GWYNNE RICHARDS

ONLINE RESOURCES

WAREHOUSE MANAGEMENT

4TH EDITION

THE DEFINITIVE GUIDE TO IMPROVING EFFICIENCY AND MINIMIZING COSTS IN THE MODERN WAREHOUSE

KoganPage

PRAISE FOR *WAREHOUSE MANAGEMENT*

This book is both an essential textbook for students and a valuable handbook for practitioners. All of the most important warehousing concepts are thoroughly explained, and drawing on his specialist knowledge and experience, Gwynne Richards uses case studies to bring them to life for the reader. Highly recommended reading!
Clare Bottle, Chief Executive, United Kingdom Warehousing Association

Warehouse Management, fourth edition, is an essential 'one-stop shop' for both experienced practitioners and those who want to fully understand the fundamentals of how to manage a business storage facility. This is a technical topic, yet the book is accessible, with industry terms clearly explained and examples of best practice provided. *Warehouse Management* is a must-read for everyone in the supply chain and logistics industries, business students and those who want to understand more about how to operate a warehouse.
Phil Wood, Strategic Programmes Director – Northern Europe, Mondelēz International

This fourth edition of *Warehouse Management* is very welcome and provides great insight into all aspects of the subject. I know from my work with Gwynne Richards at The University of Warwick that his students appreciate the book as a source of reference during their studies. It is an invaluable addition to the bookshelves of students and experienced practitioners alike.
David James, VP of Subsidiary Development and Management, KNAPP AG

The publication of the fourth edition of Warehouse Management is timely. We have learnt a huge amount about supply chain logistics generally, and warehouse operations specifically, during the challenging COVID-19 pandemic period. In this context, Gwynne Richards brings his unique and unrivalled knowledge of the subject to this new edition. It can be read equally profitably by supply chain practitioners and students alike.

Edward Sweeney, Professor of Supply Chain Management, Heriot Watt University

Warehouse management, fourth edition, is a truly comprehensive piece of work. It caters for all aspects of the logistics and supply chain world, from the basic industry terminology to the latest in robotics. My daughter has just started a career in logistics and has found the book to be an invaluable reference.

Gordan Knox, Chief Operating Officer, FitFlop

Warehouse Management

The definitive guide to improving efficiency and minimizing costs in the modern warehouse

Fourth Edition

Gwynne Richards

KoganPage

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ONLINE RESOURCES

The above symbol indicates that a video of the equipment or process discussed is available. All the videos can be accessed at https://vimeo.com/showcase/wm. The password is W4r3h0us3v1d30s.

Schools and universities that have adopted the book in their curriculum can access PowerPoint slides on the Kogan Page website at www.koganpage.com/WM4.

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Introduction

What is a warehouse?

A warehouse should be viewed as a temporary place to store inventory and as a buffer in supply chains.

> It serves as a static unit – in the main – matching product availability to consumer demand and as such has a primary aim which is to facilitate the movement of goods from suppliers to customers, meeting demand in a timely and cost-effective manner. In today's e-commerce world we also need to think about reverse logistics and the handling of returns.
>
> (Adapted from Van den Berg, 2011)

When people are asked to define a warehouse, the word 'storage' is always first on the list. In a perfect supply chain there shouldn't be a need for warehouses as products will be manufactured 'just in time' and shipped directly to the customer.

I certainly prefer the following dynamic definition.

Primarily, a warehouse should be a trans-shipment point where all goods received are despatched as quickly, cost-effectively and efficiently as possible. They are not there to store goods ad infinitum.

Today's warehouses, distribution and fulfilment centres are becoming key to ensuring that customer expectations of on-time, in-full, damage-free deliveries are met.

This has resulted in greater investment in technology and automation with companies building warehouses and fulfilment centres closer to the point of need.

Some might argue that the miniaturization and digitization of products will reduce the need to hold inventory; however, the OECD suggests that global freight volumes are expected to triple between 2018 and 2050, thus necessitating the requirement for warehouses for the foreseeable future.

When I wrote the third edition of this book four years ago, I talked about how technology and automation will play a part in warehouse operations in the future; however, today we are already experiencing a significant shift towards advanced technology such as vision systems, full automation and robotics.

