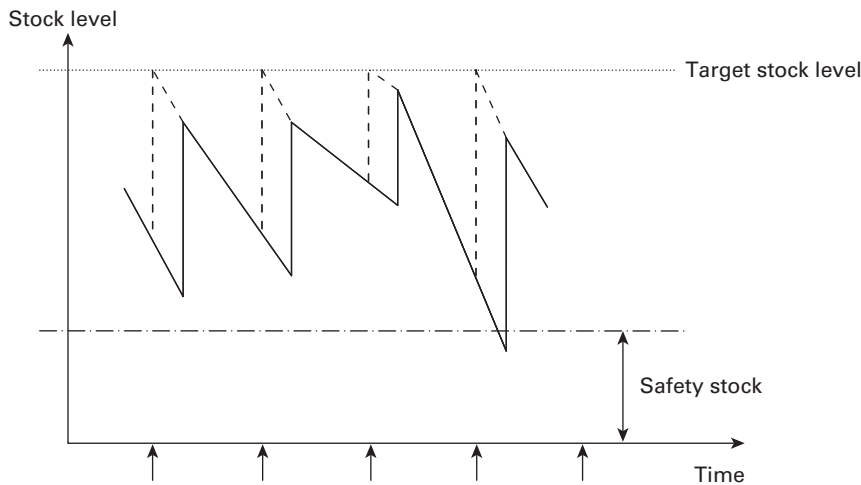
### 3.8 Periodic review inventory management system

#### Introduction

The specific characteristic of a periodic review system is that the level of inventory is checked at regular intervals and it is decided at the moment of review whether to place a replenishment order or not. This is in contrast to the reorder point system where the time between successive orders can vary.

Figure 3.2 shows the idea. A target stock level (TSL) has been set, made up of safety stock plus cycle stock. The cycle stock is the amount of stock that is used and replenished under normal circumstances; that is, the amount of stock between the level of safety stock and the TSL. The stock level is reviewed at regular intervals (indicated by small arrows on the horizontal axis in Figure 3.2). At each review, a quantity is ordered that takes the actual stock level back up to the TSL (dotted line). An order is placed and the replenishment quantity arrives in due course (indicated by the solid vertical lines). The horizontal distance between the vertical dotted line and the vertical solid line is the delivery lead time (reliable in this example). During this lead time the stock is still available for use and so the stock level will fall during the delivery lead time.

**Figure 3.2** Periodic review system



Clearly, this type of method suits computerized inventory management systems, where the computer program checks the stock level of every item in the system against its TSL and generates a group of orders, grouping items together on the same purchase order where they come from the same supplier. A computer system can thus review the inventory status for thousands of items very quickly. This is rather difficult to handle in a manual system. Where inventory is managed using a manual system, it is possible to get the same benefits from grouping together items from the same supplier, by reviewing all the items from the same supplier at the same time, and spreading the suppliers over different days of the week, for example all items from supplier P on Monday, all items from supplier Q on Tuesday, and so on.

### **When to use**

This is a method for managing inventory of items subject to independent demand, that is, items that are sold from finished goods inventory. It may also be used for C items, subject to dependent demand, that are used regularly. This method also forms the basis of a family of related inventory management systems.

In a typical supermarket, the computerized inventory management system reviews the stock levels at the end of each afternoon and sends an order to the distribution centre for delivery during the night or early morning.

### **How to use**

This type of system is characterized by regular review intervals and a variable order quantity. The key parameters required to set up the system are the review period (R), i.e. time between successive reviews, and the TSL.

The time between successive reviews can be any convenient period depending on the location of the supplier and the ease of delivering regularly. Although we saw above that a supermarket typically receives deliveries every 24 hours, the delivery frequency can vary enormously in a manufacturing company. Usually A items are delivered more frequently and so the review period for these items may be daily or weekly. Vendor-managed inventories also use this system (see tool 3.17). A TSL is agreed between the customer and the supplier and the vendor makes deliveries at a convenient time to 'top up' the stock. This might be weekly when delivering fasteners to a manufacturing company or every two hours when delivering freshly made sandwiches to the shop at a petrol station.

The review period is taken into account when calculating the TSL. Longer time intervals between reviews means that a higher TSL will be required. The TSL must allow for enough stock to support the users until the next review period and until the following delivery arrives. Consider the case where the review period is one week and the lead time is two days. A replenishment order will be placed to take the inventory back up to the TSL and this will arrive in two days' time. This stock must be capable of supplying demand until the next review period (one week from now) and until the order placed then arrives (two days after that). Hence, we need to take into account the average demand ( $D_{av}$ ) over this extended time period (formula 1):

$$\begin{aligned} \text{TSL} &= (D_{av} \times [\text{review period} + \text{lead time}]) \\ &+ \text{safety stock level} = (D_{av} \times [R + L]) + S_b \end{aligned} \quad (1)$$

If the delivery lead time  $L$  is reliable, then the level of the safety stock  $S_b$  is calculated in exactly the same way as for the reorder point system. Note that it is critical to ensure that all elements use the same unit of time, e.g. average weekly demand with review period and lead time expressed in weeks.

The quantity to be ordered ( $O_q$ ) is calculated from the TSL (formula 2). Let  $S_c$  represent current stock level and  $Q_{open}$  be the quantity of items on any outstanding orders (orders already placed for this item but which have not arrived yet):

$$\begin{aligned} O_q &= \text{TSL} - \text{current stock level} - \text{any open orders} \\ &= \text{TSL} - S_c - Q_{open} \end{aligned} \quad (2)$$

## Example

### Example 1: Find the TSL

Item Z has the following characteristics:

$$\begin{aligned} \text{Lead time} &= 2 \text{ weeks} \\ \text{Review period} &= 1 \text{ week} \\ \text{Average demand} &= 60 \text{ per week} \\ \text{Safety stock} &= 20 \text{ units} \end{aligned}$$

The TSL is found by applying formula 1:

$$\text{TSL} = (D_{av} \times [R + L]) + S_b = (60 \times [1 + 2]) + 20 = 200$$

### Example 2: Find the order quantity

The TSL for item V is 120. At the time of the periodic review, it is found that the current stock level is 42. There are no open orders.

Applying formula 2:

$$\begin{aligned} Oq &= \text{TSL} - \text{current stock level} - \text{any open orders} \\ &= \text{TSL} - S_c - Q_{\text{open}} = 120 - 42 - 0 = 78 \end{aligned}$$

An order should be placed for 78 units of item V.

### Further information

See Wild, T (2005) *Best Practice in Inventory Management*, 2nd edn, Butterworth-Heinemann, Oxford

## 3.9 Reorder point inventory management system

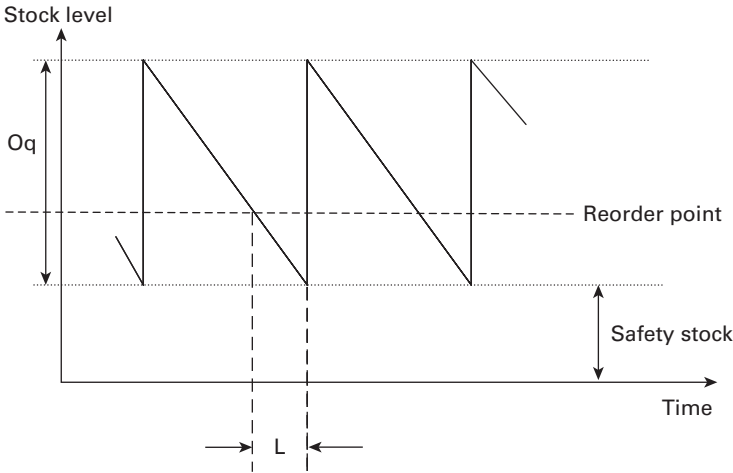
### Introduction

The reorder point system is based on the idea that when the inventory level falls to or below a certain level, the reorder point, we place an order for more, for a predetermined quantity. Figure 3.3 shows what happens under ideal conditions. The reorder point (sometimes called the reorder level), shown as a dotted line in Figure 3.3, is one of the defining parameters of this type of system and is set in advance. The reorder quantity ( $Oq$ ) is also set in advance.

It can be seen from Figure 3.3 that the reorder point has two components. The first is the quantity between the level of safety stock and the reorder point. The reorder point must be set high enough to meet the expected average demand during the delivery lead time ( $L$ ), i.e. while waiting for the replenishment quantity to arrive. If there is a safety stock, the reorder point must also take into account that we do not expect to use the safety stock under average conditions. The emphasis has been placed on 'average' here because we only expect to use the safety stock under conditions that are not average, e.g. lateness in delivery or higher than average demand.

So the reorder point is the sum of the quantity of safety stock,  $S_b$ , and the quantity that is expected to be used during the delivery lead time,  $L$ . The

**Figure 3.3** Reorder point system



quantity that is expected to be used during the delivery lead time is easily found by multiplying the average rate of demand,  $D_{av}$ , by the lead time,  $L$  (see formula 1):

$$ROP = (L \times D_{av}) + S_b \quad (1)$$

After each transaction, the residual inventory level is checked against the safety stock. If the inventory level is at or below the reorder point (taking into account any existing open orders), a replenishment order is created. This is therefore a continuous review method, with fixed order quantity. According to the rate of demand, replenishment orders are raised as and when required, and the time between raising successive replenishment orders can vary. This means that a number of different orders could be raised on the same supplier during the day, where a vendor supplies a number of different items. This may not be the most efficient method for minimizing transport costs.

Note that it is critical to express all data in the same time units, usually days or weeks.

### When to use

This is a method that is suitable for items subject to independent demand, that is, sales from finished product stock. It can also be used for regularly used C items subject to dependent demand (i.e. materials and components

required for a production schedule). There are many different inventory management systems for managing inventory subject to independent demand and this method is one of the building blocks for many other methods.

Historically, when inventory was managed using manual records, it was an advantage to raise orders continuously so as to spread the administrative load. Today, using computer systems, and trying to group as many items as possible to as few suppliers as possible, periodic review systems are more prevalent, particularly in retail distribution.

## ***How to use***

To set up a system like this, the following steps must be taken for each item:

- 1** Analyse demand to obtain an average level of demand per time unit,  $D_{av}$ , say average demand per week.
- 2** Obtain an indicative lead time,  $L$ , for each item and express this in terms of the same time unit, say weeks.
- 3** Set the inventory parameters –  $O_q$  and  $S_b$ . For guidance, see the sections on replenishment quantities (tool 3.10) and setting safety stock levels (tool 3.14).
- 4** Determine the reorder point,  $ROP$ , from the data above.
- 5** Monitor the average demand and lead times. If they differ significantly from the quantities used previously to calculate the reorder point, the reorder point should be updated.

## ***Example***

### **Example 1: Setting the reorder point**

A new item has been added to the inventory management system of a warehouse and so the reorder point must be calculated. It is expected that about 20 boxes of this item will be sold per week and it has been decided that there should be a safety stock of 10 boxes. Using a delivery lead time of three weeks, we now have all the data required to set the reorder point:

$$D_{av} = 20 \text{ units per week}$$

$$L = 3 \text{ weeks}$$

$$S_b = 10$$

$$ROP = (L \times D_{av}) + S_b = (3 \times 20) + 10 = 70$$

After each transaction, the residual inventory level is checked against the reorder point, taking into account any open orders (formula 2):

$$\begin{aligned} &\text{If (stock balance + quantity on outstanding orders)} \\ &\leq \text{ROP, then place an order.} \end{aligned} \quad (2)$$

### Example 2: Raising a replenishment order

An order has just been received in a warehouse for 10 boxes of plastic gloves. The inventory record shows that there are 69 boxes in stock. The reorder point is 60. The reorder quantity is 200. There are no open orders. Should a replenishment order be raised? Remember that this system is a continuous review system and we review the stock level after each transaction.

$$\text{New stock balance} = \text{opening stock} - \text{quantity issued} = 69 - 1 = 59.$$

Then we apply formula 2:

$$\text{Stock balance} + \text{quantity on outstanding orders} = 59 + 0 = 59$$

$$\begin{aligned} &\text{If (stock balance + quantity on outstanding orders)} \\ &\leq \text{ROP, then place an order} \end{aligned}$$

We can see that 59 is less than the reorder point of 60, so an order is raised.

Let us say that later the same day another order for boxes of plastic gloves is received. This time the order is for two boxes. We make the issue as before and the new stock balance reduces to 57. Should we order more? We apply formula 2 again, but this time we have an open order:

$$\text{Stock balance} + \text{quantity on outstanding orders} = 57 + 200 = 257$$

The stock balance plus quantity on open orders is greater than the reorder point, so another order will not be placed.

### Further information

Tony Wild's book is highly recommended for learning more about inventory management: Wild, T (2005) *Best Practice in Inventory Management*, 2nd edn, Butterworth-Heinemann, Oxford.

For those who wish to explore inventory management in even more detail, see: Relph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London, and Silver, E and Peterson, R (1985) *Decision Systems for Inventory Management and Production Planning*, 2nd edn, Wiley, New York.



## 3.10 Replenishment order quantities

### Introduction

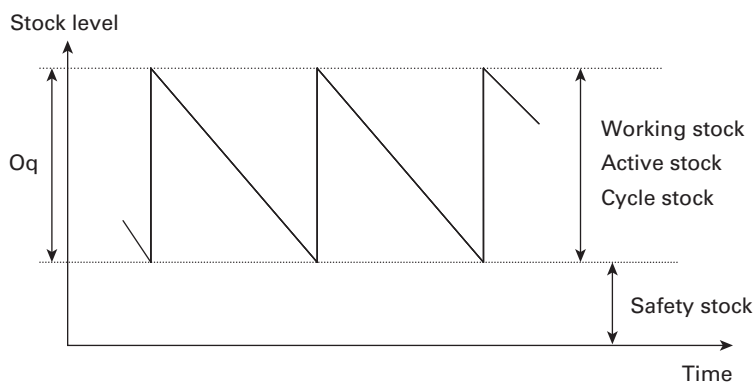
A replenishment order is raised to trigger purchase or production of more units of an existing inventory item to replace what has been used or sold. If the replenishment order is to be produced (rather than purchased), the order quantity will have a major impact on the level of work in progress, the number of setups and the overall lead time. The size of the reorder quantity also has a major impact on the average level of finished goods stock that is held. We can see this from the traditional ‘saw tooth’ inventory model shown in Figure 3.4.

The model shows that the average inventory level is given by the safety stock level plus the average level of cycle stock (formula 1). In this simple model, the average level of cycle stock is half the total amount of cycle stock:

$$\text{Average level of inventory} = \text{safety stock} + \frac{1}{2} (\text{cycle stock}) \quad (1)$$

We know that if we place a lot of small orders (where  $Oq$ , the order quantity, is small), the cost of administration and delivery for those small orders will be high. Similarly, if we order in large quantities, the cost of administration and delivery will be low but the average level of stock (formula 1) will be high. Many years ago, these two conflicting factors were encapsulated into another theoretical model, called the economic order quantity (EOQ) (tool 3.11), and it was used in some industries for a number of years. These days, however, we prefer to use this model to

**Figure 3.4** Saw tooth theoretical inventory model



understand where improvement should be sought but use other methods to calculate the actual quantity to be ordered. In short, we need to find the smallest order quantity that is practicable. There are many more reasons for ordering the smallest quantity possible:

- less safety stock required;
- more frequent deliveries, which leads to greater reactivity to changing demand;
- lower stock levels, which requires less storage space;
- less chance of obsolescence, damage and other shrinkage;
- easier to count;
- easier to introduce new items.

It can be seen that it is the 'soft' costs, or hidden costs associated with inventory, that are reduced by ordering in smaller quantities and so it often takes more effort to justify this method financially. Methods for reducing the administration and delivery costs associated with small orders include:

- using local vendors where possible;
- using milk rounds to collect supplies from vendors;
- purchasing as many items as possible from the same vendor to render frequent deliveries of small amounts of each item economic;
- raising a blanket order and calling off deliveries against it;
- using 'soft' forms or ordering by internet;
- using VMI;
- using Kanbans.

In production, it is necessary to continue to keep reducing set-up times in order to minimize the penalty for switching production from one product to another, and thus enable smaller and smaller production quantities to be economic.

## ***When to use***

Sometimes we have little control over the size of the replenishment quantity. The supplier insists on a minimum order quantity (or value) or supplies only in multiples, e.g. boxes of 100. The factory insists on a certain run time or a production tank holds only a certain volume. However, when you can buy or make exactly what you want, how much should you buy or make?

## How to use

If you are in the fortunate position of being able to set any replenishment quantity you wish, a good starting point is to consider what delivery frequency is ideal and then try to figure out how this can be sensibly achieved. A useful guide for doing this is, once again, ABC analysis. The delivery frequency will differ according to the sector. Some examples are given below.

## Example

An ABC delivery schedule for replenishment quantities will be developed for three different sectors (see Table 3.9).

Automotive assembly lines work at a certain speed or rhythm, and to a sequenced schedule made up of customer and stock orders. The consumption rate of parts and assemblies, and the sequence in which they should be delivered, is therefore known. Ideally, parts should be delivered at the last possible moment (to minimize storage space required) and, ideally, to the lineside without any unreturnable packaging.

Typical engineering companies do not consume the same volume of parts and assemblies as automotive assembly lines and are also usually subject to greater variation in demand. Although this means that safety stocks are likely to be higher, it also means that deliveries will be necessarily less frequent.

In the retail sector, supermarkets are supplied with fresh goods and fast movers every 24 hours, while dry goods and household items may be replenished every two to three days.

## Further information

See Wild, T (2005) *Best Practice in Inventory Management*, 2nd edn, Butterworth-Heinemann, Oxford, and Relph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London.

**Table 3.9** Typical delivery intervals for ABC items in different sectors

Pareto class	Automotive	Engineering	Retail
A	2 hours	Weekly	Daily
B	½ day	Monthly	2–3 days
C	Weekly	Quarterly	Weekly

# 3.11 Economic order quantity (EOQ), by Geoff Relph

## Introduction

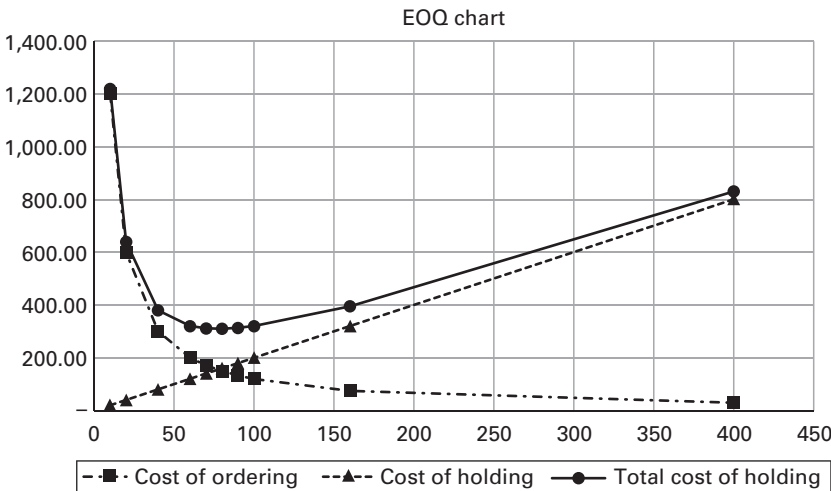
Ford W Harris, while working for Ford Motors in Michigan in 1913, derived a method of establishing an economic order value. It is based on the principle that there is a balance between the cost of ordering and the cost of holding stock. Figure 3.5 shows this relationship graphically.

The essence of the formula is that the cost of holding inventory is expressed as the cost of of:

- owning/renting the warehouse;
- staff to secure and run the warehouse;
- losses of stock through waste, obsolescence and shrinkage;
- lost opportunity of the money tied up in the stock.

It is expressed as the formula  $\text{Quantity ordered} \times \text{Unit cost} \times (\text{Cost of holding}/2)$ .

**Figure 3.5** Economic order quantity



This is then balanced against the cost of ordering inventory, which is expressed as the cost of:

- placing order with supplier;
- transport to warehouse;
- receiving and putting to stock.

It is expressed as the formula (Demand × Cost of ordering)/Quantity ordered.

Figure 3.5 shows that the two costs reach a balance point – this is the economic order quantity ( $Q^{OPT}$ ). It can be expressed as a formula, whose derivation is shown in Figure 3.6. Figure 3.7 shows how the formula works and the data needed to calculate the value.

There has always been a lively debate as to the effectiveness and suitability of the EOQ, the key being the difficulty in determining the true values of the cost of ordering and the cost of holding inventory. However, it highlights the essential relationship that needs to be considered when determining the most effective order size, which balances these two costs. The issues of not being able to evaluate these costs are addressed in the next section.

**Figure 3.6** Deriving the EOQ

TC = Total annual cost  
 D = Demand  
 P = Part cost per unit  
 Q = Order quantity  
 C = Cost of placing an order or set-up cost  
 i = inventory carrying rate %

Inventory management cost =  $\frac{D}{Q} C + \frac{Q}{2} i P$

$$TC = DP + \frac{D}{Q} C + \frac{Q}{2} i P$$

Cost is at a minimum when Cost of ordering equals the Cost of holding

$$\frac{D}{Q} C = \frac{Q}{2} i P$$

By manipulating the formula you get

$$Q_{OPT} = \sqrt{\frac{2DC}{iP}} = \sqrt{\frac{2(\text{Annual demand})(\text{Order or set-up cost})}{(\text{Unit cost})(\text{inventory carrying rate})}}$$

**SOURCE** Based on Chase et al (1998) *Production and Operations Management*, p 588

**Figure 3.7** EOQ formula for item 9 in Table 3.2

D = Demand		150	
C = Cost of ordering/set-up		£80.00	
P = Unit cost		£13.25	
i = inventory holding rate as %		30%	
W = working days in a year		250	
Economic order quantity	$Q = \sqrt{\frac{2 * D * C}{P * i}}$	$Q = \sqrt{\frac{2 * 150 * 80.0}{£13.25 * 30\%}}$	77.70

### When to use

All too often when suppliers are asked to give a suggested minimum order quantity (MOQ), their motivation is to minimize their production cost and thus maximize their profit. Often a supplier may incentivize larger batches by offering discounts for the larger quantities. The buyers typically have ‘cost down objectives’ so will find this attractive; however, the planners/operations team will suffer as a result of higher inventories.

### How to use

EOQ is useful when testing to see if the discount is really worthwhile, given that you have a reasonable estimate of the cost of ordering and cost of holding stock. It is easy to test the offer made by the supplier by calculating the EOQ for the two costs offered by the supplier and then seeing how close to the calculated EOQ the MOQ requirements are.

### Example

Let’s say that our supplier for item 9 in Table 3.2 (tool 3.2) is offering a discount of 5 per cent if we increase the MOQ to 150 units. We had asked for an MOQ of 75 based on our calculations.

Table 3.10 shows the EOQ calculated for a range of different costs/discount percentages from 5 to 75 per cent. It is clear from this analysis that the 5 per cent discount does not justify the increase to a MOQ of 150 as the equivalent EOQ for 5 per cent discount or unit cost of 12.59 is only 79.72. To achieve an equivalent EOQ to the offered 150, the discount would need to be just below 75 per cent, which would give an EOQ of 155.41.

**Table 3.10** Showing EOQ varying with supplier discount

Annual demand	Unit cost	Annual usage value	EOQ	% discount
150.00	13.25	1,987.50	77.70	
150.00	12.59	1,888.13	79.72	5
150.00	11.93	1,788.75	81.91	10
150.00	10.60	1,590.00	86.87	20
150.00	7.95	1,192.50	100.31	40
150.00	3.31	496.88	155.41	75

**NOTE** Assuming cost of ordering is £80.00 and cost of holding is 30%

Table 3.10 shows that if only the cost of managing inventory is considered, then the MOQ of 75 is cheaper, even with the 5 per cent discount on the unit cost. However, when the cost of purchase is also taken into account, giving the total inventory cost, the larger MOQ is cheaper. This is because, based on the same annual demand, the savings from the cost of purchase more than offset the higher cost of holding.

This simple financial analysis would therefore suggest that a higher MOQ was acceptable. However, in this case additional considerations will need to be taken into account. For example, the MOQ will be buying 12 months' stock; is there a risk that the demand may change in the 12 months, or the stock may deteriorate or become obsolete? Overall the benefit is only 2 per cent rather than the 5 per cent offered by the supplier, with any increased costs and risks moved from the supplier to the business.

**Table 3.11** Analysis of total inventory management cost to review MOQ discount

MOQ	Unit cost	Cost of ordering	Cost of holding	Cost of managing	Annual cost of purchase	Total inventory costs
75	13.25	160.00	149.06	309.06	1987.50	2296.56
150	12.59	80.00	283.22	363.22	1888.13	2251.35

## Further information

See Harris, F W (1915) *Operations Cost, Factory Management Series*, Shaw, Chicago, IL; Relph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London; Relph, G J and Newton, M (2014) Both Pareto and EOQ have limitations: combining them delivers a powerful management tool for MRP and beyond, *International Journal of Production Economics*, 157 (C), pp 24–30.

## 3.12 Combining Pareto with EOQ to enhance group analysis, by Geoff Relph

In tool 3.2 we looked at Pareto and tool 3.11 looked at EOQ as two techniques for the management of inventory groupings and determining the optimum batch size. In tool 3.10, Table 3.9 gives suggested order periods based on industry types. If our business does not exactly fit one of the three categories described, the answer may be to use the EOQ.

### When to use

If we are unsure of where we are in relation to the industries shown in Table 3.9, we may want to compare the EOQ with the recommended delivery intervals. The EOQ is a quantity and the values in Table 3.9 are time intervals. We can convert the EOQ to a time interval, known as the economic order period (EOP). We can calculate the EOP for each item and list them against the recommended Pareto class calculated in Table 3.3.

### How to use

If we use the formula from tool 3.2 and the items in Table 3.2, we can calculate EOQs for the 10 items, as shown in Table 3.12. What is clear is that there is no specific relationship between the annual usage, unit cost or annual usage value of the product to the recommended EOQ. However, items 3, 4 and 5 have similar EOQ in spite of having entirely different Pareto positions. The typically used order periods shown in Table 3.9 may not necessarily be the best ones.

However, we can easily convert EOQ to economic order period (EOP), which would allow us to evaluate the days of cover. Figure 3.8 shows how to extend EOQ to EOP – or the optimum period represented as number of days of stock rather than the absolute quantity.



**Table 3.12** Items listed in Table 3.2 with EOQ values

Item	Average annual usage	Unit cost	Annual usage value	EOQ
4	185.00	320.00	59200.00	17.56
6	780.00	12.80	9984.00	180.28
5	43.00	118.00	5074.00	13.94
1	10.00	295.00	2950.00	4.25
10	225.00	10.35	2328.75	107.68
2	5720.00	0.40	2288.00	2761.64
9	150.00	13.25	1987.50	77.70
3	22.00	18.00	396.00	25.53
7	550.00	0.50	275.00	765.94
8	365.00	0.50	182.50	623.97

EOQ calculations based on (i=30% and C = 80.00)

**Figure 3.8** Extending EOQ formula to represent the EOP

D = Demand C = Cost of ordering/set-up P = Unit cost i = inventory holding rate as % W = working days in a year		150 £80.00 £13.25 30% 250	
Economic order quantity (EOQ)	$Q = \sqrt{\frac{2 \cdot D \cdot C}{P \cdot i}}$	$Q = \sqrt{\frac{2 \cdot 150 \cdot 80.0}{£13.25 \cdot 30\%}}$	77.70
Economic order period (EOP)	EOQ/D (EOQ/D) * W		77.7/150 0.518 years 129.50 days
Economic order period (EOP)	$\left(\frac{EOQ}{D}\right) \cdot W$	$EOP = \left(\frac{77.70}{150}\right) \cdot 250$	77.7/150 0.518 years 129.50 days

We now add the EOP calculation to and create Table 3.13. Looking at the annual usage values, we can see the higher the annual usage value, the lower the EOP days. What is obvious in Table 3.13 is that there is a direct relationship between EOP and the position of a part in the Pareto list, with item 4 being the top-ranked part having the lowest EOP of 24 days, item 5 a B-class part with an EOP of 81 days, and item 3 a C-class part with 290 days. We can compare the average EOP for each class and compare to the industry types shown in Table 3.9.

### Example

In Table 3.13 we can see that for the items in class A an appropriate frequency might be monthly, for the B-class quarterly and the C class would be annually.

**Table 3.13** Items from Table 3.3 with EOP values added

Item	Average Annual Usage	Unit Cost	Annual Usage value	Cumulative Usage Value	Cumulative Percentage of Annual Usage value (%)	ABC Class	EOP days
4	185.00	320.00	59,200.00	59,200.00	70.07	A	23.73
6	780.00	12.80	9,984.00	69,184.00	81.89	B	57.78
5	43.00	118.00	5,074.00	74,258.00	87.89	B	81.05
1	10.00	295.00	2,950.00	77,208.00	91.39	B	106.30
10	225.00	10.35	2,328.75	79,536.75	94.14	B	119.64
2	5,270.00	0.40	2,108.00	81,644.75	96.64	C	125.75
9	150.00	13.25	1,987.50	83,632.25	98.99	C	129.50
3	22.00	18.00	396.00	84,028.25	99.46	C	290.13
7	550.00	0.50	275.00	84,303.25	99.78	C	348.16
8	365.00	0.50	182.50	84,485.75	100.00	C	427.37

Based on  $i=30\%$ ,  $C = 80.00$  and  $W=250$  working days in a year

## 3.13 Material Requirements Planning (MRP)

### ***Introduction***

Materials requirements planning (MRP) first became known in the 1960s when computers were used to calculate the timing of manufacturing and purchase orders for dependent items, i.e. raw materials and components to be used in production where the quantities required depended upon the quantity of finished product to be made. Later, MRP was a module in MRP2 systems and subsequently ERP (enterprise resource planning) systems.

MRP calculations require information from the bill of materials (BOM), the delivery schedule or demand forecast and the inventory management system. Due to the amount of computing power required, it was common to use MRP for A- and B-class items only and to use classical inventory management methods (such as periodic review or reorder point, tools 3.8 and 3.9) for C-class items.

### ***When to use***

When planning delivery of raw materials, components and sub-assemblies for production to meet a delivery forecast of a product.

### ***How to use***

There are two processes in MRP, 'netting' and 'offsetting':

- 1** Net requirements = Gross requirements *minus* inventory
- 2** Time to launch the order = time when delivery is required *minus* lead time

Starting from product level, we work through the bill of materials, netting out existing inventory and taking account of already scheduled arrivals into stock, in order to determine the net requirements. Taking into account production and procurement lead times, manufacturing and procurement orders are planned and launched at the appropriate times to ensure the demand forecast is met.

### ***Example***

We will use the example of an office chair. The full example can be downloaded for free as an Excel spreadsheet from <http://howtologistics.com>.

**Table 3.14** Extract from the bill of materials (BOM) for an office chair

Level	Item	Quantity	LT (days)	M/P	Order qty
0	Office chair (OC)	1	1	M	LFL
1	Rolling base (RB)	1	1	M	100
2	Spokes (S)	5	1	M	1000
3	Tube B (TB)	0.35 m	3	P	≥ 150 m

Key:

LT = lead time

M/P = manufactured or purchased

qty = quantity

LFL = lot for lot

**Table 3.15** Level 0: Office Chair (OC)

Day	20	21	22	23
GR (OC)	100	150	180	140
SR (OC)	80	0	0	0
OH (OC)	50	30	0	0
NR (OC)	0	120	180	140
MOP (OC)		120	180	140
MOR (OC)	120	180	140	

Table 3.14 shows an extract from the indented bill of materials. One office chair needs 1 rolling base in the final assembly. The rolling base is made up of 5 spokes, 1 hub (not shown) and 5 wheels. Spokes are cut from tube. Fasteners are not shown.

Order quantities may be fixed (or multiples thereof), a minimum quantity or ‘lot for lot’ (LFL) meaning that you can order exactly the quantity required.

We start at product level, so level 0, the office chair (Table 3.15). The forecast delivery schedule is shown as gross requirements (GR). Scheduled receipts (SR) and on-hand inventory (OH) are netted out, leaving a net requirement (NR) of 120 units for day 21, 180 on day 22 and 140 on day 23. Since the order quantity for office chairs is lot for lot (LFL) we plan manufacturing orders (MOP) for these quantities. Offsetting by a lead time of one day releases these orders (MOR) on days 20, 21 and 22 respectively.

Release of an order for office chairs generates a demand for rolling bases at level 1, 1 base for 1 office chair (Table 3.16). There is no on-hand inventory, but a previously planned manufacturing order is expected to arrive on day 20, enough to cover the demand on day 20 and part of the demand on day 21. The net requirement for 140 units on day 22 generates an order quantity of 200 because the order quantity is fixed at 100 or multiples thereof.

Demand on day 20 for 100 rolling bases generates a demand for 500 spokes (Table 3.17). There are no scheduled receipts but a projected available inventory of 800. Thus, demand on day 20 is covered but more are required to cover demand on day 21. Spokes are ordered in lots of 1,000. A lot is therefore planned to arrive on day 21, for which the order is launched on day 20.

**Table 3.16** Level 1: Rolling Base (RB)

Day	19	20	21	22	23
MOR (OC)		120	180	140	
GR (RB)		120	180	140	
SR (RB)		200			
OH (RB)		0	80	0	0
NR (RB)		0	100	140	0
MOP (RB)			100	200	
MOR (RB)		100	200		

**Table 3.17** Level 2: Spokes (S)

Day	18	19	20	21	22	23
MOR (RB)			100	200		
GR (S)			500	1000		
SR (S)			0	0		
OH (S)			800	300		
NR (S)			0	700		
MOP (S)			0	1000		
MOR (S)			1000			

**Table 3.18** Level 3: Tube B (TB) Requirements for tube are shown in metres

Day	17	18	19	20	21	22	23
MOR (S)				1000	0		
GR (TB)				360	0		
SR (TB)				0	0		
OH (TB)				0	0		
NR (TB)				360	0		
POP (TB)				360			
POR (TB)	360						

Key:

POP = purchase order planned

POR = purchase order release

Spokes are cut from tube B. Tube B is delivered in 5 metre lengths. Hence, each length of tube B can make  $500/35$  spokes = 14.28 or 14 spokes. For 1,000 spokes, 72 lengths are required, or 360 metres (Table 3.18). The procurement lead time is three days. The minimum order quantity is 150 metres so this requirement is met.

### Further information

Download the full BOM explosion as an Excel spreadsheet for free from <http://howtologistics.com>

*Orlicky's Material Requirements Planning* by Carol Ptak and Chad Smith, published by McGraw Hill, is highly recommended.

## 3.14 Safety stock calculation

### Introduction

Safety stock is sometimes also called buffer stock or security stock. If we examine the consumption patterns over the same 10-week period of the two items A and B in Table 3.19, we can see that they both have an average demand of 50 units per week. Now look for the maximum and minimum

**Table 3.19** Demand data for two different items

Week number	Demand for item A	Demand for item B
20	48	47
21	54	72
22	57	12
23	49	25
24	51	54
25	50	89
26	46	36
27	47	68
28	53	23
29	45	74
Total:	500	500
Average demand:	50 per week	50 per week

values in each column. It can be seen that item B has much greater variability in demand, ranging from 12 to 89.

Let's say that we replenish the stock of both items once per week. Since item B has a very high variability in demand, a lot of extra stock, or safety stock, will be required to ensure that we can supply during the weeks of high demand. This is stock that is held over and above the amount of stock required to meet *average* demand. A key question to examine is just how important a stockout is to you. If a stockout means losing a contract or a customer, a life-or-death situation (hospital, aircraft, pharmaceuticals, for example), you will be prepared to invest more in safety stock. If the items are easily substitutable (different colour, make, package size), you may not be prepared to finance a significant amount of safety stock.

So we need to be able to measure this variability to determine how much safety stock is required for a given level of customer service or 'protection level' (protection against stockouts). If you are familiar with statistics, you will know that standard deviation is used to measure variability in data. The standard deviation of demand for item A is 3.8 and for B is 25.7, reflecting the greater variability in demand for item B.

Standard deviation is the preferred method for setting safety stock levels but there are other methods for those who are not familiar with statistical methods. Two easier methods are ‘time buffer’ and using historical data. In the time buffer method, we add safety stock to cover average demand for a certain period of time, for example two days or a week, according to how safe you want to be. Using the historical data method, we look back at demand over previous periods and identify the few times when demand was very much higher than average. A common-sense decision must then be made about whether to cover these occasional high demands and therefore how much safety stock to keep.

The ‘How to use’ section will present all three methods. We will focus mainly on covering variability in demand rather than variability in lead time.

## **When to use**

Safety stock is required whenever you want to meet demand that is greater than average and/or if the replenishment lead time is highly variable. Longer than average lead times can result in failure to meet demand and so safety stock can be used to compensate for this.

## **How to use**

### **Method 1**

Formula 1 shows how to calculate standard deviation:

$$SD = \sqrt{(\sum(x - x')^2 / (n - 1))} \quad (1)$$

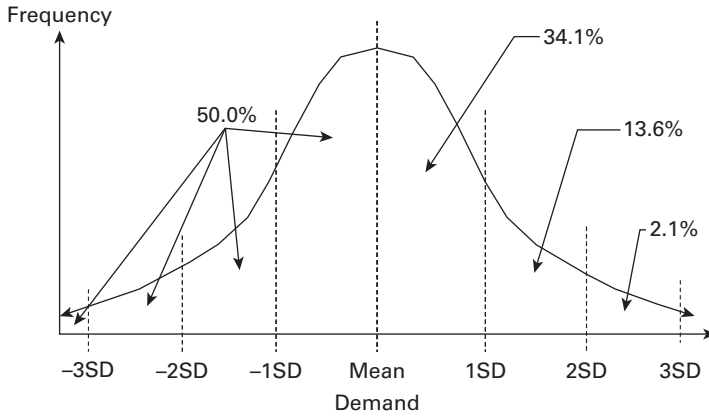
Where:  $n$  = number of weeks (10 in Table 3.19)

$x'$  = mean demand (50 in Table 3.19)

$x$  = data item (actual demand in Table 3.19)

The normal distribution is used to determine the ‘protection level’ required, i.e. the proportion of time that demand can be met. In our example, adding safety stock equivalent to one standard deviation of demand would yield a protection level of 84.1 per cent (50 per cent + 34.1 per cent), since this is the proportion of the population under the normal distribution curve (Figure 3.9) from minus infinity up to the mean plus 1 standard deviation of demand.



**Figure 3.9** Normal distribution

## Method 2

In the time buffer method, we add enough safety stock to cover demand for a certain time period. For example, a particular supplier is often one week late in delivering but rarely more, and so we may decide to add safety stock equivalent to one week of demand for that item.

## Method 3

In the historical demand method, we look at historical data. Consider the demand for item B in Table 3.19 once again. If these 10 weeks are indicative of demand over the year, we can see that in 10 per cent of the weeks, demand is over 80; and in 30 per cent of the weeks, demand is over 70. Using 50 weeks per year for simplicity, we might decide that it is acceptable to have stockouts in five weeks of the year (10 per cent), but unacceptable to be out of stock during 15 weeks of the year (30 per cent). We would then keep a safety stock of 30 units (remembering that 50 is the rate of average demand and safety stock is used to cover demand that is greater than average). Data for more weeks will give a more accurate picture of demand variation and result in a more accurate estimate of the safety stock required.

## Example

Let us say that we are looking for a 90 per cent protection level for item B in Table 3.19, i.e. we want to meet demand for 90 per cent of the time:

- Using method 1, normal distribution tables show us that 90 per cent protection level requires safety stock equivalent to 1.28 standard deviations of average weekly demand, so  $1.28 \times 25.7 = 33$  units.
- Using method 2, we may estimate that we need about three days of safety stock, or half a week's demand, so a proportion of  $3/5$  or  $2.5/5$  of average weekly demand (assuming five trading days per week), which would be 25 or 30 units of stock.
- Using method 3, and assuming that these 10 weeks are indicative of the year's weekly demand pattern, it was shown earlier that 30 units of safety stock would give a protection level of approximately 90 per cent.

(This example can be downloaded for free from <http://howtologistics.com>)

## Further information

For those who are unfamiliar with statistical methods, it is highly recommended that logistics managers get some training in this area. Many books and general training courses are available.

Those who are familiar with statistics may be interested in looking at Stock and Lambert (2001), which gives a formula for safety stock that takes the standard deviation of lead time into account in setting safety stock levels as well as the standard deviation of demand: Stock, J and Lambert, D (2001) *Strategic Logistics Management*, 4th edn, McGraw Hill/Irwin, New York. Further information can be found in: Relph, G J and Milner, C Z (2019) *The Inventory Toolkit*, Kogan Page, London.

## 3.15 Stock counting

### Introduction

To have confidence in the inventory management system it is vital to count stock regularly and ensure that the quantities shown in the inventory management system are actually present in stock. In this section, we consider the nitty-gritty of looking for explanations of any differences.

## ***When to use***

All companies should count their stock at least once per year for the purpose of preparing the annual accounts. In the section on cycle counting (tool 3.5), it is explained that it is often beneficial to count fast movers and higher-value items more than once per year in order to maintain close control and high availability.

## ***How to use***

If there is a significant amount of stock to check it may be necessary to close the business while counting takes place. It may be carried out by the company's employees only, over a weekend or during a shutdown, and temporary staff may be hired to supplement existing staff and speed up the process.

### **1. General process**

- Plan the stock count well in advance and train the staff who will be carrying it out.
- Specify the area to be checked and ensure that each zone and location is clearly identified (to prevent omissions and duplications in counting).
- Produce a list of what is expected to be found in each zone or sub-area, including identity, description and location, listed in the order in which it is expected that the items will be found. Do not include the actual quantity. This list may be either in hard copy or accessed electronically by a handheld device.
- The stock checker moves systematically along each zone, up and down each rack or shelf, according to the layout and height of the storage area, identifying and counting items found.
- Note that two staff will more than likely be required to count stock at height.
- It is important that there is ready and adequate means of recording any anomalies or deviations from the list. For example, an item may be found earlier or later than its stated location (and the new location must be recorded), an item may be found damaged or missing an identity label, etc, and all this must be carefully recorded.

Great care should be taken over the unit of measure for each item. For example, should a box of 50 items be recorded as 50 items or as one box?

Normally the list of items should show the unit quantity of each item clearly or the stock checker should make clear what has been counted.

Some special equipment may be required, e.g. weigh scales for loose items, dipsticks for fluids, measuring tapes, gauges, reel measuring devices, cages for lifting personnel, etc. Sometimes it is necessary to open a box or crate. Materials must be provided for closing and resealing. Sometimes opening such packages may damage the contents, e.g. for some aircraft parts, and therefore information on the external labelling will have to suffice.

## 2. Resolving differences

A procedure must be followed to identify the source of each difference, be that quantity, location or condition. If the difference cannot be found, the data in the system must be adjusted.

First, we look at differences in quantity. Before making any adjustments to the system data, consider the following questions:

- Were any issues or receipts of the item in question made while the stock check was being carried out?
- If a manual system is being operated, have any arithmetic errors been made in the receipts and issues calculations since the last stock check?
- Was it difficult to count these items? If so, go back and recount them.
- If using a paper-based system, are the figures recorded by the staff legible? Could a 1 look like a 7, for example?
- Is it possible that the items are stored in more than one place? If so, consult the stores person or the inventory management system to find other locations.
- Is it possible that the count itself is not very accurate (for example, weighing a bottle of a chemical fluid to estimate how much remains, or measuring a length of tubing to estimate how much remains)? If the difference is less than  $x$  per cent, then make no adjustment. The value of  $x$  depends on the accuracy of the measuring system and the desired accuracy of the stock count.
- If more was found than expected, does this difference tally with a recent loss of stock at the last count? For example, the material could have been put in the wrong place and then somebody found it and restored it to the right place.
- Are there any unfulfilled orders in the warehouse or could there have been a short shipment recently?

- If there is less than expected, have any unauthorized personnel been in the storage area since the last count? Has somebody removed the item without recording the issue?
- If there is less than expected, is this item of use outside the business? Might somebody have an interest in stealing it? (In general, look for system errors first before thinking about theft. There are so many opportunities for system errors and they are the cause of the difference in most cases.)

Next, we consider differences in location. We have already seen that items may be stored in more than one location. The fifth point above indicates that we did not find enough stock at a certain location and that we should look for more locations of stock for this item. Secondly, we may find stock of an item in an unexpected location. It is important that the location data are correct so that the stores people can find a required item quickly and efficiently. Any differences in location should be discussed with the stores personnel so that a decision can be made about which are the 'correct locations' and then the data records can be updated accordingly.

Finally, the stock checker may notice that some items are damaged or dirty or otherwise not in good condition. Each case should be examined and a decision made on the future of the stock, for example whether the stock is usable or must be removed and replaced. This can also be a good time to identify stock that has been in the warehouse for an excessive time period and is unlikely to be used in future.

### 3. How to improve future accuracy

Stock data accuracy must become part of company culture, requiring a high level of operator discipline:

- New employees should be well trained in company procedures and be told exactly what is expected of them, including use of computer systems, counting practices, etc.
- All stock should be protected by access control measures such as card readers, or closed-circuit television cameras.
- All items and locations should be clearly identified. Procedures should be accessible to all personnel, maybe via a shared area on the company network, or printed in a folder in a common area.
- There should be easy feedback mechanisms for any comments, observations, etc, with a clear point of contact. A responsible 'help' point should be available 24 hours a day, seven days a week.

## Example

A new set of materials-recording processes had been implemented by consultants into a medium-sized manufacturing company. It appeared that the set of processes was either incomplete or erroneous since the company was obliged to count stock every quarter and effectively write off around 25 per cent of material that was believed to be on site! In view of the nature and size of the materials involved, theft was not the source of the problem.

All raw materials issues, production records, semi-finished product processing records, finished product inspection records and finished product stock records were examined for a period of eight weeks in order to understand the flow of material through the factory from suppliers to customers, and many system and discipline errors were found. To correct the problems, it was necessary to:

- explain to personnel the importance of system discipline and ensure that each person was familiar with the recording processes and was properly trained;
- create procedures for special products that had been ignored in the original system;
- clarify the production routes and recording points for each product type, including in particular handling of withdrawals from finished stock for further processing;
- clarify how to record problems, e.g. rejection at inspection, re-work.

In consequence, the stock check became an annual event, carried out by personnel over a weekend, saving 10–12 production days per year. Inventory accuracy increased to over 95 per cent in the first year after implementation of the changes.

## Further information

For further information about sources of error and methods of correction, David Piasecki (2003) has summarized years of experience: Piasecki, D (2003) *Inventory Accuracy: People, processes, and technology*, OPS Publishing, Kenosha, WI.

## 3.16 Stock turn

### *Introduction*

One of the easiest measures of inventory performance to implement and to understand is ‘stock turn’. Crudely, this means how often the stock turns over during the year. In other words, how many times on average does the material flow in and out of the storage area? For the same level of availability, a higher number of stock turns indicates better management of inventory.

In practice, of course, we know that different items will have very different levels of stock turn. Some items may not be issued at all (non-movers or stock turn of zero). Some may be used and replenished every week. Hence it is useful to consider the overall stock turn for the whole inventory (formula 1) and also stock turn for each individual item (formula 2); stock turn for one item can also be calculated using values instead of quantities.

$$\text{Overall stock turn} = \frac{\text{Cost of total annual issues (£)}}{\text{Value of average inventory level (£)}} \quad (1)$$

$$\text{Stock turn for item } i = \frac{\text{Quantity of item } i \text{ issued during the year}}{\text{Average stock level of item } i} \quad (2)$$

Sometimes it is not possible to obtain the cost of total annual issues and it is easier to obtain the monthly value of stock purchases. This will work just as well so long as the data are consistent for the year.

### *When to use*

Warehouses and distribution centres measure overall stock turn as part of a daily, weekly or monthly inventory performance report. In manufacturing, monthly or even six-monthly measures suffice.

When stock turn is calculated for individual items, we can identify the ‘fast movers’ (those with the highest stock turn) and the slow movers (those with the lowest stock turn). Non-movers in a period will have a stock turn of zero.

### How to use

The average inventory level can be found from the inventory management system or by averaging the end-of-month inventory level figures over a period of time. As mentioned above, either total monthly issues or total monthly purchases can be used to indicate throughput, so long as only one type of data is used for the whole period under review.

### Examples

*Example of stock turn calculation for one item.* We are going to calculate the number of stock turns for safety boots over the year. Table 3.20 shows the issues and end-of-month stock by month for one year. Note that a delivery of 50 pairs of boots was received in June.

**Table 3.20** Issues and end-of-month stock for safety boots

	Issues	End-of-month stock
Jan	6	42
Feb	1	41
Mar	8	33
Apr	15	18
May	3	15
Jun	4	61
Jul	6	55
Aug	9	46
Sep	8	38
Oct	4	34
Nov	1	33
Dec	3	30
Total	68	



First, we need to find the average stock level. To do this we find that the average of all the month-end figures is 37.2 (take the sum of all the end-of-month stock levels and divide by 12).

Secondly, we find the total number of pairs of boots issued over the year. From Table 3.20, we see that 68 pairs of safety boots were issued over the year.

Using formula 1, we can now calculate the overall stock turn for the year:

$$\text{Stock turn for safety boots} = \frac{\text{Quantity of item } i \text{ issued during the year}}{\text{Average stock level of item } i} \quad (1)$$

Using formula 2, we can now calculate the stock turn for the year:

$$\text{Overall stock turn} = \frac{\text{Cost of total sales (£)}}{\text{Average cost of goods stored (£)}} \quad (2)$$

We conclude that stock turn for safety boots for the year was just under 2. *Example of overall inventory stock turn.* Over the last 12 months, the cost of total sales from a warehouse amounted to £5,000,000 and the average cost of goods stored in the warehouse was £500,000.

### Further information

See Relph, G J and Milner, C Z (2019), *The Inventory Toolkit*, Kogan Page, London; Waters, C D J (2003) *Inventory Control and Management*, 2nd edn, Wiley, New York.

## 3.17 Vendor-managed inventory (and co-managed inventory)

### Introduction

VMI brings efficiency through grouping more items to each supplier order, having fewer suppliers and combining these with a regular ‘milk round’ delivery by the vendor.

On perhaps a daily or weekly basis, the vendor visits the customer’s premises, checks the level of physical stock and adds sufficient replenishment items to take the stock level back up to the desired target stock level (TSL), keeping a record of what has been supplied. The customer is then

invoiced, perhaps weekly or monthly. In some cases, the vendor has remote access to the inventory management system to identify the quantities issued of each item and is thus able to prepare the replenishment stock in advance of the visit. Clearly, the ability to operate VMI correctly depends on the level of stock issue discipline being operated by the customer.

Lack of discipline in some cases has given vendors considerable problems and this is an area that must be addressed before setting up VMI. If the customer is not disciplined, there will be unexpected stockouts that have nothing to do with the vendor's activity or efficiency. On the other side, some customers have been concerned that the vendors have been keeping too much stock on site (thus taking up too much space in their warehouse) or they have experienced too many stockouts due to poor estimates of inventory parameters by the vendors. Thus VMI in many cases has been superseded by co-managed inventory (CMI) to reflect the fact that it is often better to set the inventory management parameters jointly. Maximum and minimum stock levels are agreed together, as are replenishment criteria and performance measures. If the customer anticipates extra demand, the vendor should be warned in advance. If the vendor foresees any supply problems, the customer should be notified, and so on.

The main advantages of VMI/CMI are that the administrative costs of the client company are much reduced, including the costs of setting up purchase contracts, placing purchase orders, receiving replenishment quantities, managing the stock, keeping inventory records, making issues and paying supplier invoices. This can take up a disproportionate amount of time compared to the value of the items concerned. For example, if 500 different types of fastener can be supplied from one source, with one invoice per month, there could be considerable cost savings compared with the cost of carrying out purchase and delivery arrangements with perhaps over 20 suppliers, each on different ordering and delivery cycles.

## ***When to use***

In the retail sector, VMI/CMI is used increasingly in shops of various sizes. For example, a battery manufacturer directly replenishes batteries in supermarkets. A sandwich maker delivers more sandwiches to augment the stock in petrol stations every two hours, thus ensuring that the product is fresh and that the most popular fillings do not run out.

PepsiCo delivers a whole range of products directly to many small city-centre stores in the United States, puts the stock on the shelves and invoices

the customer for the quantities delivered. This saves stockroom space and staff shelf-filling time but also has been found to prevent stockouts and increase sales for both the retailer and PepsiCo.

In industry, VMI/CMI is being used more and more for C-class items (low-value and/or low-usage quantities), typically fasteners, connectors and other non-critical items such as production consumables, office supplies, safety equipment and lubricants. In recent years, higher-value items such as spare parts have been under vendor management, stored at the hub of an express parcel company where it then becomes relatively economic for the express delivery company to deliver parts over a wide area very quickly.

### ***How to use***

First, the group of items to be supplied by a particular vendor is agreed with that vendor. It is in the interests of the customer to obtain as many items from the vendor as is possible to minimize transport and administrative costs. Sometimes the vendor is willing to add items to its stock list for a particular customer.

It is important to give the vendor appropriate historical data about item usage and the best possible forecast for future usage. If these cannot be supplied or are considered to be unreliable, larger safety stocks must be used (i.e. higher minimum stock levels).

The general conditions of setting up an operation will be discussed and agreed, including:

- frequency of visits, for example to fit in with the vendor's other clients in the area so that transport is economic;
- maximum and minimum limits for the stock of each item, calculated by the vendor (VMI) or agreed together (CMI);
- frequency of invoicing;
- taking inventory of existing stock and any outstanding orders, so that the vendor can take over management of replenishment.

### ***Example***

A customer and vendor are setting parameters for the stock of high-visibility jackets in a factory. Issues over the last three years appear to be reasonably stable (see Table 3.21). However, further analysis shows that the monthly

issue quantity can vary enormously (Table 3.22). Further questioning reveals that a party of visitors made one large withdrawal in April (which was not returned) and on induction a group of apprentices required another batch of jackets to be issued (and these jackets were then kept by the apprentices).

Although the annual rate of usage is quite small, issue quantities can be highly variable and so it was decided to have a large safety stock since a stockout could have safety implications. It was agreed to hold a safety stock of 15 jackets. Apart from the visitors and apprentices, average monthly consumption is approximately two. The minimum level was therefore set at 17 to be safe, and a maximum level of 20. Fortunately, this vendor supplies a wide range of other items, so the jackets were added to the list of stock item levels to be checked on the weekly visit. In practice, this means that the vendor checks the stock level weekly and adds enough jackets to take the stock level back up to 20 jackets. Since this is a new item for VMI, and a safety requirement, both sides agree to monitor the situation carefully. Electronic access to the company's inventory management system is being discussed.

### Further information

See Winters, J and Lunn, T (1996) The effective implementation of co-managed inventory, *Logistics Focus*, September, pp 2–7. This article describes a trial between the retailer Somerfield and a number of major suppliers.

**Table 3.21** Total issues during the last three years

High-visibility jackets	Year 1	Year 2	Year 3
Quantity issued over the year	35	31	38

**Table 3.22** Monthly issues during the last 12 months (year 3 in Table 3.19)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	1	0	14	2	0	5	1	9	0	1	0

## 3.18 Identification and disposal of surplus stock

### *Introduction*

Inventory must be managed actively or it will just grow. Whether you have taken over an inventory that has not been managed properly for a while, or you are already actively managing your inventory, you need to identify stock that is in excess, obsolete or time-expired and you need an agreed policy for disposing of it. It is not always easy to set up a disposal policy since some accountants are reluctant to dispose of stock at less than book value. Some kind of discount is usually necessary for disposal. Nevertheless, it is important to identify and dispose of surplus stock, otherwise it just ties up operating capital and storage space, both of which can be used for more profitable activities.

### *When to use*

Some businesses review their raw materials stock or finished goods stock at regular intervals, perhaps once or twice per year. Other companies use events to trigger a stock review; for example, reviewing spare parts inventory for a machine that has just been sold or scrapped, or the need to create space for a new range of products.

### *How to use*

Two separate elements are required: 1) identification of surplus stock, i.e. excess, obsolete or time-expired; 2) creation and application of a disposal policy.

#### 1. Identify surplus stock

‘Excess’ means that you have more stock of an item than is necessary and can usually be identified using stock cover, calculated as:

$$\text{Stock cover (days)} = \text{Current stock level} / \text{average daily rate of usage}$$

If the stock cover seems excessive, this may be a candidate for disposal. Investigate why the stock cover is so high. Was the demand forecast too optimistic? Is it a slow mover? Can this item only be made or obtained in

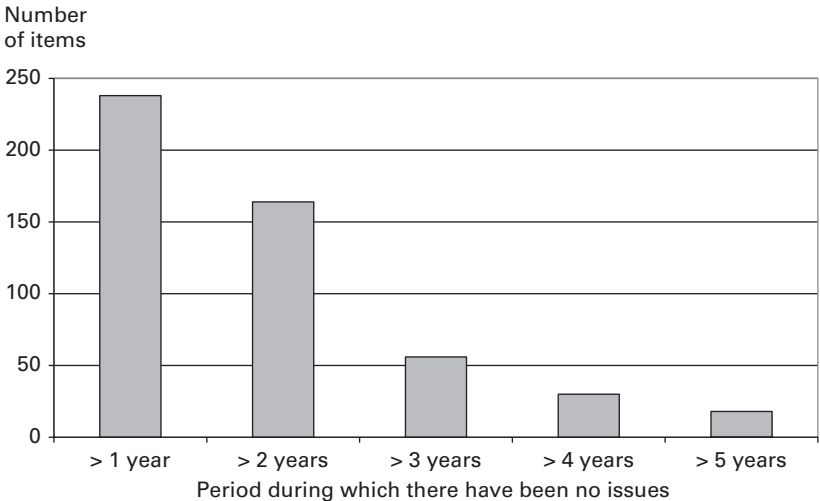
large quantities? Is there a minimum production or purchase quantity? Did somebody buy too much so as to qualify for a quantity discount?

‘Obsolete’ means that there is no further demand for this item. These items can be identified by looking for non-movers over a time period. ‘Non-mover’ means that no stock of this item was issued during that period (see Figure 3.10). The time period depends on the nature of the stock and the industry. For example, fast-moving consumer goods companies are interested in stock movements over recent weeks. Managers of spare parts inventories look at non-movers over the last few years. Again, each suspected obsolete item must be investigated before being identified as a candidate for disposal. If they have not been flagged up by the inventory management system already, time-expired items are identified by searching inventory records for their time of arrival and date of expiration.

## 2. Disposal policy

The disposal policy must be created and agreed by a group of representatives from the departments responsible for inventory management, warehousing, accounting and purchasing (for their experience of searching supply markets). It covers the identification of items that are considered to be redundant, deciding how to dispose of them, their removal from the inventory management system and final disposal. Before creating the procedure, it is useful to brainstorm all possible disposal methods. These may include:

**Figure 3.10** Non-mover analysis



- Destruction, or adding to normal company waste.
- Adding pages to a company website indicating the items that are available for sale, with or without a suggested price, and details of who to contact for more information.
- Approaching the original vendor in case these items may be of interest. This can work well for spare parts, as the vendor may know of other companies still using the same type of equipment that may be interested in purchasing a job lot of spare parts.
- Advertising in specialist magazines or websites indicating the type of items available and who to contact for more information.
- Placing the items for sale through internet sales portals, either general sales sites or specialized sites for the sector.
- Sub-contracting the advertising and sales process to a company specializing in surplus inventory disposal, usually for a percentage of the sales value realized.
- Inviting a company specializing in surplus inventory to come and remove the items for some nominal value, or for a fee.
- Charitable donation, which can be tax-efficient.

The main elements of the policy are as follows:

- 1** Identify potential stock for disposal. For example, annually create a list of surplus stock, non-movers and expired items. Apply the methods described above.
- 2** Inform the users. Circulate this list to their main users (e.g. production, maintenance, projects, engineering, transport, warehouse) for comments to be returned before a certain date. Do the users envisage any future use for these items?
- 3** Agree the final list for disposal. Each user department discusses the list of proposed items for disposal and either agrees to disposal of the item or makes a brief justification for retaining the stock. A list of items signed off for disposal is returned to the inventory manager.
- 4** The items for disposal are physically removed from the main stock to a separate area 'awaiting disposal'. Their location in the inventory management system is changed to this new location and their status is also changed to 'awaiting disposal'. The user departments are informed that this has been done.

- 5 The 'book price' of each item is given by the accounting department and the disposal group agrees the best method of disposal for each item.
- 6 When disposal occurs, the items are issued from the 'awaiting disposal' area. The items are deducted from the inventory management system and the item record is closed when all stock has been disposed of.
- 7 Finally, the accounting department writes off any difference between the book value and the realized value.

### ***Example***

Many companies manage production materials very well (raw materials, work in progress, finished product) but some do not apply the same level of inventory control to stocks of spare parts. A new manager to a company in the oil and gas sector in India identified a stock of obsolete parts worth several millions of dollars that he thought could still be useful to oil and gas companies in other parts of the world. The company set up a website that listed the items available, their prices and conditions of sale. Over a period of 12 months it managed to dispose of about three-quarters of the stock value to North Africa, South America and other exploration and production areas.

### ***Further information***

An internet search using the term 'inventory disposal' will bring up a myriad of example procedures from specific organizations as well as companies that specialize in this sector.

## **3.19 Managing spare parts inventory**

### ***Introduction***

Inventory is generally managed using forecasts and historical data (for items subject to unknown demand) and by stocking items for planned future needs (expected demand). This is also true of spare parts inventory where some spare parts are stocked for regular maintenance or projects (expected demand) and others for breakdowns (unknown demand).



There are now many options for managing spare parts inventory including:

- Using suppliers that have placed stocks of strategic items at carrier hubs for rapid delivery.
- Holding spare parts on consignment (see tool 3.4) or ‘use or return’ agreements (e.g. for planned maintenance interventions).
- Using 3D printing for certain parts.
- Sharing visibility of stocks with a sister or neighbouring company.
- Accessing a network of users of similar equipment.
- Joint planning of major maintenance activities in a group of companies to take place at different times so that ‘might be required’ inventory can be moved to the next site that may need it.
- Centralizing inventory as much as possible so as to minimize safety stock.
- Increasing the proportion of planned maintenance so as to reduce the number of spares to be stocked for breakdowns.
- Using more sophisticated software and modelling for analysing breakdowns and anticipating future failures.
- Outsourcing some maintenance.
- Using asset condition monitoring to anticipate failures.

## ***When to use***

It is worth reviewing the total value of the spare parts inventory against the level of service on an annual basis taking into account the events that have occurred over the year, e.g. new equipment to maintain, equipment that has been sold, new tools, materials, supplier agreements, particular problems that occurred as well as projects for the next year, e.g. refurbishment, new equipment, modifications or higher/lower reliability requirements.

In industries with continuous production, e.g. oil and gas, any downtime means loss of revenue. A downtime cost per minute can be calculated.

At this point, consider whether the spare parts inventory strategy should be revised.

A non-mover analysis (see tool 3.18) should be carried out annually. A large number of non-movers could also trigger a review.

## How to use

Spare parts inventory management must be linked to the management of the maintenance, repair and overhaul (MRO) activity for which the spare parts are being used. For planned maintenance, a list of parts required and the time of requirement must be supplied from the maintenance planning system to the inventory manager to enable existing stock to be checked (e.g. for items left over from the previous requirement) and allow new stock to be purchased in time.

Whether items are stocked for expected or unexpected demand, it is critical to carry out ABC analysis and identify each item's class, in terms of usage value (see tool 3.2), and also usage rate (see tool 1.3). To distinguish usage rate classes from usage value classes, we shall call them XYZ, where X represents fast movers and Z the slowest movers.

Items that are stocked in case of breakdowns are far more difficult to manage and the stock will depend on a number of key questions:

- How likely is it that the item will be required in the next year (1–10)? (1 = unlikely, 10 = certain).
- How critical is a stock-out of each item? Can we substitute another size/material, etc? Give each item a criticality rating from 1 to 10 (1 = unimportant, 10 = absolutely critical).
- How rapidly can each item be obtained in time of crisis? Give each item a rapidity rating from 1 to 10 (1 = fast, 10 = long lead time).
- What is the minimum quantity that must be bought?
- Is there a 'use or return' (consignment stock) agreement with the supplier?
- What was the average annual requirement for this item over the last five years?
- What maximum annual requirement was seen in the last five years?
- What minimum annual requirement was seen in the last five years?

The last three questions aim to understand the level of demand (1 per year? 100 per year?) and the variation in demand (e.g. 0 some years, 10 or 15 others?). Clearly, these questions are most critical for the A items. It is much cheaper to hold a bigger safety stock of a C item than an A item. More imaginative solutions, such as some of those in the introduction to this tool, will have to be employed for some of the A and B items.

Ultimately, the total number of different items and their stock levels will depend on the total budget available for inventory and the desired level of

service to the MRO operation. The ‘best guess’ of future needs will come from an analysis of past needs for the same or similar equipment, obtained from your company’s own records, the manufacturer or other users of this type of equipment. Sometimes there are user groups that are willing to share this information.

When managing spare parts inventory, it is particularly important to record:

- all failures to supply an item immediately (to determine level of service) and reason for non-immediate supply (e.g. stock-out due to late delivery, unusually large demand, dearth in supply market);
- the time required to supply items that were not supplied immediately, from time of demand to time of issue;
- all returns to stores and reasons for non-use;
- cost of any movement from one site to another (for the ‘move or buy’ decision).

Finally, it is important that the users of the inventory take a disciplined approach. In the heat of the moment, when responding to a breakdown, it is easy for the issue to go unrecorded. If, as in many cases, the spare parts stores are unmanned, security cameras or access control records must be used regularly to check that all issues have been recorded.

## ***Example***

Table 3.23 shows a selection of items from a spare parts stock and the data used to decide how each item should be managed.

## ***Further information***

A wealth of software is available for managing spare parts inventory: some of the packages are free and some are part of a computerized maintenance management system, some of which are also free.

Further useful web-based resources are: [http://en.slideshare.net/Logio\\_official/omaintec-spare-parts-workshop-part-2-8-rules](http://en.slideshare.net/Logio_official/omaintec-spare-parts-workshop-part-2-8-rules) (archived at <https://perma.cc/RJ28-G7B8>) and <https://blogs.sap.com/2016/02/22/spare-parts-management-in-sap-plant-maintenance/> <https://perma.cc/T4PU-NTGE>)

**Table 3.23** Key data for a selection of spare parts

Item code	Pareto ABC	Pareto XYZ	Demand E/U/B	Likelihood of need (1–10)	Crit. (1–10)	Diff. to obtain (1–10)	Min. purch. qty	Use or return?	Ave. ann. use	Min. ann. use	Max. ann. use	Policy decision
PX3494	A	Z	U	3	10	10	1	N	0	0	1	Hold 1 in stock
KT5228	A	Y	U	8	6	2	1	N	5	2	6	ROP = 0 ROQ = 1
HT3446	A	X	B	10	10	2	10	N	30	25	40	ROP = 5 ROQ = 1
CF7889	A	X	U	10	10	3	50	Y	33	10	50	VMI if possible, else ROP
CR9045	A	X	U	10	8	5	10	N	10	2	15	VMI if possible, else ROP
SG5786	B	Y	E	10	8	10	1	N	10	8	12	Buy ahead of planned use
MC2596	B	Z	B	10	10	5	1	N	1	0	1	ROP = 0 ROQ = 1

(continued)

**Table 3.23** (Continued)

Item code	Pareto ABC	Pareto XYZ	Demand E/U/B	Likelihood of need (1–10)	Crit. (1–10)	Diff. to obtain (1–10)	Min. purch. qty	Use or return?	Ave. ann. use	Min. ann. use	Max. ann. use	Policy decision
AV5489	C	Z	U	10	5	10	1	?	3	1	3	Aim for consignment
MT3214	C	Z	B	10	8	10	1	N	1	0	1	Aim for consignment

Key:  
E/U/B = Expected, unexpected, both  
TSL = target stock level  
ROP = reorder point  
ROQ = reorder quantity

Note:  
PX3494 is a very high-value highly critical item that is rarely required and difficult to obtain because it is customized, e.g. a furnace lining



# Supply chain management tools

## 04

### 4.1 Supply chain management audit

#### *Introduction*

Many companies have still not integrated their logistics functions (customer order processing, transport, warehousing and storage, inventory management, planning and scheduling, distribution) into a seamless supply chain operation capable of interacting smoothly with their suppliers, customers and service providers. This audit aims to highlight some of the elements of a seamless operation in order to give companies that wish to implement supply chain management some idea of what has been achieved already and what, if anything, remains to be done.

The questions are organized in seven sections: logistic customer service, strategic procurement, supplier management, inbound transport, 3PLs, sales and operations planning, and production planning and scheduling.

The fact that we talk about a supply *chain* indicates the linkage necessary between the different stages of movement of a product and the different parties involved to achieve this, rather than a simple series of transactions, which is logistics management. Table 4.1 shows an extract from the full supply chain management audit. The complete audit can be downloaded for a small charge from <http://howtologistics.com>; the discount code for readers is **lsct2024**.

**Table 4.1** Template for supply chain management audit

Supply Chain Management Audit				
Carried out by:	Location:			
Date:				
Item	No	Yes	N/A	Comments
<b>Logistic customer service</b>				
Is there a range of defined logistic customer service measures for each sales channel ?				
Is the % of perfect orders measured?				
Are customer complaints systematically logged and investigated?				
Are supply chain analytics used to investigate demand and performance statistics?				
<b>Strategic procurement</b>				
Have you carried out Pareto analysis to classify items/families?				
Do you use Pareto classification in setting procurement policy for items/families?				
Do you use Kraljic matrix (or some other purchasing portfolio method) in setting procurement policy for items/families?				
Do you use category management?				
Are suppliers classified according to their importance and performance?				
Do you consciously apply a range of supplier relationships according to supplier importance?				
Is supplier performance included in vendor selection?				
Is a clear and coherent set of supplier performance measures included in the supply contract?				

(continued)

**Table 4.1** (Continued)

<b>Supply Chain Management Audit</b>				
<b>Carried out by:</b>	<b>Location:</b>			
<b>Date:</b>				
Are key suppliers involved in Kaizen or joint problem solving when necessary?				
Are suppliers involved in new product development?				
<b>Supplier management</b>				
Do suppliers have access to a platform or extranet (for orders, performance, demand forecasts, etc)?				
Do suppliers have access to demand forecasts?				
Do suppliers have access to order history?				
Are suppliers given regular feedback regarding delivery: on time, in full (OTIF), accuracy, quality, etc?				
Has there been an effort to reduce the total number of suppliers?				
Is collaborative planning and forecasting carried out with key suppliers?				
Do key suppliers have longer contracts than other suppliers?				

## 4.2 Collaborative planning, forecasting and replenishment (CPFR®)

### Introduction

(CPFR® is a registered trademark of VICS.)

We know from supply chain research that the more information that is exchanged between suppliers and customers in the supply chain about



demand, the less inventory we need in the chain to maintain stock availability to the final consumer and in the chain in total. In the mid-1990s, the Voluntary Inter-industry Commerce Standards (VICS) Association agreed to support an initiative to enable manufacturers and retailers to forecast demand jointly and subsequently plan together the supply of certain items traded between them. This involved not only delivery planning but also exchanging information about forthcoming promotions and other commercial activities, usually regarded as confidential. Since this required communication between information systems, some major software houses were involved as well. The overall results reduced the number of stockouts, reduced inventory levels, increased stock turns and increased sales, by ensuring that the pattern of supply met the pattern of demand more closely. Protocols and other operating methods were established.

Owing to advances in computer systems, and in the exchange of data between companies in particular, more and more companies are undertaking some kind of joint planning and forecasting with key suppliers and customers to achieve these benefits, even though it may not be through membership of GS1 US (which merged with VICS in 2012).

## ***When to use***

A lot of attention has been paid to improving on-time delivery in the last few years and this has enabled incoming inventories to be reduced. Further reductions to overall inventory levels can only be made by improving information about demand and this is proving more difficult to achieve. Any company that wishes to improve information flow regarding demand would benefit from closer communication with key customers and by exchanging information about their respective commercial actions (e.g. promotions, new products) for the forthcoming months. Some companies simply have too many products to track in this manner and so the items generating 80 per cent of sales would be an obvious focus to start with. Although the manufacturer–retailer relationship has been most publicized, the supplier–manufacturer link can also benefit.

## ***How to use***

Although CPFR<sup>®</sup> represented a specific agreement between companies under the aegis of VICS, many companies can carry out some form of joint planning and replenishment in other ways. Many companies do this by simply

exchanging Excel spreadsheets. Many of these simple business tools are sent via the internet, are undocumented and are clearly open to abuse or problems if one of the parties suffers illness or worse. If a supplier and customer find that this kind of exchange is beneficial to them, it should be worth investing in a more formal process to increase security and ensure business continuity.

A visit to a major supplier or customer to discuss how this could operate and the benefits that it could bring is a good way to start. It is critical that both parties are in agreement about the objectives and methods of data exchange. It is useful to set up a workshop for the main personnel from each party to discuss their business processes, planning tools and decision timing. It may require two or three days to agree the most efficient way to work together. Process maps or flow charts (see tool 1.28) are a useful tool for this.

The main process steps are:

- 1 Supplier first creates a top-level forecast from historical records.
- 2 Customer updates this forecast to include any extra information it has, e.g. more/fewer shops, expanding/contracting business, and adds information regarding commercial actions.
- 3 Supplier adds information regarding promotions, product launches, etc.
- 4 Supplier proposes replenishment plan.
- 5 Customer agrees or modifies and sets up replenishment orders.

## **Example**

One CPFR<sup>®</sup> case study that really grabs the attention was the cooperation between Henkel and Eroski. Henkel is a large multinational manufacturer of over 10,000 items with headquarters in Germany. Eroski is a retail chain of supermarkets and hypermarkets mainly based in Spain. A CPFR<sup>®</sup> pilot study was introduced for nearly 2,000 items supplied by Henkel to Eroski. Overall results included an increase in customer service level while also reducing inventory in the Eroski warehouse, significantly improving the reliability of forecasting, increasing truck and pallet fill and reducing the number of urgent orders.

Another example concerns a supplier to the automotive aftermarket and a major customer who wanted to carry out joint planning and replenishment, rather than formal CPFR<sup>®</sup>. A team of three or four people from each organization spent several days together in a Kaizen workshop to discuss their processes for replenishment planning and how they could work

together in the most efficient way. The overall objective was to reduce the ‘soft’ costs associated with replenishment planning and ordering while minimizing the level of stock and maximizing availability of product. The outcomes of the workshop included harmonized timing of decision making, an agreed format of data in an Excel worksheet, and clear processes and responsibilities.

### ***Further information***

URLs for the Henkel–Eroski case study keep changing but it is well worth the effort to look for it. The search terms ‘Henkel Eroski CPFR case study’ will usually find a document or slide show summary pretty quickly.

Simply using the search terms ‘CPFR case study’ will find many more cases of interest. See <http://www.gs1us.org/> for a wealth of information on supply chain data standards.

## **4.3 Demand forecasting**

### ***Introduction***

Many companies do not produce good forecasts, if any. This can be understood to a certain extent since the mathematics can rapidly become complicated. This tool will not enable you to make forecasts, but it is hoped that you will be inspired to think about how better forecasting can help your business, and then take steps to implement an improved forecasting process.

In essence, forecasting uses historical data to identify patterns that are likely to continue, enabling us to predict what may happen in future. The safest way to handle forecasts is to remember that ‘All forecasts are wrong!’ but some are better than others. It is worth making the effort to improve forecasting. Companies that have a better idea of what the future may bring are usually better prepared for that future.

Demand forecasting is particularly critical in supply chain management. The more information we can get about future demand, the less likely we are to suffer from excess inventory or shortages.

### ***When to use***

Forecasts are important for planning and decision making. We use sales forecasts to ensure that we have enough capacity for production and enough

orders placed with suppliers for goods and services. The sales forecast is the basis for the procurement budget, which in turn must be financed. Similarly, the sales forecast will determine the capacity plan, which must be resourced in terms of space, equipment and labour.

Depending on the purpose of the forecast and the sector, the frequency of forecasting can vary from a rolling 20-year plan for equipment investment in the heavy engineering sector to a daily sales forecast for fast-moving consumer products in the retail sector.

## ***How to use***

It is beyond the scope of this short introduction to describe forecasting methods in any detail but we can consider the major elements of forecasting to see what is involved. The overall process has three steps:

- 1** Collect data on historical demand, by product family or individual items.
- 2** Use a mathematical method to create the forecast.
- 3** Use market-specific knowledge to add any other factors that may have a bearing on the situation and determine whether the forecast is pessimistic or optimistic and whether some ‘tweaking’ is required.

### **1. Collect data**

This information can be extracted from an inventory management system to identify sales or usage of an item on a daily, weekly or monthly basis.

### **2. Use a mathematical method to analyse the data**

The first method to look at is ‘time series analysis’ where the historical data can be considered to be a ‘time series’, i.e. a data item that is changing over time. A time series has four major components that can be separated out:

- a** Overall trend – is the level of sales increasing, decreasing or remaining stable over time?
- b** Seasonality – is there an effect of changing demand at different times of the year, for example increased sales of chocolate at Christmas and Easter?
- c** Cyclic change – are there other factors that increase demand on a regular basis, for example increased sales of DIY products at the weekend?
- d** Random variation or ‘noise’ – if the effects of trend, seasonality and cyclic change are removed from the time series, some random variation will remain.

Any demand forecast will have to take account of trend, seasonality and cyclic change. Our next stage is to consider how to create the forecast. There are many methods, ranging from simple moving averages to exponential or regression models, and others.

A certain amount can be done by hand but the use of forecasting software is highly recommended, either as part of the business management software that you are using already, or as a separate package. It is worthwhile identifying somebody in your organization who has an appropriate mathematical background or capability and who would be willing to undertake a short course in forecasting, or learn to use a forecasting package.

Finally, it is worth mentioning that there are several methods for measuring the accuracy of the forecast and this is an essential part of generating confidence in the forecasting process. As data quality and forecasting methods improve, there should be an equivalent improvement in forecasting accuracy, measured and observed.

## **Example**

The Henkel and Eroski case study used to illustrate CPFR® (see tool 4.2) is an excellent example of how forecast accuracy can be improved and the benefits this can bring. The majority of demand forecasts were more than 50 per cent wrong at the beginning of the project period but within 12 weeks, 80 per cent of the product forecasts were less than 20 per cent wrong. This was achieved by improving the quality of data being used by both companies for forecasting.

In summary, it is possible and highly desirable to improve the quality of forecasts used in your business but it does take some mathematical effort and interest to do so.

## **Further information**

Many standard texts on operations management give a good introduction to forecasting. For those who really want to study the subject, Makridakis et al (1998) explain the many different approaches clearly: Makridakis, S, Wheelwright, S C and Hyndman, R (1998) *Forecasting: Methods and applications*, 3rd edn, Wiley, New York.

Use search term 'Henkel Eroski CPFR case study' to find a document or slide show on this case study.

## 4.4 Factory gate pricing (FGP)

### *Introduction*

FGP was introduced into the UK in the early 2000s by UK retailers to reduce their overall transport costs, reduce inventory holding in their distribution centres (DCs) and stores, and increase efficiency by reducing the number of vehicles delivering to site and improving throughput through improved co-ordination and consolidation. The introduction of lean principles into the retail supply chain (known as quick response) led to smaller, more frequent deliveries, which increased the pressure on the DCs.

Previously this system would have been described as supplier collection and – to a certain degree – nominated carrier schemes. The principle is very similar to an ex-works situation (see tool 2.5) whereby the consignee collects from the consignor and is liable for all the costs entailed. From a retailer viewpoint, vehicles delivering to stores from the distribution centres are able to call back into suppliers on their return journeys and collect product destined for the DC. This can be full or part loads or a number of collections from multiple suppliers. This will ultimately depend on the capacity available on the truck and the time available for the driver.

This will result in an increase in on-time delivery at the DCs and greater visibility within the supply chain. Studies have shown (Potter et al, 2007; Le Blanc et al, 2004) that logistics-related costs can be reduced by between five and eight per cent. Potter et al (2007) describe FGP as ‘the use of an ex-works price for a product plus the organization and optimization of transport by the purchaser to the point of delivery’.

### *When to use*

When companies are looking to reduce costs and improve visibility within the supply chain. In reality, any company with a fleet of vehicles making deliveries to customers that has suppliers in close proximity can use this system. This can include the collection of raw materials, provided that the vehicles are suitable for both inward and outward journeys.

If vehicles are continually running back empty to base and have sufficient time available to collect goods from local suppliers, then, provided that an agreement on cost can be arrived at with the supplier and a regular pattern of collections set up, there is no reason why it cannot be instigated. Daily

fixed transport costs are now shared across two deliveries rather than one. This also reduces the amount of empty running that takes place on today's roads.

However, there can be issues for the suppliers who may well have optimized their fleet and achieved transport efficiency when including these deliveries to the customer. Any reduction in delivery volume will have an effect on the cost per delivery and the overall efficiency of that operation. This is also the case where suppliers have contracted with a local haulier or 3PL to undertake their deliveries, with FGP resulting in less volume being transported by these companies.

In fact, suppliers need to address the following, according to Alan Braithwaite, a leading British expert on logistics and supply chain management:

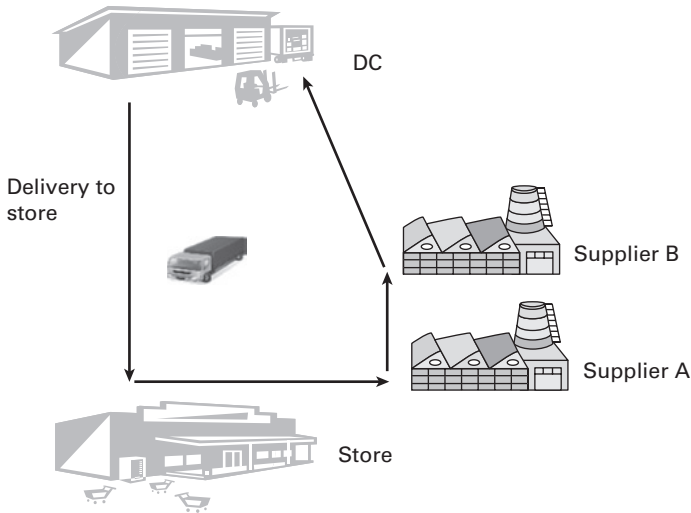
- How much discount can they afford to allow the retailers for collecting their product?
- How do they deal with the different pace of change adopted by the various retailers who will introduce FGP at different speeds?
- How do they deal with their existing infrastructure and logistics contracts as volume is transferred to retail control – making it less cost-effective?
- What commercial, pricing and 'terms of trade' policies and structures are appropriate in this new era?
- Finally, how will FGP affect their own fleet operations if volumes are going to reduce significantly?

There needs to be a workable agreement between supplier and buyer and if the supply chain as a whole is going to gain, the two parties need to work together on this initiative. It can be seen as very one-sided.

## ***How to use***

The first step is to identify which suppliers can be incorporated into the scheme. This will be based on location, volume, frequency of delivery, outbound vehicle delivery schedules and current cost of outbound and inbound delivery (if this can be extrapolated from the product cost).

Where it is not cost-effective to change from supplier delivery to FGP, the situation with those particular suppliers will remain as is. However, there are instances where suppliers are now collecting from DCs and delivering to stores on their route back to their facility (see Figure 4.1).

**Figure 4.1** Example of supplier collections on return from DC to store delivery

The buyer will need to invest in an IT system that can manage this whole process. There are many transport management and supply chain optimization systems on the market; many of these can be found from tool 2.9.

Compatibility of product is a factor in terms of which supplier collections can be consolidated. This can include cube, weight, temperature requirements, fragility and whether hazardous or not. Scale is also important here, as is the availability of a good information technology system to manage the movements.

Finally, there needs to be an understanding on behalf of the buyer's logistics team of the supplier's warehousing operation. This needs to include hours of operation and means of loading vehicles. The increasing use of double-deck trailers by retailers for store delivery can cause issues at supplier locations if their loading bays are not capable of receiving such vehicles.

Communication between the inventory and logistics team is vital, as is the relationship with the suppliers to ensure a smooth and accurate flow of information between parties.

## References

Le Blanc et al (2004) *Factory Gate Pricing: An analysis of the Dutch retail distribution*, Center for Applied Research Discussion Paper No. 2004-35, Tilburg University, Netherlands



Potter, A, Mason, R and Lalwani, C (2007) Analysis of factory gate pricing in the UK grocery supply chain, *International Journal of Retail & Distribution Management*, 35 (10), pp 821–34

## 4.5 Kanban

### *Introduction*

Kanban is the Japanese word for signboard or card (Japanese Management Association, 1986) and is just one element of the Toyota Production System that has been generalized into ‘Lean’ production. Here, we are looking at how Kanbans are used as a method of replenishment.

There are different types of Kanban signals and Kanban systems, but for our purposes we will just consider a simple circuit where Kanbans are used to pull parts from a previous stage in the supply chain. These parts could be coming from a previous production stage or an external supplier.

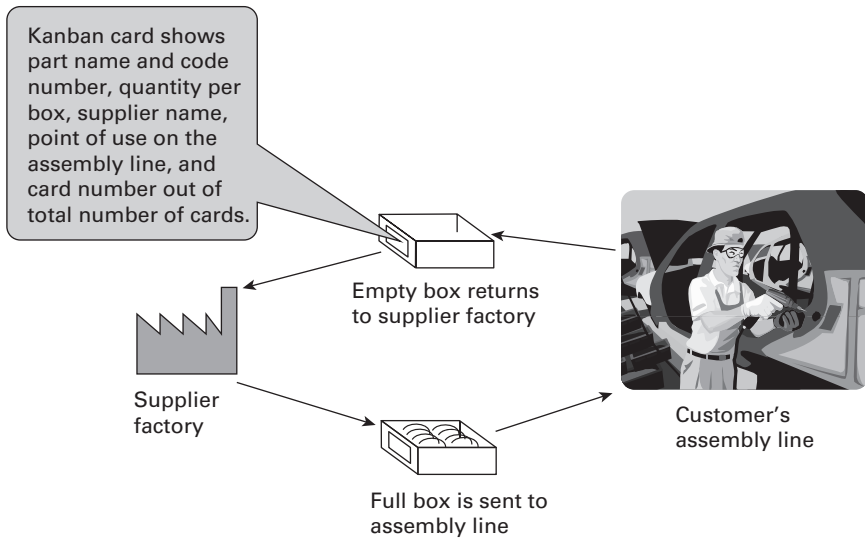
### *When to use*

This is particularly useful for supplying to production lines parts of high value or parts that are frequently used. It can be used for parts that are supplied nearly all the time (runners), or regularly (repeaters), but is not appropriate for parts that are rarely supplied again (strangers). It is an excellent method for reducing cycle stock of parts from external suppliers (particularly if they are local) or for minimizing work in progress for parts from internal suppliers.

### *How to use*

Figure 4.2 shows the Kanban circuit. It can be seen that a full box of parts is sent to the customer, internal or external. Once all the parts are used, the empty box is returned to the previous production stage or to the supplier to be refilled. If the supplier is external, the supplier collects the empty boxes when the next delivery is made, whether that is by the supplier’s own vehicle or milk-round vehicle, or other transporter.

There are three essential elements to setting up and running a successful Kanban system. The first is the nature of the containers that move the parts and the second concerns the number of containers or boxes in the system. The third element is system discipline.

**Figure 4.2** Kanban circuit

Parts are moved in boxes, where a known and fixed number of parts are allowed in the box. Although boxes are used most frequently, the 'container' may be anything that holds a certain number of parts safely and can be moved easily. This could be, for example, a hanging rail, tube, crate or trolley; 'box' is used here for simplicity. Normally, 'inserts' (formed packaging with shaped spaces for the parts) in the box ensure that only that type of part can be put into the box, and only a certain quantity of parts. The ideal quantity and therefore size for a box is about one hour's work or a box that will hold a weight that can be easily lifted. This varies enormously according to the size and weight of the part. Usually a Kanban card is attached to the box and the Kanban identifies the part name, part number, quantity to be held in the box, source of the part, destination of the part, and the sequence number of the box against the total number of boxes for that part type.

The total number of cards for that part type in circulation controls the overall level of inventory that is allowed for that part type. The more cards that exist, the greater the amount of inventory there will be, with all its associated holding costs and tied-up operating capital. The number of cards and boxes required, however, depends on all the elements that control the flow of parts in terms of capability to supply and rate of consumption of boxes.

The number of boxes is calculated from formula 1 below. It can be seen that a longer lead time to supply will result in more cards being required. Similarly, if there is high hourly demand or if a greater safety stock is required, a greater number of cards are necessary. However, if parts are

small and the capacity of the container is relatively large, then a smaller number of cards will be required.

$$\text{Number of Kanbans (N)} = \frac{d \times (t + s)}{c} \quad (1)$$

Where:  $N$  = number of Kanbans

$d$  = hourly demand

$c$  = capacity of container

$t$  = average time to obtain a replacement box (in hours)

$s$  = safety stock (in hours)

For the system to operate well, the rules must be strictly observed. The box must contain only the exact number of parts shown on the Kanban card, no more, no less. Only the appropriate box for that part may be used to transport it. The box must contain only good, usable parts. A box must never be supplied without a Kanban card. The box must be emptied completely before being returned to the supplier.

### Example

An assembly line makes 100 washing machines per day and the motors are supplied by Kanban in containers holding five units. The working day is eight hours. A safety stock of two hours is required.

It can be seen immediately that 20 ( $= 100/5$ ) containers of motors will be required each day, but how many boxes should there be in the circuit? Empty containers are picked up every hour to be taken back to the goods receiving area, awaiting collection when the next delivery arrives from that supplier. This supplier delivers every two hours, and the supplier is about half an hour away from the washing-machine assembly company. The supplier usually refills the boxes within an hour of their arrival and then they go out on the next delivery run. Once at the washing machine company, it may take up to an hour before the boxes are delivered to the assembly area. The total time in this refill circuit is summarized in Table 4.2.

Let us now substitute this data into formula 1:

$d$  = hourly demand =  $100/8$  hours = 12.5 units per hour

$c$  = capacity of container = 5 motors per box

$t$  = average time to obtain a replacement box (in hours) = 7 hours

$s$  = safety stock (in hours) = 2 hours

**Table 4.2** Time in the Kanban circuit

Stage	Maximum time required (hours)
Removal to goods receiving	1
Collection by supplier	2
Travel to supplier	0.5
Refilling by supplier and wait for next delivery to customer	2
Travel to customer	0.5
Delivery to assembly area	1
Total hours =	7

$$\text{Number of Kanbans } (N) = \frac{d \times (t + s)}{c} = \frac{12.5 \times (7 + 2)}{5} \approx 23$$

It is concluded that we need 23 containers and cards in the circuit. We can see that, at any one time, there could be five full boxes waiting for assembly (safety stock of 2 hours =  $[12.5 \times 2]/5$ ), two or three boxes waiting to be returned to goods inwards ( $12.5/5$ ), plus a maximum of five boxes waiting to be returned to the supplier ( $[12.5 \times 2]/5$ ), plus five boxes coming back from the supplier plus two or three boxes waiting to be delivered to the assembly area, plus some in transit for a short time (5 boxes for half an hour  $\approx$  2 or 3 on average). In practice, we would see how this number of Kanbans worked and then adjust it accordingly.

### Further information

See Bicheno, J and Holweg, M (2009) *The Lean Toolbox*, PICSIE Books, Buckingham.

### Reference

Japanese Management Association (ed) (1986) *Kanban: Just in time at Toyota: Management begins at the workplace* (tr DJ Lu), Productivity Press, Portland, OR

## 4.6 Kraljic matrix

### *Introduction*

The procurement function has changed dramatically since the 1990s, from a 'purchasing' activity that was regarded as primarily administrative, looking for the 'best value' items to buy, to a strategic function (see tool 4.22) that is capable of generating profit and competitive advantage for the business by sourcing from high-performing suppliers. One of the milestones in this transformation was a paper by Peter Kraljic (1983) in which he described a way of analysing the portfolio of purchased items and services. The purpose was to adapt the method of procurement to the complexity of the supply market, and the relative importance of that purchasing decision to the business.

The overall complexity of the supply market depends on such factors as the number of potential suppliers available, the rate of technological change, barriers to entry for potential new suppliers and potential transport complexity, perhaps due to distance or special packaging requirements.