COVID-19 has also had a significant part to play in the increase in e-commerce sales and a move towards greater use of automation and advanced technology within the warehouse. E-commerce sales volumes that were predicted to become the norm by 2026 are suddenly a reality. Based on the US Census Bureau, there was more e-commerce growth in the first six months of COVID-19 than the previous five years combined.

In the UK this growth caps a standout year in e-commerce, with online retail sales growth for the full year up 36 per cent year on year – the highest annual growth seen since 2007 according to IMRG. This being the case, automation will play a much larger part in the warehouse of the future.

According to Statista, the size of the warehouse automation market worldwide will more than double from $13 billion in 2019 to $27 billion in 2025, and according to ReportLinker (2020) the Global Warehouse Robotics Market is expected to grow from $3.546 billion in 2019 to $7.953 million by the end of 2025 at a compound annual growth rate (CAGR) of 14.4 per cent. Some countries are more advanced than others in terms of introducing automation; however, the growth of e-commerce will certainly concentrate the mind in this area as volumes increase significantly.

The basic processes within warehouses have remained relatively the same over time. We receive goods into the warehouse, we process and pick orders, we replenish, include some value-adding services and then we despatch the product. Advances in warehousing today tend to relate to the increased use of technology and automation, increased speed and accuracy, improved performance measurement and the effective management of resources.

In this fourth edition of the book we have retained the core concept of discussing each warehouse process in turn, together with putting the role of the warehouse into context within the overall supply chain. We also concentrate on the many challenges faced by warehouse managers specifically in the area of e-commerce.

In this edition we have increased the number of case studies from companies who have achieved improvements and cost savings through the introduction of new technology and equipment, leaner processes and environmental initiatives and added more videos. The old adage of ‘a picture paints a thousand words’ is true; however, videos are even more powerful in terms of sharing knowledge

The warehouse continues to play a major role within supply chains and will continue to do so for the foreseeable future, although these warehouses will appear in different guises.

The growth in fulfilment centres for e-commerce, for example, is certainly changing the warehousing landscape. Finished stock needs to be held as close to the point of use or consumption as possible to reduce ever-increasing transportation costs and to meet increasingly demanding customer delivery requirements. This has led to many warehouses transforming into cross-dock and trans-shipment centres, fulfilment centres, sortation and consolidation points, and reverse logistics centres, as well as fulfilling their roles as storage facilities.

Some retailers are also utilizing their stores as fulfilment centres to further enable them to meet exacting delivery lead times. Items can now be despatched from the warehouse, the distribution centre or the fulfilment centre, direct from the supplier or from the store – whichever is the nearest point to the customer. By introducing a ‘click and collect’ service, they can provide a more flexible service to their customers.

As a result, managers need to have a greater understanding of the various roles that warehouses can fulfil and how these affect the business and the supply chain as a whole. There is also a requirement for greater visibility within the supply chain. The deployment of artificial intelligence (AI) will have a profound effect on supply chains going forward.

No two operations are exactly the same, even within the same company, although the underlying principles remain. This book aims to share these principles and enable managers and students to get a better understanding of how to achieve best-in-class status.

It aims to further update readers on current and potential future advances in warehouse management whilst tackling the issues that are challenging today’s managers.

These include the pressure on managers to increase productivity, reduce cost and improve customer service at least cost to the environment whilst ensuring the health and safety of staff employed in the warehouse.

The author and contributors have a number of years' experience in managing and consulting on warehouse operations. This book is written from the perspective of hands-on operators and aims to share past experiences and knowledge gathered over recent years.

Having moved into consultancy, the author is continually updating his knowledge in this rapidly changing sector of logistics. This book also draws on the knowledge and experience of colleagues and peers and features the results of recent studies and surveys from all over the globe.

Warehouses evolve. Technology has moved on apace and, as a result, opportunities to improve efficiency and effectiveness within the warehouse are constantly being introduced. This, together with increasing demands from customers and internal pressures to reduce costs yet improve service levels, can prove a significant challenge to warehouse and logistics managers everywhere.

The introduction of sophisticated automation, robotics and advanced software systems into warehouse operations can potentially have an effect on logistics operations comparable to the introduction of the wheel millennia ago. These advances in technology are likely to lead to a significant reduction in staff and improved efficiency. This comes at a cost, both monetary and human, however. As a result, suppliers of automation and robotics are looking at ways to make their product offering more attractive, including leasing and short-term rental rather than outright purchase. Companies also need to think about retraining and redeploying staff.