The relative importance of the purchasing decision to the business depends on such factors as the overall value of the decision, the strategic importance of the item to the business and impact of the price of this item on profitability.

These two factors form the axes of a  $2 \times 2$  matrix and an approach to the procurement task is defined for each quadrant (see Figure 4.3).

### *When to use*

This is not an everyday tool but is useful for periodic re-evaluation of procurement approaches in the business. The relative importance of items or families can change over time as new products are introduced and the product mix changes. It can also be useful before the introduction of a new product in order to review the relative importance of its different components, assemblies or raw materials.

The Kraljic matrix is a good communication tool for explaining procurement methods and strategies to different user functions. Communication between the procurement function and user departments is vital to making the best supplier and product selections.

**Figure 4.3** Kraljic matrix

Importance of purchasing decision	High	<b>Material management</b> (Leverage items)  Group items together and negotiate with several potential suppliers 12–24-month contracts Negotiate delivery frequency	<b>Supply management</b> (Strategic items)  Evaluate potential suppliers very carefully Set up long-term agreements Explore mutual cost reduction Invite supplier's experience for new products and projects
	Low	<b>Purchasing management</b> (Non-critical items)  Annual contracts Look for local suppliers Vendor-managed inventory	<b>Sourcing management</b> (Bottleneck items)  Keep searching for alternative suppliers/products Devise contract to minimize risk Relationship development
		Low	High
		Supply market complexity	

### How to use

It is advisable to carry out a Pareto or ABC analysis (see tool 3.2) first in order to understand which purchased items or families have the greatest financial importance. Then the items or families can be placed in the quadrants, either by the procurement function or by discussion between procurement and user functions. Finally, the appropriateness of current procurement methods for each family can be reviewed against the methods appropriate to that quadrant.

### Example

A manufacturing company has determined that its outsourced logistics and supply chain services fall into six main categories:

- 1 full vehicle ambient transport;
- 2 market distribution transport to customer;
- 3 global sea freight services;
- 4 global air freight services;

- 5 a single national distribution centre providing co-packing and returns management services;
- 6 pallet supplies.

After some discussion, they position each family into the matrix as shown in Figure 4.4. One of the outcomes of the discussion was to try to find alternative suppliers for some of the specialist transport and market distribution services where there was currently only a single supplier identified, and that fell in the 'sourcing management' quadrant. It was recognized that the security and development of the single national distribution centre was key and that the current supplier might not be the right partner for the joint development of after-care services.

Global air and sea freight services had high spend and criticality in service for the company and needed to be tendered regularly.

(Example provided by BigChange, [bigchange.com](http://bigchange.com), formerly Labyrinth Consulting)

## Reference

Kraljic, P (1983) Purchasing must become supply management, *Harvard Business Review*, September–October, pp 109–17 (or find out more by googling 'Kraljic matrix')

**Figure 4.4** Application of Kraljic matrix to outsourced logistic and supply chain services

Importance of purchasing decision	High	<b>Material management</b> (Leverage items)  Global sea freight Global air freight	<b>Supply management</b> (Strategic items)  National distribution centre
	Low	<b>Purchasing management</b> (Non-critical items)  Full vehicle transport Normal pallet supplies	<b>Sourcing management</b> (Bottleneck items)  Some specialist transport Some market distribution Some pallet supplies
		Low	High
		Supply market complexity	

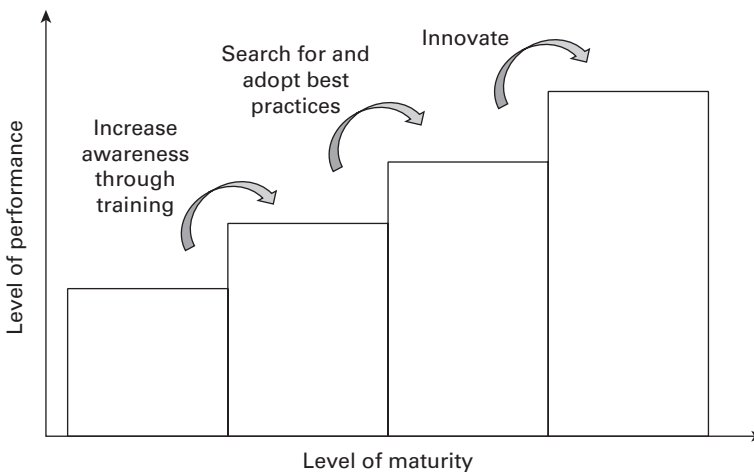
## 4.7 Maturity models

### Introduction

The general purpose of a maturity model is to enable users to position themselves in terms of the level of advancement, or ‘maturity’, of the function or activity under consideration and thus to determine what to do next to seek improvement towards some kind of ideal or high-performing function or activity. Typically maturity is described at four or five levels, from low performing to high, but any number of levels can be included (see Figure 4.5).

There is a good parallel between a maturity model for the logistics and supply chain function and the four ‘stages in the evolution of manufacturing’s strategic role’ proposed by Hayes and Wheelwright (1984, 1985). At the lowest level of contribution to the business, they describe the manufacturing function as being ‘internally neutral’ where it is reactive and requires outside assistance to make strategic decisions. Looking outside the business, it can move to the next level of performance and become ‘externally neutral’ by adopting industry best practices. The next level, ‘internally supportive’, is achieved by ensuring that manufacturing strategy is developed from, and supports, the business strategy. The highest level, ‘externally supportive’, is achieved when manufacturing has a level of innovation in processes and technologies such that it is involved in major marketing and engineering decisions.

**Figure 4.5** Linking improving performance with maturity





Maturity models have thus been created for many purposes and many different activities. They are particularly useful in logistics and supply chain management, as some companies still have a long way to evolve in terms of supply chain management while others have developed significantly in the last couple of decades. A maturity model enables a company to create a 'route map' for improvement to best performance.

A maturity model can be created for any 'pillar' of supply chain management, e.g. inventory management, warehouse management (see maturity scan for warehouse management in tool 1.21), information systems, transport or procurement, or an integrated model can be created to communicate overall direction.

### ***When to use***

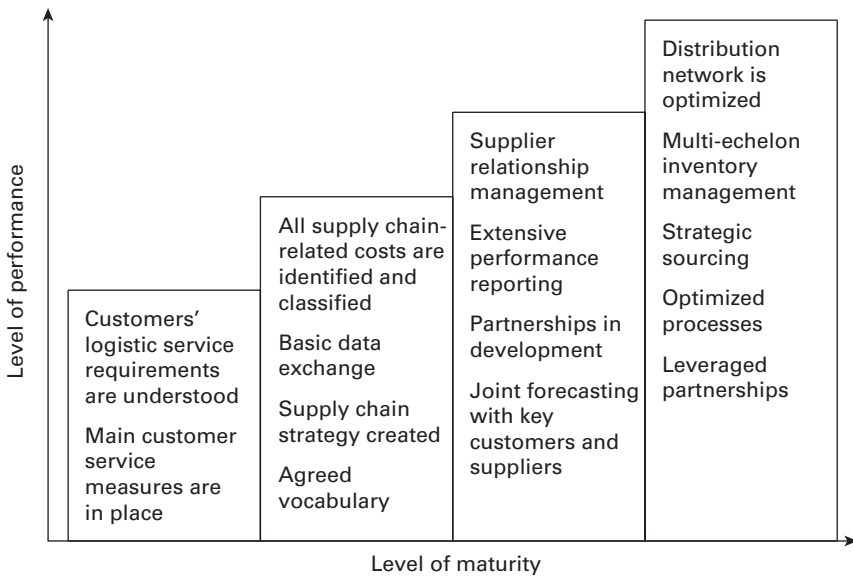
A maturity model is a tool for determining strategy for the development of a function leading to improvement of the business. A functional workshop can be used to set up the first maturity model and thereafter it can be the basis of an annual review to discuss progress, how the model should be further developed to explain the long-term direction and agree on how the priorities for the next two to three years will be delivered.

### ***How to use***

Two approaches can be taken. The first is to task a manager with searching the literature for all existing models, selecting desired characteristics and then creating an initial model, perhaps with some alternatives at each stage. The second approach is to use the concept to develop a shared vision of how supply chain management should develop in your business, by means of a facilitated workshop involving all those concerned with the high performance of the supply chain. This might include, for example, representatives from marketing, the customer service function, accounting and operations. The outcome of the workshop should be an agreed, summarized diagram, rather like Figure 4.6, plus an action plan for moving to the next level of maturity.

### ***Example***

Figure 4.6 shows a simplified example of a general maturity model for supply chain management.

**Figure 4.6** Simplified supply chain management maturity model

## Further information

See Lahti, M, Shamsuzzoha, A H M and Helo, P (2009) Developing a maturity model for supply chain management, *International Journal of Logistics Systems and Management*, 5 (6), pp 654–78, also available at [https://www.researchgate.net/publication/235256591\\_Developing\\_a\\_maturity\\_model\\_for\\_Supply\\_Chain\\_Management#fullTextFileContent](https://www.researchgate.net/publication/235256591_Developing_a_maturity_model_for_Supply_Chain_Management#fullTextFileContent) (archived at <https://perma.cc/B4GD-FRMJ>)

Two examples of supply chain maturity models can be found at:

<https://talkinglogistics.com/2018/04/17/data-transform-supply-chain/> (archived at <https://perma.cc/Y28F-Q99P>)

<https://slidemodel.com/how-to-start-digitizing-your-supply-chain-management/four-stages-of-supply-chain-maturity/> (archived at <https://perma.cc/684H-AK27>)

## References

- Hayes, R H and Wheelwright, S C (1984) *Restoring Our Competitive Edge: Competing through manufacturing*, Wiley, New York
- Wheelwright, S C and Hayes, R H (1985) Competing through manufacturing, *Harvard Business Review*, January–February

## 4.8 Postponement

### *Introduction*

‘Postponement’ is the term applied to the customization of a product at the latest possible time. One of the earliest well-documented examples was the Hewlett-Packard LaserJet printer. Instead of making all the different variants of the LaserJet printer at the factory, it was decided to produce a generic printer there, and ship the generic printers to the regional warehouses across the world. The final customization and packaging for a particular market was carried out at the warehouse. Although this finishing operation was slightly more expensive to carry out in the warehouse, the savings in transport costs and inventory massively outweighed this small disadvantage.

Another famous example is provided by Benetton, the Italian clothing group, which delays dyeing of knitted products until orders are received from the shops. Similar to HP, just one stock reference is held of each knit-wear design and this stock may be transformed into a range of SKUs. In general, the advantages of postponement are:

- having common product and associated processes until a very late stage encourages economies of scale, reduces the number of set-ups or changeovers required and reduces the amount of product to be managed;
- adding variety as late as possible reduces the financial risk of holding inventory of less popular variants;
- ability to meet rapidly increasing demand for those members of a product family that are selling well;
- reduced number of SKUs to be managed;
- early processes can be standardized, usually leading to advantages in processing time and cost.

Products subject to postponement are sometimes called ‘T’ products or ‘mushroom’ products, to indicate graphically that variety is introduced towards the end of the process.

### ***When to use***

When designing a product, or the production process, ask yourself if the components or processes that give rise to product variety can be delayed to the final stages of production, or even to the point of distribution.

## How to use

First, consider the importance of product or service variety to your customers. For those products or services where variety is or could be important, consider how and when that variety is introduced.

It requires some imagination to review all the different ways in which variety can be introduced later in the sequence of processes rather than earlier, so that the product design and production processes are common for as long as possible. This may require a cross-functional team or process design review project.

## Example

Flat laminated glass for architectural purposes is a ‘sandwich’ of glass and vinyl layers and is used in a number of security applications. For example, shop windows can be fitted with laminated glass to stop would-be thieves from entering the shop. Even though the glass will break under attack, the vinyl layer will usually prevent the aspiring robber from gaining access. Thicker and more complex ‘sandwiches’ enable the glass to become bullet-proof, such as is used on high-security delivery van windscreens and side windows.

Because of the number of layers involved, thick laminated glass can have very many different specifications and it was common at one time to make up the ‘sandwich’ for a specific order. In order to use the glass economically, the different glass layers were cut to size before layering up the ‘sandwich’. However, the complexity of the production process meant that the customer would usually see a minimum lead time of at least 24–48 hours before the finished product was available.

It was recognized that one way of reducing the lead time to the customer would be to have stock sheets of thick laminate available, to a commonly accepted specification. Customers requesting thick laminate were offered a lead time of several days for their own specification or several hours if they accepted the standard specification laminate. On receiving an order for standard thick laminate, the stock sheet could be sawn to size and the edges finished. The total lead time for these operations was three to four hours. Customers were generally happy to pay a premium for speedy delivery.

In this example, two elements caused variety: the laminate specification and the dimensions of the product. Both causes were addressed. The

specification variety was eliminated by encouraging customers to choose a standard specification, with the advantage of greatly reduced lead time, and the dimension variety was managed by introducing the variety at a much later stage in the process – final sawing.

The disadvantage was that stock of expensive product was held. This financial risk was minimized by holding a minimum amount of stock of a very small number of specifications, but which could nevertheless cover more than 50 per cent of applications if the customer was flexible enough to accept a slightly different specification.

### **Further information**

Ronald Ballou (2004) gives a good summary of the principle of postponement and the types of firms that could be potentially interested: Ballou, R H (2004) *Business Logistics Management: Planning, organizing, and controlling the supply chain*, 5th edn, Prentice Hall, Upper Saddle River, NJ.

Early work in this area was carried out by Walter Zinn and Donald J Bowersox: Zinn, W and Bowersox, D J (1988) Planning physical distribution with the principle of postponement, *Journal of Business Logistics*, 9 (2), pp 117–36.

An internet search for information about the HP LaserJet printer supply chain will give rapid results.

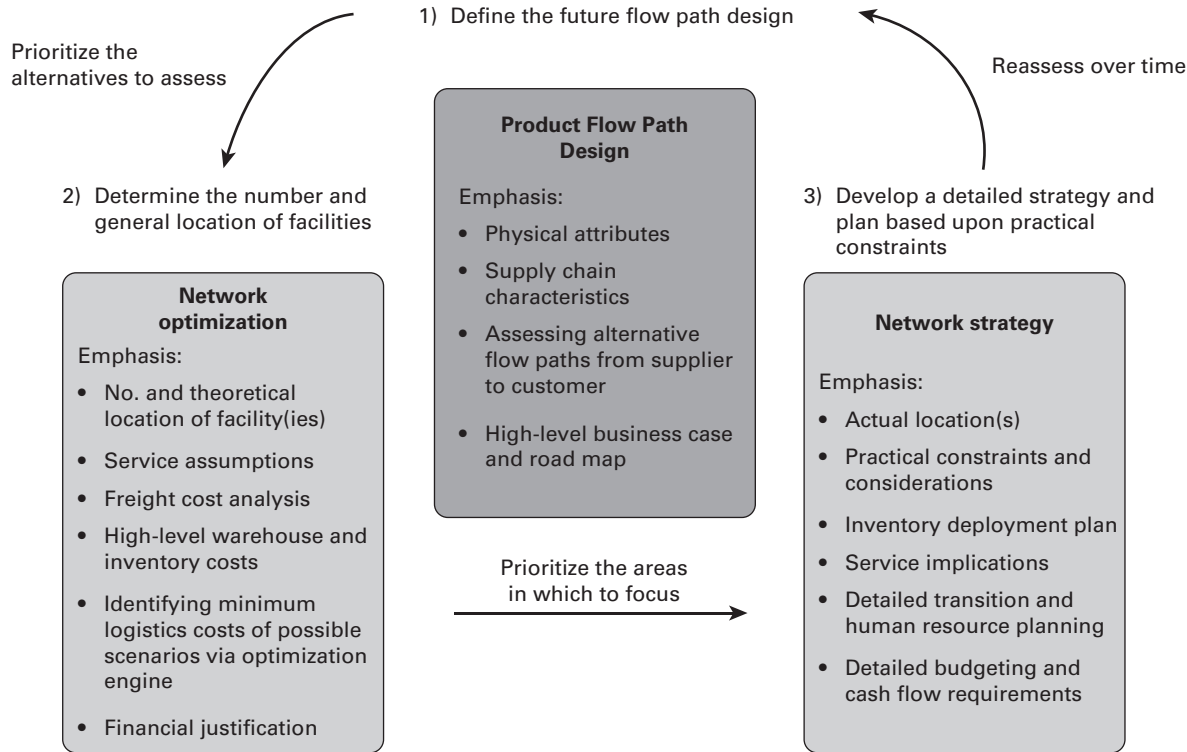
## **4.9 Product Flow Path Design, by Fortna**

### **Introduction**

Product Flow Path Design, introduced by Fortna, defines the most cost-efficient and service-effective routes by which to move products from suppliers to customers. It provides a strategy, a business case and a prioritized road map for moving forward. It is seen as the critical link in the distribution network strategy cycle (see Figure 4.7).

To execute the Product Flow Path Design (PFPD), an important question often is: ‘How many facilities do you need and where should they be?’ Ideally, this is answered through a network optimization analysis. Network

**Figure 4.7** Outline of the distribution network strategy cycle



**SOURCE** Reproduced by kind permission of Fortna, [www.fortna.com](http://www.fortna.com)

optimization takes an in-depth look into the estimated freight costs associated with alternative distribution facility locations.

Most often, a commercial software tool is used that has an optimization algorithm that essentially functions like a linear programming model to determine the minimum cost of alternative locations and product flows. (Examples of companies supplying this software are listed at the end of this tool.) It's a highly data-intensive and theoretical process requiring trained analysts. The most important input is identifying the alternative scenarios and flow paths to analyse. Rarely do these projects have sufficient time or budget to evaluate all the potential flow path scenarios or product segment permutations. So, a PFPD avoids sub-optimizing your study by providing a prioritized set of alternatives to evaluate.

The resulting network optimization analysis following PFPD is valuable input to the broader and more comprehensive requirements of a distribution network strategy. A distribution network strategy includes inventory deployment planning, service capability definition across channels, systems planning and detailed financial budgeting. It is also based on practical constraints and considerations such as the availability of resources and logistics partners to execute and maintain the strategy.

Because all businesses change over time, the network strategy needs to be periodically re-evaluated. This need creates a loop back to PFPD.

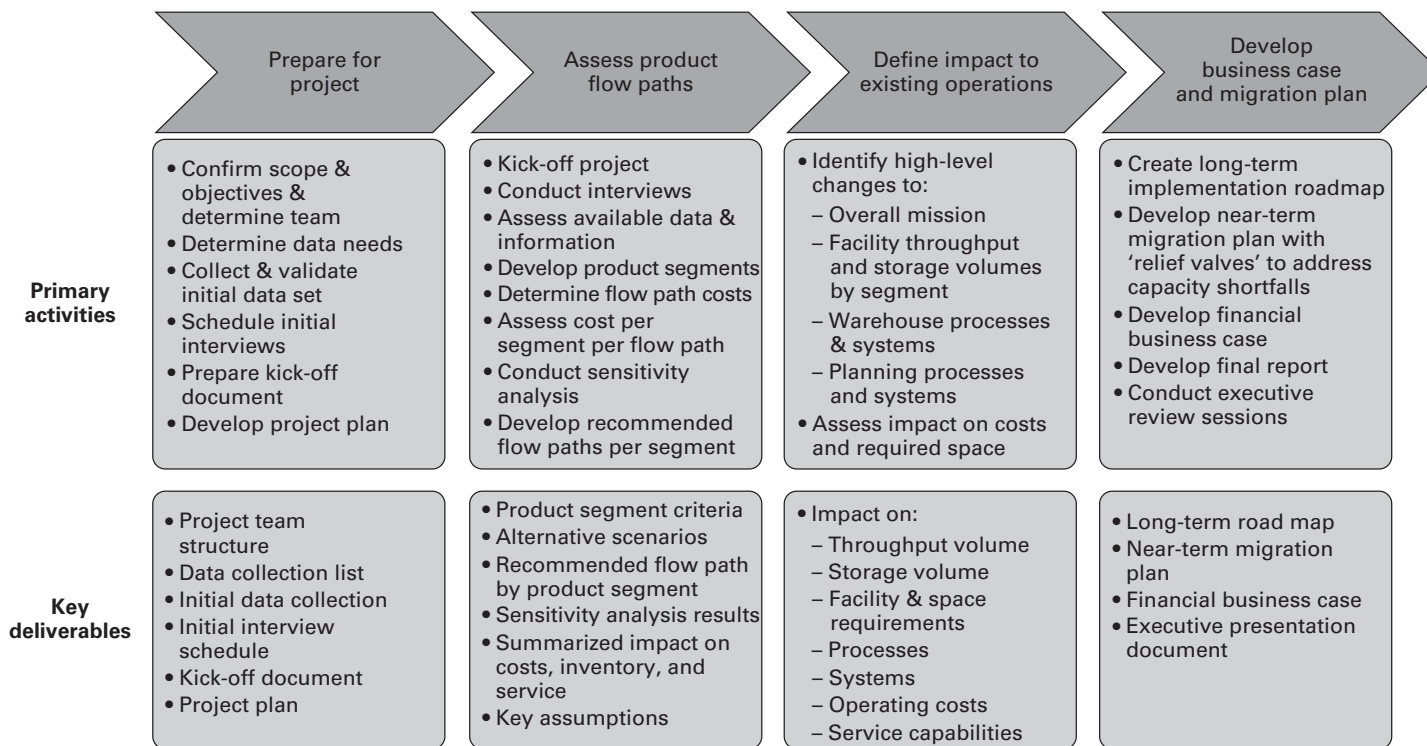
A PFPD aims to answer three strategic questions:

- 1** What are the most effective and efficient methods (balancing cost and service) to flow unique product groupings from suppliers to customers or stores?
- 2** What is the impact of the recommended product flow paths on existing operations (near and longer term)?
- 3** What is the supporting business case and migration plan to support the recommended changes?

Recommended tasks and deliverables from this effort are outlined in Figure 4.8.

The result can be a myriad of alternative flow paths depending on product attributes, source, lead times and destinations. These can include direct shipments, global distribution centres, national distribution centres, regional centres, cross-docking and consolidation centres, local warehouses or a

**Figure 4.8** Tasks and deliverables in a Flow Path Design Project



**SOURCE** Reproduced by kind permission of Fortna, [www.fortna.com](http://www.fortna.com)



combination of the above. It is crucial, therefore, to produce a more manageable set of alternatives to evaluate. A sensible approach is to:

- apply deductive reasoning in developing a set of hypotheses for the potential future supply chain;
- allow business priorities to dictate where to focus your analysis;
- create a set of logical product segments by which to assess alternative flow paths;
- develop and use a financial model to compare the impact and sensitivity of each hypothesis versus your current operation, which becomes the baseline.

PFPD takes a holistic view of supply chain assets, service levels, cost to serve, profits and investments. The idea is to think outside the box, look beyond what you've done in the past, improve on benchmarked results, define the possibilities and evaluate what is practical.

Suppliers of supply chain network design software include the following:

Coupa – <https://www.coupa.com/products/supply-chain-design>

Infor – [www.infor.com/solutions/scm/](http://www.infor.com/solutions/scm/)

Supply Chain Optimizer – [www.insight-mss.com](http://www.insight-mss.com)

Blue Yonder – <https://blueyonder.com>

Logility – [www.logility.com/](http://www.logility.com/)

We Supply – <https://www.truecommerce.com/uk-en/>

## 4.10 SCOR®

### *Introduction*

The Supply Chain Operations Reference (SCOR®) model is a product of the Supply Chain Council (SCC), which merged with APICS, now called the Association for Supply Chain Management (ASCM). The SCOR® model is a framework that links business process, metrics, best practices and technology features together into a unified structure to support communication between supply chain partners. It assists companies in improving the effectiveness of their supply chain management and related supply chain improvement activities.

SCOR® identifies five core supply chain performance attributes: reliability, responsiveness, agility, costs and asset management. Consideration of these attributes makes it possible to compare an organization that strategically chooses to be the low-cost provider against an organization that chooses to compete on reliability and performance.

Membership of ASCM is open to all companies and organizations interested in applying and advancing state-of-the-art supply chain management systems and practices. Member companies pay an annual fee to become involved and have access to:

- frameworks, benchmarking, templates and other resources developed from ongoing research efforts;
- professional development via training and certification programmes;
- networking via peer events and online portals.

Members include manufacturers, distributors, retailers and service providers as well as technology solution providers, business consultants, academic institutions and government organizations.

## ***When to use***

SCOR® is typically used to identify, measure, reorganize and improve supply chain processes.

## ***How to use***

SCOR® works through a cyclic process of:

- Capturing the configuration of a supply chain, which is driven by:
  - plan: levels of aggregation and information sources;
  - source: locations and products;
  - make: production sites and methods;
  - deliver: channels, inventory deployment and products;
  - return: locations and methods;
  - enable: manage the supply chain.

- Measuring the performance of the supply chain and comparing against internal and external industry goals. Supply chain performance is focused on:
  - reliability: achievement of customer demand fulfilment on time, complete, without damage, etc;
  - responsiveness: the time it takes to react to and fulfil customer demand;
  - agility: the ability of the supply chain to increase/decrease demand within a given planned period;
  - cost: objective assessment of all components of supply chain cost;
  - assets: the assessment of all resources used to fulfil customer demand.
- Realigning supply chain processes and best practices to fulfil unachieved, or changing, business objectives. This realignment is achieved through a combination of:
  - classic process re-engineering from ‘as-is’ to ‘to-be’;
  - lean manufacturing analysis and process change;
  - Six-Sigma analysis of defective processes;
  - theory of constraints analysis of systems or processes to elucidate root-cause issues;
  - ISO-9000-style process capture and control;
  - Balanced SCOR® cards and benchmarking;
  - a host of other combined industrial-engineering-based best-practice techniques in improvement.

The SCOR® process reference model contains:

- Performance metrics: standard metrics to measure process performance. There is a suite of key performance indicators but first-line metrics include:
  - the perfect order: on time, in full, damage free and complete document accuracy;
  - order fulfilment cycle time;
  - supply chain flexibility;
  - supply chain management cost;
  - cash to cash cycle time;
  - total cost to serve.

- Processes: standard descriptions of management processes and a framework of process relationships.
- Practices: management practices that produce best-in-class performance; they help companies:
  - Standardize processes: what is our standard way of operating this part/aspect of supply chains?
  - Identify alternative ways of operating the supply chain: how can we organize the process differently to address performance gaps?
  - Formulate a wish list of process configurations/automation.
  - Formulate a blacklist of undesired (move-away-from) process configurations.
- People: training and skills requirements aligned with processes, best practices and metrics.

## **Example**

One of the success stories of SCOR<sup>®</sup> implementation is the use of this methodology by Siemens Medical Solutions for their ‘computed topography’ devices. These medical devices are made to order in Germany and China for customers all over the world. Several hundred employees were organized in teams for the project. Although the original aim of the project was to move supply chain processes to an e-business environment, there were stunning results in the supply chain itself. Delivery time was reduced from 22 to 2 weeks, costs were reduced by 30 per cent, and inventory reduced by 60 per cent.

## **Further information**

SCOR<sup>®</sup> is copyright Association for Supply Chain Management (ASCM); see:

<https://www.ascm.org/corporate-solutions/standards-tools/scor-ds/apics-scc-scor-quick-reference-guide.pdf> (archived at <https://perma.cc/E4FS-ESFG>)

## 4.11 Supplier relationships

### *Introduction*

An important component of the inbound side of supply chain management – supply management – is the development of an appropriate relationship with each supplier. Kraljic's matrix (see tool 4.6) gives guidance on an overall approach to the procurement of different items according to the complexity of the supply market and the strategic importance of the item. In recent years, a lot more effort has been focused on identifying different kinds of relationships that may exist with suppliers and when each type of relationship is appropriate.

At one time the focus was on 'partnerships', a word that was much used – and abused. One useful classification is given by Lambert et al (1996), where they see a progression of relationships from 'arm's length' transactions, through three levels of partnership to joint ventures and finally, vertical integration. Rather than use the word 'partner', some companies identify 'preferred' or 'principal' suppliers, to indicate a relationship that is closer than 'arm's length'.

### *When to use*

It is worth carrying out an annual review of the supplier base, looking at those suppliers that represent the top 80 per cent of spend. These are the key suppliers and a closer relationship with them can bring significant advantages. Stock and Lambert (2001) make the point that partnership is not a requirement for business success but not having a partnership where one is appropriate wastes the opportunity for competitive advantage. It is therefore useful to review the nature of the relationship with these key suppliers against the list of criteria below and consider whether there is any benefit in moving towards a closer relationship with any of them, and what this would entail.

### *How to use*

Many companies recognize the advantages of closer links with their key suppliers. In purely economic terms, better understanding of how the other party works can save a lot of time and energy when placing and monitoring orders, or when sorting out problems. However, there can also be significant

**Figure 4.9** Supplier relationships added to Kraljic matrix

Importance of purchasing decision	High	<b>Material management</b> (Leverage items)  Low-level partnership	<b>Supply management</b> (Strategic items)  Strategic alliance or close partnership
	Low	<b>Purchasing management</b> (Non-critical items)  Arm's length transactions	<b>Sourcing management</b> (Bottleneck items)  Medium-level partnership
		Low	High
		Supply market complexity	

advantage in involving the supplier in new product development projects, or sharing plans regarding future demand and promotions (see CPFR® for example, tool 4.2).

Looking at the Kraljic matrix again, one can allocate a type of supplier relationship according to the matrix quadrant (see Figure 4.9). To be more specific, the following points indicate some of the dimensions that can constitute the relationship:

- Giving information about production schedules to suppliers – the more they know about your exact requirements, the more likely they are to fulfil them on time and in full.
- Number of people in each business interacting with one another – the closer the relationship and the longer that it has been in existence, the more points of contact there are likely to be.
- How problems are resolved – fast resolution by joint discussion and investigation (looking after the final customer first) is preferable to reading the fine print of the contract to apportion blame.
- Date of termination of relationship – the closer the relationship, the less likely there is to be an envisaged termination date.
- Meetings to discuss how to work better together – members of both companies come together in a workshop to discuss how to streamline the ordering/delivery processes.

- Level of management effort required to maintain an expected level of supplier performance – close and healthy relationships are based on high levels of performance as well as trust.
- Involvement in new product design – suppliers in close relationships are consulted and involved in new projects, to engage their experience and innovations.

Finally, it is worth remembering that ‘partnerships’ are rarely built on the first meeting. It usually takes time and experience of working together for two organizations to achieve the level of trust and confidence required to make a partnership work.

### **Example**

In 2008, Airbus signed a major contract with Kuehne and Nagel to manage and operate Airbus’s logistics hubs in Germany, France, the UK and Spain. Although Kuehne and Nagel started by operating the existing warehouse facilities, the agreement foresaw Kuehne and Nagel consolidating the storage requirements and rationalizing the delivery network across Europe. Kuehne and Nagel had been working with Airbus since 2003, so both companies had had the opportunity to understand one another’s needs and operations before Kuehne and Nagel were appointed ‘lead logistics provider’ for a significant contract period.

### **References**

- Lambert, D M, Emmelhainz, M and Gardner, J T (1996) Developing and implementing supply chain partnerships, *International Journal of Logistics Management*, 7 (2), pp 5–13
- Stock, J R and Lambert, D M (2001) *Strategic Logistics Management*, McGraw Hill, New York

## **4.12 Supply chain risk assessment**

### **Introduction**

Two other sections in this book discuss risk assessment and management: warehouse risk assessment (tool 1.22) follows the recommended health and safety approach to managing risk in a warehouse, and supply chain risk

mitigation and contingency planning (tool 4.13) describes the risks to monitor and what to do when things go wrong. This tool brings the other sections together to create a supply chain risk management framework, based on a simplified version of failure mode effect and criticality analysis (FMECA), the methodology developed by NASA to eliminate the chance of a potential failure or mitigate its impact should it occur.

## ***When to use***

The first risk management plan can be set up at any time: the sooner the better! After this, it is highly recommended that an annual review takes place. An important event, such as a major contract or concern about a critical supplier or customer, could trigger a review of the plan before the anniversary review.

## ***How to use***

The overall approach is as follows:

- 1** Brainstorm the potential things that could go wrong at each stage of your supply chain, working systematically through the supply side, your operations, outbound side, customers and general business environment.
- 2** For each potential failure, use the SLD matrix in Figure 4.10 to award levels of severity of impact (S), likelihood of occurrence (L) and chance of detecting the failure before it occurs (D).
- 3** For each potential failure, calculate the criticality number (CN) from the product of S, L and D. Thus  $CN = S \times L \times D$  (thus CN will be a minimum of 1, maximum of 125).
- 4** Rank the potential failures in order of criticality, largest first.
- 5** Going down the list of potential failures in turn, starting with the highest CN, brainstorm ways of eliminating the risk. For each potential solution, estimate the cost of implementation and the practicality of the solution in eliminating the potential failure. For each potential solution, reassess the SLD values, find their product, and use this as an estimate of 'residual risk'.
- 6** If the risk cannot be eliminated, what mitigating actions can be taken to reduce the impact if failure occurs? For each potential solution, estimate the cost of implementation and the practicality of the solution in mitigating the potential failure. For each potential solution, reassess the SLD values, find their product, and use this as an estimate of 'residual risk'.



- 7 From all the solutions proposed for elimination or mitigation, choose the solution that gives an acceptable reduction in risk for an acceptable cost to implement. Include this in an action plan, showing clear responsibilities for implementation and the target completion time.
- 8 Record the solution implemented and the residual risk.
- 9 Continue to monitor risks and review the plan periodically.

## Example

A country in Africa was evaluating the idea of using container-based fuel stations for distributing fuel more widely across the country, in particular to rural areas. A specially designed 40-foot container would house two pumps, a supply of diesel and a supply of petrol. When the fuel supplies were exhausted, the whole container would be replaced by a full one.

Table 4.3 shows the beginning of the risk assessment, with the identification of potential problems and their CN ranking. Table 4.4 shows some of the potential solutions, and residual risk.

**Figure 4.10** SLD risk assessment

	S	L	D
	Severity of effect	Likelihood of occurrence	Likelihood of detection
1	No direct effect on operating service levels	Probability of occurrence: once in many years	Detectability of the failure in the long term is very high
2	Minor deterioration in operating service levels	Probability of occurrence: once in many months	Considerable warning of failure before occurrence
3	Definite reduction in operating service levels	Probability of occurrence: once in some weeks	Some warning of failure before occurrence
4	Serious deterioration in operating service levels	Probability of weekly occurrence	Little warning of failure before occurrence
5	Operating service levels ceased	Probability of daily occurrence	Detectability is effectively zero

**SOURCE** Adapted from Slater (2005)

It can be seen that location of the containers was thought to be critical in reducing their exposure to bad driving. Once located, however, only some kind of mechanical barrier would prevent a vehicle impacting the container, and a surrounding fence was believed to be the best solution. Unfortunately, this was expensive and needed a higher-level decision.

Meanwhile, it was decided to locate a manned cabin with a telephone to address the other potential problems. Placing equipment on site capable of handling leaks or fires is a mitigation measure in case the failure occurs.

The overall idea of using containers to deliver and dispense fuel in remote areas was believed to be feasible enough for further evaluation.

### ***Further information***

More rigorous approaches to FMECA can be found from any good textbook on total productive maintenance.

### ***References and further reading***

- Gibson, R (2013) Know your risk, know your risk appetite for growth, *Focus*, 15 (5), pp 40–43
- Slater, A G (2005) Vulnerability in the supply chain, Visiting Professor of Logistics, Huddersfield University, lecture notes.

## **4.13 Supply chain risk mitigation and contingency planning**

### ***Introduction***

According to SCOR®:

supply chain risk management is the systematic identification, assessment, and mitigation of potential disruptions in logistic networks with the objective of reducing their negative impact on the logistic network's performance. Potential disruptions can occur either within the supply chain (e.g. insufficient quality, unreliable suppliers, machine breakdown, uncertain demand, etc) or outside the supply chain (e.g. flooding, terrorism, labour strikes, natural disasters, etc).

**Table 4.3** Risk assessment part 1 – identifying and classifying the potential problems

Failure no	Potential failure or problem	L (1–5)	Effect of failure	S (1–5)	Cause of failure	D (1–5)	CN = L × S × D
1	Car/lorry crashes into the container	3	Explosion, death of driver	5	Poor driving skill	5	75
2	Attempts to steal fuel	4	Potential explosion	5	Container left in unsafe condition	3	60
3	Attempts to steal the whole container	1	Operation ceased, loss of asset	5	Criminal interference	5	25
4	Pump failure	2	Customer frustration	3	Poor maintenance	4	24
5	Leakage	1	Fire risk, environmental damage	5	Bad handling	3	15



**Table 4.4** Risk assessment part 2 – action plan for elimination or mitigation of the risks

Failure no	Action	Target completion date	Whose responsibility?	Residual L (1–5)	Residual S (1–5)	Residual D (1–5)	Residual CN
1	Locate containers carefully, not near bends or other potentially hazardous places	03/20xx	GM	2	5	5	50
1	Fencing around whole area to prevent accidental approach from road	Wait for budget		1	5	4	20
1	Protective posts or bars around edge of container zone, to take first shock of impact	Wait for decision on fence		2	5	5	50
2	Permanently manned cabin	04/20xx		2	4	3	24
3	Manned cabin – permanent guard	04/20xx		1	5	3	15
4	Set up and follow maintenance plan	04/20xx		1	3	2	6
5	Ensure drivers are trained to handle these containers carefully	04/20xx		1	5	3	15
5	Appropriate equipment on site for handling leaks or fires	04/20xx		1	4	3	12

Both are considered in an integral multi-phase approach for supply chain risk mitigation and contingency planning. SCOR® best practice suggests undertaking the following:

- Establish context: define and document the objective and scope (internal and external) for managing risk.
- Identify risk: collect and document all potential risk events that may impact the organization and prevent it from meeting its goals.
- Assess risk: collect and document for each potential risk the causes, probability and consequences (understand the value at risk).
- Evaluate risk: prioritize risks, determine for each risk whether mitigation actions are required or the risk is acceptable.
- Mitigate risk: determine the actions required to eliminate, reduce, or accept and monitor the risks (risk mitigation plan).
- Monitor risk: continuously monitor effectiveness of mitigation plans; identify emerging risks and changes in internal and external context.

A 10-step plan to avoid or minimize disruption in the supply chain has been put forward by JP Morgan Chase; this is an adaptation:

**1 Undertake regular risk assessments – identify areas of concern:**

- Political and labour issues.
- Physical and geographical risks such as weather.
- Market conditions.
- Oil prices.
- Currency fluctuation.
- Inflation.

**2 Create a response team:**

- Create an empowered group responsible for decision making during an emergency and communicate their actions throughout the supply chain.
- Ensure they have suitable competencies.
- Ensure access to communication lines.
- Both suppliers and customers have to be informed.
- Ensure you have trained staff to deal with the media.

**3 Produce a contingency plan:**

- Ensure that your suppliers also have a workable and realistic contingency plan.

- List details of emergency services.
  - List details of providers of agency labour.
- 4** Give yourselves options:
- Establish and maintain relationships with alternative suppliers and logistics networks.
  - Use multiple shippers, forwarders, ports and transport modes.
  - Alternative power sources.
- 5** Test the contingency plan regularly:
- Review and update regularly.
  - Run potential scenarios.
- 6** Keep documentation and information up to date:
- Ensure that telephone numbers and email addresses are up to date.
- 7** Continue to track and be aware of current events likely to impact your supply chain:
- Weather patterns.
  - Political unrest.
  - Labour unrest.
  - Labour shortages.
  - Market conditions.
  - Raw material shortages.
  - Natural disasters, earthquakes, floods, volcanic eruptions.
  - Terror attacks.
  - Major fires.
- 8** Introduce cross-training:
- Develop a flexible workforce that can react quickly.
  - Ensure staff have a cross-section of skills and abilities.
- 9** Save time and avoid congestion:
- Utilize quieter shipping routes.
  - Move product away from ports quicker.
- 10** Back up and save all documentation:
- Ensure that this is done daily and stored off site electronically.

## References

Supply Chain Operations Reference (SCOR<sup>®</sup>) model Overview <https://www.ascm.org/corporate-solutions/standards-tools/scor-ds/> (archived at <https://perma.cc/267N-NZ4T>) Adapted from J P Morgan Chase Vastera cited in *The Unexpected Happens: Is your supply chain prepared?* by William Keenan, Jr, <http://www.inboundlogistics.com/cms/article/the-unexpected-happens-is-your-supply-chain-prepared/> (archived at <https://perma.cc/8QDF-GTKB>)

## 4.14 Sustainable sourcing

### Introduction

As natural resources become scarcer and as companies want to extend their level of corporate social responsibility (CSR) back up the supply chain, sustainable sourcing is becoming more and more important in procurement.

Companies that are most closely involved are those that use natural materials directly in their product, for example palm oil, coffee beans or timber. Sustainable sourcing aims to ensure that the plantations and farms that produce these natural materials are managing their land and other natural resources in such a manner as to ensure that production can continue in the long term by putting as much back into the environment as is being taken out of it. For example, this includes replanting areas that have been harvested, managing water use and treating all waste products before releasing them back into the environment. Fair pay for the workforce and appropriate training, working conditions and contracts are increasingly part of the evaluation.

Beyond the purchase of these natural resources, all companies that buy goods and services can still implement sustainable sourcing, focusing on the carbon footprint (see tool 2.2) and overall environmental impact of the processes of their suppliers: use of energy, use of water, treatment of waste, packaging materials, etc. Note that sustainable sourcing will not be credible unless your company is also making clear progress to sustainability itself.

### When to use

Sustainable sourcing is a policy that must be agreed and supported by top-level management. Having decided how to approach this, the procurement

function will review the existing supply base for sustainable practices and will be looking for commitment from all new suppliers.

## **How to use**

Once top-level commitment has been obtained, the procurement function will be asked to develop a company policy and then implement it. A good approach is to assemble an internal working party made up of interested members of different functions, including accounting and finance, marketing, operations and supply chain. Even though the focus will be on sustainable sourcing, information will be required from different functions. There will also be implications for different user functions and a learning process for the whole business to improve the sustainability of their own practices.

The first task of the group will be to choose a focus area as a starting point. This could be one family of items or services and could be, for example:

- transport services;
- energy or water supplies;
- cleaning services;
- raw materials;
- components;
- equipment – taking a lifecycle viewpoint of the next purchase.

In general, it is a good idea to start with products where there is a clear environmental link, such as paper or food, or products where there could be high potential for cost savings over their lifetime, e.g. high-energy-consuming products. The first family will be used as a learning process, specifically to answer questions such as:

- What criteria will be used to assess sustainability in this case?
- How will sustainability be measured?
- What are the associated costs or risks?
- To what extent do suppliers meet the new requirements already?
- Will there be any kind of consultation process with key suppliers?
- How will suppliers be informed, e.g. next invitation to tender, quarterly communication?
- How will potential or new suppliers be informed about the new company policy?



- How can we help or support suppliers in their adoption of sustainable practices?
- How important are we to these suppliers? To what extent can we influence their sustainability programme?
- How will the success of our policy be measured?
- How will we react if a supplier is not interested or pays only lip service to our proposals?

It is always useful on a new project such as this to encourage the group members to carry out background research and provide summaries of their reading or visits to other members of the working party. This will suit some people more than others, but doing the underpinning research is essential education for the whole group. The main UK professional institutions are a good source of information, as well as a growing body of accessible books on the subject (e.g. Emmett and Sood, 2010).

### **Example**

A high-profile sustainability programme was launched by Marks & Spencer in 2007. Known as 'Plan A' (there was no plan B), the project involved suppliers, customers and employees and covered the use of sustainable raw materials, environmental impact of the stores, e.g. energy and water use, waste, carbon footprint in distribution, healthy lifestyle and the final destination of its products. Its commitment has been unwavering and has brought many benefits for all concerned. More information, including the annual sustainability report which shows the progress that has been made, is available on the website: <https://corporate.marksandspencer.com/sustainability>

### **Further information**

See Emmett, S and Sood, V (2010) *Green Supply Chains: An action manifesto*, Wiley, Chichester

Browne, M et al (2015) *Green Logistics*, Kogan Page, London

These sites have a carbon footprint calculator to help companies in measuring their supply chain's impact on the environment: <https://www.gov.uk/guidance/carbon-calculator> (archived at <https://perma.cc/EE37-ZQSV>), <https://www.carbonfootprint.com/calculator1.html> (archived at <https://perma.cc/LB6E-FF8V>)

<https://www.carboncare.org/en> (archived at <https://perma.cc/2JMU-Z87Q>)  
and <https://www.carbontrust.com/client-services/advice/footprinting/>  
(archived at <https://perma.cc/ALL2-3GLB>)

## 4.15 Theory of constraints

### *Introduction*

Eli Goldratt developed the ‘theory of constraints’ in the 1980s. Following on from his work on factory scheduling by starting scheduling from the bottleneck resource (Goldratt and Cox, 1984), the theory of constraints (Goldratt, 1990) was developed as a more general approach to improving business performance.

There have been many approaches to business performance improvement, but the theory of constraints is particularly relevant to supply chain management because one of its major pillars is reduction of inventory. A major outcome of applying the theory of constraints is improved flow through a resource or series of resources, which is also an objective of supply chain management.

Goldratt (1990) argues that there are only three ways to improve business performance:

- 1** Improve ‘throughput’, that is the rate at which saleable goods are output and can therefore generate revenue.
- 2** Reduce ‘inventory’ (for the same throughput), where inventory includes fixed assets as well as materials.
- 3** Reduce ‘operating expense’, which includes overheads and operating capital.

Crucially, this improvement process must be continuous (not just a quick fix), and also must involve everybody in the organization.

### *When to use*

The theory of constraints can be used as the process for a business or supply chain improvement project. It is more suited to an ongoing improvement process than radical supply chain redesign.

## How to use

The theory of constraints is an approach to business improvement that has captured the imagination of some managers. Through training, and often the involvement of an external change agent such as a consultant, these managers will lead business improvement projects. Advocates claim that it is a flexible method that can be used to attack almost any business problem effectively.

Goldratt (1990) outlines the main steps in the process of improvement using the theory of constraints:

*Step 1:* Identify the system's constraints. A constraint is anything that is preventing the organization from achieving its business development goals. Usually there are just three or four key constraints preventing the system from performing better. In general terms, these can be, for example, capacity, product quality or lead time.

*Step 2:* Having identified the system's constraints, there is no point in the non-constraining resources operating independently and at a higher performance level than the level at which the constraints will allow the whole system to operate. Thus the non-constraint resources should serve and supply the constraint resources. The second step is to identify how this can be done.

*Step 3:* Having identified how the non-constraint resources can serve and supply the constraint resources, the constraint resources take priority from now on, and all decisions regarding non-constraint resources are secondary to decisions and actions involving the constraints.

*Step 4:* Now is the time to consider how to 'break' the constraint by doing something about it, by making some improvement to the system. In the examples in step 1, solutions to a capacity problem might include working an extra shift or reducing downtime on a piece of equipment, whereas solutions to a product quality problem might include redesigning the product, refurbishing a piece of equipment or training operators in problem solving to identify and improve process quality themselves. Solutions to a lead-time problem might include reducing set-up times and batch sizes or increasing capacity.

*Step 5:* Clearly, if a constraint in one area or activity has been eased, then another area or activity becomes a constraint. Thus improvement is an ongoing process of identifying the next constraint and tackling it using the same steps. Thus we return to step 1.

## Example

Case studies of successful implementations are available on the Goldratt Institute's website (see [www.goldratt.com](http://www.goldratt.com)). Nike reports improving stock turns of socks from 2.3 to 7 within four months, and later to around 10, using the theory of constraints. Nike says that it did not change its IT systems or improve its forecasting but simply focused on the link between manufacturing and distribution. It was also able to reduce warehousing costs by \$2 million per year and increase sales by 40 per cent during the peak season.

Reports from other companies are equally impressive and include improvements in on-time delivery, inventory reductions, increases in sales and reduced operating expense. *The Goal*, written by Goldratt, is certainly one of the most informative business books we have read and we recommend it as simple to understand and easy to read.

## Further information

See <http://www.goldratt.com/> (archived at <https://perma.cc/DJ9J-RDLE>)

## References

Goldratt, E M (1990) *What Is This Thing Called Theory of Constraints and How Should It Be Implemented?* North River Press, New York

Goldratt, E M and Cox, J (1984) *The Goal*, North River Press, New York, also published by Gower Publishing

## 4.16 Value stream mapping

### Introduction

The purpose of value stream mapping (VSM) is to understand which parts of the existing supply chain add value and which parts do not. Analysis of the existing supply chain encourages us to think about how the stages could work better and therefore enables us to map how the chain should work – the ideal future state. The task is then to create an action plan to move from the existing state to the ideal future state. Physical movement of components and products is mapped as well as information flow.

It is important to set the scope of the map. Ideally, it should go from raw materials through to the final customer, so it may be useful to involve critical suppliers and major customers to ensure cohesion and smooth flow along the chain. Areas which appear to block or slow down the flow should be investigated in more detail.

## ***When to use***

Value stream mapping is a good tool to use with a group of employees from one area. Facilitating the group to create the map provides an interesting activity in which everybody can participate and think about how the processes can be improved.

Value stream mapping is often used as part of a Lean Management introduction.

## ***How to use***

Total throughput time is made up of four components: waiting time, change-over time, cycle time and move time to the next operation. Only cycle time is value-adding time. Value-adding time is frequently just a small proportion of throughput time. The overall objective is to understand why this is and what can be done to increase the proportion of value-adding time. This may need radical change to the processes.

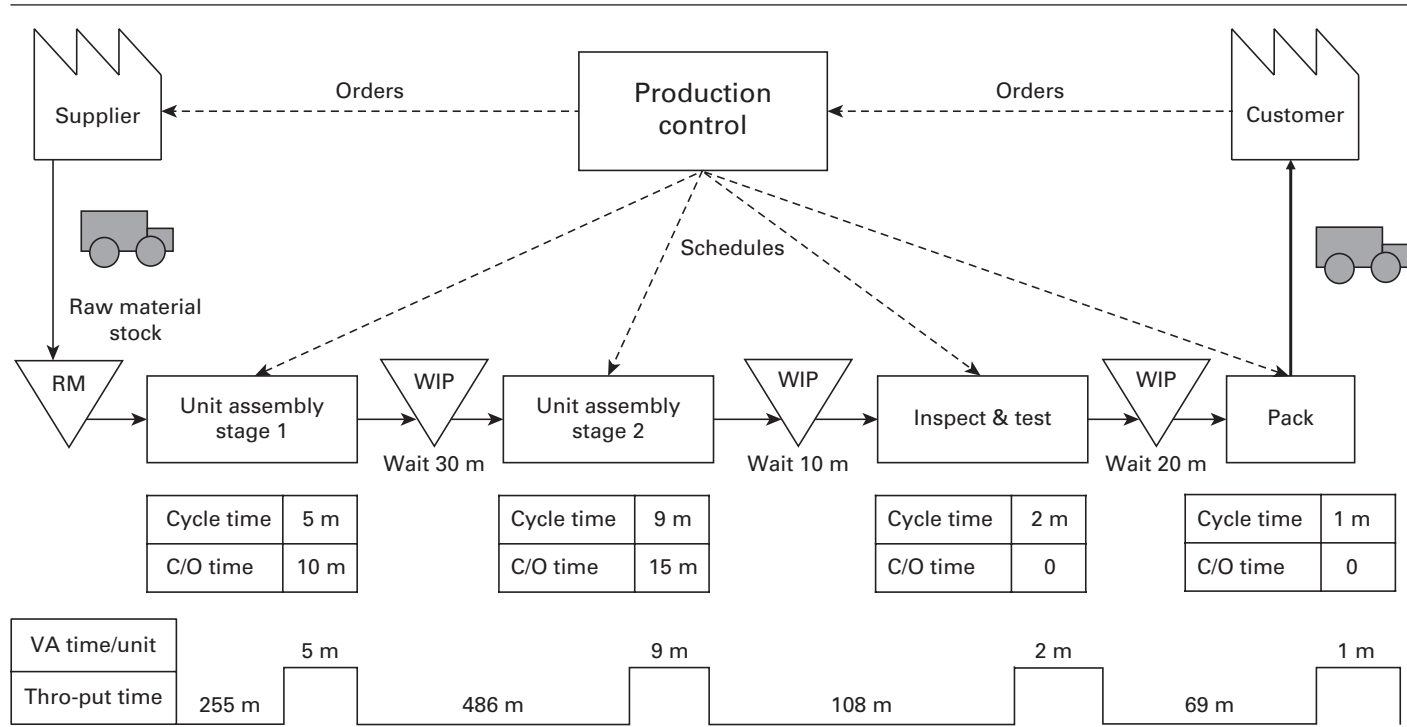
There are many variants of supply chain mapping and just one example is shown in Figure 4.11 and Figure 4.12 described below.

## ***Example***

Figure 4.11 shows the main stages in making a small electrical product. Currently, the product is made in batches of 50. The value stream map clearly shows that each product must wait for all the other units in the batch to be completed before the batch can move to the next operation. However, it is often necessary to change the set-up for another product. Thus, it is only possible to reduce the batch size if the set-up or changeover time can be reduced. Average waiting times between operations are also shown.

The current total value-adding time per unit is  $5 + 9 + 2 + 1$  minutes = 17 minutes.

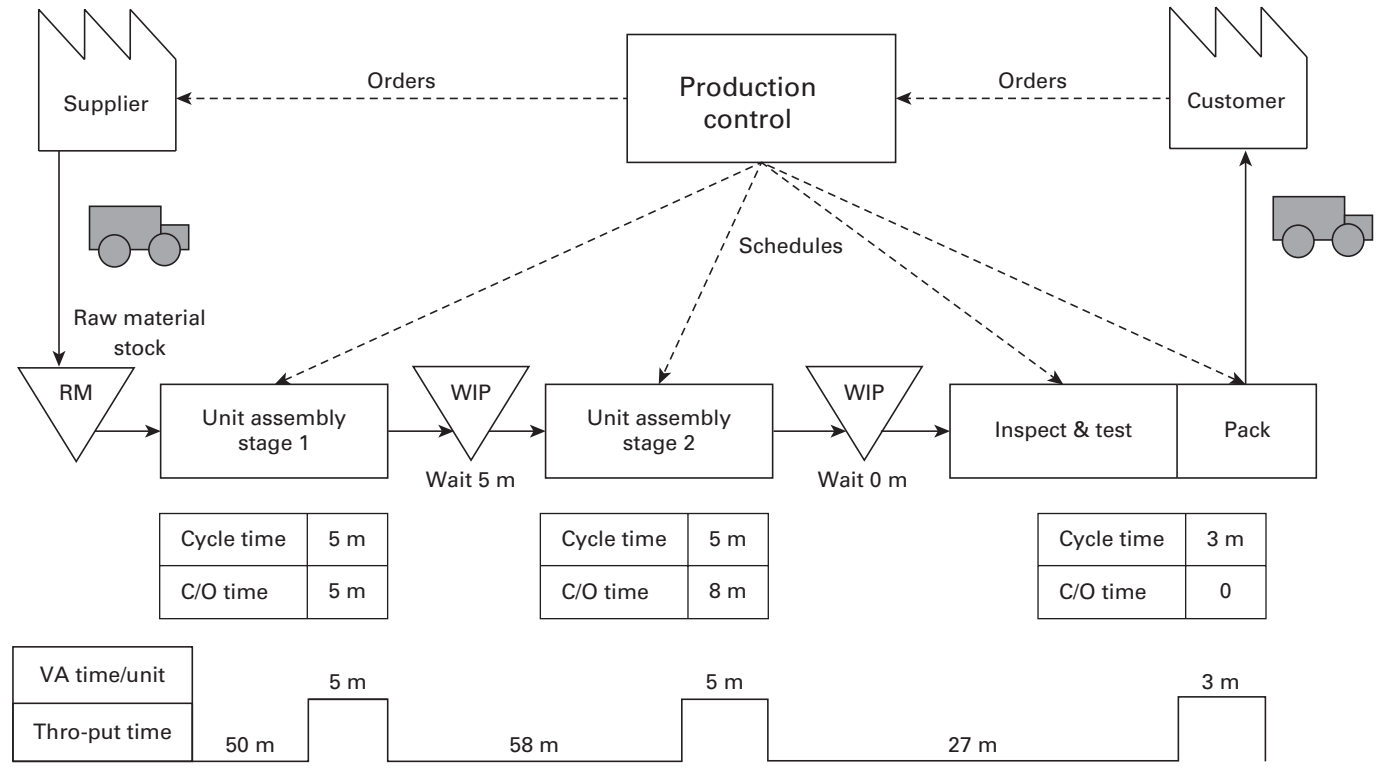
**Figure 4.11** Current state value stream map: trolley capacity = 50



Key: m = minutes, C/O time = changeover time, WIP = work in progress, VA time = value-added time



**Figure 4.12** Future state value stream map: trolley capacity = 10, takt time = 5 minutes



Key: m = minutes, C/O time = changeover time, WIP = work in progress, VA time = value-added time



However, in the worst case, where each workstation needs a changeover, the total throughput time could be  $(255 + 5) + (486 + 9) + (108 + 2) + (69 + 1) = 935$  minutes. This means over 15 hours of lead time for 17 minutes of value-adding time!

The value stream map in Figure 4.11 also shows the total imbalance between the work rate of the different stations. Under Lean, the Takt time (time between successive completions, see further information) determines the rate of work of each workstation, according to the rate of customer demand.

In order to help define a future state, the Takt time is determined to be 5 minutes. Unit assembly stage 2 will either need an improved process or two workstations to achieve this. The workstations 'inspect and test' and 'pack' could be combined.

The ideal future state would be a batch of 1 but this is not feasible until the changeover time can be eliminated. It is decided that a feasible target is a batch size of 10 and halved changeover times. Figure 4.12 shows the future state based on these criteria. If the line produces to this rhythm, then waiting times between stations should be eliminated or negligible.

The new total cycle time is  $5 + 5 + 3$  minutes = 13 minutes.

The new total throughput time is  $(50+5) + (58+5) + (27+3) = 148$  minutes.

The total throughput time is now just under three hours, reducing the level of work in progress and increasing reactivity to changing demand.

## Further information

A good presentation of mapping given in *The Lean Toolbox* by John Bicheno and Matthias Holweg, published by PICSIE books. Takt time is also explained.

There are many online sources, see for example: <https://www.lean.org/the-lean-post/articles/understanding-the-fundamentals-of-value-stream-mapping/> (archived at <https://perma.cc/8HHU-JVZ4>)

## 4.17 Demand-driven MRP (DDMRP)

### Introduction

Demand-driven MRP (DDMRP) has been developed from a combination of methodologies – MRP, periodic replenishment inventory management, Lean



and Goldratt's theory of constraints. It aims to overcome the main limitations of MRP and provide a more flexible response to changing demand.

The main purpose is to protect internal operations from variability in the external environment such as unreliable suppliers and changing customer demand, while buffering against potential difficulties in the internal environment such as bottlenecks.

Several sections of this book provide understanding of the basic components of DDMRP (tool 3.6 on strategic positioning of inventory, tool 3.8 on periodic review inventory management and tool 3.13 on material requirements planning).

## ***When to use***

DDMRP can be used for planning the supply of manufactured products and retail products.

## ***How to use***

Software is required, usually as part of an enterprise resource planning (ERP) system. Its methodology is best demonstrated by an example. We will use the same example as that presented in tool 3.13 on MRP, the office chair.

There are five stages which will be treated in turn in the example:

- 1** Determine where inventory should be strategically positioned.
- 2** Set buffer profiles and levels.
- 3** Make dynamic adjustments to buffer levels.
- 4** Carry out demand-driven planning.
- 5** Execute the plan in a visible and collaborative manner.

## ***Example***

- 1.** Determine where inventory should be strategically positioned (see tool 3.6)

In our example, wheels are considered to be a critical component subject to unreliable supply. There is a plate between the seat and the lifting mechanism which is made in-house but this operation is carried out where there is a machine bottleneck and so stockholding is required. The finished goods stock of office chairs must be protected against variability in demand. The

total cumulative production and procurement lead time is determined by the seat lifting mechanism and so a four-day buffer stock of lifting mechanisms will be maintained to reduce the total lead time to six days (five days remaining procurement + one day for final assembly).

Decoupling stocks will be put in place at each of these positions.

## 2. Set buffer profiles and levels

Buffer inventories in DDMRP have three zones called green, yellow and red, which enable rapid visual monitoring of their state, where green means all is well (no action required), yellow means that an open order should exist (if not then raise one) and red means that rapid corrective action is required.

Here is the basic data for the four buffers of our office chair:

We calculate the size of each buffer in turn, starting with yellow. The yellow zone represents cycle stock, the inventory that is normally used during the delivery lead time of the replenishment.

Yellow zone size = average daily usage rate (ADU) × decoupled lead time (DLT)

**Table 4.5** Extract from BOM (where LT = lead time, M/P = manufactured or purchased, qty = quantity, LFL = lot for lot)

Level	Item	Quantity	LT ( days)	M/P	Order qty
0	Office chair (OC)	1	1	M	LFL
2	Wheels	5	4	P	1000
1	Lifting mechanism	1	5	P	LFL
1	Plate	1	1	M	≥150

**Table 4.6** (where ADU = average daily usage, DLT = decoupled lead time, LF = lead time factor, VF = variability factor, DOC = desired order cycle)

Level	Item	ADU	DLT	LF	VF	DOC
0	Office chair (OC)	145	1	0,8	0,5	7
2	Wheels	725	4	0,8	0,2	7
1	Lifting mechanism	145	5	0,8	0,8	7
1	Plate	145	1	0,8	0,2	7

**Table 4.7** Yellow buffer calculation

Level	Item	ADU	DLT	Yellow
0	Office chair (OC)	145	1	145
2	Wheels	725	4	2900
1	Lifting mechanism	145	5	725
1	Plate		145	1

Then we calculate the red zone which mitigates two kinds of risk. The lead time factor mitigates against the higher risk associated with shorter lead times and a variability factor which mitigates against variability in the lead time associated with transport or supplier reliability.

		Min	Max	Typical value
Lead time factor (LF)	short LT = higher risk = 0.65-1.0	0,65	1	0,8
	medium LT	0,34	0,64	0,5
	long LT	0	0,33	0,2
Variability (VF)	high			0,8
	medium			0,5
	low			0,2

The impact of these values is to increase the size of the inventory by adding safety stock.

Red zone base = yellow × lead time factor = ADU × DLT × LF

Red zone safety = red zone base × variability factor = ADU × DLT × LF × VF

Finally, we calculate the size of the green buffer.

Green zone = maximum of {min OQ, ADU × DLT × LF, DOC × ADU}

**Table 4.8** Red buffer calculation

Level	Item	Yellow	LF	Red base	VF	Red safety
0	Office chair (OC)	145	0,8	116	0,5	58
2	Wheels	2900	0,8	2320	0,2	464
1	Lifting mechanism	725	0,8	580	0,8	464
1	Plate		145	0,8	116	0,2

**Table 4.9** Green buffer calculation

Level	Item	Min OQ	Red base	DOC x ADU	Choose:
0	Office Chair	–	116	1015	116
2	Wheels	–	2320	5075	2320
1	Lifting Mechanism	–	580	1015	580
1	Plate	150	116	1015	116

**Table 4.10** Buffer components

Level	Item	Red base	Red safety	Yellow	Green
0	Office chair (OC)	116	58	145	116
2	Wheels	2320	464	2900	2320
1	Lifting mechanism	580	464	725	580
1	Plate	116	23	145	116

This adds usage until the next replenishment order is raised (whereas the yellow zone covers usage during the delivery lead time) where DOC = desired order cycle (review period).

We talk about ‘top of’ each buffer section in order to get a visual image of the buffer stocks.

Top of red = red base + red safety

Top of yellow = top of red + yellow buffer

Top of green = top of yellow + green

**Table 4.11** Buffer trigger points

Level	Item	Top of red	Top of yellow	Top of green
0	Office chair (OC)	174	319	435
2	Wheels	2784	5684	8004
1	Lifting mechanism	1044	1769	2349
1	Plate	139	284	400

### 3. Dynamic adjustments to buffer levels

It is important to review buffer levels frequently as circumstances change – for example, seasonal products, increasing or decreasing demand trend, short-term shortages or transport difficulties. Thus the values of all the factors involved in the calculations are reviewed periodically.

### 4. Demand-driven planning

Office chairs will now be sold from stock according to actual demand. As soon as the stock level falls below 435 into the yellow zone, a replenishment order will be generated. The replenishment order will arrive in six days according to the new maximum lead time in the BOM due to the stock of lifting mechanisms.

The MRP process is followed as before, except for the lifting mechanism, plates and wheels. The stocks of office chairs, lifting mechanisms, plates and wheels are monitored daily and action is taken accordingly.

If the stock level is in the green zone, no action is taken.

If the stock level is in the yellow zone, check that a replenishment order has been raised.

If the stock level is in the red zone, urgent expediting action is required.

### 5. Execute the plan in a visible and collaborative manner.

It can be seen from step 4 that the colour-coded inventory levels are very helpful for rapid evaluation of any action required.

These visible stock levels can be communicated to suppliers and partners.

This example can be downloaded in full as an Excel spreadsheet for free from <https://howtologistics.com>

## ***Further information***

*Demand-driven MRP* by Carol Ptak and Chad Smith, published by McGraw Hill, is highly recommended.

## **4.18 Calculating ordering cost**

### ***Introduction***

Historically, knowledge of the ordering cost enabled some 'ideal' purchase quantity to be defined that minimized the total cost of stockholding and replenishment (see tool 3.11). Typically, 'ordering cost' was the total cost of replenishment, i.e. procurement, transport, goods receiving and inspection, and costs associated with returns or non-conformance. Today, we separate out from general overhead and other catch-all budgets all these supply chain costs so that better decisions can be made about movement of product through the supply chain. Here, we evaluate the cost of the procurement activity only, or average procurement cost per order because it is the most complex. The procurement function, like any other function, must look at the value it adds to the business against its own operating costs.

The costs of goods receiving and inspection may be taken as the time (e.g. hours per week, month or year) spent on these activities multiplied by the hourly cost of employment of the person carrying out the task. Reducing the need for these activities, for example by making suppliers responsible for inspection before shipment, will result in a cost reduction. The costs associated with returns and non-conformance usually fall to the procurement function as they have to resolve the problems.

Procurement cost is also a baseline against which to measure future reductions by means of 'soft orders' (electronic), blanket orders, longer contracts, VMI (see tool 3.17), grouping more items to fewer suppliers, etc.

### ***When to use***

It is not necessary to calculate procurement cost frequently but it is a useful exercise at the beginning of a supply chain management implementation project or supply chain cost reduction exercise. Thereafter, it can be reviewed every year or two.

Some small and medium-sized businesses outsource procurement to a specialist group in order to benefit from greater purchasing power. In this case, it is important to understand the internal procurement cost against the benefits and costs of external procurement.

## How to use

As with any ‘office-based’ activity, the procurement function is embedded in the business and the costs of its activities are often divided between an operating budget for direct costs (salaries, expenses) and general overhead for indirect costs (telecommunications, IT systems, heating, lighting, etc).

The first stage is to complete Table 4.12 by obtaining as much data as possible from the accounting system and then making sensible estimates for

**Table 4.12** Cost data required to estimate total procurement cost

Category	Description	Estimated annual cost
Office space	Rental or depreciation Taxes General maintenance Fire detection and extinction system Office equipment – desks, chairs, etc Insurance Utilities – electricity, water, etc	
Office systems	Telecommunications Computer hardware, software, support Mobile phones	
Direct employment costs	Salaries Overtime Agency costs	
Expenses	Staff cars Transport, subsistence, accommodation costs Training Office consumables Postal	
Cost of services consumed	Access control Security Fire system testing Cleaning Waste disposal	
Proportion of cost of shared functions	Legal Personnel Accounting Inventory management Production management Transport Logistics Other	

the missing data. For example, heating cost can be estimated by taking the floor area occupied by the procurement function as a proportion of the total office floor area and using this as the proportion of total office heating cost.

The second stage is to make use of this information by analysing the orders placed:

- 1 Calculate average cost per order placed (for use as a future comparator).
- 2 Carry out Pareto analysis to understand the spread of order cost and in particular the C orders – those 50 per cent of orders that likely account for 5 per cent of the total annual value of orders placed.
- 3 Carry out Pareto analysis based on number of order lines to find the C orders – those 50 per cent that have very few order lines.
- 4 Consider how these C orders can be reduced, e.g. by management credit cards, VMI, grouping items to fewer suppliers.
- 5 Consider the items on the B orders and look at where they are placed on the Kraljic matrix (see tool 4.6). Can they be moved to a more regular contract or agreement? Can the contract time be extended for some items?
- 6 Review the total procurement cost and cost per order.

(Table 4.12 can be downloaded for free as a template from <http://howtologistics.com>). In summary, a general expression of ordering cost against quantities delivered will not be obtained (as required for EOQ calculations) but total procurement cost and average cost per order can be useful markers against which to measure progress in reducing operational costs during a project to improve supply chain or procurement efficiency.

## **Further information**

Ordering cost is part of acquisition cost. See Burt et al (2003) or any comprehensive textbook on procurement or supply management for a further discussion: Burt, D N, Dobler, D W and Starling, S L (2003) *World Class Supply Management*, McGraw Hill, New York.

## **4.19 How to calculate stockholding cost**

### **Introduction**

Calculating the costs associated with material flow, that is ordering, transport and stockholding costs, is one of the first stages in implementing supply chain management. It is essential to know these costs in order to make the



best choice from among the many alternative options for managing procurement, transport, storage and warehousing.

For specialist transport or warehousing operations, it can be easy to access these costs. In other cases, they must be carefully separated out from overheads or shared facilities' costs. As a simple example, what is the cost of providing hardware, software and support for the computer system in the finished goods store of a factory? In this case, perhaps the number of terminals located there as a proportion of all terminals across the site might yield a proportion of system cost that could be allocated to the warehouse. This is just one element of a multitude of costs that must be added together to understand the real cost of holding stock.

### When to use

Stockholding cost is part of the first stage of a supply chain management project. Recalculation every two to three years should suffice unless there are major changes to some of the factors.

### How to use

Select a person to do this who is tenacious, capable of searching through cost data and making sensible estimates. Complete the template in Table 4.13 as far as possible and arrive at a total annual cost.

**Table 4.13** Template for estimating annual stockholding cost

Category	Description	Estimated annual cost
Building	Rental or depreciation Taxes Maintenance Fire detection and extinction system Office equipment	
Storage	Depreciation of: Racking Shelving Pallets, totes, boxes, etc	
Packaging consumables	Stretch wrap, bubble wrap, boxes, tape, etc	

(continued)

**Table 4.13** (Continued)

Category	Description	Estimated annual cost
Mechanical handling equipment (MHE)	Depreciation Fuel, tyres, lubricants, etc Maintenance	
Services	Utilities: water, gas, electricity, steam MHE maintenance and repair Pallet maintenance and repair Environmental control Pest control/access control Security/fire system testing Cleaning Waste disposal	
Systems and communications	Hardware Software System support Telephone/internet Staff mobile phones	
Personnel	Full employment costs (salary plus overheads) Overtime Staff vehicles Training Personal protective equipment	
Safety/security	Insurance/special licenses	
Stock losses	Spoilage/breakage Obsolescence Shrinkage: theft; errors in location, counting or issues from stock	
Costs of shared or relocated inventory	Transport to other sites Returns to supplier	
Proportion of cost of shared functions	Personnel Site maintenance Accounting Legal Project engineering Other	
	<b>TOTAL:</b>	

To this must be added the financial investment in the stock and, particularly, the loss to the business of having capital tied up in the stock. Some companies use lost opportunity cost for this; others use the bank interest rate.

Since the loss to the business of the financial value of the stock is usually expressed as a percentage of its value, it is common to express total stockholding cost as a percentage of the value of the stock rather than as a dollar/pound cost. Both figures are useful. The most important point is that a year-on-year reduction is sought, either as a reduction in the stock value or the cost of holding stock or both.

Some people say that if you have a warehouse, you might as well fill it! In supply chain thinking, we are always trying to reduce the amount of inventory (thus increasing stock turns). If this frees up part of the warehouse, then rent out that space to another business and receive some income for it. If you are renting the warehouse anyway, move to a smaller one.

Further categories of costs are shown in tool 7.1, activity-based costing. (A comprehensive table can be downloaded for free as a template from <http://howtologistics.com>)

### **Further information**

A good description of the elements of stockholding cost can be found in any good textbook on supply chain management, logistics or warehousing, for example: Stock, J R and Lambert, D M (2001) *Strategic Logistics Management*, McGraw Hill.

## **4.20 Sales and operations planning (S&OP)**

### **Introduction**

For many people, S&OP is just a module in the enterprise resource planning (ERP) system or a process to balance future demand and supply but research into top-performing companies has shown that a good S&OP process is an important element of supply chain and business success. On a rolling basis, S&OP provides a continuously renewed coherent plan that is created jointly and followed by the supply functions (procurement and production) and demand (sales and distribution) functions. The plan states how much will be produced and sold over the coming months. Involving the finance

department gives confidence that the plan is feasible, and that the cash and profit implications are understood. The critical success factor is that all functions involved take ownership of the plan and contribute to its maintenance and execution. In large companies with multiple sites, product families and markets, S&OP may be carried out at site level as well as at regional and corporate levels. Achieving a good balance between sales and production ensures that customer demands are met with minimum inventory and greatest production efficiency.

Using S&OP for demand and supply balancing is beneficial at the operational level. However, the S&OP can provide an effective cross-functional forum for discussion of future business shape and performance. Conducted at the most senior levels, this form of S&OP provides an important tactical and strategic vehicle for business management. Sometimes the higher-level planning is called integrated business planning, to distinguish it.

Although much of the discussion will be in value terms, the easiest common currency, quantities are usually expressed per product family in broad brush terms, in whatever units have common meaning in the business, e.g. tonnes, dollars, square metres, millions of units and so on. Depending on the sector, the horizon can be one to five years (ideally 18 months or longer).

Having agreed the plan, it then becomes the basis for more detailed capacity planning, materials forecasting, the procurement budget, recruitment (if necessary), and other plans that ensure that the overall plan is executed.

Some companies with sophisticated information systems are now finding it possible to automate parts of the S&OP process. At the simplest level, digital technology can help compile reports. Greater levels of analytics can automate parts of the process and support decision making. However, despite these capabilities, it is important to recognize the human side of the process and that great value comes from constructive dialogue between the functions and a shared approach.

## ***When to use***

S&OP is necessary when the company's products are sufficiently complex or numerous to warrant a higher-level process than a master production schedule (MPS). However, S&OP can still be valuable in smaller organizations in developing a shared business plan and a forward-looking view of the company.

## ***How to use***

The following steps are carried out in each monthly cycle:

- 1** Supply-side progress against the current plan is monitored using a group of key performance indicators (KPIs) including supplier performance, procurement expenditure, production volumes, stocks, percentage achievement of plan, production costs, etc.
- 2** Sales progress against the current plan is monitored using a group of KPIs including sales volumes, revenue, percentage achievement of plan, delivery achievement to customers, service levels achieved, etc.
- 3** The sales function updates the demand forecast and makes this available to the production and supply chain functions. Note that good forecast accuracy is critical for realistic S&OP (see tools 4.2 and 4.3). Product launches, promotions, new market entries or other non-routine events are flagged up.
- 4** Taking into account projected available inventory in future and safety stock requirements, the production function updates the production forecast. Major changes in capacity (shutdowns, new/closing facilities, etc) are flagged up.
- 5** The supply chain function reviews the sourcing requirement and flags up any potential problems.
- 6** The demand (sales) and supply (procurement and production) forecasts are then used as the basis for a number of sub-calculations, carried out either by the S&OP module in the ERP system or in Excel, including:
  - revenue forecast;
  - production cost forecast;
  - feasibility of obtaining all parts and materials in time by using macro-bills of material, i.e. the most critical items due to long lead times or other market difficulties;
  - estimation of the labour workload and the capacity required on the most heavily loaded machines by using macro-routings, i.e. operations on bottleneck and near-bottleneck workstations;
  - proposing alternative scenarios if production and supply cannot be balanced, for example products may need to be allocated to customers or markets if capacity is constrained;
  - procurement budget forecast and cash flow projections.

- 7 Supply chain analytics may be used to spot trends, identify cause and effect links and hence enhance the information available during S&OP decision making.
- 8 An S&OP information pack is created and circulated to the managers of the key functions involved. Each manager prepares for the monthly S&OP meeting, which may require some extra preparation on potential solutions if problems are anticipated. A cover sheet using traffic light indicators allows focus on areas that need attention.
- 9 The team discusses the results of the sub-calculations and adjustments are made until final agreement is reached between all parties on a feasible and coherent S&OP. The S&OP is then used as the basis for the MPS. Once a management team becomes familiar with the S&OP process, it has been found that it is more efficient to focus on exceptions and key issues rather than going through every detail of the plan each month.
- 10 The team executes the plan and monitors its progress. Any serious deviations are investigated and logged for future learning. Thus the cycle recommences.

## **Example**

Wacker Polymers (see URL below) has made available a slide set that explains its S&OP process. The plan covers the next 18 months and is updated monthly on a rolling basis. It enables the business strategy to be realized and resources to be planned. The plan is expressed in dollar terms and also units.

Using 18-month forecasts, first the demand plan is reviewed, then the supply plan. The supply plan is then agreed and used as the basis for the revenue forecast, procurement planning, production and distribution plans, and financial and sales planning.

In consequence of better S&OP, improvements have been seen in four key measures: improved forecast accuracy, improved adherence to production schedules, reduction in inventory days of supply (stock cover) and improved financial forecast accuracy. The process seems to be working so well that S&OP meetings have become boring – a sign of success!

## **Further information**

Propokets (2012) and Iyengar and Gupta (2013) give good introductions to S&OP. Wallace and Stahl (2008) present a comprehensive guide to sales

and operations planning. Ling et al (2010) provide a good overview of S&OP deployment to drive business performance and its use in more complex business environments. They also provide a means of assessing the maturity of S&OP use in a company.

Wacker Polymers' presentation can be found at: <http://fr.slideshare.net/guestdd5f19/executive-sop-case-study-gpseg-1915590> (archived at <https://perma.cc/VN9S-NBN3>)

## References

- Iyengar, C and Gupta, S (2013) Building blocks for successful S&OP, *Supply Chain Management Review*, November, pp 10–17
- Ling, D, Coldrick, A, Bissell, B and Whitewood, D (2010) *Breakthrough Sales & Operations Planning*, Touchmark Publishing, Tukwila, WA
- Propokets, L (2012) S&OP: What you can learn from the top performers, *Supply Chain Management Review*, May/June, pp 28–35
- Wallace, T F and Stahl, R A (2008) *Sales and Operations Planning: The how-to handbook*, T F Wallace and Company, Montgomery, OH

## 4.21 S&OP self-assessment by Supply Chain Movement and Involvement

### Introduction

Your objective is a supply chain which is optimally aligned with market demand. Hence, sales and operations planning (S&OP) is crucial. But what does S&OP really contribute to your company's performance? Is S&OP delivering demonstrable results? To help you discover how well your S&OP process is actually functioning, Supply Chain Movement and Involvement have developed this practical self-assessment model.

### When to use

When you wish to review the S&OP activity in your business.

## How to use

Fill in the answers, scoring zero for each 'No' and the number of points shown for each 'Yes'. Add up the points to find your total score. There are two groups of questions which will form the two axes of a matrix: integral/holistic approach (Table 4.14) and alignment with business strategy (Table 4.15).

**Table 4.14** Integral/holistic approach

		Yes	No	Score
1	Our company has to contend with a certain degree of supply and demand complexity	10	0	
2	The tasks and responsibilities of Sales and Operations are clearly defined.	10	0	
3	Involvement in the S&OP meetings is proactive and constructive	15	0	
4	All participants appreciate the benefit and importance of S&OP	15	0	
5	Decisions by Sales and Operations are supported by figures and assumptions	15	0	
6	KPIs are defined at group level and do not lead to sub-optimization per discipline	15	0	
7	Within our company there is sufficient transparency and trust between Sales and Operations	10	0	
8	Communication between the various disciplines runs smoothly	10	0	

**Table 4.15** Alignment with business strategy

		Yes	No	Score
1	The business strategy is clear and unambiguous, and has been translated into operational execution	10	0	
2	In business planning, there is a clear distinction between long-term and short-term planning. The S&OP focuses primarily on the medium-long term (3–18 months)	10	0	

(continued)



**Table 4.15** (Continued)

		Yes	No	Score
3	In S&OP there is a continual evaluation of trade-offs between supply and demand.	15	0	
4	In S&OP we make decisions at aggregated level without getting bogged down in the operational details.	15	0	
5	Our KPI structure is aligned with business strategy	15	0	
6	In S&OP we make use of scenario planning so that we can proactively anticipate opportunities and threats	10	0	
7	Gap analysis between target and forecast is part of our S&OP process	15	0	
8	Our CEO and CFO both regard S&OP as an important instrument for achieving business objectives	10	0	

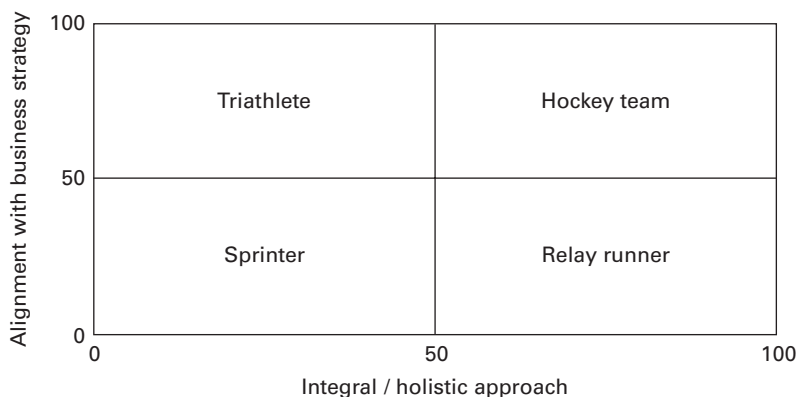
Add up the scores for each axis and determine in which quadrant of the 2 × 2 matrix you are (Figure 4.13).

Score 0–50 points for integral/holistic approach and 0–50 points for strategic alignment:

The S&OP process is like a 100-metre *sprinter* who is striving for personal victory, focused only on the next race. In this type of S&OP, there is little to no alignment between the various disciplines. Departments have individual targets that bear little or no relation to the overall business strategy.

Score 51–100 points for integral/holistic approach and 0–50 points for strategic alignment:

S&OP is like a *relay runner* who must deliver an optimal team performance in the next race. Within companies with this type of S&OP, there is some degree of collaboration and alignment between departments. However, the focus is on short-term operational execution and there is little connection to the long-term strategy.

**Figure 4.13** Result positioning matrix

Score 0–50 points for integral/holistic approach and 51–100 points for strategic alignment:

S&OP is like a *triathlete* who must deliver a strong individual performance and follows a strategy for optimally completing the various stages in order to secure the gold medal. Companies with this type of S&OP primarily strive towards their own departmental goals, yet with a focus on long-term success.

Score 51–100 points for integral/holistic approach and 51–100 points for strategic alignment:

S&P is like a *hockey team* in which each team member fulfils their role for the benefit of the whole team in order to seize the title at the end of the season. In this type of S&OP the business strategy and the vision are central when considering trade-offs between different disciplines. The disciplines are focused on the achievement of long-term success and all activities are aligned with the long-term objectives.

## References

This and other self-assessments can be found at [www.supplychainmovement.com](http://www.supplychainmovement.com) (archived at <https://perma.cc/R9QS-A9G6>)  
<https://www.supplychainmovement.com/sop-self-assessment-2023/>  
 (archived at <https://perma.cc/J75L-3JHG>)

## 4.22 Strategic procurement

### *Introduction*

Strategic procurement is the result of major changes to the purchasing function since the 1990s. The name acknowledges the strategic importance of good procurement practices. Depending on the sector, the function is involved in 70–90 per cent of company expenditure (i.e. just about anything that is not salaries or depreciation) and a business of any size would do well to make sure that its expenditure is funnelled through the procurement function as far as possible.

A good proportion of this expenditure is supply-chain-related and effective procurement is an important element of supply chain management. It is critical that supply chain management, and hence procurement, has board-level representation.

### *When to use*

Many companies can improve their procurement practices and this tool is intended to give you some insight into how strategic procurement can help your business.

### *How to use*

Use this tool to review the procurement activity in your business. If you would like to know more about these ideas, shown in Table 4.16, see the further information section.

### *Example*

A procurement professional was appointed to a small business to take over all the procurement activity that had previously been handled by the managing director (MD) and his assistant. The MD made the decisions and the assistant executed them. While the MD could claim that company expenditure was being carefully controlled, this did not mean that procurement was being handled analytically or in the best long-term interests of the company.

The procurement professional immediately started analysing the item catalogue, set up families, identified different purchasing approaches for the

**Table 4.16** Some of the best practices that form strategic procurement

What	What is involved
Analysis of purchased items	<p>Set up families of similar items</p> <p>Use ABC Pareto analysis to identify items and families in each class. Set up appropriate procurement strategy for each item/family according to its importance, i.e. aim to spend more time on the most important or valuable items (see tool 4.6)</p>
Category management	<p>Divide up the purchased equipment, services and materials into logical 'categories', which are then allocated to individual procurement professionals. These category managers then develop specialist knowledge of the supply market. This is particularly useful for centralized procurement of A and B items (see below). It also prevents duplication, inefficiency or vendor proliferation in large organizations with multiple sites/countries</p>
Supplier selection	<p>Set up clear procedures for selecting suppliers depending on importance and value of item, involving users where appropriate, including technical and quality assessments, financial stability, transport options, delivery reliability, ability to contribute to new product development</p> <p>Look at the local, national, regional and worldwide supply markets as appropriate</p>
Minimum number of suppliers	<p>Choose suppliers that the business wants to work with rather than the 'best' supplier for each individual item. The business works to ensure good performance from those suppliers is achieved across a wider range of items. A number of different functions could be involved as well as procurement, e.g. quality, production planning, transport</p>
Supplier status range	<p>Suppliers may be approved, preferred, lead, sole supplier etc. Set up appropriate supplier relationships (tool 4.11)</p>
Supplier management	<p>Provide close or real-time links with suppliers through access to extranet, a platform or portal, to share forecast demand, order history, recorded delivery performance and in some cases actual sales information (e.g. EPOS)</p>
Communication with suppliers	<p>Visit suppliers periodically (depending on location and importance of supplier), and give them regular feedback on performance, e.g. through a platform or portal as above. Communication could also include participation in joint workshops regarding problem solving, new product development, closer cooperation on planning and forecasting, etc</p>

(continued)

**Table 4.16** (Continued)

What	What is involved
Total cost of acquisition	In addition to the invoiced amount, take into account the cost of transport, cost of rejects, administrative effort required to work with this supplier, training, commissioning, consumables, etc
Lifetime cost of equipment	In addition to the invoiced amount for equipment, take into account the installation, commissioning, operating and maintenance costs, shipping and packaging, spare parts requirements, consumables, training, etc
Cooperation with key user functions	Remember that procurement 'serves' internal users and can only do this effectively by being involved as early as possible in development projects such as new products, new facilities, etc. This may require engaging with user departments to explain the role of procurement and the value they add to the business
Supply market monitoring	Keep up to date with the main players and new developments in the supply markets for key items and families
Supply chain risk analysis	Carry out periodic risk assessments on key suppliers, major items, new projects, etc
Information management	Use an appropriate module or package, e.g. SAP Ariba
Centralization vs decentralization	Use ABC analysis to set policy for centralized or decentralized procurement of different items or categories, e.g. centralized procurement for A and B items/families and C items where aggregated demand across all branches or sites or countries makes it worthwhile

different families, formalized a supplier database and reviewed all purchase orders (POs) placed over the previous 12 months. The majority of POs were individual transactions, many to the same companies. Supply agreements were set up with key suppliers with forecasts of aggregated demand.

After a couple of years of reviewing and renewing the supplier base, the purchasing budget had reduced by nearly 15 per cent, supplier performance had increased and production shortages significantly reduced (thus reducing the amount of time spent on expediting).

As a rule of thumb, we can say that a procurement professional can reduce the cost of purchases by about 10 per cent over two years if the expenditure has not yet been analysed methodically. Thereafter, year on year reductions of 3–5 per cent can be expected depending on the sector. This is not about ‘squeezing’ suppliers nor is it about ‘switching and baiting’. It is about choosing good and reliable suppliers, especially for key items, setting appropriate working relationships with them, securing supplies where the supply market is difficult, working closely and cooperatively with internal user functions and involving suppliers in future projects.

### **Further info**

See [www.cips.org](http://www.cips.org) (archived at <https://perma.cc/6QCK-RAZL>) for all matters regarding procurement, training, industry news, events, etc; <https://www.kearney.com/web/the-purchasing-chessboard/> (archived at <https://perma.cc/76VN-WH3P>) identifies 64 methods from AT Kearney’s experience that reduce cost and increase value with suppliers.

The following standard textbooks are highly recommended (for UK and the United States):

Baily, P, Farmer, D, Jessop, D and Jones, D (2005) *Purchasing Principles and Management*, FT Prentice Hall, Harlow (UK)

Burt, D, Dobler, D and Starling, S (2004) *World Class Supply Management*, McGraw Hill, New York (USA)

Lysons, K and Farrington, B (2006) *Purchasing and Supply Management*, FT Prentice Hall, Harlow (UK)

Monczka, R, Handfield, R, Giunipero, L, Patterson, J and Waters, D (2009) *Purchasing and Supply Chain Management*, South-Western, Mason, OH (USA)

## **4.23 Supply chain strategy, by Julian Amey**

### **Introduction**

Twenty years ago, companies developed manufacturing strategies or, in some cases, operations strategies. It is now recognized that while manufacturing can be an important capability, the company really needs an effective supply chain strategy. This recognizes the shift that many companies have

made from being pure ‘manufacturers’ to ones with more complex sourcing arrangements and that customers, products and markets are what drive company performance. Indeed, certain experts would say that companies now compete on their supply chains, necessitating a clear, well-formulated and executed supply chain strategy.

The supply chain strategy must be created to support the company’s (or business unit’s) strategy and commercial ambition. Developing the supply chain strategy requires a clear understanding of customer and market requirements, the products and services that need to be delivered and how the company competes and delivers value to its customers.

The strategy must be forward looking. Although it may seek to address current performance issues, it must consider the future needs of the company and the supply chain (e.g. what product launches are required, what the cost and cash pressures are, in what markets expansion or contraction will occur, how the company’s operating or selling model may need to change). This is necessary because of the likely time that it will take for some facets of the strategy to be implemented. An effective strategy will install the necessary capabilities ahead of their requirement in order to create a leading organization.

A supply chain strategy can have many dimensions and areas to address. These could include:

- Supply chain performance in areas such as customer service and inventory.
- Sourcing arrangements and supply chain configuration/re-configuration: asset strategy, make vs buy, supply base.
- Geographical reach: customer base, supply base, logistics services.
- Product portfolio: new product introduction, product divestments, product lifecycle-driven changes.
- Cost and cash pressures.
- People: skills and talent development, recruitment, organization development.
- Operating model changes: global vs regional vs local, value-adding service offerings.
- Technology: manufacturing capabilities, technology transfer.
- Processes and systems: streamlining or harmonizing processes, information management capabilities, digitalization.
- Infrastructure.

There is the temptation to put too much into the strategy. This should be avoided. It is important to be realistic and focus on the crucial elements that will deliver the most benefit or the changes most critical to future success. Typically, a good strategy should be simple and clear with a number of key principles or messages. A simple strategy is easier to communicate and to gain buy-in for than a complex one. It is also more likely to be implementable.

The strategy should not be seen as a document. To add value, the strategy needs to be implemented. This will require good project management and communication.

An increasing area of focus for many companies developing supply chain strategies is the impact of digital technology on their business and supply chains. Some are now considering digital transformation as the next significant step that they need to take. New digital approaches can have a fundamental impact on the business's operating model; however, there is also still a need to focus on the basics of supply chain processes and people while using digital as an important enabler.

## ***When to use***

A company should always have a valid and up-to-date supply chain strategy. Because of the pace of change of business conditions and competitive environments, the strategy should be reviewed at least annually and will probably require revision every three years, the likely time horizon for implementation of the previous edition.