Not all warehouse operations are likely to benefit from such advances or can afford large investments in technology. This book will examine the basic processes required to manage a warehouse effectively. In fact, these processes need to be in place in all warehouses prior to any thoughts of introducing new technology.

Automating a bad process might make it quicker but certainly doesn't make it more efficient. The author recognizes the huge diversity in warehouse operations globally and although the book discusses current concepts and technologies, it concentrates in the main on how all warehouses can become more efficient and effective, irrespective of budget.

Logistics is very much about trade-offs. This book will examine these in detail, as they will affect how warehouse and logistics managers approach their jobs and the decisions they take. Major trade-offs include:

- cost versus service;
- storage capacity versus speed of put-away and retrieval;
- speed versus accuracy;
- lower inventory versus stock availability;
- efficiency versus responsiveness;
- volume purchases versus storage cost and availability; and
- transportation costs versus storage costs.

These trade-offs appear both within the warehouse itself and also between the warehouse operation and other logistics services.

This book has been written in such a way that it will be a useful reference point for staff involved in the day-to-day operations of a warehouse, senior managers, designers and planners, external agencies who require a basic understanding and, finally, those who are considering a career in warehousing and logistics.

Through the use of case studies and examples, the author shares fundamental tools and processes that have been prevalent in the industry over the years and have been instrumental in assisting managers to increase efficiency and reduce costs.

The book concentrates on the areas that challenge today’s warehouse and logistics managers. These include:

- improving efficiency and productivity whilst reducing costs;
- improving quality and accuracy;
- the challenge of reduced lead times from customers;
- technological advancements;
- workforce availability and management;
- health and safety; and
- effects on the environment.

Chapters 1 and 2 of the book discuss the roles of the warehouse and the warehouse manager in today’s supply chain. Within these chapters we also examine one of the main challenges for warehouse managers – attracting and retaining quality staff.

Chapters 3 to 7 analyse the individual processes within the warehouse, outlining areas where costs can be reduced whilst productivities increase through the use of technology and improved methods.

Chapters 8 to 10 explore in detail equipment utilized within the warehouse, including warehouse management systems, handling and storage equipment.

Chapters 11 and 12 discuss how to resource and calculate the costs of a warehouse.

Chapter 13 looks at performance measurement in detail.

Chapters 14 and 15 provide an insight into areas that currently take up a significant percentage of a manager’s time today. These include health and safety and the continuing pressure on companies to reduce the effects of logistics operations on the environment.

The final chapter looks at current advances in warehousing and attempts to predict the future. Areas discussed in previous editions are now becoming commonplace and therefore a new way of thinking is required.

The book has been written by a UK-based author and has contributors from the United Kingdom, Europe and the United States. They have all worked and lectured in many different countries. It is hoped that this book will be read globally and that the information provided will resonate with warehouse operators, students and management teams worldwide. Previous editions have been translated into a number of different languages.

Books such as this are an excellent resource for today’s managers; however, they need to be used in conjunction with other easily accessible resources. These include discussions with your peers, staff on the warehouse floor, the suppliers of warehouse equipment and consultants – all of whom have a wealth of experience to share with today’s managers. Attending training courses to update your knowledge is also beneficial when things are changing so rapidly.

A large glossary of terms and acronyms can be downloaded for free from the following website: www.howtologistics.com.

There are online resources available for operators, including warehouse audits, space calculations and lists of useful websites. Many of these can be accessed free of charge.

Where you see the following symbol ▶ followed by a number, you will be able to access a video of the equipment or process discussed by linking to this url: https://vimeo.com/showcase/wm. The password is W4r3h0us3v1d30s. Note that the websites of all the video contributors are listed at the back of the book. More videos and case studies can be accessed from these sites.

PowerPoint slides can be accessed from the following Kogan Page url to aid schools and universities who have adopted the book in their curriculum: www.koganpage.com/WM4

Two sister publications, *The Logistics and Supply Chain Toolkit and The Logistics Outsourcing Handbook* are also available from Kogan Page.