## ***How to use***

The supply chain strategy must be developed in consultation and collaboration with other functions in the company. Key among these will be:

- Research and development – to understand the future product/service portfolio and plans for new product introduction.
- Sales and marketing – to understand the commercial plans, long-term forecasts and geographical ambitions.
- Finance – to understand the financial imperatives and constraints (e.g. cash flow, profitability, tax).

As part of the strategy's development, a business case needs to be created since the strategy is likely to involve change. Resources will be needed to



effect the change. Hence the business case should justify the effort and resources required. A strong financial case will also generate commitment within the business towards implementation.

Implementation of the strategy will not happen by accident. Effective project management with a clear plan and monitoring steps is essential.

### ***Example: AstraZeneca***

Following the merger of the pharmaceutical companies Astra and Zeneca in 1999, an operations strategy was generated that focused on the immediate issues of company integration and the imperative of launching major new products. In 2001, the strategy was radically revised to become a supply chain strategy that addressed issues of poor customer service and high inventories through:

- implementation of lean and demand-driven supply to reduce lead time and improve efficiencies to provide capacity headroom for new products without major capital investments;
- lifecycle management of products;
- greater emphasis on outsourcing;
- shifting the focus of operations from being a manufacturing organization to one focused on customer service and supply.

Implementation of the strategy de-bottlenecked supply of certain products, leading to increased sales, reduced inventory by circa \$500 million and raised customer service levels to >99 per cent. In consequence, operations' reputation was enhanced and it was seen as a great place to work.

Following attrition in the company's new product portfolio leading to absence of the expected product launches and confronted by impending patent expiries of a number of major brands, in 2006 the strategy was revised to:

- place more aggressive focus on the continued implementation of lean, supporting a continued drive to reduce cost of goods;
- full end-to-end supply chain management by organization realignment and implementation of advanced planning systems to provide full supply chain visibility;
- inventory optimization to free up cash for investment in licensing opportunities;
- stronger regional focus to align with the sales organization;

- shifting the geographical footprint to align with future growth in emerging markets; and
- much greater focus on outsourcing to avoid significant capital investments and manage risk.

### **Further information**

More information can be found in:

Chopra, S (2015) *Supply Chain Management: Global edition: strategy, planning, and operation*, Pearson, Harlow

Christopher, M (2005) *Logistics and Supply Chain Management*, FT Prentice Hall, Harlow

Hill, T (1993) *Manufacturing Strategy*, Macmillan, London

Slack, N, Brandon-Jones, A and Johnston, R (2013) *Operations Management*, Pearson, Harlow

## **4.24 3D printing or additive manufacturing ROI**

### **Introduction**

Additive manufacturing is a process in which a machine makes a three-dimensional (3D) object from a CAD (computer-aided design) file.

3D printing can print items with thermoplastics, photopolymers, composites and metals.

Some manufacturing-grade printers are expensive; however, you can find a 3D printer for manufacturing purposes from \$3,500. The ones costing over \$100,000 are usually large-format plastic or metal printers, which frequently require special facility requirements and safety equipment.

While some say that 3D printing is replacing high-volume manufacturing, the time and cost required to 3D print parts at high volume is often far greater than that of traditional manufacturing.

### **When to use**

The primary uses for 3D printed parts for manufacturing are prototyping, tooling and fixtures, spare parts and low-volume end-use parts.

3D printing could potentially revolutionize the maintenance stores and spare parts industry. Rather than hold a comprehensive stock of automotive parts, for example, a company can manufacture to order.

## ***How to use***

When choosing a 3D printer, you need to ask yourself these questions:

- 1** What are your biggest manufacturing challenges?
  - Prototyping (number/time of iterations, lead time/cost);
  - tooling (time/cost to tool up, custom tooling);
  - spare parts (lead time, batch sizes);
  - end-use parts (cost, quality, lead time).
- 2** What are your current costs for outsourcing or machining parts in-house?
- 3** How important is it to have strong parts?
- 4** Do your parts need to be resistant to heat or chemicals?
- 5** Do you have specific material restrictions (thermoplastic, composites, photopolymers, metal)?
- 6** Are you currently missing deadlines because of time spent machining or outsourcing parts?
- 7** Is the company losing revenue due to reduced production?
- 8** Are your engineers relying too heavily on expensive equipment for non-revenue parts?
- 9** Are you holding significant numbers of items for a ‘just in case’ scenario?

Here are a few areas where manufacturers have benefited by utilizing 3D printers:

- Design flexibility – make parts that were otherwise unable to be fabricated traditionally.
- Greater agility – 3D printing allows you to create more iterations, fail faster, and achieve better end products. Finding and fixing design flaws early also helps to avoid costly design revisions and tooling changes in production.
- Less machine downtime — continuously innovate with minimal downtime.

## ***Further information***

Each of the following websites provides an ROI calculation comparing 3D printing to either in-house manufacture or outsourcing to a third-party manufacturer.

How to calculate the ROI and cost of 3D printing <https://formlabs.com/blog/how-to-calculate-3d-printer-cost/> (archived at <https://perma.cc/3G4L-H3FQ>)

ROI calculator <https://markforged.com/blog/metal-x-roi/> (archived at <https://perma.cc/363C-ZVFG>)

Simple spreadsheet for determining the ROI of a 3D printer purchase <https://strategic3dsolutions.com/simple-spreadsheet-determining-roi-3d-printer-purchase/> (archived at <https://perma.cc/H6NB-33FP>)

## **4.25 Supply chain analytics**

### ***Introduction***

Today most businesses have the opportunity to analyse vast quantities of data efficiently and cost-effectively due to the massive increase in data available in their business and via the internet, together with the affordability of ever-increasing processing power and the continuing reduction in the cost of data storage. The use of 'big data' in business analytics attracted much attention a few years ago. Business analytics employs a range of methods for analysing data, including statistical and economic analyses and modelling, simulation and optimization, which have all been developed over many decades. However, it is only in recent years that so much information has become publicly available, and it has become time- and cost-effective to merge and sort all this information, to construct larger models than ever before and to test out many more future options. Supply chain analytics (SCA) is the application of these methods to logistics and supply chain management (LSCM).

According to Russom (2011), big data business analytics (BDBA) can help businesses make better decisions and improve their strategy, operations efficiency and financial performance.

Before getting too enthusiastic about the ability to solve all our problems at a stroke, it is wise to remember that we cannot model everything all the time. The most successful applications of SCA focus on a particular question

or set of related questions in one of the main areas of LSCM. Of interest to us here are the sorts of questions that could be asked and an understanding of the processes that can be used to address them.

Many business management systems now have SCA modules as an option and there are also SCA 'platforms', which extract and manipulate data from your business database. Often, these platforms have a specialized focus; for example, SAP Business Network focuses on procurement. Alternatively, you can outsource your problem to specialist consultants who will interrogate your database for you and may also combine it with data from public sources.

There are three general purposes of analytics (Wang et al, 2016):

- 'descriptive', which refers to identifying problems and opportunities through summarizing a situation or drilling down, either at regular intervals or as and when required;
- 'predictive', which uses algorithms and programming to discover explanatory and predictive patterns in the data; and
- 'prescriptive', which uses algorithms to create and evaluate alternative scenarios by means of multi-criteria decision making, simulation and optimization.

Many websites offering SCA modules or platforms list the many questions that can be asked. Here, our examples give a flavour of the processes used to answer a question. This is useful since you will get an idea of the wide-ranging application of the method.

## ***When to use***

When you need to make an important decision and you believe that you can obtain more and better information on which to base that decision by mining the company database and/or public data sources.

There are two key points to recognize from big data used for business analytics. First, many strategic projects would earlier have been argued from a largely qualitative point of view using common sense, experience and a few numbers created by extrapolating from, or averaging, available data. Second, the starting point of the problem given to a business analyst was quite often, 'Here's my plan, now go and find the data to support it'. In BDDBA and SCA, the starting point has changed to, 'Here is the situation, now how can we leverage this for best benefit?'

## ***How to use***

These methods require deep experience of statistical and mathematical methods as well as data management and manipulation. If neither you nor a colleague have this sort of knowledge then, from our point of view, the most important thing is that you know the method is available and roughly how it could work for you. A supply chain consultant and analyst will be able to assist you.

## ***Example***

### **1. To support the decision of where to position a new warehouse**

Current approaches to deciding where to position a new warehouse focus primarily on analysing the location of customers and their ordering patterns in terms of frequency and volume, labour cost and availability, local legislation, plus the transport infrastructure for arrival and distribution of product by different modes of transport. In the past, we might only have considered the 20 per cent of clients that represent 80 per cent of turnover. Big data allows us to consider all transactions in the last 5–10 years. In addition, however, the analyst can use public information to enrich the analysis, for example to understand the potential local workforce. Using heuristics (rules of thumb), such as 75 per cent of people live and work in the same area, or that most people do not want to travel more than 45 minutes to work, or that more highly skilled people are willing to travel further to work, the labour catchment area can be estimated. Looking at the population, roads and trains in the catchment area allows the size of the work pool to be estimated. By adding in employment data, the local availability of particular skills can be assessed.

### **2. To support the decision of where to expand a retail network**

After several years of working on different projects, and by combining data from many public and commercial sources, including, for example, Companies House, the Office of National Statistics, trade figures, business databases such as FAME, and Post Office address files, a data analysis consultancy has constituted their own database of all business premises in the UK, which number over two million. This required merging, sorting and cleaning the data and the application of many heuristics. The result is that they understand the nature and financial weight of virtually all economic

activity (e.g. gross value added) in the UK. This has been used successfully in such projects as proposing uses for wasteland that would synergize with and complement local economic activity rather than compete with it, or for predicting the growth in local employment in consequence of the establishment of a business park, or determining if there is capacity locally for an innovative business in a certain sector.

With thanks to Geoff Wainwright and John Burns of Impact Data Metrics (see [www.impactdatametrics.com](http://www.impactdatametrics.com))

## Further information

Some further insight into what can be achieved by supply chain analytics can be obtained from the following sources:

<https://www.ibm.com/blogs/watson-customer-engagement/2019/05/06/retailers-are-running-out-of-inventory-heres-what-to-do-about-it/> (archived at <https://perma.cc/ZAK3-LVYW>)

<https://www.xeneta.com/blog/supply-chain-analytics> (archived at <https://perma.cc/5XFT-GGZ3>)

<https://www.mckinsey.com/business-functions/operations/our-insights/big-data-and-the-supply-chain-the-big-supply-chain-analytics-landscape-part-1> (archived at <https://perma.cc/5LWR-6VC6>)

## References

Russom, P (2011) 'Big data analytics', TDWI Best Practices Report, Fourth Quarter, [tdwi.org](http://tdwi.org) (archived at <https://perma.cc/G28Y-GF67>)

Wang G, Gunasekaran, A, Ngai, E and Papadopoulos, T (2016) Big data analytics in logistics and supply chain management: certain investigations for research and applications, *International Journal of Production Economics*, 176, pp 98–110

## 4.26 Logistics 4.0

### Introduction

Logistics 4.0 is the term given to the concept that logistics and supply chain management will benefit from the application of similar technologies to those which make up Industry 4.0, or the arrival of smart factories, marking

the fourth industrial revolution (the first being the use of steam to power machines, the second being the use of assembly lines for mass production and the third being the application of information technology to automation).

Overall, the application of these new technologies will increase the efficiency (reducing time and cost) and effectiveness (increased customer satisfaction) of the supply chain by better integration of processes thus increasing transparency and visibility of product and data moving through the value chain (not just the supply chain). Technologies used to achieve this include the internet of things (IoT) and cloud computing, automation and robotics, machine learning, big data and artificial intelligence, simulation and augmented reality.

The main components of Logistics 4.0 are listed in Table 4.15. The reader has probably heard of most of them but it is their combination which provides the step change in performance.

## ***When to use***

Logistics 4.0 is definitely upon us but it requires understanding and vision to spot the opportunities for your business.

There is no time to lose! Learn as much as you can about Logistics 4.0 and how it can benefit you, your partners and your customers. Not all the solutions are expensive.

## ***How to use***

Potential applications in logistics and supply chain management are shown in Table 4.17 for each of the different components. You can start experimenting with some off-the-shelf solutions, e.g. IoT, drones or robots, or engage someone with more experience to help you to set objectives and draw up a strategy.

Note that increased digitalization and flow of data increases exposure to hacking and fraud. Increased cybersecurity is thus a vital additional component to any Logistics 4.0 project.

## ***Example***

Logistics 4.0 at UPS: <https://www.forbes.com/sites/bernardmarr/2018/06/15/the-brilliant-ways-ups-uses-artificial-intelligence-machine-learning-and-big-data/?sh=62d6c8885e6d>



**Table 4.17** Main components of Logistics 4.0 and their applications in logistics and supply chain management

Component	Explanation	Potential applications
Big data and analytics	We can now store and process more data than ever before, quickly and cheaply. This data can be mined using statistical applications to find the answers to ever more precise questions	Logistic system performance, analysis of customer complaints, where to locate a warehouse, breakdown analysis, data platforms
Artificial intelligence	From an initial base of facts, rules and experiences, new knowledge and competences can be inferred and generated	Re-routing packages in the case of a problem in one part of a system, optimizing a distribution system, optimizing international distribution, international inventory location determination, production planning and scheduling, augmented operators
Robotics	Machines can carry out a wide variety of tasks autonomously	Warehouse picking, autonomous delivery vehicles, autonomous ships, delivery drones, picking drones
Machine learning	Machines such as robots can be programmed to learn how to do certain tasks. Artificial intelligence allows them to design methods to carry out new and different tasks	Warehouse picking robots, ABC analysis, autonomous delivery vehicles, autonomous ships
Cloud computing	Rather than having all applications and data in a memory situated in the computer or machine, these programs and data may be stored remotely and accessed as required thanks to faster internet	Sharing data, accessing applications, connected locations and teams, software as a service (SaaS)

*(continued)*

**Table 4.17** (Continued)

Component	Explanation	Potential applications
Simulation	A virtual model can be built of a process or product enabling experimentation and testing before the process or product is created in real life and without risk of harm to the real-world product or process or their environment. A 'digital twin' (see tool 4.27) uses this technique, as well as machine learning and artificial intelligence, updating the model using real-time data	Warehouse layout and design, distribution system design, supply chain performance, picking system operation, bottleneck diagnosis
Internet of things	Devices may be connected to the internet. Connection to the internet enables remote application and analysis of the data and remote decision making	Smart products, product status and location, machine performance, remote maintenance, storage conditions, material and product movement through the supply chain
Additive manufacturing	Parts may be produced rapidly in plastic or metal thus enabling rapid prototyping or reducing the need for stocks of spare parts	Rapid prototyping, spare parts delivery
Augmented reality	Computer-generated information is applied to a real-world environment, for example to enable us to see how a new product or process fits into our world	Visualization of a new product, visualization of a new process, training warehouse staff

### Further information

See [https://www.adlittle.com/sites/default/files/prism/logistics\\_section.pdf](https://www.adlittle.com/sites/default/files/prism/logistics_section.pdf) (archived at <https://perma.cc/76D8-E4VA>) for some good examples of new businesses and transformation of existing businesses.

Also look at the websites of the leading sector players such as the big consultancies and integrators such as IBM, SAP, Microsoft. Your professional institution may also be a good source for information, meetings, conferences or presentations of ongoing projects.

## 4.27 Digital twinning

### *Introduction*

Digital twinning is one of several components of Industry 4.0 which are useful in logistics and supply chain management. A digital twin is a digital replica of a logistics system or component such that the system or component can be tested and experimented with, without any impact on the real-life system or component. However, testing and experimentation can be carried out with confidence that the real-life system or component will react in exactly the same way. For example, the digital twin could be of a warehouse or a distribution network.

This is very useful for testing out how the system or component will react under new circumstances such as extreme load, or failure of a sub-system, or when using different customer priority rules, for example.

The digital twin is not a model built separately from the real-life installation as discrete event simulation models used to be. The twin continuously monitors what is happening in the real-life system and is updated with real-time data. The digital twin uses other elements of Industry 4.0 such as machine learning to analyse changes in the real-life system and artificial intelligence to assess how to integrate them, thus helping future decision making.

### *When to use*

The digital twin is constantly updating itself but becomes particularly useful if a decision is required on a new investment or to develop a new strategy.

### *How to use*

Specialist software is required but the underlying approach is the same regardless of which software is used. The main steps are:

- Define the scope of the model, its elements and the relationships between the elements.

- Collect data on the operating characteristics of the real-world situation and decide how this data will be transmitted to the future twin (sensors, video etc).
- Build the model feeding in real-time data.
- Test and validate the model by analysing its responses to changes in the real-time data against the ongoing changing real-life situation.
- Continue to develop and adjust the model until it images the real-life system or components as closely as possible.
- Once validated, the model can be subjected to analysis and experimentation which may require exporting the data to other tools.

The main software being used at the time of writing are IBM Digital Twin Exchange, Microsoft's Azure platform and Amazon Web Services (AWS) IoT TwinMaker.

## **Example**

Reckitt is an international group known for hygiene, health and nutrition products. Reckitt collaborated with Risilience, a company which has developed from research on climate risk carried out by the University of Cambridge Judge Business School, to build a digital twin model of its business. The model was deployed as part of Reckitt's strategy to reach net-zero emissions across its entire value chain by 2040 and mitigate risk due to climate change. Sub-targets included reducing greenhouse gas emissions (GHG), reducing energy consumption, using 100 per cent renewable energies and reducing its product carbon footprint.

Business functions and other stakeholders were involved in developing the platform, supplying data and testing out future scenarios, in order to mitigate climate risk and identify new business opportunities.

See the full story at <https://risilience.com/customer-stories/reckitt-2/>

Significant benefits have already been achieved. Reckitt's 2022 TCFD (Taskforce on Climate-related Financial Disclosures) report states that, compared with 2015, there has been a 66 per cent reduction in GHG and a 3 per cent reduction in use of energy per tonne in operations, while 93 per cent of the energy used in manufacturing comes from renewable sources.

The full report can be found at <https://www.reckitt.com/media/yardvb4g2s/climate-change-2022.pdf>

## ***Further information***

See <https://aws.amazon.com/fr/iot-twinmaker/> (archived at <https://perma.cc/XD2Q-QRT6>)

<https://www.ibm.com/blog/schiphol-worlds-leading-digitally-innovative-airport/> (archived at <https://perma.cc/5NBE-BX4Q>)

## **4.28 Blockchain in supply chain management by Frank Findlow**

### ***Introduction***

The use of blockchain technology offers a huge upgrade to the current supply chain system, which often relies on tracking physical paperwork between siloed parts of the multinational network. It is a trusted, decentralized network that allows for the transfer of digital values such as currency and data.

By allowing digital information to be distributed but not copied, blockchain technology has created the backbone of a new type of internet.

The world of blockchain technology has undergone a big transformation over the past 10 years as the concept evolved from offering a simple means of exchange between two parties to a broad ecosystem full of protocols with real-world applications, ranging from decentralized finance to one-of-a-kind digital art. It is fair to say the applications of blockchain are continuing to evolve almost daily.

Top of mind for efficient and reliable management of goods, the cargo industry will benefit massively from blockchain. Every year trillions of dollars of freight are transported globally, 90 per cent of which is sent via ocean freight.

Given that the major freight companies are among the largest businesses in the world, it is amazing to discover that many of their supply chain processes are still completed with paperwork. The processing of such paperwork is usually very time-consuming as it must all be completed manually, not to mention far riskier.

A lost document could cause huge delays as the handlers would need to trace transaction documents by contacting the other party for copies etc.

A blockchain database could almost completely automate the entire process, all the way from the factory to the retailer. An initial block could be created for the goods as they leave the factory, thereby initiating the blockchain.

This block would detail the time, type and quantity of goods, as well as the transport company's confirmation of goods received, etc. A new block could then be added for each step of the journey until the goods finally reach their destination.

The main benefits of blockchain within supply chain are listed in Table 4.18 below.

## ***When to use***

Blockchain is not going away and in fact, more and more examples are being developed to prove it is not just about cryptocurrency.

There is no time to lose! Learn as much as you can about blockchain in supply chain and how it can benefit you, your partners and your customers. Not all the solutions are expensive.

## ***How to use***

A blockchain is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems in the chain. Each block in the chain contains several transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger.

The decentralized database managed by multiple participants is known as distributed ledger technology (DLT).

Blockchain is a type of DLT in which transactions are recorded with an immutable cryptographic signature called a hash.

This means if one block in one chain is changed, it would be immediately apparent that it had been tampered with. If hackers wanted to corrupt a blockchain system, they would have to change every block in the chain, across all the distributed versions of the chain.

To get the best from blockchain, **think big, but start small.**

Your final goal may be to completely revamp all your businesses' supply chain processes but it is very likely that you will not get buy-in for that.

Start with a project that can go from pilot project to production quickly.

**Table 4.18** Main benefits of blockchain within supply chain

Component	Explanation	Potential applications
Faster & leaner logistics in global trade	Invoicing and inventory management, by removing friction from multiparty workflows – these systems save cost and time.	Documents upload, manage, edit, and share any type of document along your supply chain.  The Documents module helps optimize efficiency for information management, certify origins, and ensure they are real.
Improving transparency & traceability	From an initial base of facts, rules and experiences, new knowledge and competences can be inferred and generated. Companies that attain top recall accuracy and speed by implementing investigation improvements can reduce recall costs, losses, reputational damage and, in the case of food recalls, save lives.	The ability to successfully stop outbreaks of food-borne illnesses through food traceability protocols includes the accuracy and speed of obtaining tracking information and the inability of third parties to manipulate that tracking information.  Unlike traditional supply chains, blockchain-based supply chains will automatically update the data transaction records when a change is made, enhancing traceability along the overall supply chain network.
Automating commercial processes	With the use of ‘smart contracts’. Smart contracts work by following simple ‘ <i>if/when... then...</i> ’ statements that are written into code on a blockchain. A network of computers executes the actions when predetermined conditions have been met and verified.	Identity – document-less citizenship, promotes portable identification. Healthcare – eliminates drug counterfeits, tracks patient information.  Banking & finance – better processing of cross-border payments – higher level of security & privacy.

Component	Explanation	Potential applications
Trust & single version of the truth	<p>Business model innovation – this is the next level of the sharing economy where there needs to be a higher degree of collaboration in real time where participants work off a common ledger or <i>single version of the truth</i>. Blockchain solves a ‘social problem’ – it enables privacy and transparency at the same time when sharing data.</p> <p>This is very useful whenever there are ‘issues of trust’ between parties.</p>	<p>We will increasingly see blockchain-based systems used to demonstrate compliance with regulations regarding data source and data handling. Trustworthy data is also key to sustainability reporting: a bonus is that many blockchain-based solutions (e.g. track-and-trace, or contract compliance in resource extraction) already have this data.</p> <p>A classic example of a shared network is an airport, used by many different airlines which are in competition with each other. Imagine a world where each airline had to build its own airport – <i>it would be a mess and very expensive</i>. But that is the system in which we exchange our data today.</p>



Choose one that makes an existing process more efficient and will result in a win/win situation. Tangible business benefits will make it easier to get more funding; and, as decision makers get more comfortable with the technology, they will start championing the initiative.

They may even come along with new ideas.

### ***Further information***

See <https://medium.com/enrique-dans/the-blockchain-is-coming-so-get-on-the-program-87ae373859d9> (archived at <https://perma.cc/4ZEP-RXBA>)

Frank Findlow Triple EFF Consulting – <https://tripleeffconsulting.com/> (archived at <https://perma.cc/U558-2EQR>)

Also look at the websites of the leading sector players such as the big consultancies and integrators such as IBM, SAP and Microsoft. Your professional institution may also be a good source of information, meetings, conferences or presentations of ongoing projects.

# Outsourcing tools

## 05

### 5.1 Outsourcing

#### *Introduction*

Outsourcing is about recognizing a task or process that isn't your organization's core competence and getting a third party to operate it more efficiently and hopefully more cost-effectively. There are many models to guide companies through the process of determining whether to outsource, how to go about outsourcing and how to ensure that the implementation is successful.

We have looked at a number of different models and combined the best elements of each to ensure a complete end-to-end process. We have also simplified the model and taken into account the likely benefits and barriers to outsourcing.

#### *When to use*

There are many situations when a company needs to evaluate whether outsourcing logistics can be a fundamental part of an ongoing strategy. This model enables the company to assess its current situation and decide whether to outsource or not. Part two of the model (Figure 5.2) provides a methodology for outsourcing and implementation.

#### *How to use*

Before tackling the main model, there is a simplified version produced by Kate Vitasek et al (2013), which can be seen in Figure 5.1.

**Figure 5.1** Outsourcing decision matrix

Potential Value to the Organization	High	Non-Core  Collaborative approach	Core activity for the company  Do not outsource
	Low	Non-Core  Transaction based  Conventional Outsourcing	Non-Core  To be driven primarily by financial consideration
		Low	High
		Organizational Expertise	

**SOURCE** Adapted from Vitasek (2013)

## Main model

At each stage in the model there are a number of questions that need to be discussed, the answers to which will, in part, determine the next steps (Table 5.1).

**Table 5.1** Outsourcing questionnaire

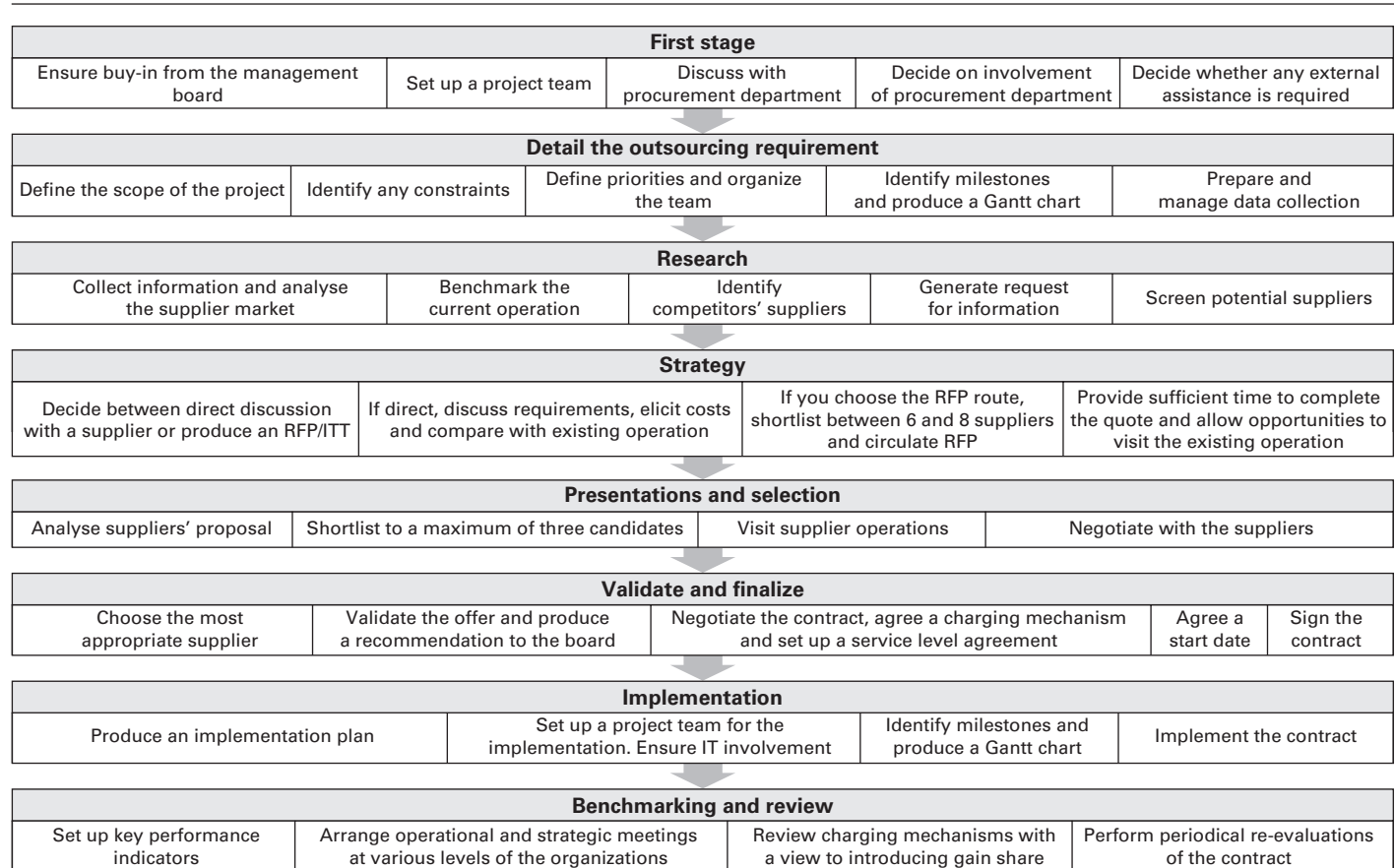
	Don't know	Yes	No
<b>Current situation</b>			
Is logistics a core activity within our business (define what is 'core')?		R	O
Do we have the expertise (core competence) internally?		R	O
Do we compare favourably against our competitors in logistics terms?	BM	R	O
Does our logistics operation give us differentiation?		R	O
Are we able to leverage economies of scale within the operation?		R	O
Are there internal political reasons for retaining an in-house operation?		R	O

(continued)

**Table 5.1** (Continued)

	Don't know	Yes	No
Do we have sufficient capital to fund a logistics operation?		R	O
Are we a risk-averse company?		R	O
Do we worry about losing control of a key activity?		R	O
Does operating our logistics give us greater flexibility?		R	O
Is there a likelihood of a loss of crucial expertise if we outsource?		R	O
Do we have sufficient wider market knowledge?		R	O
Can outsourcing threaten our corporate image?		R	O
Are we able to manage industrial relations issues internally?		R	O
<b>Feasibility of outsourcing</b>			
Is the availability of suitable suppliers a problem?		R	O
Is comprehensive market knowledge essential for our business?		R	O
Do we have greater capability than the potential suppliers?		R	O
Are there constraints to outsourcing (list constraints) e.g.: • Legal, e.g. TUPE • Existing long-term leases • Unionized environment?		R	O
Is our logistics operation very complicated?		R	O
Are there likely to be technological issues with outsourcing?		R	O
Are there confidentiality and security issues with outsourcing logistics?		R	O
Do we have problems finding suppliers with the right cultural fit?		R	O
Do we have the capability and expertise to undertake value-adding services?		R	O
Is our own performance sufficiently reliable to avoid issues with the LSPs?		R	O
<b>Cost and service</b>			
Are service levels likely to decline if we outsource?	BM	R	O
Are costs likely to increase if we outsource?	BM	R	O

O = Strongly consider outsourcing; R = Retain in-house and optimize performance; BM = Benchmark (see tool 6.7)

**Figure 5.2** Stages of an outsourcing process

We aren't always going to get absolute yes and no answers; however, there is likely to be a preference one way or the other. If it is a genuine 'don't know', you will need to undertake further work. The term 'logistics' can be replaced by any other function in the company, such as facilities management, IT, procurement, customer service, etc. (A printed version of the questionnaire can be downloaded for free from <http://howtologistics.com>)

Follow the suggestion indicated by the majority of yes and no answers. There may be a requirement to undertake a benchmarking exercise to fully assess the current logistics operation and examine the feasibility of outsourcing. If the majority of the answers point towards outsourcing, we need to follow a process to ensure that it runs smoothly (see Figure 5.2).

### **Further information**

There are numerous books to choose from on logistics outsourcing. Kate Vitasek et al's book on vested outsourcing takes us away from traditional outsourcing to more collaborative relationships: Vitasek, K, Ledyard, M and Manrodt, K (2010) *Vested Outsourcing: Five rules that will transform outsourcing*, Palgrave Macmillan, New York.

Godsmark, J and Richards, G (2019) *The Logistics Outsourcing Handbook*, Kogan Page, London

### **References and further reading**

McIvor, R (2000) A practical framework for understanding the outsourcing process, *Supply Chain Management*, 5 (1), pp 22–36

Richards, G (2017) *Warehouse Management*, 3rd edn, Kogan Page, London

Vitasek, K (2013) *Vested Outsourcing: Five rules that will transform outsourcing*, 2nd ed, Palgrave Macmillan, New York, NY

## **5.2 To 4PL<sup>©</sup> or not to 4PL<sup>©</sup>**

### **Introduction**

The decision to outsource your logistics operations is difficult enough, but then you have to decide what type of organization to place the contract with – third-party logistics providers (3PL), lead logistics providers (LLP) or fourth-party logistics providers (4PL<sup>©</sup>)?

In terms of definitions, 3PLs will utilize most of their own resources on the contract. Lead logistics providers will utilize their own assets and those of others to operate the contract, whereas, according to Accenture, which came up with the name, 'A 4PL<sup>®</sup> is an integrator that assembles the resources, capabilities, and technology of its own organization and other organizations to design, build and run comprehensive supply chain solutions.' A true 4PL<sup>®</sup> has the following attributes:

- non-asset-owning company – in terms of warehouses and trucks;
- sophisticated IT systems;
- a strategist that manages all logistics operations on behalf of companies;
- is expected to provide the most cost-effective logistics systems to its clients;
- an intermediary between the shipper and the transport companies;
- develops contracts on behalf of the shipper with an optimum number of transport and warehousing providers.

Working with 4PLs<sup>®</sup> offers the following advantages:

- the ability to step back from the day-to-day operations to see the big picture;
- a neutral party looking to optimize your supply chain rather than their own assets;
- an ability to select the best 3PLs for the task required;
- an unbiased service;
- ability to instigate shared user transportation for clients;
- greater access to resources and greater flexibility;
- greater information flow through sophisticated supply chain systems;
- single point of contact;
- seamless key performance indicators;
- shared interest with customer, better view of whole market;
- payment-by-results options such as profit-share schemes;
- a global reach in many circumstances.

The disadvantages are:

- reliant on partners to provide the service;
- profit on profit;

- reluctance on the part of 3PLs to work for 4PLs<sup>®</sup>;
- a confusing marketplace as to who are the true 4PLs<sup>®</sup>.

When to use

When reviewing your supply chain operation and your current outsourcing arrangements.

How to use

Table 5.2 is a straightforward yes or no questionnaire that will give you the opportunity to decide whether working with a 4PL<sup>®</sup> is right for your company.

**Table 5.2** 4PL<sup>®</sup> decision-making process

Question	Yes	No
Section 1		
1. Does your organization struggle to manage increasing levels of supply chain complexity?		
2. Do your customers' supply chain demands exceed your organization's capacity to deliver?		
3. Do you wish you had full visibility throughout your supply chain?		
4. Would you like to have access to the technology capabilities to integrate processes and logistics providers across your supply chain?		
5. Can you make better use of your capital currently dedicated to supply chain assets such as staff and IT?		
6. Do you wish you had experienced supply chain managers within the company?		
7. Are you operating warehouses and manufacturing plants globally with little coordination between them?		
8. Are you looking to expand your business globally?		
9. Are neutrality and objectivity fundamental to your choice of logistics provider?		
10. Is your relationship with your suppliers and logistics providers adversarial?		
11. Is dealing with a multitude of logistics providers taking up too much management time?		

(continued)



**Table 5.2** (Continued)

Question	Yes	No
12. Are you under pressure from your customers to become more environmentally friendly, with an expected target of carbon neutrality?		
13. Are you happy to enter into a longer-term partnership?		
14. Are you happy to share resources with your competitors?		
15. Are you comfortable with having 'all your eggs in one basket'?		
16. Do you want your logistics contracts to be based on a gain share/cost reduction basis?		
17. Are you looking for more than a task- or function-oriented logistics provider?		
Section 2		
A. Do you consider the supply chain critical to your organization's success?		
B. Is supply chain management a core competency within your company?		
C. Is full control of your supply chain very important to you?		
D. Do you undertake regular supply chain reviews in order to improve efficiency and reduce costs?		
E. Do you have full visibility throughout your supply chain?		
F. Is the relationship with your current logistics providers important to you?		
G. Do you want full control over the choice of logistics providers?		
H. Does your company have a policy against single supplier sourcing?		
I. Is having internal supply chain and logistics expertise important to you?		
J. Are you risk averse?		

If you have answered yes to the majority of the questions in Section 1, it is definitely worth considering 4PL<sup>®</sup> companies. If you answered yes to the majority of questions in Section 2, a 4PL<sup>®</sup> may not be a preferred option. (A printable version of the questionnaire can be downloaded for free from <http://howtologistics.com>)

## Further information

This can be obtained from the book written by Paul Van den Brande: Van den Brande, P (2010) *4PL: The book that should never have been written*, Noble House Group [https://www.amazon.com/dp/B0CDCM6MSN?ref\\_=nav\\_signin&language=en\\_US&currency=GBP](https://www.amazon.com/dp/B0CDCM6MSN?ref_=nav_signin&language=en_US&currency=GBP) (archived at <https://perma.cc/S957-TLA8>)

## Further reading

Bade, D J and Mueller, J K (1999) New for the millennium: 4PL, *Transportation and Distribution*, 40 (2), pp 78–80

# 5.3 A risk-based approach to logistics outsourcing

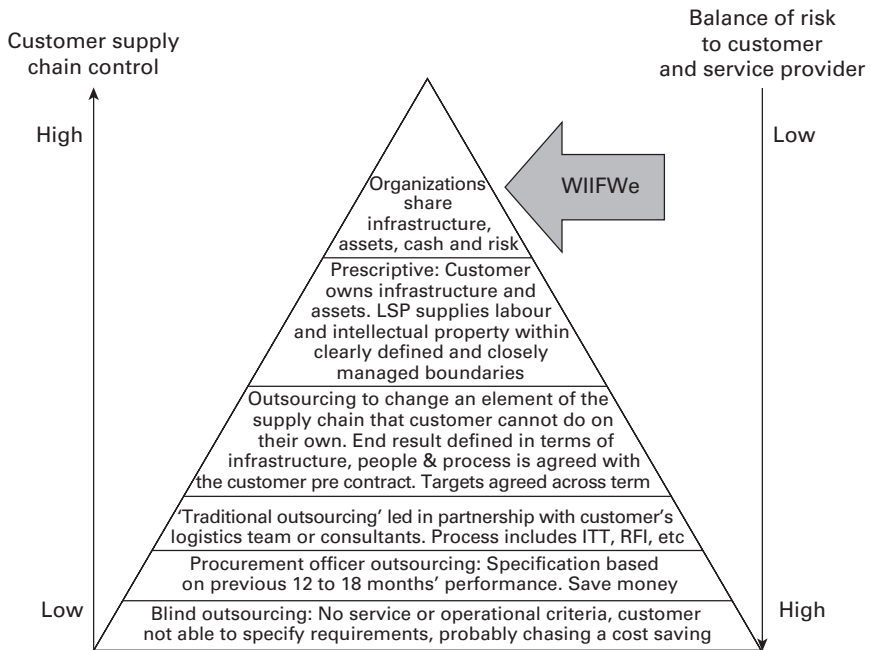
## Introduction

There are several types and levels of logistics and supply chain outsourcing solutions and the nature of the industry allows for bespoke service offerings, with an eagerness among service providers to avoid a one-size-fits-all solution, although a number of proposals are presented on that basis. A large number of customers of logistics service providers (LSPs) remain very prescriptive in their control of their LSPs and have an ongoing role in managing the outsourced relationship. It is also not always clear what degree of risk each service offering entails for the customer and the service provider.

## A risk-based approach

This approach is illustrated in Figure 5.3, which describes a pyramid of outsourcing solutions, balancing them with the degree of control and risk inherent to the parties involved.

At the base of the pyramid lies ‘buying’ the *blind outsourcing* decision, where customers aspire to a better state of affairs and see outsourcing as a route to a better way of working. There are few or no criteria and the solution is left to the incoming service provider; the balance of risk is high for both parties in the absence of agreed success criteria. In this environment the

**Figure 5.3** Control vs risk of outsourced solution

**SOURCE** Reproduced by kind permission of Dr Richard Gibson, Idris Logistics

LSP may encounter a dynamic environment with a high degree of scope drift and this poses a significant risk to any long-term commercial arrangement.

The next step on the pyramid is *procurement officer outsourcing*, which is focused on saving money using performance over the previous 12 to 18 months as a benchmark from which to make logistics procurement decisions. This commoditization of logistics procurement does not rely on a high degree of ongoing control from the customer supply chain team, if indeed there is one in situ. There is a high risk that this purchase will move to another provider at the end of the contract term, and this is not a basis for the long-term success of such an agreement.

*Traditional outsourcing* is the tried-and-tested formula developed in the post-World War II era. The familiarity with the process and pitfalls ranks this element a medium risk to the customer and service provider and requires a medium level of supply chain control on behalf of the customer. Concepts such as 3PL, LLP, 4PL<sup>®</sup> and 5PL sit in this element.

The next step on the pyramid is using *outsourcing to change an element of the supply chain*; this is when the activity moves from functional to

transformational and warrants a higher degree of control from the customer. Because this is transformational outsourcing, it may be assumed that it will be part of the customer's overall supply chain management strategy, with clearly defined objectives. The service provider becomes a means to an end with a specific remit and timescale to follow as it executes part of the customer-driven project.

The *prescriptive* step sees the balance of power in the longer-term relationship moving from the service provider to the customer. Requiring a greater degree of control, the customer typically owns the infrastructure and assets, while the service provider supplies labour and intellectual property within clearly defined and closely managed boundaries. The customer benefits from having a service provider for short-term flexibility in other parts of its supply chain and for speedy supply chain access to new markets as well as territories. This step is very much a master-servant relationship and because it is prescriptive, the balance of risk to both the customer and service provider is low.

The top segment of the pyramid moves the relationship into an equity-sharing arrangement, where both organizations share assets, cash and risk in delivering the supply chain solution. Customer and supplier are locked in a mutual arrangement with a common suite of brand delivery objectives. The behaviour set exhibited by both may be described as 'what's in it for we' (WIIFWe) (Vitasek et al, 2010).

The model links some iterations of outsourced logistics service provision with the degree of control expected from the customer and a risk of engagement profile for the logistics service provider.

## Summary

The pyramid in Figure 5.3 may be used to define and assess the risk profile of a logistics outsourcing strategy. The risk is defined in terms of 'low to high' for the parties involved; it looks at the process as a whole and is thus not blinkered to one point of view. The optimal relationship is balanced between both parties and demonstrates a WIIFWe set of behaviours.

## Reference

Vitasek, K, Ledyard, M and Manrodt, K (2010) *Vested Outsourcing: Five rules that will transform outsourcing*, Palgrave Macmillan, New York

## 5.4 Supply chain and logistics outsourcing

### *Introduction*

The supply chain satellite is a strategy assessment tool developed by a group of logistics professionals and academics. They have combined their specialist experience to develop a framework for supply chain outsourcing.

### *When to use*

When reviewing your supply chain strategy and when contemplating outsourcing all or part of your logistics and supply chain operation.

### *How to use*

The model consists of two axes, x and y, that form the basis of your position. You need to decide where you are on each axis.

#### **x. Added value of your supply chain**

This axis measures the extent to which your supply chain and specifically your logistics process adds value to your product. It determines whether, and to what extent, differentiation of your logistics processes can impact your competitive position. Indirectly this axis also measures the impact of logistics on your bottom line since a differentiated logistics model will justify higher margins.

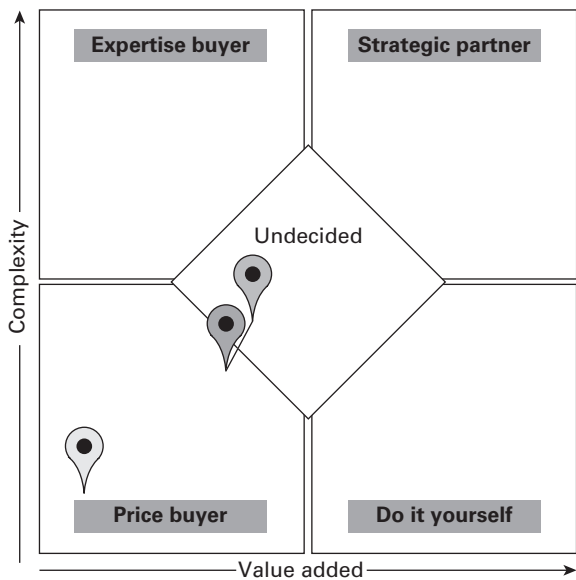
#### **y. Complexity of your supply chain**

This axis forms the unit of measure for the complexity of your logistics operation. It measures how easy it is to standardize your logistics processes. It is a fundamental factor that highly influences the type of relationship you will have with a logistics service provider. The four segments shown in Figure 5.4 are discussed below.

#### **1. Price buyer**

Cost containment in the logistics chain is your main objective. You have limited or no need for the highly specialized logistics competences of the LSP. This makes it easy for you to select a provider. You make sure you know the cost leaders among the LSPs and develop relations with them in each geographical market.

**Figure 5.4** Supply chain satellite matrix



Minimizing the logistics cost as part of the final selling price of your product represents an important source of competitive advantage. It can lower the price for which you can offer your product to the end user, or improve your margin. The logistics operation should contribute to these objectives but does not, in itself, impact the perceived value of your products.

2. Do it yourself

You do not outsource or hardly outsource any logistics activities and have no need to develop relations with LSPs. Because of your highly customized handling and shipping requirements you have custom built these capabilities yourself. Other reasons for your situation could be that you are locked into an insourced logistics operation. Reorganization costs would outweigh the potential benefits of outsourcing. Alternatively, you could have had previous negative experiences with LSPs or you are sceptical about the true cost of outsourcing.

3. Expertise buyer

Your logistics activities are complex and you have a wide portfolio of products, suppliers and customers. Product lifecycles are short and you face critical time-to-market requirements in a volatile market. Logistics outsourcing in



principle should be a long-term commitment to the LSP as this allows you to capitalize on continuous improvement and cost reduction. LSPs are selected on specialist expertise, technologies and assets and will be deployed in those parts of the supply chain where they bring substantial benefit.

#### 4. Strategic partner

Your logistics activities are complex and of high strategic importance. You have a wide portfolio of products, suppliers and customers. Product lifecycles are short and you face critical time-to-market requirements in a volatile market. Your contracts with LSPs aim to facilitate long-term commitment. Together with your LSPs you work on a programme of continuous improvements in service levels, flexible delivery options, lead times, warehouse efficiency and eventually cost reduction.