01
The role of the warehouse

Introduction

Warehouses have, in the past, been constantly referred to as cost centres and rarely adding value. The movement of production to lower-cost countries, a significant growth in e-commerce and increasing demands from consumers has seen a step change in warehouse operations. Warehouses are now seen as a vital link within today's supply chains. In fact, as stated in a recent survey by Motorola:

> Warehouses are no longer necessary evils that are fundamentally cost centers. Warehouses today can drive competitive differentiation and, by doing so, increase profitable growth.

The way consumers shop today, their behaviour and expectations, are having a significant effect on how retailers are engaging with their customers. Retailers and manufacturers have to become more innovative within their supply chains and therefore pressure remains on managers to increase productivity and accuracy, and reduce cost and inventory whilst improving customer service in the face of significantly reduced order lead times. The role of the warehouse in a supply chain has never been more visible to the general public with the onset of COVID-19 bringing the logistics industry into even sharper view, and is now being touted as a driver of future economic recovery.

As an introduction to the main aspects of the book, we set the context by examining the role of the warehouse in today's society and its likely place within future supply chains.

We will also look at the factors involved in choosing a suitable location for a warehouse and how many warehouses might be required.

We have also included four examples of specialist warehousing and expanded on these. We believe that the same underlying principles apply whatever type of warehouse you operate. The role of a supply chain, and therefore a warehouse within that chain, is to deliver the right products, in the correct quantity, to the right customer, at the right place, at the right time, in the right condition, at the right price – the seven rights of customer service. We can also include an eighth 'right' today, that being 'at the right cost environmentally'. The warehouse plays a significant role in this. Delivering the right product in the right quantity relies on the warehouse picking and despatching products accurately. Delivering to the right customer at the right place, on time, requires the product to be labelled correctly and loaded onto the correct vehicle with sufficient time to meet the delivery deadline. The warehouse also has to ensure the product leaves the warehouse clean and damage free. In order to deliver at the right price we require a cost-efficient operation that provides value for money.

Finally, the warehouse has to play its part in ensuring that the supply chain is operated in an environmentally friendly way through the use of alternative energies, improved efficiency, waste management and committed staff.

The warehouse is therefore crucial in delivering the perfect order – that is, On Time, In Full, Damage Free and with the

Correct Paperwork. In the past, warehouses were seen mainly as stockholding points, attempting to match supply to demand and acting as a buffer between raw material and component suppliers and manufacturers and between the manufacturers and the wholesalers, distributors and retailers and/or consumers. Stock visibility along the supply chain was limited and information flow was very slow, resulting in companies holding more stock than necessary.

Warehouses also fulfilled a major role in storing raw materials. As land and buildings were relatively cheap, the cost of holding significant quantities of raw materials and finished stock was seen as the norm and totally acceptable.

Production runs in those days were very long as it was an expensive process to change machinery, models, colours, styles, etc. The economy was also seen as supply-driven with manufacturers producing products in the hope and expectation that retailers would stock them and consumers would buy them.

As a result, there was a large proliferation of warehouses, not all of which were fit for purpose and stockholding increased appreciably.

In today's market with expensive land, buildings, labour and energy costs, together with the introduction of concepts such as just-in-time (JIT), efficient consumer response (ECR) and quick response (QR), companies are continually looking to minimize the amount of stock held and speed up throughput. The use of tools such as postponement – where products are finalized in the warehouse, not at the manufacturing location – are becoming commonplace.

We have gone from a ‘push’ to a ‘pull’ supply chain over recent years. In fact, the phrase ‘supply chain’ can be a bit of a misnomer; rather, it should be called a demand chain, with consumers holding sway.

In the past, manufacturers produced goods and passed them onto the retailers, expecting them to sell as many of their products as possible. The manufacturers operated a large number of local warehouses and delivered product direct to store.

This situation changed in the 1980s when retailers took significant control of their supply chains and began to build national and regional distribution centres. This changed the face of warehousing with a move towards larger, multi-temperature sites owned by the retailers and in many situations operated by third-party logistics companies.

These sites continue to grow, with Tesco building a 1.2 million square foot warehouse at Teesport in the United Kingdom and Target in the United States operating a 3.4 million square foot import warehouse and distribution centre in Rialto, California. Amazon has built a 2 million square foot warehouse at Tilbury, near London. The location of these warehouses is also part of a movement towards port-centric logistics.

Budget supermarket retailer Lidl is operating a warehouse at London Gateway, the United Kingdom’s newest port complex. The siting of warehouses close to ports is not confined to seaports; we are also seeing a growth in logistics centres in and around airports.

CASE STUDY Tradeport Hong Kong

Background

Established in 2001, Tradeport Hong Kong is the only regional distribution centre located at Hong Kong International Airport (HKIA), which is the world's busiest cargo airport. Serving 100+ airlines collectively flying direct to over 190 destinations worldwide, including 40 cities in Mainland China, HKIA handled over 4.5 million tons of air freight during 2016.

The Tradeport operation is a premium-grade logistics centre comprising 300,000 square feet of space from where they provide customers with logistics solutions, including vendor-managed inventory, kitting, pick-and-pack services.

With its unique on-airport location and highly secure TAPA (Class A)-certified facility, Tradeport provides logistics services for products that are time-critical, fast-moving and valuable – for example, electronics, luxury items and industrial parts.

Strategically located at the heart of the Pearl River Delta region of southern China, Tradeport's hinterland embraces a population of 100 million people, increasingly inter-connected by high-speed rail, road and bridge infrastructure networks.

The challenge

Tradeport's initial discussions (back in 2004) with Eurocopter Asia (now Airbus Helicopters Asia) identified a need to provide a storage-and-service solution for critical spare parts and emergency handling service for over 1,500 helicopters operating in the Asia Pacific region. The spare parts portfolio consists of 16,000 stock-keeping units (SKUs) with inventory replenished on a weekly basis via consolidated air freight shipments from France and Germany. The geographic territory to be serviced from the Hong Kong hub includes 30 countries reaching from North Asia down to Australasia and across the Pacific Ocean.

According to Even Lam, Tradeport's chief operating officer:

> *The demands were very challenging, including extremely high requirements for speed of response and service levels. The emergency response element for Aircraft on Ground (AOG) scenarios requires parts being picked and packed, ready for despatch on the next flight out, within a maximum of just two hours from the phone call requesting support; with the service available around-the-clock, 24/7/365, including on public holidays.*

The solution

Tradeport worked with the customer on developing solutions for the challenging service requirements. It was clear that taking a proactive, collaborative approach to tackling the issues would be critical to achieving a successful outcome.

Due to the 24/7/365 service requirements, Tradeport management engaged closely with all key members of the front-line operations team throughout the solution development process, in order to finalize a solution that would work for all stakeholders in the project.

Successful employee engagement resulted in a creative solution for staff involved in the call-out roster, including targeted changes to remuneration and company provision of mobile equipment, together with training from the customer.

The benefits

During the past decade, the scope of the programme has developed and grown in line with the customer's business needs. The Tradeport spare parts operation is now internationally recognized as providing some of the best service levels across the entire network of Airbus Helicopters.

Tradeport's chief executive officer, Kenneth Bell, adds:

> *Engaging the key stakeholders from the outset – including our staff, who ultimately have to deliver on these high service standards, day-in and day-out – was a fundamental step in empowering the whole team with the confidence to make it happen.*

The trend towards outsourcing Western production eastwards has resulted in companies having to hold higher levels of finished goods stock than previously. This is to cover the extended lead time between production and final delivery.

Containers from Shanghai to the United Kingdom, for example, can take upwards of 31 days, not including clearance at the port of entry.