#### Undecided

There is no or almost no conscious strategic approach. You either take conflicting approaches to the management of your logistics operations or you lack a clear approach. There can be many possible reasons for this lack of strategic direction. In a positive scenario you find yourself in a transitional period where a strategy is defined but far from implemented. Conflicting views within the supply chain function or in your company's strategic management can also cause logistics processes and improvement projects to even each other out and result in a status quo.

## 5.5 Non-disclosure agreement (NDA)

### *Introduction*

A non-disclosure agreement is used when sensitive and confidential data is shared between two or more parties. In a situation where a company is planning to outsource its logistics or supply chain operations it needs to provide the logistics services provider (LSP) with sufficient data to provide a meaningful quotation for the services to be outsourced.

### *When to use*

At the beginning of the outsourcing process.

How to use

The party planning to outsource its operations should send a copy of the NDA to each of the participating organizations and ensure that it is signed by a senior director and returned before any data is sent to the LSP.

Figure 5.5 Non-disclosure agreement example

**CONFIDENTIALITY AGREEMENT – Project Echo**

THIS AGREEMENT is made between the PARTIES

I. Apprise Consulting Ltd (Registration number:4987218) whose registered office is at: 1 & 2 Mercia Village, Torwood Close, Westwood Business Park, Coventry, CV4 8HX acting on behalf of its client (To be advised) and

II.

.....

*Please enter the name of your company, registration number and registered office address*

BACKGROUND

“Apprise Consulting Ltd” acting on behalf of its client wishes to disclose information to you relating to the client’s business for the purpose of producing a proposal for the warehousing and distribution of its products in the UK.

IT IS AGREED as follows:

1) In this Agreement:

a) “Authorised Representative(s)” means those employees, officers and directors of the receiving party or any member of its group together with its professional advisers;

b) “Confidential Information” means any information or data relating to the disclosing party, any member of the disclosing party’s Group or to their respective businesses which is in written, electronic or other visual or machine readable form or which is communicated orally, including but not limited to, any kind of commercial or technical information, business, financial and marketing information, computer software and know-how which is made available to the receiving party in connection with the Purpose.

(continued)





**Figure 5.5** (Continued)

- 2) PROVIDED THAT Confidential Information does not include any information which the receiving party is able to demonstrate:
  - i) is already in the public domain or which becomes available to the public through no breach of this Agreement by the receiving party or its Authorised Representatives;
  - ii) was in the possession of the receiving party prior to receipt from the disclosing party;
  - iii) is independently developed by the receiving party without any use of Confidential Information;
  - iv) is approved for release by the written agreement of the disclosing party; or
  - v) is required to be disclosed by law or the rules of any governmental or regulatory organisation.
- 3) "Group" means the group of companies comprising the company in question together with its subsidiaries and affiliates as implied by the company registration number above.
- 4) The territory covered by this agreement is the UK.
- 5) For a period of five years following the date of this Agreement the receiving party shall procure that the members of its Group and its Authorised Representatives shall:
  - a. keep the confidential information confidential and shall not disclose it to anyone other than to its Authorised Representatives who need to know such information for the purposes of considering or advising in relation to the Purpose; and
  - b. use the Confidential Information exclusively for the Purpose and shall not permit the Confidential Information to go out of its possession or control; and
  - c. not make any announcement concerning, or otherwise publicise, the Purpose or any other arrangement with the receiving party in any way relating to the Purpose; and
  - d. procure that each Authorised Representative to whom disclosure of Confidential information is made, is made aware in advance of disclosure of the provisions of this Agreement and shall procure that each Authorised Representative adheres to these provisions as if such person were a party to this Agreement; and
  - e. immediately upon request by the disclosing party deliver to the disclosing party all Confidential Information (including all copies, analyses, memoranda or other notes made by the receiving party or its Authorised Representatives) and delete all electronically held Confidential Information or, with the consent of the disclosing party, destroy the same and provide the disclosing party with a certificate confirming that the provisions of this clause 5.e have been complied with.

*(continued)*

**Figure 5.5** (Continued)

- 6) No right or licence is granted to the receiving party in relation to the Confidential Information otherwise than as set out in the Agreement.
- 7) The receiving party acknowledges that damages would not be a sufficient remedy for any threatened or actual breach of this Agreement and that the disclosing party will be entitled to other remedies, incl. but not limited to, injunctive relief and specific performance.
- 8) The receiving party acknowledges that neither the disclosing party nor any of its Authorised Representatives makes any express or implied warranty about, or accepts responsibility for, the accuracy or completeness of any of the information supplied under this Agreement.
- 9) Neither party shall assign this Agreement without prior written consent of the other party.
- 10) Notices under this Agreement shall be in writing and shall be deemed validly given if delivered by hand, email, fax (supported by positive transmission report) or post (recorded delivery, with proof of posting) and shall be deemed served on the date of despatch.
- 11) This Agreement shall be governed by and construed in accordance with the laws of England and Wales.

SIGNED by  
duly authorised for and on behalf of  
.....

Print name:  
Date:

SIGNED by  
duly authorised for and on behalf of  
APPRISE CONSULTING LTD  
Print name: Gwynne Richards  
Date: 24/09/2023

## 5.6 Outsourcing questionnaire

### Introduction

A logistics services provider (LSP) requires comprehensive data in order to provide a quotation for their potential customer. This questionnaire can be utilized by an LSP to elicit data from a potential client or it can be utilized by a potential outsourcer to gather the data required.



## When to use

When collecting data for a potential logistics outsourcing contract.

## How to use

This questionnaire (Figure 5.6) can be utilized for a standard warehousing and distribution operation. It can be adjusted in line with the customer operation.

The first section is specifically for the LSP.

The second section is for both parties.

**Figure 5.6** Outsourcing questionnaire

Company name:
Contact:
Contact email:
Contact telephone number:
Company website address:
Types of product involved:
Timeline for outsourcing process:
Potential contract start date:
Current situation – in-house/outsourced
Type of service required? Freight transport/Warehousing/Returns operation/Combination
Is there a temperature-controlled environment required?
Are the products of a hazardous nature?
Is there a requirement for a Customs and/or Excise regime?
Please provide a brief outline of the services required (as much detail as can be shared)
Type of contract envisaged – Open Book/Transactional/Gainshare

(continued)

Figure 5.6 (Continued)

Data required - General			
Current turnover			
Expected growth over the next 5 years			
Current & required hours of operation?			
Current indirect/direct head count?			
Inbound			
Total Units received per week over 12 months?			
Number of vehicle deliveries per annum by type:			
Loose-loaded	Total number	Average cases per load	Average SKU per load
45' container			
40' container			
20' container			
Courier deliveries			
Palletised	Total number	Average no. pallets per load	Average SKU per load
Full truck loads 26 pallets+			
Rigid truck load			
45' container			
40' container			
20' container			

(continued)

**Figure 5.6** (Continued)

Average Units per carton?
Average cartons per Pallet?
Size of pallet – 1200 x 1000; 1200/800; other – please state
Average pallet heights on receipt
Average pallet weight on receipt
If mixed pallet sizes state %
Are cartons single SKU or mixed? If mixed is inbound sortation required?
Are pallets white pallets or rental e.g. Chep Blue, LPR red
If mixed pallet types state % rental v non-rental
Is product clearly labelled/barcode labelled? Type of barcode?
Do products require batch control? If yes what %?
Does any stock require any rework at inbound? E.g. labelling or re-boxing? If so, please provide %s and brief details
How many different suppliers?
Level of Inbound Count/Check Required by %?
% of QC checks required if required?
<i>Please provide an Excel spreadsheet with inbound volumes per day/week for past 12 mths</i>
<i>Please provide an Excel spreadsheet detailing product codes, carton sizes and weights</i>
<b>Storage</b>
Total number of SKU to be stored
Average number of pallets to be stored
If block stacked – how high?
Average number of shelf locations occupied (1400 w x 450 d x 600 mm high)
Any additional floor space required – please state?

(continued)

**Figure 5.6** (Continued)

Any office accommodation required – please state?
Current warehouse footprint and height (sq. ft)
How many pallets of consumables do you require stored?
Potential expansion/reduction requirement?
Annual stock turn
<i>Please provide a week-by-week picture of pallets stored and shelves occupied</i>
<b>Outbound</b>
Total Number of orders received per week?
How are orders received – EDI, Email, Post, Telephone, Other
Total Number of Units ordered by week?
Average Units per Order
Average Number of SKU per order
Average order size
Number of Parcels despatched by week
Number of full pallet, single SKU despatched per week
Number of mixed pallets despatched per week
Order lead time – same day, next day, 3 day etc.
Order cut off time for next day delivery?
Inventory control procedure – FIFO, LIFO, best before date, batch numbers, specific serial nos?
Types of delivery points by % – DCs, business premises, home delivery, lockers
If applicable, which platform(s) do you use for e-com?

(continued)

**Figure 5.6** (Continued)

% of International Orders despatched
<i>Please provide an Excel spreadsheet with outbound volumes per day/week for past 12 mths</i>
<i>Please provide an Excel spreadsheet showing product code, units in stock, sales per annum</i>
<b>Value Added Services</b>
Please detail the outbound packing process with any additional requirements (labelling, gift wrapping, shrink and stretch wrapping, inserts, product configuration/assembly etc.) Please provide photographs if possible
Packaging specification, % in mailing bags, cartons, totes etc.?
Do you require any kitting or point of sale kits produced? (please provide examples)
<b>Despatch</b>
Names of parcel and pallet carriers used?
How do you integrate with them? e.g. Direct or via CMS (Carrier Management System)
<b>Returns Process</b>
% of returns. Units despatched / units returned %
How will return stock be delivered to the warehouse?
Please explain the basic returns process & any detailed rework/salvage required (spot cleaning, repairs, steaming etc.)
Return to Stock %?
Disposal routes? Landfill/charity/eBay

(continued)

**Figure 5.6** (Continued)

<b>Information Technology, Reporting and Performance Measures</b>
Any specific reporting requirements?
Any specific administration/management requirements?
Is there a requirement for a full, wall-to-wall stock count? How often?
Is a perpetual inventory count sufficient?
Which ERP system are you using?
Do you require the warehouse operator to provide a Warehouse Management System? If no, which WMS will be used? Please provide as much detail as possible.
What is your current method of integration with your/your current warehouse operator's WMS and current capabilities to integrate via different means?
Expected KPIs and targets? E.g.
Dock to stock time
In full despatch
On time despatch
Order lead time
Damage %
<b>Distribution</b>
Delivery addresses
Any issues regarding opening times, height restrictions etc.
Transportation method – box vans, tail-lifts, curtain siders, hanging garments, refrigerated
Delivery methods – pallets, cartons, totes, roll cages, other
List of delivery addresses including postcodes
Delivery frequency i.e. x times per week (milkround) or as and when ordered?

(continued)



**Figure 5.6** (Continued)

Any delivery time information i.e. 08:00-16:00 any day
Any delivery point restriction information if known i.e. pedestrian precinct
Any vehicle size restrictions if known
Any other information that will help model the requirements

## 5.7 Logistics services provider (LSP) criteria and decision table

### *Introduction*

When outsourcing a logistics operation it is likely that the company will have contacted a number of companies to quote for the business. The company will need to differentiate between the different potential suppliers, and a decision table will assist you greatly in deciding on the most suitable LSP.

Having decided on your criteria as listed in Table 5.3, weigh their importance and score each company against these criteria, which will vary from company to company, as will the weighting for each criterion.

### *When to use*

When looking to choose the most suitable supplier for logistics services.

### *How to use*

Form a team of people to first choose the criteria and provide weights to them, then ask each member of the team to score each of the LSPs based on their requirements.

The team is normally made up of managers/directors from a number of departments including logistics, finance, operations, human resources, IT and procurement.

**Table 5.3** Criteria for general logistics services

Criteria	Source	Comments
Price	RFP	Are they competitive? How does the price compare across different routes or elements of the services? When you weight this with volume are they still competitive?
Value and price credibility	Historic pricing; market research; competitor pricing spread	Has the specification delivered a tight and credible spread of pricing? Does it match expectations? Is it likely to be sustainable? Does it represent value?
Experience of supplying service	Market research; RFP response; interview response; references	How credible is their experience of operating in this marketplace? Do they work for your competitors?
Synergies in logistics market	As above	Are they part of, or operating, a relevant network of transport movement, hubs or shared services?
Locations	RFI, RFP	Are the geographies in which they have capability a match for your business? How will they manage new areas or areas with low volume?
Size relative to purchasing organization	RFI, RFP	What is the size of their relevant operations versus the business you are awarding?
Dependency	RFI, RFP	Are they dependent on one or more customers? What would happen if this customer removed the business (particularly relevant for shared warehousing services and transport networks)?
Growth potential	RFI, RFP, interview response, references	Do they have the capability to match your growth forecasts? What evidence is there of this?
Use of subcontractors/partners	RFI, RFP, interview response, references	How do they manage the performance and risk of their subcontractors? What proportion of the service are they planning to outsource?
Personal relationship/fit	Face-to-face meetings	Have you met them? Are they responsive and easy to deal with? Is there a cultural fit? This is a crucial element for strategic services.

(continued)

**Table 5.3** (Continued)

Criteria	Source	Comments
Alignment	RFP/interview/ market research	Are the objectives of the supplier aligned to your own? Is your segment/service a core or development area for them? Are you an attractive client for this service?
Technical credibility and resilience of the proposal	RFP/interview/ benchmarking/ expert review	Are the assets proposed sufficient? Is there enough flexibility and resilience built in for peak demand/growth/failures? Have they suggested improvements or changes to your specification? For strategic services it is worth getting an expert review of this.
Continuous improvement	RFI/RFP/ references	Do they have a track record of making improvements during the life of a contract? What structure have they put in place to support this?
Innovation	RFI/RFP/ references	Does the company have a track record of innovation (over and above continuous improvement)? Only include a criterion if truly important for your service. If important, is it properly resourced?
Other customers served	RFI/RFP	Credible list of customers? Do you know any of them?
Financial status	P&L; company accounts	Is the business stable? Is there a parent company?
Quality systems and accreditations	RFI/RFP	What quality management systems and relevant accreditations do they have? Only review ones that are relevant to your business.
Terms and conditions	Pre-contract discussion	Have they accepted your contract/terms? Are they insuring the goods for sufficient value?
KPI acceptance	RFP	Will they provide management reports and KPI reporting? Do their suggested KPIs match your requirements?
Human Resources capability	RFP response/ interview	Is this a unionized environment or will there be a transfer of staff? Will there be redundancies? Does the company have the resources, experience and approach to manage these issues well?

(continued)

Table 5.3 (Continued)

Criteria	Source	Comments
IT capability	RFP response/IT analysis of response/ references	Does the supplier have the internal or external capability to deliver the IT aspects of the services including timely implementation of any interfaces and changes to systems?

The next tool explains how to use a decision table in this process.

## 5.8 Decision matrix analysis (DMA)

### Introduction

Decision matrix analysis is a quasi-scientific method to aid decision making when there are many different factors to take into account and a number of alternative options or courses of action. It is particularly useful when a group of people must make a joint decision, since it allows the discussion to be more objective, giving some distance from individual ‘pet’ projects.

This can be an effective tool when there are a significant number of competing alternatives and myriad factors that need to be taken into account. This tool can assist managers in making a choice where there isn’t a clear and obvious outright candidate, supplier or product. Being able to use DMA means that you can take decisions confidently and rationally, at a time when a team is finding it difficult to come to a consensus.

In all cases, a method of this nature improves the quality of discussion, moving the arguments away from the subjective and closer to the objective.

### When to use

This is a useful technique when you have a difficult choice to make; where you have a number of alternatives and many different factors to take into account. This could be, for example, the choice of some major piece of equipment, location of a new plant or warehouse, or for comparing tenders. Note that the method does not make the decision for you – it is not that sensitive – but it does enable a more objective and analytical discussion to take place among a group of decision makers, or the range of options to be narrowed down to the last two or three.



## How to use

Identify the key criteria that will be used to compare the different options and give them a relative weighting from 1 to 5 (where 5 is most important). Each factor is allocated to a row in the decision matrix. Each option is allocated to a column in the decision matrix.

Working across each row, score each option on a scale of 1 to 5 (where 5 is best) on how well it meets the criterion. Multiply the score awarded by the weighting to arrive at a sub-total for that criterion for that option. Add up all the subtotals for that option to arrive at a total score. The option with the highest score is the most logical choice based on the scores and weightings allocated.

When using this tool, don't assume that it is totally objective. If the scores are very close, further analysis should take place. Utilize a spreadsheet to compile the figures as this will enable you to change weights and scores very quickly and produce overall totals in a much faster time.

## Example

The following is taken from an outsourcing exercise where a company was looking to change supplier for its warehousing and pallet load distribution operation. It is a comparison based on the tender responses and presentations made by the 3PLs.

All of the criteria were discussed internally and given weights based on the consensus of opinion. Each member of the management team involved in the decision-making process scored the contractors based on the criteria. The weighting and scoring criteria were:

Weighting	Score
1. Nice to have	1. Very poor
2. Fairly important	2. Poor
3. Important	3. Average
4. Very important	4. Good
5. Most important	5. Excellent

**Table 5.4** 3PL decision matrix

Service/Benefit	Weight	Company A		Company B		Company C		Company D		Company E	
		Score	Total	Score	Total	Score	Total	Score	Total	Score	Total
Total cost	25	3	75	2.8	70	1.8	45	4.5	112.5	5	125
Proof of continuous improvement culture	25	3	75	2.3	57.5	4.8	120	4.8	120	1.5	37.5
On-site pick and pack experience	20	2.5	62.5	1.8	45	4.8	120	4.8	120	2.8	70
Staff flexibility	20	4	100	3.8	95	4.5	112.5	4.3	107.5	2.3	57.5
System ability to deal with multiple clients	20	2.8	70	4.5	112.5	4	100	3.5	87.5	1.5	37.5
Management team we are comfortable working with	20	2.8	70	3.5	87.5	4	100	3.8	95	3.3	82.5
Dedicated senior contract management	15	3.5	87.5	2.8	70	2.5	62.5	3.5	87.5	5	125
End-to-end supply chain management capability	15	2.8	70	3.8	95	4	100	3.3	82.5	2.3	57.5
Warehouse management system (WMS) capability	15	4	100	3.8	95	4.3	107.5	4.3	107.5	1.3	32.5
Current use of scan technology within the warehouse	15	3.3	82.5	2.8	70	4.3	107.5	3.5	87.5	1	25
Pool of capable management talent	15	3.5	87.5	3	75	4	100	3.8	95	1.3	32.5
Capacity to expand	15	3.8	95	4.3	107.5	2.5	62.5	4	100	3	75
Proposed service levels	15	2.8	70	3.8	95	4	100	3.5	87.5	3.5	87.5
Suitability of space	15	2.8	70	4.5	112.5	3.5	87.5	3.8	95	3	75
Implementation costs	10	1	25	4	100	3	75	3.8	95	5	125
Payment terms	10	3	75	3	75	4.8	120	3	75	3	75
Existing supplier/understanding of culture	10	2.3	57.5	4	100	3	75	2.8	70	4.8	120
Implementation timescale	10	3.8	95	3.5	87.5	3.8	95	4.3	107.5	1.5	37.5
Other customer synergy	10	3	75	3.3	82.5	4.8	120	3.8	95	2	50
<b>Total score</b>	<b>300</b>		<b>1,442.5</b>		<b>1,632.5</b>		<b>1,810</b>		<b>1,827.5</b>		<b>1,327.5</b>

**NOTE** Scores are rounded up or down based on decimal places.

Table 5.4 is an amalgamation of the scores from each of the management team involved. As can be seen from the table, the contract is likely to be placed with either Company C or Company D after further discussion and negotiation. (A spreadsheet version of the matrix can be downloaded for free from <http://howtologistics.com>)

## References

Turner, S (2002) *Tools for Success: A manager's guide*, McGraw-Hill, London  
Decision Matrix Analysis: [http://www.mindtools.com/pages/article/newTED\\_03.htm](http://www.mindtools.com/pages/article/newTED_03.htm) (archived at <https://perma.cc/8DQZ-GD59>)

## 5.9 Mind maps

### Introduction

The 'brain' of a computer operates in a purely linear fashion; our brains do not. Brains work by comparing, processing and integrating information; in essence, they work associatively. Every single thought that we produce is linked to other thoughts, sights, sounds and concepts.

Mind maps were developed by British psychology author Tony Buzan. Tony also hosted a BBC TV series called *Use Your Head*. During this show, Tony frequently and enthusiastically used a 'tree-like' diagram to visualize his thoughts while also using colours to highlight key words and phrases.

The reason we often 'sketch' things in this format is down to the fact that this 'map' takes on the same structure as our memory, i.e. it is associative. It is an easier way to see and recognize things and thus recall them. Mind mapping is therefore a way of 'brainstorming' (see tool 8.1) or making notes but in a more visual way.

### When to use

When you want to brainstorm a particular problem and then provide a visual representation to both yourself and your colleagues.

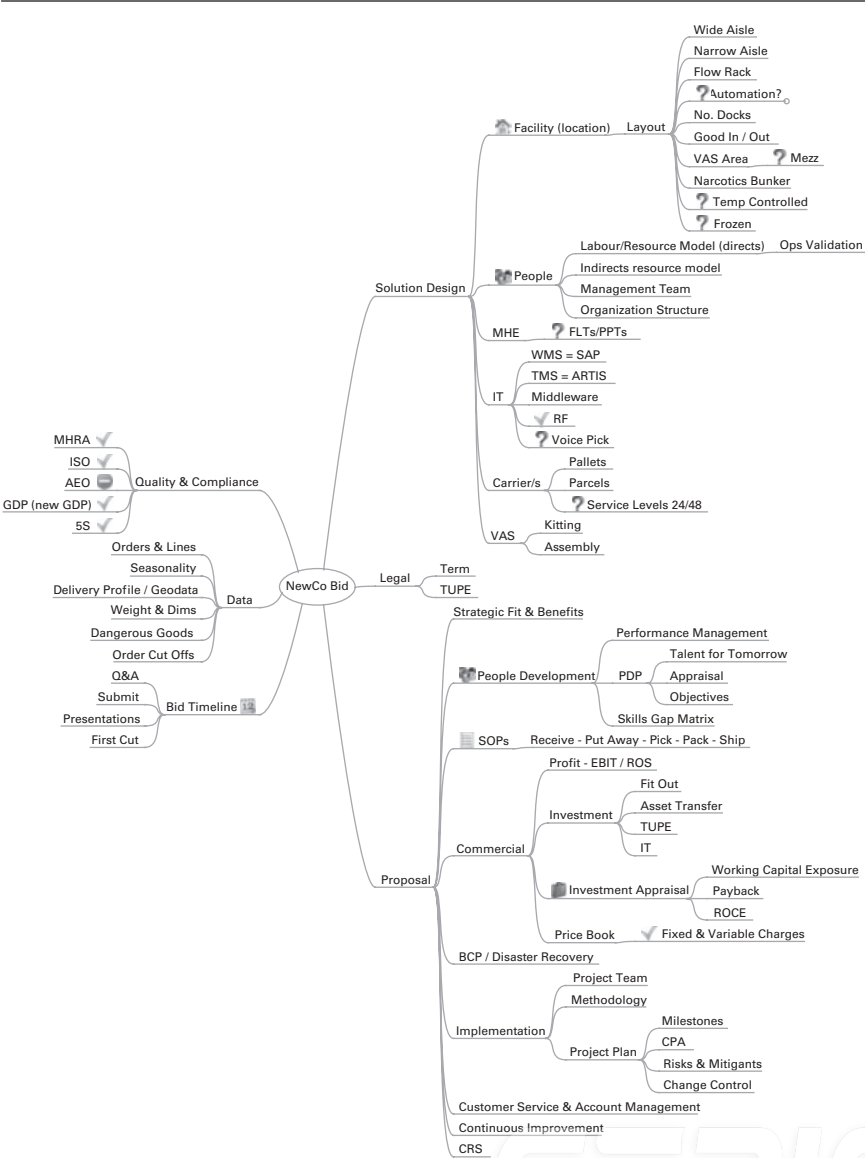
### How to use

The brainstorming potential of a mind map is immense. You start with a basic problem and put it at the centre of the 'map' and then generate ideas from it. As you generate these ideas, other thoughts come to mind that are

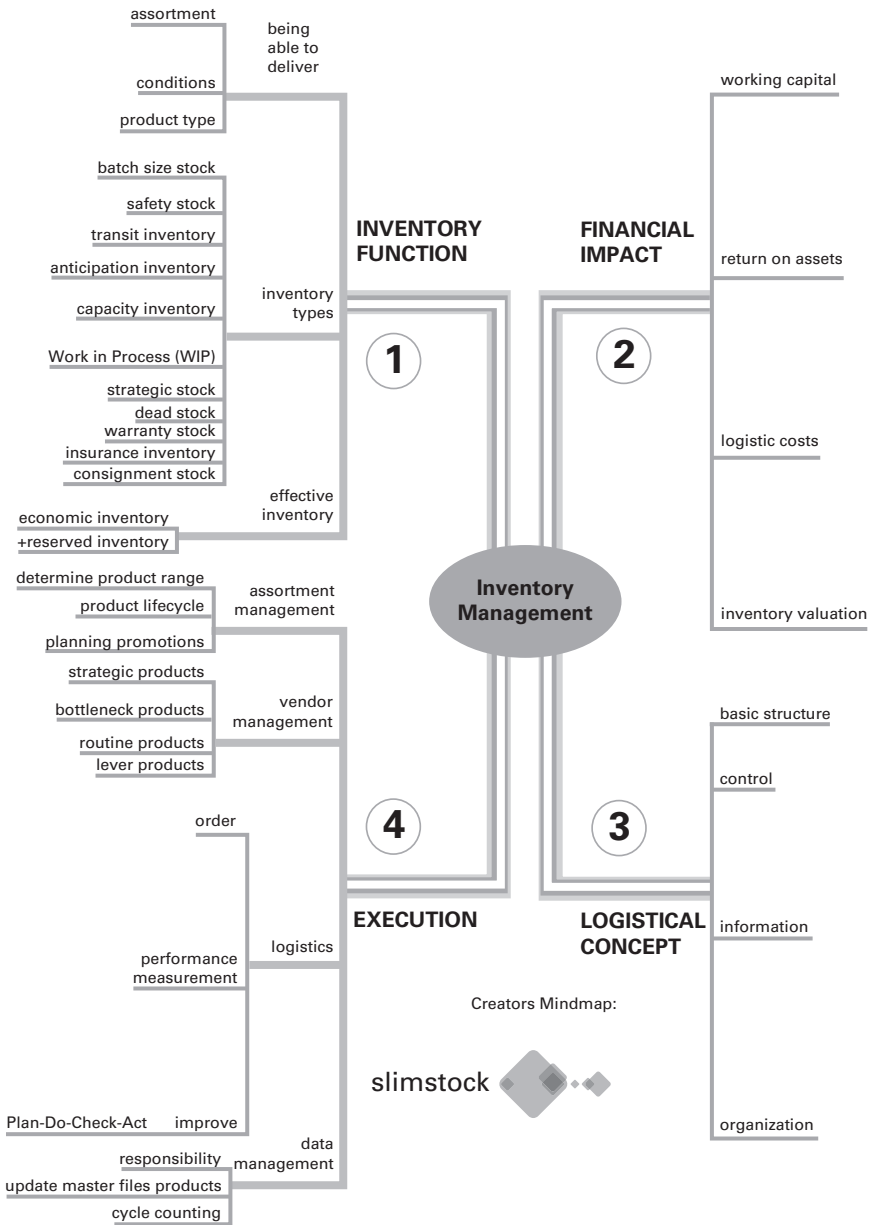
then added to the major spurs. By presenting your thoughts in this visual way a better overview is frequently gained. Colours and pictures can be used to accentuate the data.

The mind map shown in Figure 5.7 has been produced in response to an enquiry to outsource a logistics operation. The diagram shows the thought processes that the person went through when thinking about the task in hand. Figure 5.7 is a simplified version; Figure 5.8 shows how complex a

**Figure 5.7** Mind map for outsourcing a logistics operation





**Figure 5.8** Mind map for inventory management

mind map can be. We can see that the central theme is inventory management but with a number of sub-themes such as finance and logistics.

The inventory management mind map replaces pages of text that the reader would find difficult to take in all at once. The map not only provides

information but also helps in decision making. (The full version of this mind map can be downloaded from <http://howtologistics.com>)

Utilizing a mind map enables you to quickly understand, identify and absorb the structure of a subject. However, more important and due to the fact that a mind map is the ‘same shape’ as your memory, it enables you to recall the information.

## ***Further information***

Free mind map software can be found at: [http://freemind.sourceforge.net/wiki/index.php/Main\\_Page](http://freemind.sourceforge.net/wiki/index.php/Main_Page) (archived at <https://perma.cc/59CZ-N9A6>)

(With thanks to Joe Fogg of BIS Henderson and Richard Evans from Slimstock.)

## **5.10 RACI matrix by Rod Turner**

### ***Introduction***

During any project, it is important to identify all the roles and activities that are affected to any degree by the changes required to deliver a successful outcome in a specific project. These individuals and groups are all stakeholders in the project and may be either internal stakeholders (working in the organization delivering the project) or external stakeholders (external to the organization but impacted by the project).

As stakeholders, they can be impacted positively or negatively by the project as a whole or by specific steps in the project. Such projects are not unique to logistics and supply chain management – indeed the tool is used extensively in general project management activities.

In this arena, there are often wider implications to any change project and there can be impacts on very diverse groups and individuals both within and outside the organization.

The RACI (Responsible, Accountable, Consulted, Informed) matrix focuses on the requirement to communicate with different internal stakeholders at different stages of the project. It identifies the key tasks and/or decisions involved in the project and assesses the expectations of stakeholders, but also the needs of the project at each of these points if the overall project plan is to be achieved.

The outcome of the correctly completed RACI matrix is to ensure data is available when needed, decisions are reached when required, and information is shared when necessary.

This matrix supports three important aspects of the change management process:

- 1** Identification of the steps in the project that impact on key stakeholders or require input from key stakeholders.
- 2** Identification of the individuals or groups that are affected by the project.
- 3** Clarification of the relationship between each stakeholder and each step in the project.

## ***When to use***

During the process of establishing a project plan for any significant change management activity and when creating a list of stakeholders for any project.

## ***How to use***

Review the project plan (the list of activities needed to deliver the project with timings for each activity). If there is no formal project plan, create a list of all the activities needed to deliver the project.

Identify all items that require information, approval or other input from any stakeholder and list those items in the first column of the spreadsheet. Focus on items that are internal to the organization – the intention is not to replicate every item in the project plan in the RACI.

Create a column for each stakeholder. There is no need to list stakeholders in order of importance or seniority. It is possible to combine groups of individuals – for example, the project ‘Steering Committee’ or ‘Human Resources’ or ‘Demand Planning’ may be a homogenous group.

Identify which of the four categories (see below) best reflects the relationship between each item in the first column and each stakeholder.

The four categories are:

- 1** Responsible: Must endorse or approve any decision taken or action planned on this item – for example, the ‘Steering Committee’ should endorse the selection of a key supplier for a project.
- 2** Accountable: Must provide the data or perform the work required to deliver a specific item – for example, the HR team are expected to recruit 10 warehouse workers by the end of Q3 or the Demand Planners provide a forecast for stockholding levels by the end of Q4.

- 3 Consulted: Before a decision is taken, the project team will engage with this group to include their opinions and feedback – for example, the Head of Finance should be consulted on the expected payment terms with a chosen supplier or the budgeted annual costs.
- 4 Informed: After a decision is taken, there will be formal communication with these groups and individuals – for example, heads of departments should be informed about the choice of lead supplier.

Place a single value ('R', 'A', 'C', 'I') in the cell that intersects the stakeholder with the project step.

Review the chart once completed to ensure expectations are realistic and achievable – for example, normally only one stakeholder is 'Accountable' for a task and, normally, only one stakeholder is 'Responsible'.

If it is not clear who is responsible or accountable for a task to be completed, the project team should clarify with the project sponsor or the project Steering Committee. This is one of the critical benefits of a complete RACI matrix – it becomes clear to all involved who is responsible, and accountable, for every step of the project. Therefore, ensure that whoever is noted as 'Responsible' or 'Accountable' for any task is both aware and in agreement with the actions required of them.

Allocating responsibility or accountability for a task without communicating is a recipe for failure! Equally, note that the RACI matrix is not 'time-bound' so the overall project plan must be available in the communication process.

Once the cell allocation process is complete, and the final chart has been reviewed and accepted, the project team should begin to communicate to all stakeholders, so they understand the expectations and timing and required outputs.

### **Typical example**

In the first column, list all elements of the project plan that require internal stakeholder interaction. In the top row, allocate a separate column to each of the internal stakeholders and enter the relevant initial at the intersection of each column and row. If the matrix looks too big or too complex, sub-divide into functional areas such as 'IT/IS/Systems' or 'Planning'.

**Table 5.5** RACI template example

	Project sponsor	Project Manager	Head of Sales	Head of Procurement	Head of IT	Head of Planning	Head of Production	Head of Finance	Head of Customer service	Head of Engineering	Head of Human Resources	Head of Legal
Task												
Agree volume forecast for Q2 and Q3	C	I	A	I	I	R	A	C	I	I	I	I
Agree new product launch programme Q2	C	I	R	C	I	C	A	C	C	I	I	I
Confirm IT system freeze dates	C	C	I	C	R	A	I	C	C	I	I	I
Complete 'make' or 'buy' decision	R	A	I	A	C	C	C	I	I	I	I	I
Identify and qualify suppliers	A	C	I	R	I	I	C	I	I	I	I	C
Launch tender	R	C	I	A	C	C	C	I	I	I	I	I
Agree budget	A	C	C	C	I	I	I	R	I	I	I	I
Negotiate with suppliers	A	A	I	R	I	I	I	I	I	I	I	C
Agree supplier choice	A	A	I	R	I	I	I	I	I	I	I	C
Sign contract	A	A	I	R	I	I	I	I	I	I	I	A
Complete project team	R	A	I	C	I	I	I	I	I	I	A	I

Key

- R – Responsible
- A – Accountable
- C – Consulted
- I – Informed

**NOTES:** Add columns for additional stakeholders as required.  
Add rows for additional tasks as required.



## Further information

The RACI matrix was adapted from: <https://www.stakeholdermap.com/> (archived at <https://perma.cc/8VU8-T9VJ>) which has many useful resources for Project Planning.

More details on using the template can be found in *Delivering Change: The art and science of successful change management in logistics* by Rod Turner, available on Amazon.

Rod Turner can be contacted via [www.rodturnerlogistics.co.uk](http://www.rodturnerlogistics.co.uk) (archived at <https://perma.cc/CXY4-8PG9>)

A new book on logistics outsourcing was published in December 2019: Godsmark, J and Richards, G (2019) *The Logistics Outsourcing Handbook*, Kogan Page, London.

# Performance measurement and quality improvement

06

## 6.1 Performance measurement and quality improvement

### *Introduction*

‘If you do not measure, you cannot manage’, or so the theory goes. According to a survey by Aberdeen Group (2010), best-in-class companies are 1.9 times more likely to utilize established standards against which employees can be measured. They are also 2.7 times as likely to undertake employee-specific data collection. The companies will use both individual and group performance metrics to monitor, motivate and encourage the workforce.

KPIs are introduced into companies to both measure and control performance:

- To measure in order to extend vision and strategy to performance, create a discipline and communicate the non-negotiables, i.e. those targets that are essential.
- To control so as to expose gaps between aspirations and actual performance and to close those gaps.
- To change behaviours and future performance to let people know what a good job looks like and create understanding, change attitudes and align energies.

KPIs should not primarily be thought of as measures but as drivers and enablers of vision – they should help take you where you want to go by translating your vision into effective performance.

CEPIEC

## When to use

When looking to improve performance within the company.

## How to use

You have to translate the board's vision into bite-sized chunks to let every employee know what a good job looks like. To achieve this, you need to:

- *Structure* the plan, i.e. determine the scope of the activities to be measured and identify the organization and department-level objectives.
- *Communicate* the plan.
- *Drive* the plan by determining the operating processes and methods required and set the goals.
- *Measure* against the plan.
- *Support* employee behaviours through training and mentoring.
- *Report* progress.
- *Initiate* remedial action where required.
- *Benchmark* excellence to create best practice (see tool 6.7).

You need to monitor performance against the criteria that are important to your customers (service). You also need to monitor performance against the criteria that are important to you (costs).

Do not introduce too many measures, as you will end up spending too much time measuring and not enough time managing and controlling. To ensure success you need to:

- produce accurate data;
- validate and ensure completeness of data;
- target the correct audience;
- put emphasis on user ownership;
- react to changes in business activity;
- measure against historical data but also benchmark current best practice;
- simplify processes and measurements to ensure ease of maintenance;
- spend less than the savings gained from improved productivity.

Finally, these KPIs need to be focused on the future, lead to behaviour change and help you realize your vision.



Table 6.1 provides examples of eight measurements for four key business drivers that are introduced in the Balanced Scorecard tool (tool 6.5).

Taking customer service as an example, Table 6.2 provides details of each of the KPIs for customer service together with standards and targets. As discussed in tool 6.2, these need to be SMART.

In Table 6.2, ‘critical’ is a situation in which, unless improvement is introduced quickly, the business will fail. A failing score denotes a requirement for immediate action to be taken to prevent the operation reaching a critical stage where loss of business is inevitable.

**Table 6.1** Eight measurements for each of the four perspectives of the Balanced Scorecard

	<b>Customer service and satisfaction</b>	<b>Financial performance</b>
1	On-time delivery	Operational cash flow
2	Orders in full first time	Budget vs actual
3	Error-free documentation	Days’ sales outstanding
4	Damage claims	Overtime costs
5	Perfect order	Inventory days of supply
6	Total order cycle time	Logistics cost as a % of sales
7	Customer complaints	Logistics cost per unit shipped
8	Returns level	Stock loss/stock obsolescence
	<b>Business process improvement</b>	<b>People and environment</b>
1	Forecast accuracy	Employee turnover
2	Stock accuracy	% turnover spent on training
3	Dock to stock time	Training days per employee
4	Picking accuracy	Accident levels
5	Returns percentage	Sickness and absence
6	Space efficiency percentage	Carbon emissions/carbon footprint
7	Order to completion time	Level of waste
8	Audit results	Energy usage

**Table 6.2** Performance indicators for customer service with standards and targets

1. Customer service and satisfaction							
Key indicator	Precise definition	Critical	Failing	Standard	Above standard	Target	How verified?
On-time delivery	Number of orders delivered on or before the agreed-upon time, against total number of orders received, expressed as a %	<90	<95	97.5	98.5	99.5	System check/ manual records
Order in full first time	Number of orders that shipped completely as per the initial order, against total number of orders received, expressed as a %	<90	<95.5	98	99	99.5	System check/ manual records
Correct documentation	Number of orders for which the customers received an accurate invoice and other required documents etc. against total number of orders dispatched	<96	<98	99.3	99.7	100	System check/ manual records
Damage claims	This measures the number of customer orders received in good and usable condition expressed as a % of total orders dispatched	97.5	98.5	99.5	99.8	99.9	System check/ manual records
Perfect order	The result of multiplying the above four metrics together	75.8	87.6	99.4	97	98.9	System check/ manual records

(continued)

Table 6.2 (Continued)

1. Customer service and satisfaction							
Key indicator	Precise definition	Critical	Failing	Standard	Above standard	Target	How verified?
Total order cycle time	The time taken in hours from placement of order to receipt of order by the customer	>72	48–72	40	33	30	System check/ manual records
Customer complaints	Time taken in hours to fully answer a customer query/complaint	48	24	6	4	2	System check/ manual records
Back orders	Back orders as a % of total orders received	>8	>4.5	2	0.6	0.2	System check/ manual records

SOURCE Table adapted from Performetrix



A standard is that which must be achieved for the warehouse/team/individual to be seen as being satisfactory – this is the minimum level of acceptable performance. Finally, a target is a level of performance above standard that is desirable to achieve in order to impress and stretch the warehouse/team/individual. It is likely to be best in class in the industry.

Performance results need to be communicated both internally and externally. This can be achieved through regular operational meetings – weekly, monthly and/or quarterly. Results can be posted on noticeboards for all staff to see.

As for incentives, these can be individual or team based. In the case of outsourcing, a gain share arrangement can be introduced where logistics service providers share in the savings and productivity increases they have instigated.

To complete the process, ensure that the KPIs are aligned within the company – a customer's perception could be totally different from that of individual departments. For example:

- 100 per cent dispatch of what's available from the warehouse doesn't mean it's what the customer ordered – the order may have been stock adjusted before being sent to the warehouse for picking.
- Dispatch within 24 hours of the warehouse receiving the order from sales may not have been 24-hour dispatch from receipt of the customer order – it could have sat on someone's desk for a day!

## Further information

See Rushton, A, Croucher, P and Baker, P (2010) *The Handbook of Logistics and Distribution Management*, Kogan Page, London

Further information on automating your performance management system can be found at <https://performetrix.wordpress.com/> (archived at <https://perma.cc/FP5A-J9P6>)

Further information on performance management within warehousing can be found at [www.WERC.org](http://www.WERC.org) (archived at <https://perma.cc/7ZB8-4PGG>)

## References

Aberdeen Group (2010) Warehouse management excellence <https://www.supplychainmarket.com/doc/warehouse-management-excellence-0001> (archived at <https://perma.cc/5G55-4LWT>)

## 6.2 SMART

### *Introduction*

Many companies operate with far too many key performance indicators (KPIs), which leads to problems not only in terms of the time taken to capture and analyse the data but also the relevance to the staff of some of the measures. This tool focuses management attention on a number of aspects in relation to KPIs.

### *When to use*

When a company is looking to introduce performance measures, there are a number of stages that need to be followed. A company needs to choose the KPIs that are right for it and its customers and will lead to improved performance.

### *How to use*

The first known uses of the mnemonic SMART appeared in an article by George T Doran in the November 1981 issue of *Management Review*. It gives guidance to managers to ensure that the correct measures are chosen. When deciding on a KPI, that measure needs to pass five tests:

*S – Specific.* The measure has to explain exactly what the company is measuring and why. This includes the specific area to be measured, how it is measured and who is involved in the measurement. It needs to be clear and unambiguous to all involved. For example, ‘On-time delivery’ relates to the number of orders that were delivered to the client at the time requested. This can be expressed as a percentage based on the number of on-time deliveries divided by the total number of deliveries made within a particular time frame. However, if the delivery is made 24 hours before the deadline is this on time? This is why the KPI needs to be specific. A less specific measure would be customer satisfaction, which is, as we will see next, more difficult to measure.

*M – Measurable.* The performance indicator has to be measurable. You need to be able to compare the current figures with past data, or data from other sources such as budgets, competitors, peers. The measure needs to

be objective rather than subjective, with little room for ambiguity. It needs to be quantifiable in terms of numbers, monetary value, time etc.

*A – Achievable.* There is no point in setting targets that cannot be achieved under any circumstances. This leads to demotivation. The performance measure also needs to challenge staff and therefore should not be set too low either. The target should be achieved ‘with effort’. An on-time delivery target of 100 per cent every time is probably not achievable, yet a delivery target of 50 per cent on time should be easily achievable and therefore not a realistic target.

*R – Relevant.* The indicator also needs to be relevant to the business. It should dovetail with other parts of the business and assist in achieving the company’s overall goal and vision. The specific goal needs to take you somewhere, i.e. it needs to drive the business forward. This can be seen clearly in the Balanced Scorecard tool (see tool 6.5) where different departments share the same goals but have their own specific targets in order to achieve these goals.

*T – Time-based.* This covers a number of areas. For example, we need a time frame over which to measure so that we can compare year-on-year data, and we also need a target date to ensure that everyone knows we are working towards a deadline.

Finally, according to Matthews (2013), KPIs need to be future focused:

- a clear vision will drive KPIs;
- effective KPIs will drive effective behaviours;
- effective behaviours will drive effective performance;
- effective performance drives sustainable profit.

## References

- Doran, G T (1981) There’s a SMART way to write management’s goals and objectives, *Management Review*, 70 (11) (AMA Forum), pp 35–36
- Matthews, E (2013) <https://performetrix.wordpress.com/> (archived at <https://perma.cc/AVD4-LVCV>)

## 6.3 Performance measures for freight transport

As previously discussed, it is not a good idea to have too many KPIs. Here we have provided a comprehensive list from which you can choose those most relevant to you as a company and for your customers. Table 6.3 shows examples of freight transport KPIs. It is not suggested that all of these measures are introduced.

**Table 6.3** Examples of performance indicators for freight transport

Key performance indicator	Description
<b>Cost indicators</b>	
Average cost per unit delivered (£)	Average cost of delivering a specified unit (e.g. a pallet or tonne of goods)
Total whole vehicle cost (pence per mile/kilometre)	Total cost of your fleet per mile/kilometre. Made up of running, standing (fixed) and driver costs
Average running cost (pence per mile/kilometre)	Average cost of running your fleet per mile/kilometre. These are the costs incurred for running the vehicles (fuel, tyres, additives, lubricants and maintenance)
Average standing cost (cost per day based on number of days worked per annum)	Average standing costs for your fleet. Standing costs are those incurred whether or not the vehicle is running – depreciation of the vehicle, vehicle excise duty, vehicle levy, operator licence fees, overheads, insurance etc
<b>Operational indicators</b>	
Asset efficiency	Average utilization of fleet in cubic capacity or tonnes carried (outbound and inbound)
Vehicle fill efficiency	This calculates the percentage of actual load carried against the potential capacity of the vehicle fleet (tonnes or cube). Note it should include both inbound and outbound

(continued)

**Table 6.3** (Continued)

Key performance indicator	Description
Average miles per gallon/ Litres per 100 km	Average fuel consumption rate for your fleet or by individual truck and driver
Total empty miles/km run ('000s)	Total number of miles/km run by your fleet without a payload
Total miles/km run ('000s)	Total number of miles/km run by your fleet
Percentage empty running total	Total distance run by your fleet without a payload as a % of total miles/km run
Average time utilization	This calculates the percentage of time that the vehicle fleet was actually in use against the potential time available
Demurrage time	Excess time spent at premises waiting to load or be unloaded
<b>Service indicators</b>	
Percentage of late deliveries/on-time deliveries	Late/on-time deliveries made by your fleet as a % of total deliveries
Percentage of damaged items	Damaged items as a % of total items delivered
Number of claims	Number of claims received as a % of total deliveries
Correct paperwork	Number of delivery notes/invoices, etc completed correctly/total number of deliveries
<b>Compliance</b>	
Overloading	Total number of overloads in the fleet as a % of loads moved
Traffic infringements	Total number of traffic infringements in the fleet as a % of vehicle movements
Drivers' hours infringements	Total number of drivers' hours infringements in the fleet as a % of trips made

(continued)



**Table 6.3** (Continued)

Key performance indicator	Description
<b>Maintenance</b>	
Failed safety inspections	Number of failed or overdue safety inspections for your fleet as a % of total safety inspections
Vehicle maintenance downtime (VOR)	% time vehicles off road (VOR) due to maintenance/accidents
Total maintenance cost (pence per mile/kilometre)	Total cost of maintaining the fleet per mile/kilometre
Vehicle maintenance capability	Percentage of defects rectified in 24 hours total
<b>Environment</b>	
CO <sub>2</sub> produced per km	Average CO <sub>2</sub> produced (kg) per mile/km travelled by your fleet
Total CO <sub>2</sub>	Total CO <sub>2</sub> emissions produced by the fleet over a period
<b>Safety indicators</b>	
Accident record	Time lost through incidents as a % of total working days
Accident record	Number of days/miles/km since last reportable incident

## 6.4 Warehouse KPIs

Table 6.4 shows some examples of KPIs that can be applied in a warehouse. It is not suggested that all of these measures are introduced; choose the ones that are important to you as a company and to your customers. Note the warehouse is not responsible for final delivery, therefore in these KPIs we use dispatched on time as opposed to delivered on time.