VIDEO 1i Samsung television supply chain

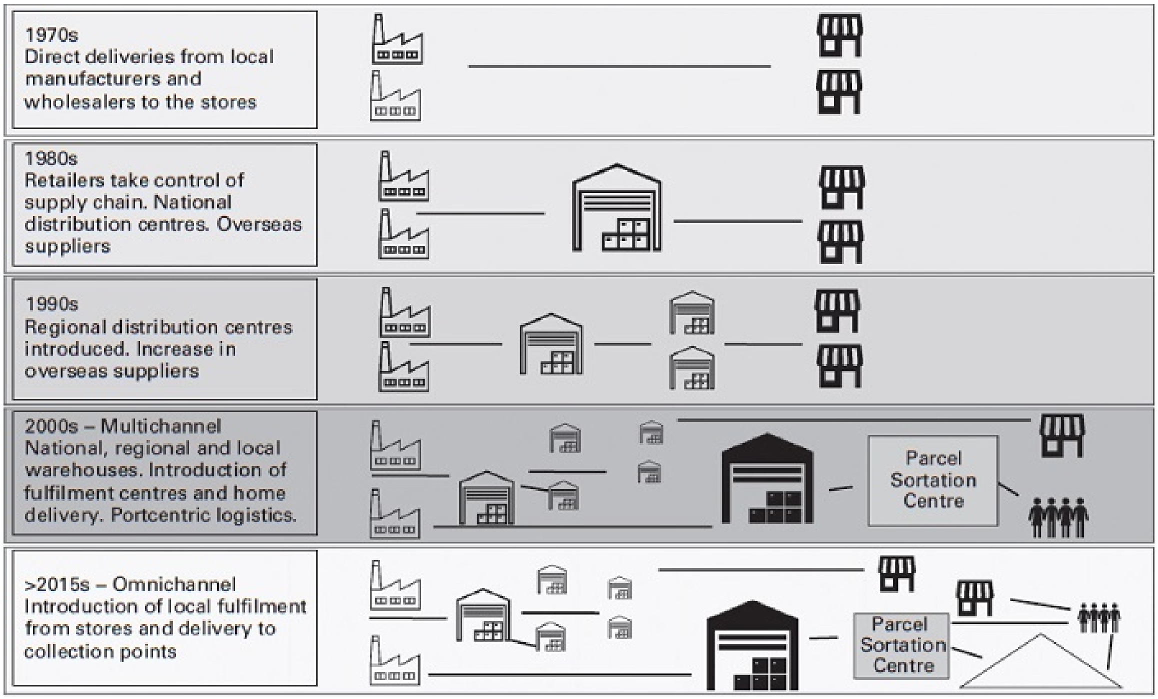
Video 1i shows a Samsung television being moved between a UK port and a customer. Note the role of warehouses in this operation including at the store.

The United Kingdom's exit from the European Union together with the impact of COVID-19 on international trade, a blockage at the Suez Canal and turmoil in many countries potentially point towards bringing production closer to the point of consumption.

It will be interesting to see whether the Biden administration will continue with an 'America First' policy, persuading US companies to transfer production back to the United States. All of this could well have an impact in the future as we see unparalleled uncertainty within today's supply chains.

What we are also seeing is the evolution of warehousing as shown in Figure 1.1.

Figure 1.1 Evolution of warehousing



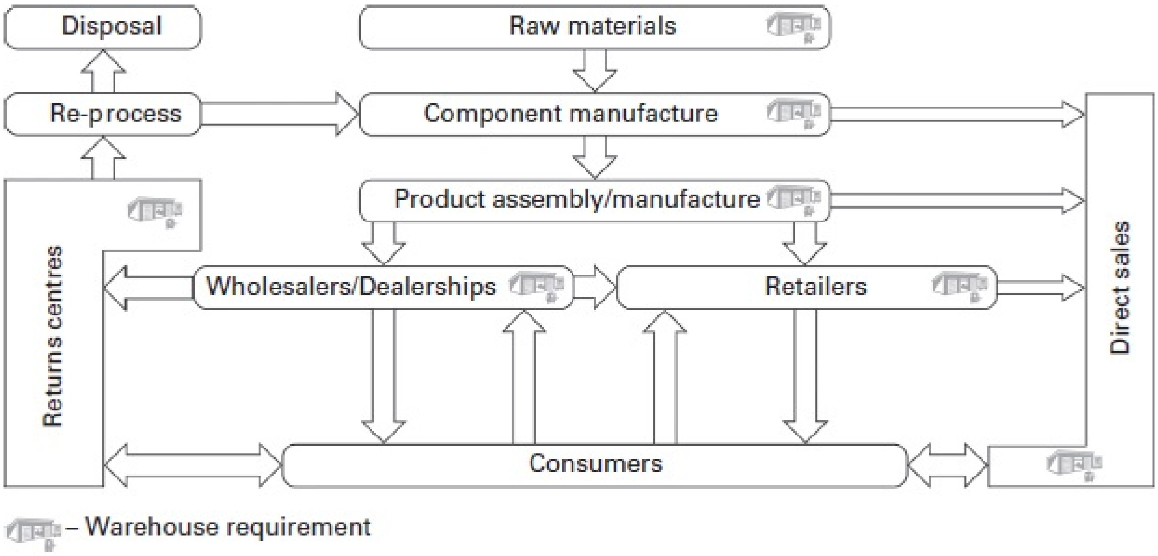
SOURCE Adapted from JLL.com

▶ Figure 1.1 details

Types of warehouse operation

There are many different roles for a warehouse in today's supply chain. As can be seen in Figure 1.2, warehouses can be operated by raw materials suppliers, component and finished goods manufacturers, wholesalers, retailers and companies involved in reverse logistics. The warehouses can be owner operated or subcontracted to logistics service providers.

Figure 1.2 Warehouses in the supply chain



▶ Figure 1.2 details

These warehouses fulfil the following roles.

Raw materials storage

These warehouses store raw materials and components either close to the point of extraction or close to the manufacturing point. Raw materials must be held in order to ensure continuous production. These materials include plastics, precious metals, sand, aggregates, cocoa and other food ingredients, etc. Food products may also be purchased in advance to guarantee supply in the event of poor weather conditions and possible conflict.

Storage facilities can include buildings, tanks, hoppers and open spaces.

Intermediate, postponement, customization or sub-assembly facilities

These warehouses are used to store products temporarily at different stages in production. These centres are also used to customize products before final delivery to the customer.

Postponement and sub-assembly activities can include the following:

- specific packaging or labelling being changed or added, eg for store-ready items or printing in different languages;
- computer assembly to include different graphics cards, memory chips, software, etc;
- product bundling for promotional activity;
- country-specific items being added such as electrical plugs; and
- special messages being added, eg stencilling of greetings messages on mobile phones.

Finished goods storage

These warehouses store products ready for sale, on behalf of manufacturers, wholesalers and retailers. They provide a buffer or safety stock for companies, enabling them to build up stock in preparation for new product launches, expected increases in demand and to deal with seasonality.

Consolidation centres, sequencing centres and transit warehouses

Consolidation centres receive products from different sources and amalgamate them for onward delivery to the customer or onto a production line. This can include JIT centres where automotive parts are delivered to a warehouse where they are brought together and sequenced for delivery onto the production line.

They can also be retail stock consolidation warehouses where products from different suppliers are consolidated for onward delivery to the stores. Rather than deliver part-loads to the National (NDC) or Retail Distribution Centres (RDC), manufacturers deliver to these consolidation facilities where their stock is amalgamated with other suppliers for onward delivery to the NDC or RDC. These differ from cross-dock centres in that product can remain in the centre for a period of time awaiting call-off from the final destination. Many of these consolidation centres are operated by third parties.

Trans-shipment or break-bulk centres

Trans-shipment centres receive products in large quantities from suppliers and break them down into manageable quantities for onward delivery to various locations.

Cross-dock centres

Cross-dock centres are seen as being the future for warehousing alongside fulfilment centres. ECR and QR within retail require operations to be able to move goods quickly through the supply chain.

According to Datex Corporation there are four main scenarios where cross docking is used most frequently:

1. When the demand for any given inventory item is stable and shows strong consistency. These items can be placed on a reoccurring fulfilment schedule using cross docking.

This eliminates the need for surplus inventory to be stored in case of out-of-stock situations.

2. When handling time-sensitive and perishable inventory. Due to the reduced shelf life, inventory needs to reach retailers with a reasonable remaining shelf life. By foregoing storage and utilizing cross docking, delivery time is reduced. This provides the goods with a longer sales window.
3. Because customers cannot expect a specific inventory item to be in stock, cross docking can be utilized to quickly deliver bulk shipments of varying inventory on a reoccurring schedule. In this case, out-of-stock scenarios are not a concern and storing surplus inventory is not necessary.
4. When fulfilling orders for which customers are willing to wait. With items such as appliances and furniture, customers typically expect to wait a short time for delivery. Rather than storing these large items in-store or at a distribution centre, retailers can efficiently fulfil orders from a single facility using cross docking to help reduce the delivery period.

Cross docking requires deliveries into these centres to be already labelled and ready for onward delivery. Here the items are identified and consolidated with other deliveries, ready for despatch. Items should remain in the warehouse for as short a time as possible. Same-day receipt and despatch is the target.