**Table 6.4** Examples of performance indicators for a warehouse

Key performance indicator	Description
<b>Cost indicators</b>	
Average cost per unit shipped (£)	Total cost of warehouse operations/Total units shipped
Warehouse costs as a percentage of cost of goods sold	Total cost of warehouse operations/Cost of goods sold (as per the P & L statement)
Warehouse costs as a percentage of sales	Total cost of warehouse operations/Total sales (as per P & L statement)
Cost per order shipped	Total cost of warehouse operation/Total orders shipped from warehouse
Actual cost per activity	Total activity cost/Activity instances
<b>Productivity indicators</b>	
Orders picked per hour	Orders picked/Warehouse labour hours allocated to picking
Product lines picked per hour	Lines picked/Warehouse labour hours allocated to picking
Items picked per hour	Items picked/Warehouse labour hours allocated to item picking
Pallets picked per hour	Pallets picked/Warehouse hours allocated to pallet pick
Cases picked per hour	Cases picked/Warehouse hours allocated to case pick
<b>Service indicators (no = number)</b>	
On-time dispatch	Total no orders shipped on time/Total no orders shipped
Order fill rate	Orders filled completely/Total no orders shipped
On time in full first time	No orders filled completely first time and dispatched on time/Total no orders

(continued)

**Table 6.4** (Continued)

Key performance indicator	Description
Damage-free shipments	Damage-free items shipped/Total items shipped
Paperwork accuracy	No orders shipped with correct paperwork/Total no orders shipped
Order accuracy	No orders shipped without errors/Total no orders shipped
Line accuracy	No lines shipped without errors/Total no lines shipped
Order cycle time	Actual ship date <i>minus</i> date customer order received
Internal order cycle time	Order ready time <i>minus</i> order receipt by warehouse time (hours)
Perfect order completion	No orders shipped on time, in full, damage free, with correct paperwork/Total no orders shipped
Dock to stock time	Time taken from vehicle arrival to stock input onto sales system
<b>Utilization percentage</b>	
Operator hours	$100 \times \text{Labour hours used} / \text{Labour hours available}$
MHE utilization	$100 \times \text{MHE hours used} / \text{MHE hours available}$
Picker utilization	$100 \times \text{Actual case pick rate achieved} / \text{Expected cases to be picked}$
Pallet locations	$100 \times \text{Pallet locations occupied} / \text{Pallet locations available}$
<b>Environment</b>	
Total CO <sub>2</sub>	Total CO <sub>2</sub> emissions produced by the warehouse over a period
<b>Safety indicators</b>	
Accident record	Working days lost through incidents as a % of total working days
Accident record	Number of days since last reportable incident
Near miss reports	Number of near misses reported each month

(continued)

**Table 6.4** (Continued)

Key performance indicator	Description
<b>Other measures</b>	
Workforce turnover	Number of operatives who left during the year/Average number of operatives employed over the year
Inventory days on hand	$365 \times \text{Average inventory value} / \text{Total cost of goods sold}$
Inventory count accuracy	Items in correct locations in correct quantity/Total number of locations counted
Stock turnover	Total annual cost of goods sold/Average inventory value (can also be calculated with no of units)
Inventory shrinkage	Items lost and damaged/Total items in stock (in quantity or value)

## Further information

*DC Measures* is published every year. The report is now sold through WERC. The most recent report can be purchased from <https://werc.org/page/DCMeasures> (archived at <https://perma.cc/P4PU-SCF6>)

## 6.5 Balanced Scorecard

### Introduction

Much has been written on the Balanced Scorecard and we cannot do full justice to the subject in a few pages; however, we will outline the premise and suggest how you can begin the process and decide whether this is a performance tool you can use in your own company.

Kaplan and Norton (1992), who developed the Balanced Scorecard, believe that you cannot judge the performance of a company solely through financial measures. They suggested three other areas that required a company's attention. The model is now made up of four areas, namely: financial; customer satisfaction; internal practices and procedures; and training and development. The first two perspectives are relevant to the here and now

(customers and shareholders) and the last two are relevant to the future (people and processes), thus forming a balanced approach. Many writers have looked to enhance the model by including other aspects within the business that require the attention of staff at all levels throughout the organization.

Figure 6.1 shows an adaptation of the Balanced Scorecard model produced by Performetrix, a producer of software, to enhance the Balanced Scorecard. As can be seen, environmental issues have been added to the people quadrant. The Balanced Scorecard is no longer just a simple performance measurement framework but has evolved into a strategic planning tool and management system.

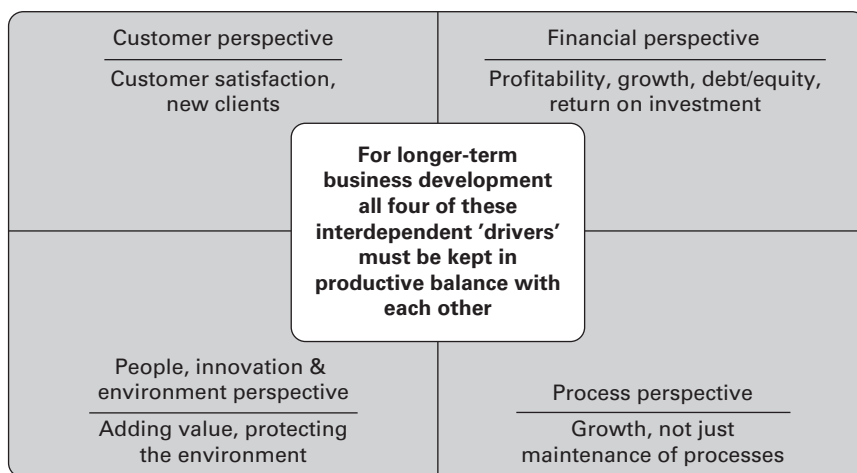
## When to use

When the company is looking to establish and formalize a performance measurement system and instil a culture of continuous improvement. Note that a Balanced Scorecard will take some time to set up.

## How to use

The premise is to begin with a vision, determine a strategy or strategies to achieve it and then break these down into activities that have their own

**Figure 6.1** Adaptation of the Balanced Scorecard



**SOURCE** Reproduced by kind permission of Performetrix

measurements. The ideal scenario sees departments within the company all working towards the same vision, with relevant and related KPIs.

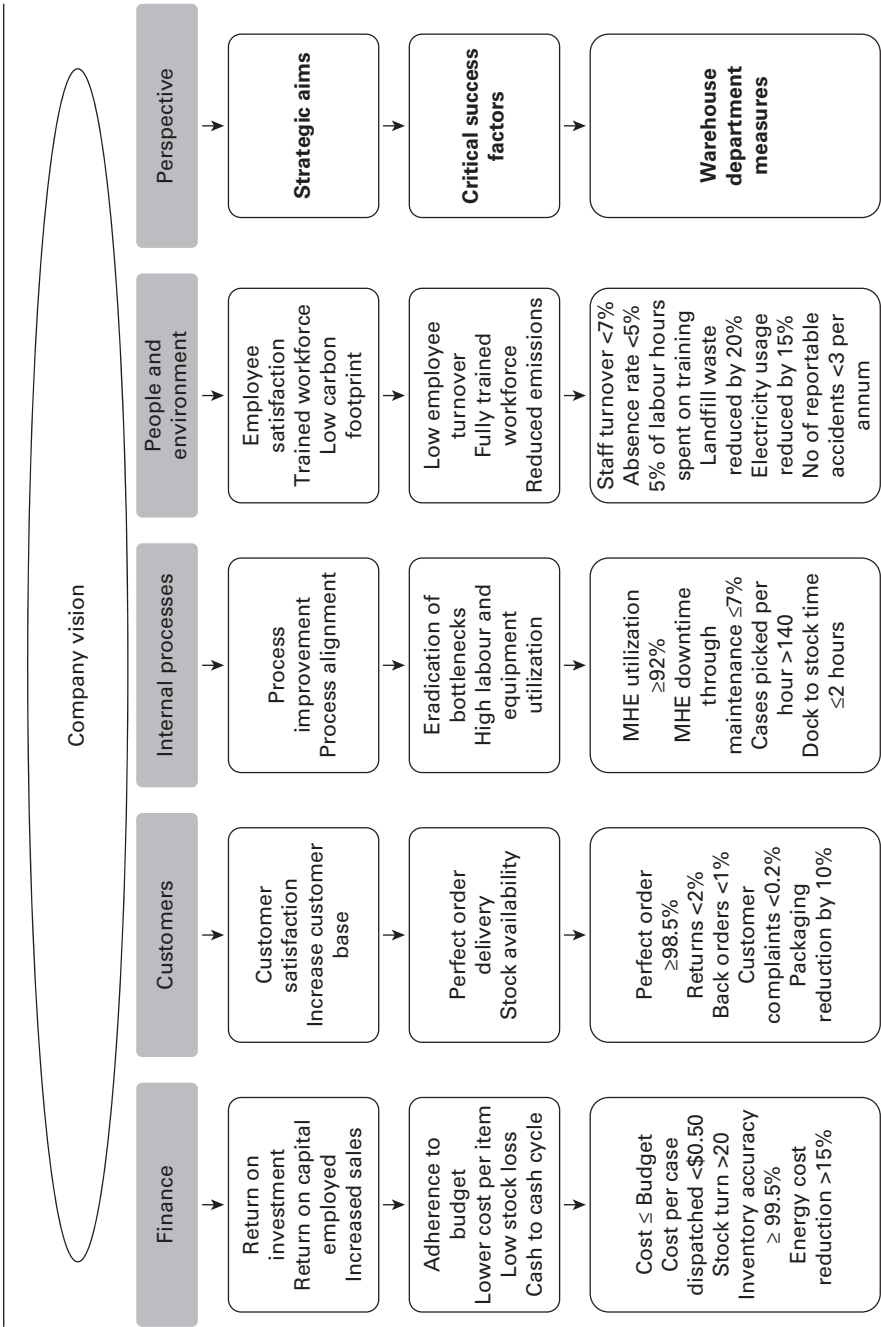
First, you need to set out the company's vision and the strategies to achieve this. A SWOT analysis (see tool 6.9) is a good tool in this respect. The perspectives mentioned above need to be clear and understandable to all, both within and outside the business. The top-level scorecard needs to be translated into more detailed plans and tasks and each department given measures and goals that will play a part in achieving the overall vision of the company.

The following steps need to be taken (this can take up to two months to complete):

- 1** As with the majority of new initiatives, you need to gain board commitment.
- 2** Find a suitable project owner.
- 3** Confirm/review/revise your company vision.
- 4** Define your four business perspectives and ensure clarity and understanding.
- 5** Formulate the overall strategic aims.
- 6** Identify the critical success factors and create your initial KPIs with unambiguous definitions. Ensure they are SMART (see tool 6.2).
- 7** Create the metrics for your KPIs (see tools 6.1, 6.3 and 6.4). Each measure has objectives and targets that are measured against actual performance.
- 8** Analyse the measures and ensure that they provide 'balance'.
- 9** Establish a comprehensive top-level scorecard and filter through the organization.
- 10** Translate the vision into a strategy and the strategy into day-to-day tasks.
- 11** Produce both long- and short-term goals.
- 12** Develop an action plan to achieve these goals.
- 13** Continuously review and be prepared to change.

Figure 6.2 is an example of how a warehouse operation can assist in the success of the company's vision by providing a performance that leads to the achievement of the goals set.

**Figure 6.2** Warehouse operation Balanced Scorecard



The use of a Balanced Scorecard in this example should result in:

- greater staff safety;
- improved practices and procedures;
- fully trained and inspired employees;
- improved communication and information systems;
- a significant increase in customer satisfaction;
- improved environmental credentials;
- increased profit.

A software program that can help companies in setting and reviewing their performance can be found at <https://performetrix.wordpress.com/>

## **Further information**

See the original papers by Kaplan and Norton (1992, 1993, 1996) and their book (1996), listed below.

## **References and further reading**

[http://www.businessballs.com/balanced\\_scorecard.htm](http://www.businessballs.com/balanced_scorecard.htm) (archived at <https://perma.cc/8FF9-JYJ8>)

Kaplan, R S and Norton, D P (1992) The Balanced Scorecard – measures that drive performance, *Harvard Business Review*, Jan–Feb, pp 71–9

Kaplan, R S and Norton, D P (1993) Putting the Balanced Scorecard to work, *Harvard Business Review*, Sep–Oct, pp 134–42

Kaplan, R S and Norton, D P (1996) Using the Balanced Scorecard as a strategic management system, *Harvard Business Review*, Jan–Feb, pp 75–85

Kaplan, R S and Norton, D P (1996) *The Balanced Scorecard*, Harvard Business School Press, Boston, MA

Turner, S (2002) *Tools for Success: A manager's guide*, McGraw Hill, Maidenhead



## 6.6 Radar chart

### *Introduction*

This tool can be used to show the gap between actual and targeted performance and present it visually. Normally you would include 6–10 organizational factors. Radar charts can also be used to compare alternative methods or equipment and their efficiency against expected results.

### *When to use*

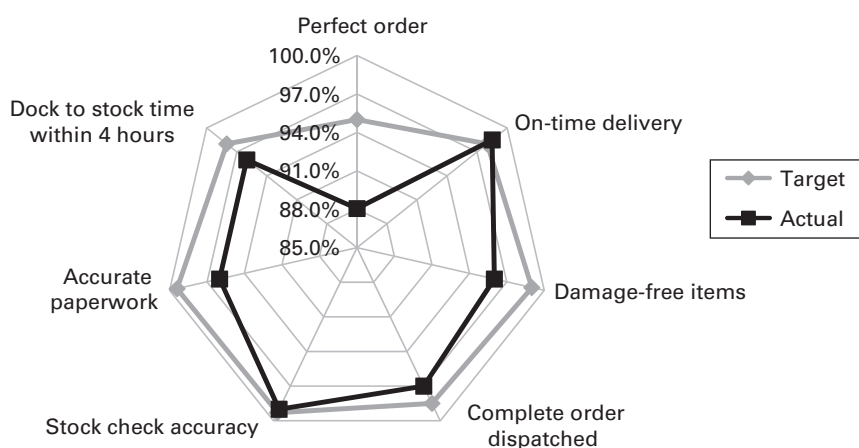
When you wish to present to a customer or show internal colleagues where there are gaps in performance. The chart clearly shows which factors require the most attention.

### *How to use*

Decide on the performance categories to be measured and compared (KPIs can be taken from the lists shown in tools 6.1, 6.3 and 6.4). Ensure that each category has consistent measures both for the target and actual performance. These can be shown as percentages or scales from 0–10 or 0–5, for example. Then, produce the chart:

- 1 Draw a diagram with as many sides as there are performance categories. In Figure 6.3 we have drawn a heptagon.
- 2 Label each of the outside points with the performance category.
- 3 Draw lines from the outside points to the centre of the shape.
- 4 Beginning from the outside, draw parallel lines from the outside to the inside at increments denoting the performance figures. This can be from 5 (excellent performance) to 0 (poor performance) or you can use percentages as shown in Figure 6.3. Ensure that the number of lines drawn equates to the number of increments.
- 5 Plot the target scores and connect each of the target scores.
- 6 Plot the actual results figures and link them.
- 7 Once complete, evaluate the figures and look for areas for improvement.

Figure 6.3 looks at seven specific KPIs related to warehouse operations and plots the difference between target and actual performance.

**Figure 6.3** Radar chart

	Target	Actual
Perfect order	95.0%	88.1%
On-time delivery	98.0%	98.5%
Damage-free items	99.0%	96.0%
Complete order dispatched	98.5%	97.0%
Stock check accuracy	99.3%	99.0%
Accurate paperwork	99.4%	96.0%
Dock to stock time within 4 hours	98.0%	96.0%

As can be seen in the figure, there are issues in terms of paperwork accuracy as well as damaged items, which both impact perfect order attainment. On-time delivery is ahead of target.

With regard to performance improvement, it is important to focus on the biggest gap in the most important category.

## Further information

Radar charts are found in Excel and PowerPoint and are easy to construct.

## 6.7 Benchmarking

### *Introduction*

According to Natarjan (2005), benchmarking is:

the practice of being humble enough to admit that someone else is better at something and being wise enough to try to learn how to match and even surpass them at it. It is a systematic approach to business improvement where best practice is sought and implemented to improve a process beyond the benchmark performance.

Best practice as it is today is not the best possible practice. 'As good as' is not 'better than'. It is not a substitute for creativity and innovation.

Benchmarking is a way of comparing your own performance with that of your peers, be they internal or external, to find out how efficient and effective your business or department is compared to others. By identifying high-performance or best-in-class operations, you can learn what it is they do that allows them to achieve competitive advantage. It also provides you with targets based on other operations currently achieving these levels of performance. Note that, according to Sweeney (2007):

Benchmarking is not about copying other companies' approaches; rather it is about learning and adapting appropriate practices so that they can be usefully adopted in an effort to improve efficiency and/or effectiveness (adapt before adopting!). Companies do not need to be the world's best at everything. All companies have finite resources and benchmarking can help to identify where these resources should be targeted.

### *When to use*

- When you need to understand your own business performance.
- When you want to identify areas for improvement.
- When the competition is stealing a march on you and you need to discover what they are doing better.
- When you need to manage and accelerate change within the business.
- When you are looking to set performance targets that can be proven to be achievable.

**Table 6.5** Stages of benchmarking

Stage	Explanation
<b>DEFINE</b>	
Select the area to be studied	Think about what your customers want from the business. What are the issues likely to attract and retain business today and in the future?
Define the process to be benchmarked	Think about those processes that can really make an impact on the business. Think about the parts of the business that add value for the customer and can produce a competitive edge.
Identify potential benchmarking partners	Who do you consider the best in the industry? Who is regarded as being world class in this area? Are there companies in other industries with a reputation for excellence?
Identify the data required, sources and appropriate methods of collection	Brainstorm ideas for the types of data that you can collect to measure the performance of your own and the benchmark company. Alternatives to contacting external companies include trade fairs, company accounts, journals, magazines, customer surveys, etc – these can all provide useful information.
<b>ANALYSE</b>	
Collect your data and select benchmarking partners	From all the ideas created from the Define stage you need to evaluate the various options. Take into account factors such as the quality of the data, the cost and time involved in collecting it and whether you are prepared to share the data with other companies. An independent consultant or educational establishment can provide anonymity and independence in this.
Determine the performance gap	Make honest comparisons between your performance and that of the companies you are benchmarking. You need to identify areas where there is significant room for improvement and which will contribute to business success.
Establish the difference in the process	Examine the benchmarked company in more detail. Dig beneath the data to understand what they are actually doing better than you and, more importantly, how they are doing it.

(continued)

**Table 6.5** (Continued)

Stage	Explanation
Target future performance	Once you have understood the potential for improvement, you need to develop realistic targets for internal improvement projects.
IMPLEMENT	
Communicate and gain commitment	The data collected during the Analysis stage can be used to convey the scale of the problem and potential for improvement. This can help to create acceptance and commitment to the improvement process.
Adjust targets and develop improvement plan	Individual improvement projects should be established to address the areas for improvement. Plans and targets for these projects should be developed by the people who will be running them, not necessarily the benchmarking team.
Implement and monitor	There is no point in benchmarking if you are not going to make improvements. You need to implement any changes and monitor them to ensure they are achieving what you expected.
REVIEW	
Review progress and recalibrate	Note that the best in the business is always improving on current performance, so you need to continue the process. If you are fully satisfied with a particular area, look for others to improve.

**SOURCE** Adapted from Sweeney (2007)

## How to use

### Step 1

Decide the critical success factors or areas of improvement that you want to measure. Don't choose processes that do not have a significant effect on the business or sufficient potential for improvement.

### Step 2

Have a detailed knowledge of your own operations and processes. Gather sufficient data to be able to compare accurately with other operations.

### Step 3

Decide whether to benchmark internally or externally. Mondelez (previously Cadbury) compares the internal performance of its warehouse with that of its third-party logistics providers. If you are looking to compare performance with your competitors, you need to choose carefully. At the end of this section there is a list of specific supply chain and logistics benchmarking clubs you can join to share data and best practice.

A point to note here is that accurate benchmarking relies on companies being open, honest, willing to collaborate and respect confidentiality. According to Turner (2002), there is a benchmarking code of conduct that states: 'Never ask for something you would not be prepared to share in return.'

### **Example**

Table 6.6 shows a benchmark exercise for a leisure clothing producer. As can be seen, most companies provided comprehensive information, with a few exceptions. The companies were all able to measure their own performance against their peers and concentrate on their areas of weakness, be it stock turn, items picked per hour or cost as a percentage of sales.

A word of warning: not every competitor or peer for that matter will have exactly the same product and order profile, for example, and therefore an exact comparison is rarely achievable.

### **Some benchmarking clubs and reports**

#### UK

Logmark – <https://ciltuk.org.uk/Membership/Organisation/LogMark>  
(archived at <https://perma.cc/T8GD-ZZSP>)

Palmark – <https://ciltuk.org.uk/Membership/Organisation/PalMark>  
(archived at <https://perma.cc/U6M4-99QD>)

#### United States

APQC – <https://www.apqc.org/benchmarking-portal/learn-more> (archived at <https://perma.cc/868A-ZSQQ>)

DLMB Consortium – <http://dlmbc.com/benchmarking-clients>

WERC – <http://www.werc.org/> (archived at <https://perma.cc/4VA5-KF5X>)

**Table 6.6** Example benchmark exercise – clothing producer (NK = not known)

Measure	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Stock turn	7	8	20	5.2	11	7	7
Logistics costs as a % of sales	6.04%	NK	8–10%	NK	Reluctant to share	Reluctant to share	4.7%
Warehouse costs as a % of sales	3.16%	2.90%	3.2%	2–5%	2.75%	3%	4.25%
Lines per hour picked	Not measured	Not measured	50	9.3	Not measured	8	8
Units per hour picked	79.4	48	Not measured	Not measured	89	Not measured	Not measured
Shipping accuracy	99.89%	99.9%	98%	99.2%	99%	98.2%	98.6%
Stock accuracy	99.89%	99.995%	99.6%	98.66	99%	97.5%	98.1%

## Australasia

Benchmarking Success – <https://www.benchmarkingsuccess.com/> (archived at <https://perma.cc/TZT7-K52N>)

## Other benchmarking sites

[www.benchmarking.com](http://www.benchmarking.com) (archived at <https://perma.cc/QWQ4-QVLS>)

[https://www.valuebasedmanagement.net/organizations\\_benchnet.html](https://www.valuebasedmanagement.net/organizations_benchnet.html) (archived at <https://perma.cc/WF8A-TTVW>)

## References and further reading

Natarjan, R (2005) *Technical Education, Current Status and Future Direction, vol III*, ICFAI University Press, India

Richards, G (2017) *Warehouse Management*, 3rd edn, Kogan Page, London

Sweeney, E (2007) Supply chain benchmarking and performance measurement: towards the learning supply chain, in *Perspectives on Supply Chain Management and Logistics: Creating competitive organizations in the 21st century*, ed E Sweeney, Blackhall Publishers, Dublin, ch 15, pp 283–94

Turner, S (2002) *Tools for Success: A manager's guide*, McGraw-Hill, Maidenhead

## 6.8 DMAIC: a process improvement tool

### Introduction

The DMAIC tool tends to be synonymous with Six Sigma. The tool is used to identify problems, develop ideas on how to improve the process, produce a solution and finally ensure that the fix is sustainable. DMAIC is not exclusive to Six Sigma and can be used as a framework for other improvement applications.

DMAIC stands for Define, Measure, Analyse, Improve and Control. All of these steps are necessary and are undertaken in that order (see Figure 6.4):

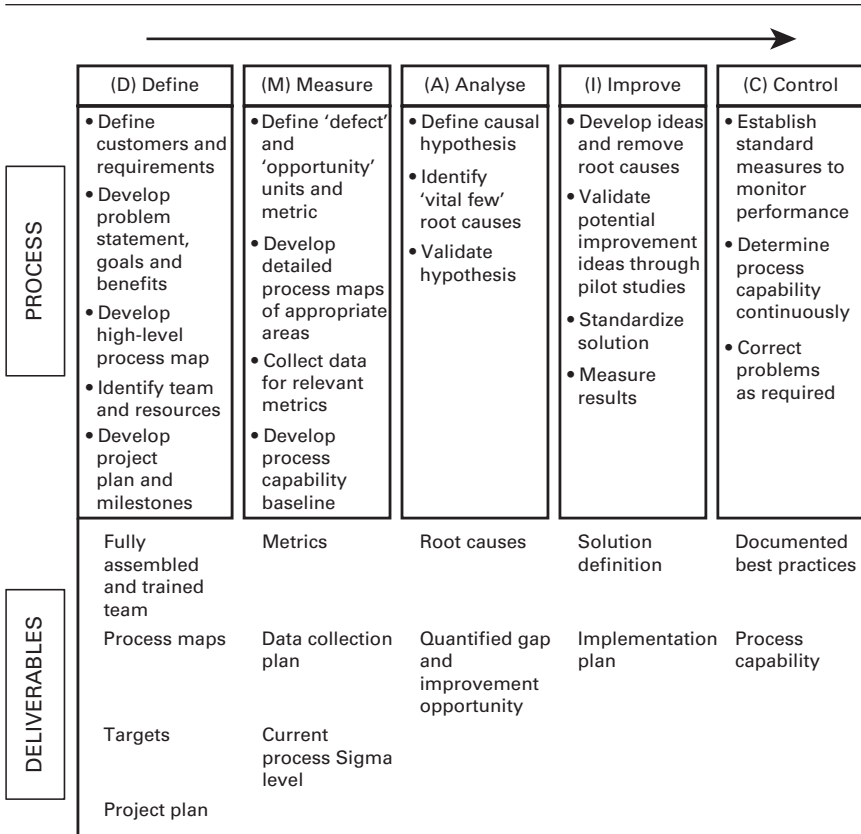
- 1 Define. Document what is known about the problem, assess and clarify the facts, set objectives and put together a project team to work on the problem.



- 2 Measure. Decide what is to be measured and how to measure it. Ensure that the measures are specific, the data easy to collect and monitor. At this stage the process needs to be tested to ensure feasibility.
- 3 Analyse. The data collected are analysed to determine the root cause of the problem. A gap analysis can be undertaken to identify differences between current performance and the target performance.
- 4 Improve. At this stage, ideas for improvement can be discussed. The most feasible ideas can be tested and the most effective idea introduced.
- 5 Control. Finally, once introduced, the improvements need to be monitored to ensure continued success.

Process documents need to be produced together with a system of continuous improvement. At this stage, the new ideas can be shared and, as in the 8-D model (see tool 8.4), the project team should be recognized for their efforts.

**Figure 6.4** DMAIC



**SOURCE** Diagram courtesy of Precision CEM

## When to use

This tool is used to identify problems and form ideas on how to solve them and ensure that there is no recurrence.

## How to use

Let's take achieving 'Daily cycle counting for 98–100 per cent inventory records accuracy' as the project at hand:

- 1 Define what our goal is: 98–100 per cent daily inventory records accuracy.
- 2 Measure where we are now: take a sample cycle count of a mixture of A, B, C and D items.
- 3 Divide the total count into the amount correct: let's say 10 items were counted and six were correct = 60 per cent inventory records accuracy for this trial count. This is far from good enough.
- 4 Analyse: why were four counts incorrect? Analyse the transaction detail in the warehouse management system (WMS) to find the root causes for the four variances: warehouse counts to computer counts.
- 5 Improve: improve through daily cycle counting of A, B, C and D items throughout the warehouse. As you find root-cause errors, do a root-cause error frequency distribution and eliminate these root causes by writing standard operating procedures (SOPs).

You should be holding steady at 98–100 per cent daily inventory records accuracy if you follow this proven system.

The key now is C = Control. You must maintain and control this 98–100 per cent inventory records accuracy level through daily cycle counting and root-cause analysis. This control step is the most critical step. You can reach this point, but it has to be maintained and controlled. When you do control this level of inventory records accuracy, you can consider eliminating the annual wall-to-wall physical inventory count if this is also agreed with your auditors.

## Reference

Using *DMAIC Aside from Six Sigma*, by Chuck Intrieri for *The Good Word*, experienced Third-Party Logistics (3PL), Logistics, and Warehouse Operations Consultant. Article used with permission.

## 6.9 SWOT analysis

### *Introduction*

Undertaking a SWOT analysis enables companies to identify their Strengths, Weaknesses, Opportunities and Threats. Strengths and weaknesses tend to concentrate on the internal situation, whereas opportunities and threats look outside the organization. It is a strategic tool to identify the company's current situation and how it needs to adapt to future challenges.

### *When to use*

When the company is looking to change strategy or make certain strategic decisions as a result of a performance issue, an acquisition, governmental intervention or in response to a change in the market.

### *How to use*

The first step is to assemble a group of people to identify the strengths and weaknesses of the company, and potential and existing opportunities and threats. The group should be cross-functional and all points should be considered and evaluated. This can be done through brainstorming (see tool 8.1).

The next step is to draw out a four-box grid as shown in Table 6.7. This grid can be used to record the points discussed. Continue the discussion until the list is exhausted for all four areas. As for a number of the other tools, honesty and openness are vital for the success of this exercise.

### *Example*

Let us take for example both the US and UK postal services. They are under threat from the growth of the internet in terms of a reduction in letters posted, but have an opportunity to expand with an increase in e-commerce, both business to consumer and consumer to consumer. Table 6.7 shows an example of a SWOT analysis for these corporations. As can be seen in the table, a threat could potentially be an opportunity, such as the possibility of being privatized.

**Table 6.7** SWOT analysis for postal service

	<b>Strengths</b>	<b>Weaknesses</b>
Internal	Nationwide coverage Worldwide/European network through partnerships Advanced technology – readable postcodes, digital signature capture, online Mailshots door-to-door service Recognizable and strong brand Cost advantage Property portfolio Large database of individuals and companies Retail and financial business	Strength of labour unions Industrial unrest among long-term workers Uniform charge for 1st class mail (UK) Loss-making in the main Lower revenue generated per employee compared to competition High employee costs
	<b>Opportunities</b>	<b>Threats</b>
External	Growth of online shopping globally Growth of C-to-C business (consumer to consumer) Last-mile deliveries for other organizations Large number of collection points and drop-off points Privatization	Electronic communication such as email and text messaging Online greetings cards Increasing number of competitors Fuel price increases Economic slowdown Reduction in government support Increased postal deregulation Being privatized and broken up Industry consolidation Internet banking

Once the table is completed, produce a plan to maximize the strengths, compensate for the weaknesses, understand and look to combat the threats and take advantage of the opportunities.

### **Further information**

Further information can be found in Ansoff, H I (1987) *Corporate Strategy*, Penguin, Harmondsworth.

# Financial management tools and ratios

07

## Introduction

These tools can be utilized in all aspects of logistics and supply chain. The examples provided are all related to logistics.

### 7.1 Activity-based costing (ABC) and time-driven activity-based costing (TDABC)

#### *Introduction*

ABC is a financial cost accounting model. It differs from traditional finance models as it attempts to allocate all costs, including overheads, directly to each product, activity or customer.

Traditional cost accountancy models allocate indirect costs or overheads on the basis of volume or as a percentage of total direct cost. In a traditional costing model, all products and customers are allocated the same percentage overhead, such as management time spent on them, irrespective of activity. As a result, low-volume products and smaller customers are not always allocated the true cost of producing or servicing them. This can result in under-priced products and customers being either under- or overcharged. This became very apparent to the author when he became customer services manager for a leading 3PL. With over 25 clients, it always seemed to be the smallest client that took up a large percentage of time, rather than the large corporate clients – yet the same percentage costs were spread across the clients, based on their volume of business.

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As ABC assigns the cost of each activity in an organization to all products, services and customers according to the actual consumption of the resource, this becomes more difficult when we look to allocate costs such as the human resources, finance, sales and marketing, IT, and health and safety departments.

The main drawback to ABC is the time it takes to gather all of the information and to accurately allocate the indirect and overhead costs. A further drawback is the fact that not all costs can be allocated precisely. With this in mind, Kaplan and Anderson (2004) came up with time-driven activity-based costing, which will be discussed in the last section of this tool.

## ***When to use***

This tool is for companies that want to be more accurate in terms of allocating costs. It can also be used to identify non-value-adding processes such as relabelling or double checking. Time-driven ABC also highlights available capacity and areas for productivity improvements.

## ***How to use***

To illustrate the tool we have used the example of a shared user third-party warehouse. First, we need to gather the overall cost of the business by category:

- 1** Identify the major elements of cost within the company:
  - a** Labour (direct and indirect)
    - Salary, overtime, NHI, pension, insurance, PPE, holiday pay, sick pay, training
    - Agency labour
  - b** Equipment
    - Fork-lift truck, lease or rental, depreciation and interest, maintenance, energy
    - Automated equipment depreciation and interest
    - Cleaning equipment, stretch-wrap machines
    - Scanners, voice units, pick to light systems depreciation and interest
    - Pallets and packaging material

**c** Storage

- Facility – lease, rent or depreciation and interest, rates, taxation, insurance, maintenance, landscaping, cleaning, security, sprinkler depreciation and maintenance, alarms, pest control, waste disposal
- Equipment – rack and shelving depreciation, maintenance, inspection

**d** Utilities

- Heat, air conditioning, lighting, water

**e** Overheads

- Management, supervision, administration, office equipment depreciation and interest, IT hardware and software rental or depreciation and interest, maintenance, training, communication costs, legal and professional, taxation and licences, travel expenses, insurance and claims, claim losses due to damages, shortages, errors

**2** Identify and define the relevant activities carried out in the company:

- a** In-handling
- b** Put-away
- c** Storage
- d** Order picking
- e** Replenishment
- f** Value-adding services
- g** Dispatch

**3** Determine the relationships between activities and costs.**4** Identify cost drivers to assign costs to activities. These can include number of pallets stored, orders processed, pallets received, etc.**5** Any costs that cannot be attributed to specific activities should be pooled together with other one-off costs, such as donations to charity, and termed residual costs.

Points to note here are that the cost of collecting, analysing and allocating the data should not outweigh the benefits, and that allocation within 5–10 per cent is acceptable in the initial stages.

Finally, when asked how much time staff spend on activities, they neglect to mention the idle time, including breaks, waiting for instructions, delays, etc.

This needs to be addressed by examining the warehouse management or labour management systems or undertaking time-and-motion studies.

## **Example**

In the standard ABC model the information shown in Table 7.1 applies for a warehouse with a total cost of £3,500,000.

In terms of the traditional costing model, it is likely that the IT and telecoms cost will have been combined with the support costs and allocated equally across all of the activities. As we can see in Table 7.1, the support costs are allocated based on the time involved on each activity by the support staff.

Having calculated the total cost by activity, we can now identify the cost drivers. For example, in terms of in-handling we can choose the number of pallets and/or cases received, and for order pick we can use the number of orders processed or the number of cases picked. In the case of in-handling, if both pallets and loose cartons are received the cost will need to be broken down further, as shown in Table 7.2.

## **Time-driven ABC**

In time-driven ABC (TDABC), Kaplan and Anderson (2004) have come up with a simpler version of ABC. They suggest that managers need to work out the resource required to service a transaction, product or customer. We therefore need to know the cost in time units (and space if we are discussing warehouses) and the time taken per activity.

First, we need to estimate the actual productive time of the staff. This can be done by interrogating WMS and LMS systems or initially producing a guesstimate. For example, where staff are working a 45-hour week we can guesstimate their productive time at 80 per cent of the total available hours. This equates to 36 hours per week.

When reporting the time it takes to undertake a task, it is unlikely that staff will include such things as delays, preparation time and breaks, either scheduled or non-scheduled. We therefore need to check the WMS system again or undertake a time-and-motion study for the various tasks. In terms of the in-handling example, we end up with Table 7.3, based on the time taken to undertake each of the tasks.



**Table 7.1** ABC model

Warehouse activities								
Cost centres	Total cost (£)	In-handling	Put-away	Storage	Order pick	Replenishment	Value adding services	Dispatch
Direct employees	862,000	10%	5%		55%	10%	10%	10%
Supervision and management	200,000	10%	5%		55%	5%	15%	10%
Building	1,400,000	10%		75%			5%	10%
Equipment	386,000	15%	5%	5%	45%	10%	5%	15%
Material	38,000	15%		40%	15%		25%	5%
IT and telecoms	200,000	10%	5%	20%	45%	10%	5%	5%
Support costs	414,000	10%	5%	20%	35%	5%	15%	10%
Total	3,500,000	371,200	103,100	1,207,300	998,400	175,500	287,100	357,400
Potential cost drivers		No of pallets	No of pallets	No of pallets/ locations	No of orders	No of pallets	No of units	No of pallets
		No of loads	No of cases	Square metres	No of items	No of cases	Time taken	No of loads
		No of cases	No of units	Cubic metres	No of lines	No of lines	No of staff	No of cases
		No of units	Cube/weight		No of units	No of locations		No of orders

**Table 7.2** Cost allocation

Activity	% time spent	Allocated cost	Volume	Rate per item
In-handle pallets	13.9%	51,556	52,000	0.99
In-handle cases	86.1%	319,644	1,395,000	0.23
Total		£371,200		

**Table 7.3** Time-driven ABC

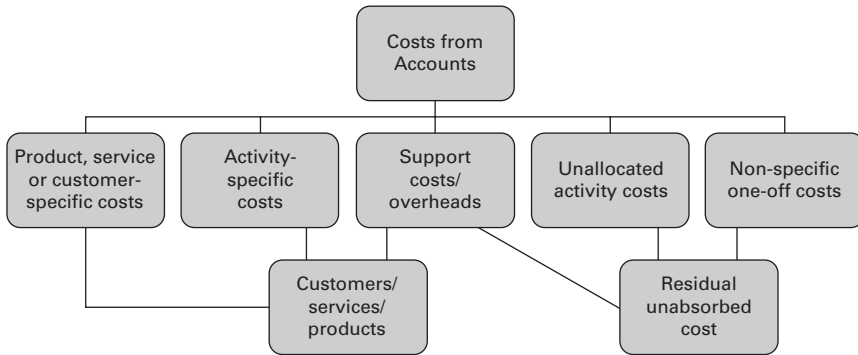
Activity	Unit time (minutes)	Volume	Total minutes	Total cost (£)	Cost per unit
In-handle pallets	1.154	52,000	60,000	39,600	0.762
In-handle cases	0.3	1,395,000	418,500	276,210	0.198
Total capacity used			478,500	315,810	
Total supplied			561,600	371,200	
Unused capacity			83,100	55,390	

If we base our calculations on five staff members, we have a productive time of 36 hours × 5 staff × 52 weeks × 60 minutes, which gives us a cost per minute of £371,200/561,600 = £0.66. In Table 7.3 we see that the cost per unit is lower than in the traditional ABC method and we end up with £55,390 of unallocated costs and 1,385 spare hours. Based on the above figures, we know that we have additional capacity for increased volumes and additional clients. We can also determine whether, by further increasing productivity, we can reduce the head-count by at least one person.

Figure 7.1 shows that a percentage of support costs/overheads and some of the unallocated activity costs end up as residual cost, and therefore they are not allocated to specific products or customers unfairly, as they would be in a traditional overhead allocation system. These costs become indirect until they are reduced, removed or allocated to new customers.

## Further information

Further information and articles can be found at: <http://www.brighthub.com/office/finance/articles/78752.aspx> (archived at <https://perma.cc/2S9U-WZHU>)

**Figure 7.1** Cost allocation based on consumption

**SOURCE** Adapted from FSN© 2013 FSN Publishing Limited

## Reference

Kaplan, R S and Anderson, S R (2004) Time-driven activity-based costing, *Harvard Business Review*, 82 (11), November, pp 131–8, p 150

## 7.2 Calculating return on investment and payback period

### Introduction

Return on investment is a financial measure used widely within companies to decide whether investment in an asset such as technology, machinery or software is going to be cost-effective and how long the payback period is likely to be. The tool can also be used to compare investment in different projects, thus enabling the company to decide on the most efficient and cost-effective investment. The higher the ROI and the shorter the payback period, the more attractive the investment.

### When to use

When you are contemplating the introduction of new equipment or technology to improve processes and/or reduce cost.

Seeking improvements in a process can require investment in new equipment, technology or software. As a manager you are likely to need to justify such an investment. You will therefore need to know the cost of the enhancement along with other costs such as training, annual maintenance, loss of performance during implementation, etc, together with the potential savings and, once calculated, the time frame for the return on your investment.

ROI time-frame expectations are reducing and therefore the more accurate the report and the shorter the time frame, the more likely the investment is going to be considered.

## ***How to use***

When deciding to introduce a new solution into the business you need to understand the total costs of the project. This not only includes the cost of the hardware and software but also the cost of implementation, staff costs, training and peripherals. You also need to know what your operation is achieving at present (the base case) without the enhancement and what it is likely to achieve once the enhancement has been introduced. Having calculated these figures, you can then work out what your savings are and, as a result, your ROI and the timescale over which the new system will pay for itself.

## ***Example***

During a recent voice picking trial a client calculated that its ROI, by replacing barcode scan picking, was approximately 25.4 per cent in the first year, with a payback period of nine and a half months. The method of calculation was as follows:

$$\frac{(\text{Gain from investment [or savings made]} - \text{cost of investment})}{\text{Cost of investment}} \times 100$$

A similar calculation was the payback period. This is calculated by dividing the net investment by the benefit accrued. This basically measures how long an investment takes to pay for itself. It does have drawbacks, however, as it does not properly take into account finance costs and opportunity costs,

opportunity cost being what must be given up (the next best alternative) as a result of the decision. The figures were as follows:

Pick productivity savings	£52,800
Increased accuracy savings	£33,600
Total savings (TS)	£86,400
Investment in voice (I)	£68,900
Therefore $(£86,400 - £68,900)/£68,900 = 25.4\%$	
Payback period = $£68,900/£86,400 \times 12 \text{ months} = 9.6 \text{ months}$	

This isn't a totally accurate picture as no account was taken of the extra training costs and the effect on the business during the early stages of implementation, etc. However, as the voice system is likely to last at least five years, this looks like a good investment.

A risk analysis should also be undertaken to confirm that these potential savings are accurate and can be achieved with the introduction of voice. This gives the company a reasonably accurate picture of the potential ROI achieved through the introduction of voice technology.

One drawback of using payback period as a method of choosing which investment to go for is that it doesn't take into account the cash flow outside the payback period, as is illustrated in Table 7.4. Project A has the shortest payback period; however, projects B and C have the greatest profit/saving.

**Table 7.4** Payback period comparison

	Project A	Project B	Project C
Initial investment ('000)	240	240	300
Year 1 profit/saving	80	60	60
Year 2 profit /saving	80	60	60
Year 3 profit/saving	80	60	60
Year 4 profit/saving	10	60	60
Year 5 profit/saving	0	60	60
Profit/saving over 5 years	250	300	300

Payback period

## Further information

Marsh (2013) provides step-by-step guides and templates for different finance models.

An ROI payback calculator for voice picking can be found at <https://www.bcpsoftware.com/solutions/voice-technology-solutions/voice-payback-calculator/> (archived at <https://perma.cc/A9LA-NV9K>)

## References and further reading

Marsh, C (2013) *Business and Financial Models*, Kogan Page, London

# 7.3 An engineered approach to calculate equipment ROI, by Aaron Lininger

## Introduction

Too many companies buy warehouse equipment and technology on a ‘best case’ scenario. Using an ‘engineered’ approach to evaluating the ROI provides a more accurate picture of cost and productivity benefits. This is an alternative to the method discussed in tool 7.2.

Many investments fail to deliver promised gains because vendors’ initial estimates of cost and productivity benefits are often based on a ‘best case’ scenario. Those estimates often prove to be inaccurate because each facility has unique physical, process and data constraints, making it difficult to determine what a new technology or piece of equipment can accomplish in a particular environment.

An ‘engineered’ approach is a more effective method for evaluating potential capital investments. It entails studying the current state of operations at a ‘micro’ level and pinpointing the specific elements affected by introducing a new technology. The degree to which each element will be affected can be assessed using work-study techniques and/or realistic estimates made by experts. This approach develops a savings estimate reflecting the reality of a particular facility, thereby improving a company’s insight into bottom-line impacts of cost-saving initiatives and reducing the potential for costly mistakes.

## ***When to use***

When contemplating the purchase of new technology or equipment.

## ***How to use***

### **Step 1**

Identify specific aspects of an operation the company is targeting for improvement, and how each will change as a result of introducing new technology or equipment.

### **Step 2**

Consider how this solution will impact other areas of the operation, both upstream and downstream processes, as well as maintenance and support functions – if at all.

### **Step 3**

Consider the impact on a facility's physical layout and traffic patterns. For example:

- Can the equipment be positioned so as not to impede the traffic flow?
- How will the equipment interact with other pieces of equipment in the workspace?
- Will the pre- and post-trip inspections or preventive maintenance programmes need to be modified and/or introduced to ensure the safety of those working with it or in its vicinity?

### **Step 4**

Understand the degree of reliability the new solution must have and the maintenance needed to support the new solution.

### **Step 5**

Gather a baseline value (often measured in time for labour savings) for each step of the task being examined. Each step is broken into smaller steps called elements. Elements unaffected by the new technology can be ignored, allowing the buyer to isolate the true differences between the operation before and after the new solution has been implemented. Methods of collecting the

times to carry out each element include stopwatch studies and time-and-motion studies.

## Step 6

Project how each element will be affected after implementation. Under ideal circumstances, a potential buyer would introduce the equipment or technology into a facility, train individuals in how to employ it, and then study how it performs and what impact it has in the environment in which it will actually be used. Testing the solution at a facility can reveal unforeseen pitfalls and shortcomings as well as provide fact-based information for subsequent discussions with the vendor. Because many capital investments are large and complex, it may not be possible to test them like this. In such cases, simulation models can be used; however, it is imperative to document all assumptions as they will form the framework for any conclusions drawn from the data.

## Step 7

Calculate the differences and apply them to the labour model and affected processes in order to determine the new solution's cost and productivity implications (see Table 7.5).

## Example

The management team of Company A's distribution centre (DC) attended a trade show where a vendor was showcasing a new electric pallet jack that automatically advances to its next location without the operator touching the controls. Company A's DC uses pallet jacks during order selection (picking), which is the largest use of labour in the facility. The vendor claims that its automatic pallet jack will improve productivity in order selection by up to 30 per cent by eliminating the steps operators take to return to the equipment controls, allowing them to walk directly to their next location.

When scaled to its facility, the 30 per cent productivity improvement represented huge financial savings for Company A; even achieving one-third of that would be worth serious consideration. Before making a large capital expenditure, the company opted to take an engineered approach to evaluating the technology.



The company already had baseline numbers for the potentially impacted areas:

- the steps to and from the pallet jack to the pick location;
- the steps from the case-placement location back to the equipment controls;
- grasping of the controls;
- the acceleration constant for their fleet of equipment.

The vendor allowed Company A to test one of the automated pallet jacks at its facility to help in the decision-making process and hopefully close the sale. Company A invested several weeks in training an individual so that the pallet jack would be operated as the vendor intended. An engineer then studied the equipment under normal operating conditions, focusing on generating values for the affected elements of the picking process. In studying the new equipment, the engineer discovered an additional factor to consider: a system-response delay before the equipment moves forward. Table 7.5 shows a summary of the values collected.

The element values indicate that potential savings exist but overall savings cannot be determined until the appropriate frequency of occurrence for each element is applied to each value. In the absence of simulation capabilities in a labour management system, the frequencies can be calculated using the following:

- total cases selected;
- total locations visited;
- percentage of cases selected after short travel (from 9 feet to 40 feet (2.77 to 12.31 metres) between selection bays; manual travel will still be used for longer distances);
- percentage of locations visited after short travel (from 9 feet to 40 feet between selection bays).

Once the company calculated those frequencies and knew the elemental times, it simply had to 'do the maths': see Table 7.5. Several factors were not considered in this calculation, including maintenance-support hours and the impact on congestion delays. With these factors excluded, the values shown represent a 'best case' scenario. Based on the cost of the additional investment in this technology, the results of the study would need to yield at least a 10 per cent saving to justify serious consideration of such an investment.

**Table 7.5** Engineered approach to ROI using time-and-motion studies

Element	Baseline (seconds)	Future state	Difference	Frequency 1	Frequency 1 data	Frequency 2	Frequency 2 data	Labour savings (hours)
Steps to first case	3.0	2.5	-0.50	100,000	Locations	30,000	% locations after short travel	-4.17
Steps with first case	2.9	2.25	-0.65	100,000	Locations	30,000	% locations after short travel	-5.42
Steps to additional case	2.5	2.4	-0.10	125,000	Cases	43,750	% cases after short travel	-1.22
Steps with additional case	2.5	2.4	-0.10	125,000	Cases	43,750	% cases after short travel	-1.22
Return to drive short distance	3.0	0.0	-3.00	100,000	Locations	30,000	% locations after short travel	-25.00
Grab equipment controls for travel	1.0	0.0	-1.00	100,000	Locations	30,000	% locations after short travel	-8.33
Pallet jack acceleration/ deceleration	5.0	6.0	1.00	100,000	Locations	30,000	% locations after short travel	8.33
System response time	0.00	1.0	1.00	100,000	Locations	30,000	% locations after short travel	8.33
Labour hours reduction Current labour hours New labour hours % impact								-28.7 580 551.3 4.95%

After calculating a solid value of the projected labour gains, the management team decided not to purchase the equipment unless the vendor was able to significantly reduce the price or further enhance the equipment to provide additional gains at the same price. The vendor's projected gains of 30 per cent were actually closer to 20 per cent and new pallet jacks would only affect 25 per cent of the total labour component of order picking, thus bringing down the overall savings into the neighbourhood of 5 per cent. Other factors not included in the trial results include improved health and safety of the operators.

This methodology can also be used for increased accuracy in resource planning (see tool 1.8).

(Adapted from 'A better way to calculate equipment ROI' by Aaron Lininger, a manager at West Monroe Partners LLC, which first appeared in the Quarter 2 (2012) edition of *CSCMP's Supply Chain Quarterly*.)

## 7.4 Supply chain financial ratios and metrics

### *Introduction*

An understanding of finance is essential for the majority of managers in today's business world. Supply chain and logistics is no exception so we have put together a list of financial ratios that can impact supply chain operations.

Financial ratios are used as a tool to analyse the financial situation of your business through its financial statements. The following ratios and metrics are used substantially within the supply chain.

### *Return on assets (ROA)*

This ratio determines how efficiently assets are being used to generate income; it is expressed as a percentage. A high return on assets can suggest a rapid turnover of assets or a high profit margin, or both.

$$\text{ROA} = \frac{\text{Net profit before income tax}}{\text{Total assets} \times 100}$$

## ***Return on capital employed (ROCE)***

ROCE can be calculated in a number of different ways. Calculations can be made with actual figures or averages. It has the advantage of being simple to use but it doesn't take into account the timing of cash flows. ROCE is calculated as follows:

- Average profit before interest and tax (PBIT)/Capital employed  $\times 100$ .
- Where PBIT or operating profit is defined as sales minus operating expenses before the payment of interest and taxes.
- Where capital employed (CE) is defined as share capital plus reserves plus long-term loans or fixed assets plus working capital (net current assets).

For a specific investment of, say, \$120,000 and average profit returned over a period of 5 years of \$24,000, we get a ROCE figure of 20 per cent.

## ***Discounted cash flow and net present value/internal rate of return***

According to Marsh (2013), these are the most widely used methods of investment appraisal as they take into account the timing of cash flows. As money changes value over time, we need a method that takes account of this.

The net present value (NPV) calculation compares the price of the investment to the level of future savings that it will provide. One simple example of an NPV calculation is to consider whether you would rather have \$100 today or \$120 a year from today. To arrive at an answer in this example, you would have to decide how much interest could be earned in a year on the \$100. If you could earn more than 20 per cent you would accept the \$100 today, because your earnings after one year would be greater than the \$120 you would otherwise receive.

To calculate the NPV on an investment, several pieces of information are needed. First, determine the total cost of the project. Second, calculate the annual savings for at least the first four years after implementation. Finally, determine the rate of return required by the company on capital investments.

### ***Example***

Assume you spend \$300,000 today for a WMS that will provide estimated savings of \$100,000 in the first year and \$150,000 in years two to four. Note that the present-day value of these savings is less than \$100,000 and

\$150,000, respectively. Your objective in calculating the NPV is to determine the value of those annual savings today and compare it to present-day cost (\$300,000).

Assume that your management requires a return of 15 per cent on all capital investments. At 15 per cent, the first year's savings of \$100,000 is worth \$86,960 at the present day. Present-day value of \$150,000 savings for years two to four are \$113,415, \$98,625 and \$85,770, respectively. Add the total savings in today's dollars and you get \$384,770. Because the total saving in today's dollars (\$384,770) is greater than the total price of the WMS (\$300,000), the investment can be justified.

### ***Operating profit/net profit***

$$\frac{\text{PBIT}}{\text{Sales}} \times 100$$

Where PBIT = Sales – operating costs. This measures the profit of a company before the payment of interest and taxes.

### ***Days payable outstanding***

$$\frac{\text{Accounts payable}}{(\text{Total annual cost of goods sold} / 365)}$$

This measures the average number of days a company takes to pay its suppliers.

### ***Days sales outstanding***

$$\frac{\text{Accounts receivable}}{(\text{Annual revenue} / 365)}$$

This measures the average number of days it takes a company to collect its money from its customers.

## Inventory turnover ratio

$$\frac{\text{Cost of goods sold}}{\text{Average inventory value}}$$

A low number here may indicate that either your stock is slow moving or that there may be problems such as the presence of obsolete stock, low customer demand or order quantities are too high for the demand, resulting in little or no movement. Low numbers are typical in a spare parts operation where stock is held just in case.

## Inventory days of supply

$$\frac{\text{Current total inventory value}}{(\text{Total annual cost of goods sold} / 365)}$$

This measures the quantity of inventory on hand in relation to the number of days of usage to be covered.

## Distribution cost as a percentage of sales

$$\frac{\text{Total distribution costs}}{\text{Total sales}} \times 100$$

$$\frac{\text{Total distribution costs}}{\text{Total cost of goods sold}} \times 100$$

Both these metrics can be used to benchmark against other companies. Total distribution costs can include both warehousing and transportation costs. It can also be widened to include inbound costs.

Other financial metrics include:

- Fixed cost versus variable cost split.
- Cost increase versus sales revenue increase.
- Inventory value change versus sales value change.

All of these are compared with previous years' figures.

## Reference

Marsh, C (2013) *Business and Financial Models*, Kogan Page, London

# Problem-solving tools 08

## Introduction

These tools can be used in all aspect of logistics and supply chain management. All the examples provided relate to logistics.

## 8.1 Brainstorming

### *Introduction*

Brainstorming is an organized problem-solving discussion. It is when a team of people get together to produce ideas for the solution of a problem or for a new service or product. A cross-functional team is seen as ideal, as sometimes people are too close to a problem to come up with workable solutions.

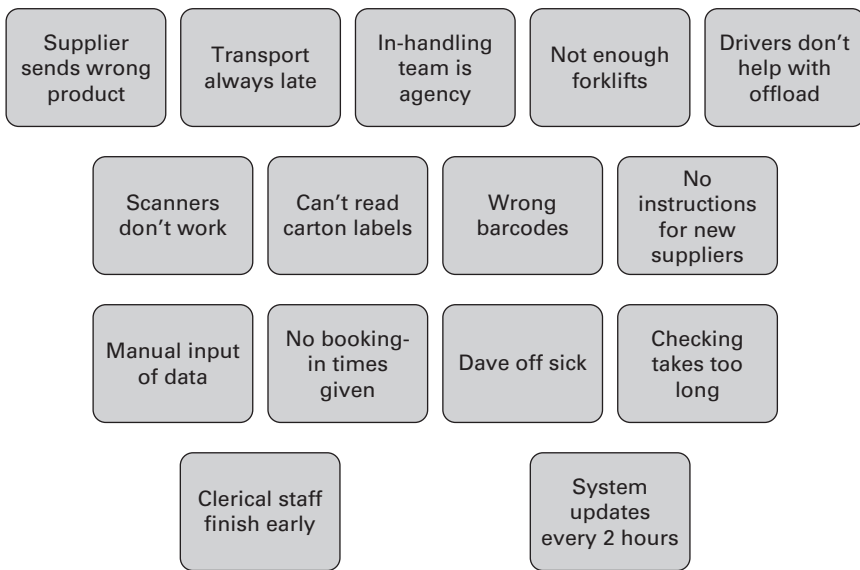
### *When to use*

When solutions for a particular problem are hard to come by and it needs a team of people to come up with some new ideas or solutions.

### *How to use*

Assemble a group of people together in a room to suggest as many ideas as possible in the hope of arriving at a solution to an ongoing problem or for a new strategy or service.

Brainstorming is normally seen as a group activity; however, recent research has suggested that individuals should spend time alone, thinking of potential solutions before coming together with colleagues to discuss their various ideas. This overcomes some of the issues of people being reticent about coming forward with ideas in a group environment.

**Figure 8.1** Brainstorming using Post-it® notes

All participants should write down their ideas on Post-it notes and place them on a wall or whiteboard. These can be discussed as they're placed on the wall or discussion can take place later (see Figure 8.1).

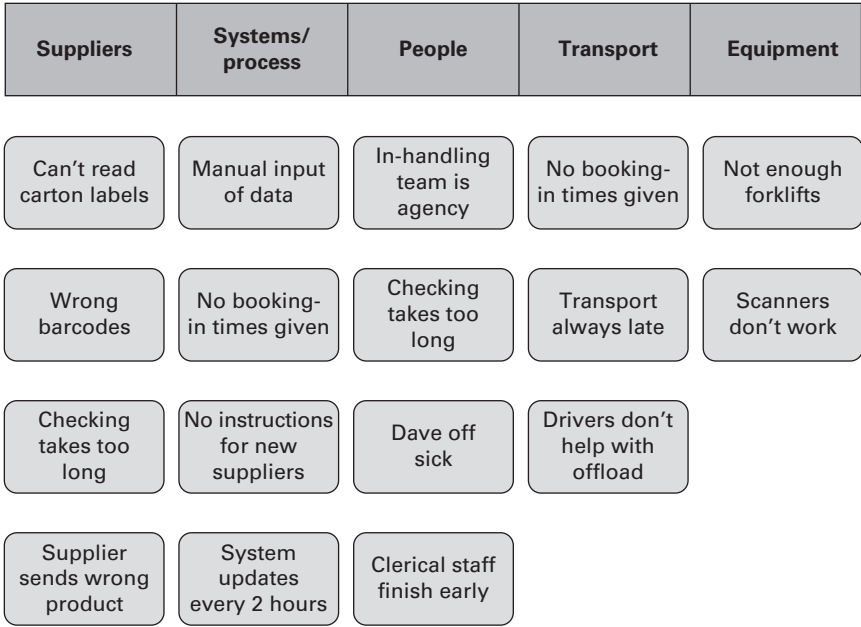
## Method

Turner (2003) proposes the following steps:

- 1 Choose a cross-section of people.
- 2 Set aside sufficient time with no interruptions.
- 3 Clearly state the problem or topic and make sure everyone understands.
- 4 Ask each team member to present his or her ideas, one at a time, in sequence (team members can pass if they don't have anything to add).
- 5 Record all the ideas exactly as given. No judgements are made until the end of the session.
- 6 After all the ideas are listed, check for clarification from the team members.
- 7 When the ideas dry up, it's time to stop.



**Figure 8.2** Affinity diagram



**8** The group then examines each idea in turn, expanding on them, categorizing them and perhaps combining or eliminating some.

**9** Put time limits on the discussions.

It may be possible to group the ideas and put them under headings that can then be used as key areas to take forward (see Figure 8.2).

The rules for brainstorming are:

- No criticism of the person, just the idea.
- State ideas quickly.
- Basic ideas initially.
- Don't worry about stating the obvious.
- Don't worry about repeating ideas.
- Link ideas and try to improve on others.
- No questions during the session.
- Quantity is good.

Once the ideas are exhausted, they are grouped together under specific headings as shown in the affinity diagram example in Figure 8.2. Note that a problem can initially be put under multiple headings. By going through a process of 5 Whys (see tool 8.3) we can determine exactly where the problem lies.

## **Further information**

See Stevens, M (1996) *How to be a Better Problem Solver*, Kogan Page, London.

## **Reference**

Turner, S (2003) *Tools for Success: A manager's guide*, McGraw Hill, Maidenhead

# **8.2 Cause and effect analysis, or fishbone or Ishikawa**

## **Introduction**

Cause and effect analysis was introduced by Professor Kaoru Ishikawa, a quality management guru, in the 1960s. The technique was then published in his 1990 book, *Introduction to Quality Control*. The diagrams created with cause and effect analysis are known as Ishikawa diagrams or fishbone diagrams (because a completed diagram can look like the skeleton of a fish).

Cause and effect analysis was initially developed for quality control; however, it has now been extended into other areas, including problem solving. For instance, you can use it to:

- understand the specific cause of a problem;
- uncover holdups in your processes;
- discover why and for what reason(s) a specific process isn't working.

## **When to use**

This tool can be used to think through the causes of a problem that is affecting your operation. It helps you look for the root cause as opposed to the

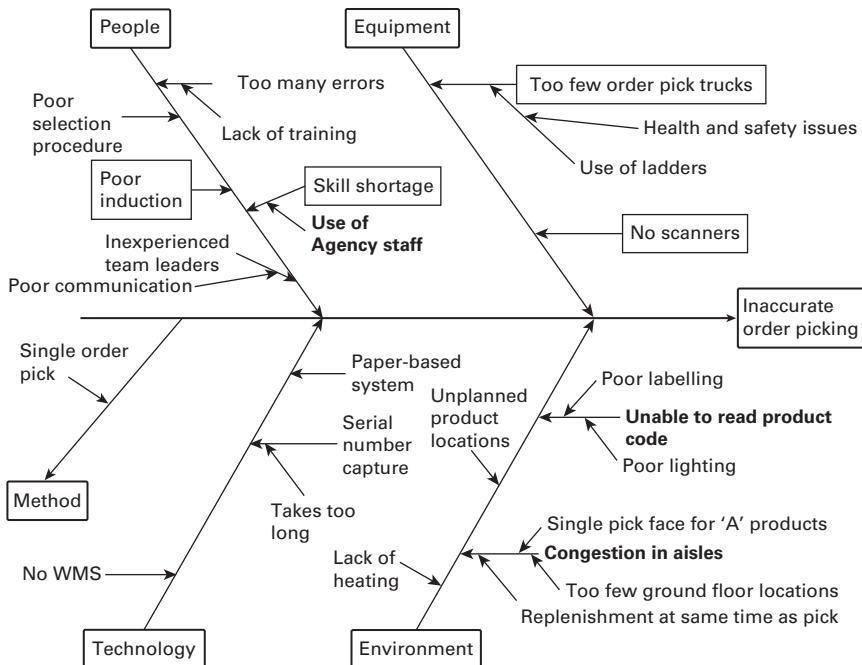
symptoms. It is based on producing a diagram that gives a visual representation of the problem. It enables you to consider all the potential factors causing the problem, not just the more obvious ones. By bringing your team together you are able to brainstorm (see tool 8.1) the problem and produce a diagram detailing all the potential factors. We find that being able to visualize a problem is very effective.

## How to use

Identify the problem and write it down on the right-hand side of a piece of paper or screen (see Figure 8.3). Then decide on the major factors that may be contributing to the problem; these can include technology, people, equipment, processes, environment, information, etc. Draw lines at an angle away from the horizontal line and record the major factors at the end of each line or 'rib'. Collect the causes within each of the major factors that contribute to the effect. Brainstorm by asking each person in the team to provide potential causes and plot them on the 'ribs' within each of the major categories.

Use the 5 Whys tool (8.3) to delve deeper into each of the potential causes. Discuss how these impact the ultimate problem and concentrate on those

**Figure 8.3** Fishbone diagram



that have the greatest impact. Once the diagram is completed, each area can be analysed in detail to find the root cause of the problem.

### ***Further information***

See [http://www.mindtools.com/pages/article/newTMC\\_03.htm](http://www.mindtools.com/pages/article/newTMC_03.htm) (archived at <https://perma.cc/A5SJ-4EKA>)

## **8.3 The 5 Whys**

### ***Introduction***

If you are a parent, you will have often heard your children ask why things are as they are. They repeat the question until they are satisfied with the answer. It's the same in business. Although called the 5 Whys tool, we need to keep asking 'why' until we get to the root cause of a problem.

This is a simple problem-solving tool that helps users get to the root cause of the problem faster. It can also be used in conjunction with cause and effect analysis (tool 8.2). The tool is based on the philosophy that a problem provides an opportunity to fully understand the causes and thus treat the cause rather than the symptoms.

### ***When to use***

The 5 Whys tool attempts to get to the root cause of any particular problem.

### ***How to use***

- 1** Define the problem, e.g. Customer X is very unhappy.
- 2** Put together a cross-functional team of people.
- 3** Ask your team why Customer X is very unhappy and capture the responses, e.g. we delivered late again.
- 4** Ensure that all staff are open and honest with their responses.
- 5** Continue to ask why until no more answers can be given, e.g. we didn't finish the pick, we were a person short, we didn't plan for this volume, we were given the wrong volume information.

- 6 Use the answers to identify the problem and the actions that need to be taken, e.g. the sales team got their forecast wrong and we need to discuss how this can be improved.

The tool enables you to drill down more than you would normally to find the exact cause of the problem. A simple example from Toyota is as follows:

- 1 Our forklifts keep breaking down – why?
- 2 Shrink wrap gets caught in the drive motors – why?
- 3 The warehouse floor gets very messy – why?
- 4 The team throw shrink wrap on the floor – why?
- 5 They don't use the bins provided – why?
- 6 They are in the wrong locations and constantly full.
- 7 *Answer:* relocate bins and empty more often.

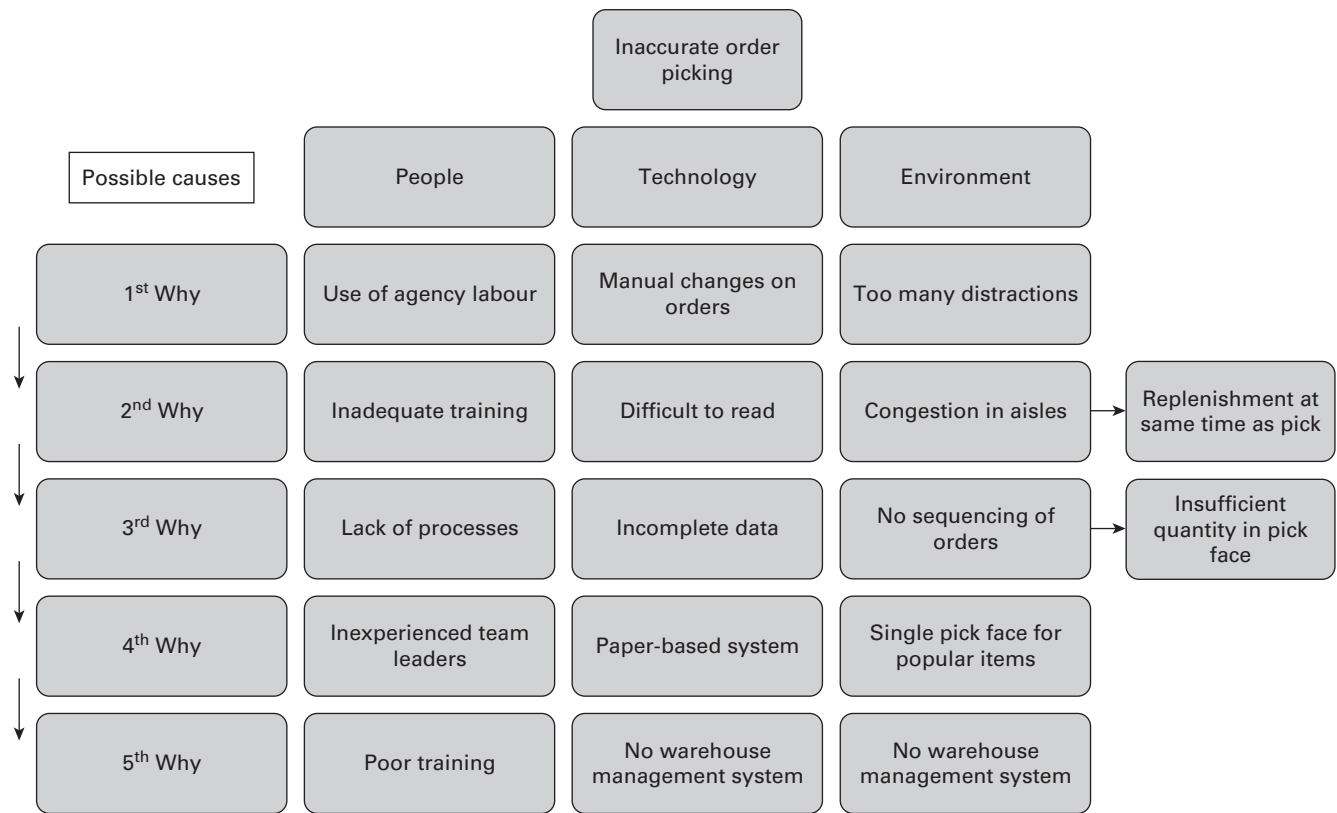
The chart shown in Figure 8.4, adapted from a design by Six Sigma Material, is a good way of mapping out the problem and the potential causes. If we take the example of the wrong items being sent to a customer, there are a number of potential causes. In this diagram we have looked at three potential areas: people, technology and the environment (in this case the working area).

Note that we may need to ask more than five questions to get to the root cause of the problem and there could be a number of reasons for the poor accuracy. The point is to take this exercise seriously, ask the difficult questions and get to the bottom of the problem. For example, two of the streams in the figure end with the fact that there is no warehouse management system, and the reason for this could be a lack of budget. Keep drilling down until you can proceed no further. Note that it can also branch off into other directions.

To concentrate resources, the following need to take place:

- Address each major cause in turn.
- Assign *one* person to the corrective actions of each root cause.
- Assign *one* person to the preventive actions of each root cause.
- Agree on a specific completion date for each assignment.
- Record all the names of the people involved in the exercise.
- Record the date the exercise was completed.

**Figure 8.4** 5 Whys chart



**SOURCE** Adapted from and reproduced with permission from Six-Sigma-Material.com. All Rights Reserved. Copyright 2007–2013

## References and further reading

<http://www.six-sigma-material.com/5-WHY.html> (archived at <https://perma.cc/3BKA-BPW3>)

Turner, S (2003) *Tools for Success: A manager's guide*, McGraw Hill, Maidenhead

## 8.4 The 8-D approach

### Introduction

8-D is a quality management tool. An 8-D resolution and corrective action approach concentrates on resolving problems permanently, with the primary objective of preventing any reoccurrence. The premise is to get to the root of the problem as soon as possible rather than use a trial-and-error approach to problem solving. The 8-D approach provides excellent guidelines, allowing us to get to the root of a problem, and provides ways to check that the solution actually works and that the same problem is unlikely to recur.

### When to use

When a potential problem has been identified and it requires a team approach.

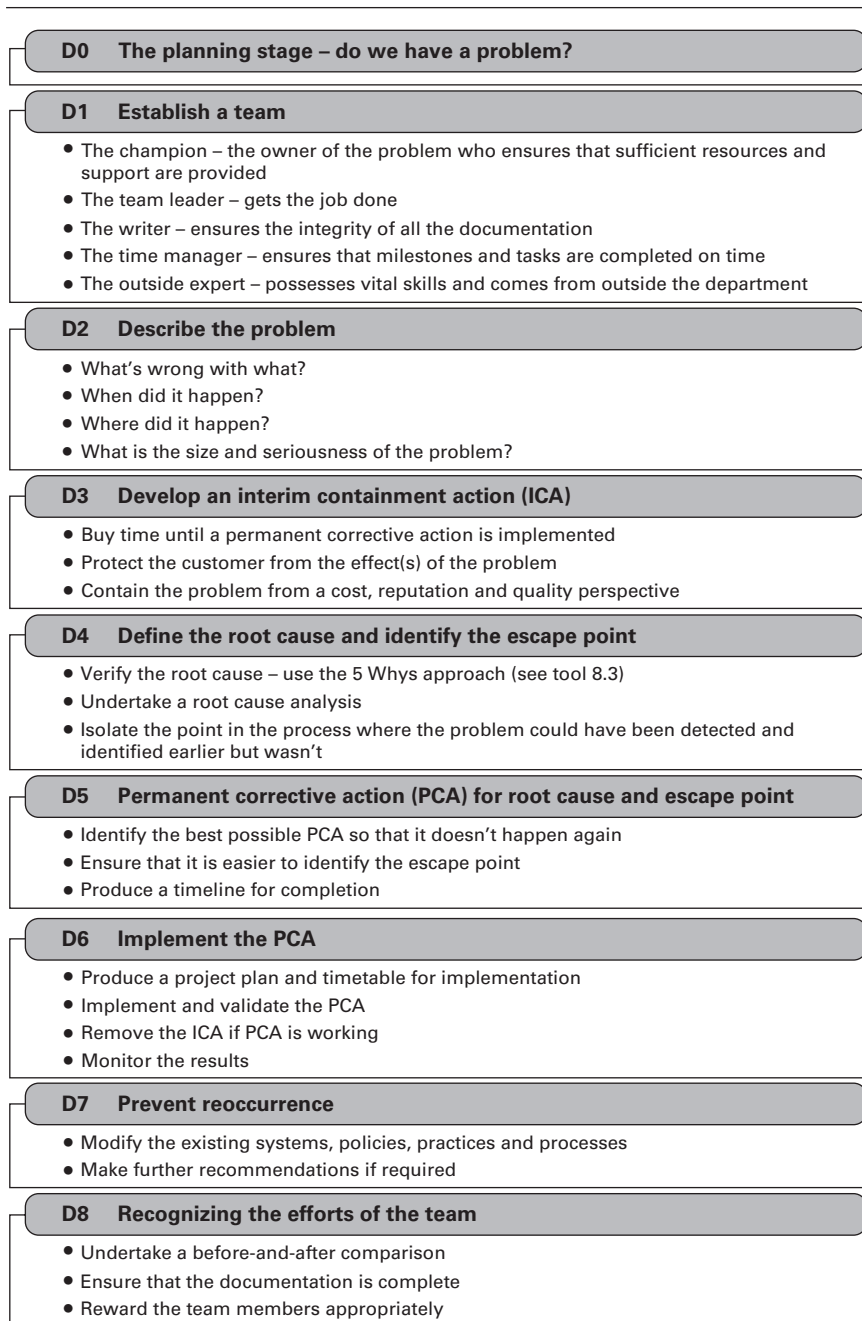
### How to use

The 8-D process follows a structured path with an emphasis on documenting every stage of the process. It also stresses the need to involve people from outside the problem area to get a different perspective.

8-D is especially useful as it results not just in problem solving, through utilizing a tried-and-tested process, but also produces an ongoing standard and a reporting format that can be utilized in many different circumstances.

It is enhanced as a problem-solving tool by introducing other tools at various stages of the process. For example, the 5 Whys tool (tool 8.3) and root-cause analysis can be used at stage D4 to discover the root cause of the problem. FMEA (failure mode and effects analysis) can be used at stage D5 to check the effectiveness of the solution.

Figure 8.5 provides a step-by-step guide to the 8-D problem-solving process. A worksheet for the 8-D approach can be found at <http://thequalityportal.com> (archived at <https://perma.cc/NU62-7Q8Y>)

**Figure 8.5** The 8-D process

**SOURCE** Worksheet provided by The Quality Portal team at <http://thequalityportal.com>



## Example

Problem: incorrect delivery to the customer:

D0 – We know we have a problem as the customer has told us so.

D1 – We form a team to investigate the problem:

- the champion: the owner of the problem who ensures sufficient resources and support are provided; in this case the warehouse manager;
- the team leader: gets the job done; in this case the outbound supervisor;
- the writer: ensures the integrity of all the documentation; in this case the general manager's PA;
- the time manager: ensures milestones and tasks are completed on time; in this case the human resources manager;
- the outside expert: possesses vital skills and comes from outside the department; in this case the operations manager.

D2 – Describe the problem. 'We received a number of calls from clients complaining they received the wrong deliveries. This has occurred over the last three days. We're not sure where the issue is but it hasn't stopped, we had another call this morning.'

D3 – Develop an interim containment action. Allocate staff to check every order before it leaves the warehouse and record any incorrect orders and who picked them.

D4 – Define the root cause and identify the escape point. Use the 5 Whys tool (8.3) to discuss the problem and identify possible causes. Could the problem have been identified earlier?

D5 – Permanent corrective action (PCA). In this example the error was a problem with the use of agency labour and their lack of product knowledge. PCA is an induction for all temporary labour, with an emphasis on product knowledge and awareness. Key performance indicators to be extended to all staff. A time frame of six weeks to introduce an abridged version of the company induction programme for temporary labour.

D6 – Implement the PCA. Induction scheme for all new and existing temporary staff. KPIs set up and monitored for existing and temporary staff. Full checks on all orders leaving the warehouse to be removed if accuracy levels have improved.

D7 – Prevent reoccurrence. Warehouse procedures to include induction for all temporary staff prior to deployment.

D8 – Recognizing the effort of the team. Team dinner organized for members and partners.

Conclusion: by following through this process, not only is the initial problem detected but a temporary fix is put in place immediately while a long-term solution is sought. The final act is to reward all those individuals who were involved, both within the team and in the implementation of the final solution.

### ***Further reading***

8-Discipline Problem Solving, Noshir Khory, PhD, Motorola, Automotive and Industrial Electronics Group, 16 October 2000, report supplied by Mark Bergkotte.

# APPENDIX 1

## Useful websites

With a large amount of business undertaken online and most people utilizing the internet to search for their service providers and for up-to-date information, we have compiled the following list of useful websites. There are many others; however, we hope that this list will help you find what you are looking for in the field of logistics. This list can be downloaded from [http:// howtologistics.com](http://howtologistics.com) where it is constantly updated.

Name	Website	Description
AIM Global	<a href="http://www.aimglobal.org">www.aimglobal.org</a>	Auto ID information
APICS – The Association for Supply Chain Management	<a href="http://www.ascm.org">www.ascm.org</a>	Professional body
Apprise Consulting Ltd	<a href="http://www.appriseconsulting.co.uk">www.appriseconsulting.co.uk</a>	Consultancy
Balance Small Business	<a href="https://www.thebalancesmb.com">https://www.thebalancesmb.com</a>	Newsletter
BigChange	<a href="http://www.bigchange.com">www.bigchange.com</a>	Logistics software
British Association of Removers	<a href="http://www.bar.co.uk">www.bar.co.uk</a>	Trade association
British International Freight Association	<a href="http://www.bifa.org">www.bifa.org</a>	Trade association
British Quality Foundation	<a href="http://www.bqf.org.uk">www.bqf.org.uk</a>	Professional body
Canada’s Supply Chain Magazine	<a href="http://www.insidelogistics.ca">www.insidelogistics.ca</a>	Magazine/blog

(continued)



(Continued)

Name	Website	Description
Capterra	<a href="http://www.capterra.com">www.capterra.com</a>	List of logistics IT companies
Chartered Institute of Logistics and Transport	<a href="http://www.ciltuk.org.uk">www.ciltuk.org.uk</a>	Professional body
Chartered Institute of Purchasing and Supply	<a href="http://www.cips.org">www.cips.org</a>	Professional body
Cold Chain Federation	<a href="https://www.coldchainfederation.org.uk">https://www.coldchainfederation.org.uk</a>	Trade association
Council of Supply Chain Management Professionals	<a href="http://cscmp.org">http://cscmp.org</a>	Professional body
DC Velocity	<a href="http://www.dcvelocity.com">www.dcvelocity.com</a>	Magazine/blog
Department for Transport UK	<a href="http://www.dft.gov.uk">www.dft.gov.uk</a>	Government department
European Foundation for Quality Management	<a href="http://www.efqm.org">www.efqm.org</a>	Quality organization
Freight Transport Association	See Logistics UK	Trade association
Georgia Institute of Technology	<a href="http://www.scl.gatech.edu">www.scl.gatech.edu</a>	S/C Institute
GS 1	<a href="http://www.gs1.org">www.gs1.org</a>	Barcode information
Health and Safety Executive UK	<a href="http://www.hse.gov.uk">www.hse.gov.uk</a>	Health and safety
How to Logistics	<a href="http://howtologistics.com">http://howtologistics.com</a>	Online toolbox
IFW	<a href="http://www.lloydsloadinglist.com">http://www.lloydsloadinglist.com</a>	Logistics news
Inbound Logistics	<a href="http://www.inboundlogistics.com">www.inboundlogistics.com</a>	Magazine/blog

(continued)

(Continued)

Name	Website	Description
Institute of Chartered Shipbrokers	<a href="http://www.ics.org.uk">http://www.ics.org.uk</a>	Professional body
Institute of Supply Chain Management	<a href="http://www.ioscm.com">www.ioscm.com</a>	Professional body
Kogan Page	<a href="http://www.koganpage.com">www.koganpage.com</a>	Publisher
LinkedIn	<a href="http://www.linkedin.com">www.linkedin.com</a>	Professional network
Lloyds Loading List	<a href="http://www.lloydsloadinglist.com">www.lloydsloadinglist.com</a>	Freight community news
Logistics Handling	<a href="http://www.logisticshandling.com">www.logisticshandling.com</a>	Logistics news and blog
Logistics Management	<a href="http://www.logisticsmgmt.com">www.logisticsmgmt.com</a>	Magazine/blog
Logistics Manager	<a href="http://www.logisticsmanager.com">www.logisticsmanager.com</a>	Magazine/blog
Logistics Matters	<a href="https://www.logisticsmatters.co.uk/Home">https://www.logisticsmatters.co.uk/Home</a>	Magazine/blog
Logistics UK	<a href="http://Logistics.org.uk">Logistics.org.uk</a>	Professional body
Logistics Viewpoints	<a href="http://logisticsviewpoints.com">http://logisticsviewpoints.com</a>	Logistics news
Logistics World	<a href="http://www.logisticsworld.com">www.logisticsworld.com</a>	Directory
Manufacturing and Logistics IT	<a href="http://www.logisticsit.com">www.logisticsit.com</a>	Magazine/blog
Modern Materials Handling	<a href="http://www.mmh.com">www.mmh.com</a>	Magazine/blog
Motor Transport	<a href="https://motortransport.co.uk">https://motortransport.co.uk</a>	Magazine
Occupational Safety and Health Administration, US Department of Labor	<a href="http://www.osha.gov">www.osha.gov</a>	Health and safety

(continued)

(Continued)

Name	Website	Description
Road Haulage Association	<a href="https://www.rha.uk.net">https://www.rha.uk.net</a>	Trade association
Robotics and Automation	<a href="https://www.roboticsandautomationmagazine.co.uk">https://www.roboticsandautomationmagazine.co.uk</a>	Magazine
Stiq Ltd	<a href="https://www.styleintelligence.com">https://www.styleintelligence.com</a>	Research company
Supply Chain 24/7	<a href="http://supplychain247.com">supplychain247.com</a>	Magazine/blog
Supply Chain Brain	<a href="http://www.supplychainbrain.com">www.supplychainbrain.com</a>	Magazine/blog
Supply Chain Digest	<a href="http://www.scdigest.com">www.scdigest.com</a>	Magazine/blog
Supply Chain Management Review	<a href="http://www.supplychainmarket.com">www.supplychainmarket.com</a>	Newsletter
Supply Chain Market	<a href="http://www.scmr.com">www.scmr.com</a>	Magazine/blog
The Chartered Institution of Highways & Transportation	<a href="http://www.ciht.org.uk">www.ciht.org.uk</a>	Professional body
The National Industrial Transportation League	<a href="http://www.nitl.org">www.nitl.org</a>	Professional body
The Warehousing Education and Research Council (WERC)	<a href="http://www.werc.org">www.werc.org</a>	Professional body
Toyota	<a href="https://toyota-forklifts.co.uk">https://toyota-forklifts.co.uk</a>	Truck manufacturers
Transport for London	<a href="http://www.tfl.gov.uk">http://www.tfl.gov.uk</a>	UK government department
Transport Intelligence	<a href="https://www.ti-insight.com">https://www.ti-insight.com</a>	Research
TRL	<a href="http://www.trl.co.uk">http://www.trl.co.uk</a>	Logistics research

(continued)

(Continued)

Name	Website	Description
UK Chamber of Shipping	<a href="http://www.ukchamberofshipping.com">www.ukchamberofshipping.com</a>	Trade association
United Kingdom Warehousing Association	<a href="http://www.ukwa.org.uk">www.ukwa.org.uk</a>	Trade association
UTAS	<a href="https://utas.libguides.com/maritimeindustry">https://utas.libguides.com/maritimeindustry</a>	Maritime library guide
Warehouse and Logistics News	<a href="http://www.warehousenews.co.uk">www.warehousenews.co.uk</a>	Magazine/blog

# APPENDIX 2

## Imperial/metric conversions

A number of countries continue to use both imperial and metric measures. The following table helps to convert from metric to imperial and vice versa.

Function	A	B	Converting A to B multiply by	Converting B to A multiply by
Length	Millimetres (mm)	Inches (in)	0.03937	25.4
	Centimetres (cm)	Inches (in)	0.3937	2.54
	Metres (m)	Feet (ft)	3.2808	0.3048
	Metres (m)	Yards (yd)	1.0936	0.9144
	Kilometres (km)	Miles	0.62137	1.6093
	Kilometres (km)	Nautical miles	0.53995	1.852
Area	Square centimetres (cm <sup>2</sup> )	Square inches (in <sup>2</sup> )	0.155	6.4516
	Square metres (m <sup>2</sup> )	Square feet (ft <sup>2</sup> )	10.7639	0.0929
	Square kilometres (km <sup>2</sup> )	Square miles (mi <sup>2</sup> )	0.3861	2.59
	Hectare	Acre	2.4711	0.4047
Cube	Cubic centimetres (cm <sup>3</sup> )	Cubic inches (in <sup>3</sup> )	0.061	16.387
	Cubic metres (m <sup>3</sup> )	Cubic yards (yd <sup>3</sup> )	1.308	0.7645

(continued)





(Continued)

Function	A	B	Converting A to B multiply by	Converting B to A multiply by
	Cubic metres (m <sup>3</sup> )	Cubic feet (ft <sup>3</sup> )	35.3147	0.0283
Volume	Litres	UK Pints	1.76	0.5683
	Litres	UK Gallons	0.21997	4.54611
	UK fluid ounce	Millilitres	28.413	0.03519
	US Gallons	Litres	3.78541	0.26417
	<i>UK Gallons</i>	<i>US Gallons</i>	1.2009	0.83267
Fuel usage	Miles per UK gallon	Kilometres per litre	0.35400	2.82490
	Miles per UK gallon (mpg)	Litres per 100 km (lpk)	282.48/mpg	282.48/lpk
	Miles per US gallon (mpg)	Litres per 100 km (lpk)	235.22/mpg	235.22/lpk
	Miles per UK gallon	Miles per US gallon	0.8327	1.201
Weight	Tonnes	Long Tons	0.9842	1.016
	Grams	Ounces	0.0353	28.35
	Kilograms	Pounds	2.2046	0.4536
	Kilograms	Hundredweight	0.01968	50.802
Speed (lift)	Metres per second	Feet per second	3.2808	0.3048
Speed travel	Kilometres per hour	Miles per hour	0.62137	1.6093
Temperature	Centigrade (c)	Fahrenheit (f)	$(9/5) \times T_c + 32$	$(5/9) \times (T_f - 32)$

**NOTE** In this example T is the temperature, e.g. if temp is 26° Celsius the formula is (9/5)\*26+32 = 46.8+58 = 104.8 °F. If temperature is 97.4° Fahrenheit the formula is (5/9)\*(97.4-32) = 0.555556\*65.4 = 36.33 °C.



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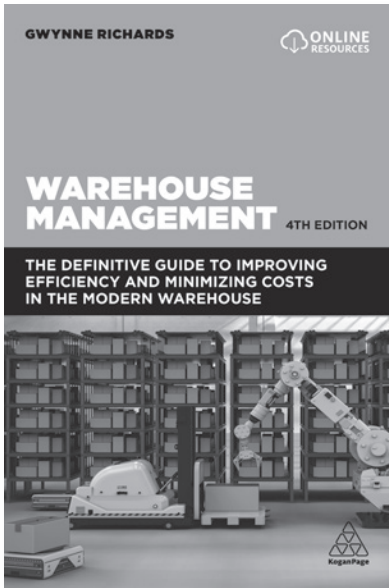
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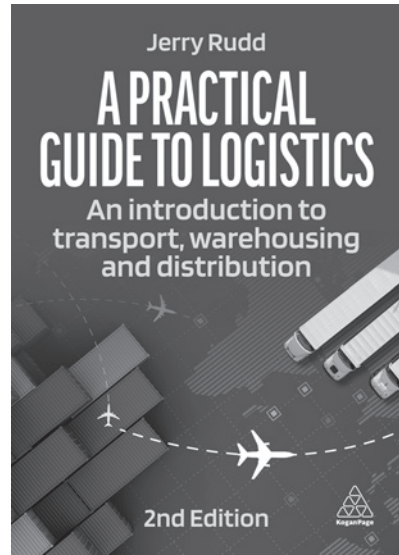


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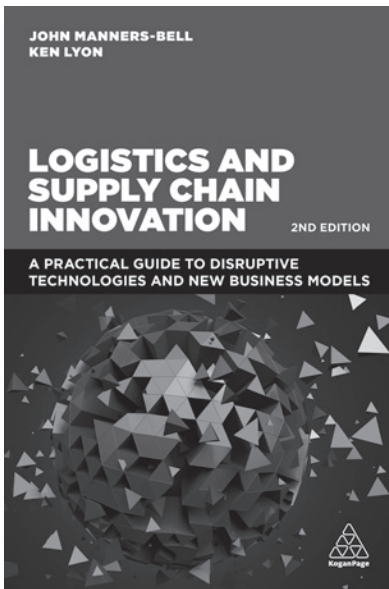
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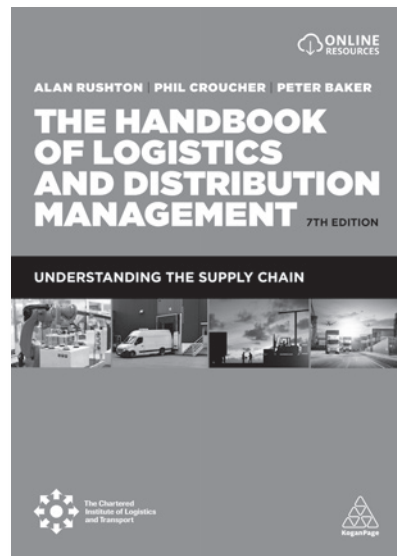
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