Although companies are beginning to realize the efficiency of cross docking, there are a number of barriers to a successful introduction. These can include warehouse management systems support, quality control systems, reliability and cooperation of suppliers and carriers, warehouse design and uncertain demand. Cross-dock warehouses or trans-shipment centres are also utilized in outlying geographic areas to transfer products onto local, radial distribution vehicles. This trans-shipment process can take place either inside or outside the warehouse. Swap bodies or demountable bodies can also be used together with stand or drop trailer systems. Typical cross-dock products are perishable items such as fruit and vegetables, flowers, meat and fish, which need to be moved quickly through the supply chain. Statistics suggest that WalMart uses cross docking for around 85 per cent of its goods, whilst the number is about 50 per cent for its rival Kmart.

Sortation centres

Sortation centres are used in the main by letter, parcel and pallet distribution companies. Goods are collected from all parts of the country, delivered into hubs or sortation centres, sorted by zip or post code, consolidated and delivered overnight to their respective distribution areas for onward delivery. These operations are increasing and the hubs are getting bigger in order to cope with the growth in e-commerce.

Today's retailers are also moving towards automated sortation centres with pallets being de-layered on entry, the use of mini-load systems for temporary storage and retrieval and finally automated pallet build on exit.

Figure 1.3 shows a Hermes parcel sortation centre.

Figure 1.3 Parcel sortation hub

SOURCE Courtesy of Hermes

Fulfilment centres

The growth of e-retailing has seen an increase in the number of customer fulfilment centres. These warehouses have been designed and equipped specifically to manage large volumes of small orders. Videos 1ii and 1iii show the fulfilment operation of an internet retailer called i-herb.com and how it has moved from a person-to-goods system to that of a goods-to-person system.

VIDEO 1ii iHerb.com person-to-goods system

VIDEO 1iii Video case study of Perfect Pick – iHerb.com

These centres can also double up as returns processing centres, as e-commerce has a larger percentage of returns than bricks and mortar retail activities.

Reverse logistics centres

The growth of e-retailing and specific environmental legislation such as the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive (2007) has compelled companies to focus time and energy on reverse logistics. Today, companies recognize that returning product to stock or disposing of it quickly can positively affect cash flow.

As a result, a number of warehouses have been set up specifically to deal with returned items. Third-party contractors are providing a service to retailers where customers return unwanted or defective items to the stores; the items are then consolidated and sent to the returns centre, where they are checked and repackaged, repaired, recycled or disposed of.

Waste legislation has also resulted in large quantities of returned packaging having to be disposed of in an environmentally friendly manner. This includes sortation by type and use as fuel or recycled material. There are case studies in the environmental section that go into more detail on this subject.

Other reverse logistics processes include the return of reusable transit packaging equipment such as roll cages, barrels, kegs, pallets, tote boxes and trays. When used in the food industry added services include washing and sanitizing the items before they re-enter the supply chain.

For example, XPO Logistics, a 3PL, service and maintain more than a million roll cages, as well as 230 million trays, flower buckets and dollies for Tesco. Recent and planned initiatives include the development and implementation of a live data capture system and the trial of a segregation system to improve the quality and value of plastic waste.

Public sector warehousing

Outside the commercial world there are also warehouse operations that support the public sector, armed forces and the third sector.

The increasing number of natural disasters such as earthquakes, droughts and tsunamis is resulting in third-sector organizations opening up warehouses in strategic locations across the globe. This ensures that they are closer to the disaster areas and thus able to react quicker.

Other public sector warehouses will store supplies for local government facilities such as schools and offices. Products will include stationery, uniforms, furniture, computer hardware and software, etc.

All the warehouse operations mentioned above can either be owned or leased by the principal or owned, leased or operated by third-party companies on behalf of a principal.

Warehouses operated by third-party logistics providers are either dedicated operations on behalf of a single customer or can be shared-user or public warehouses where a number of different customers share resources and are accommodated under one roof.

These include:

- companies with different products but with common customers such as retailers or automotive manufacturers;

- companies with the same or similar products delivering to common customers, eg tyre manufacturers, bicycle manufacturers, pharmaceutical companies and consumer goods companies;
- companies needing similar types of service, eg fulfilment or returns processing; and
- companies requiring the same environmental conditions, eg hazardous goods, explosives or temperature controlled.

Users of shared-user warehouses are, in the main, companies looking for economies of scale through sharing facilities, equipment and labour costs. They can also be start-up operations where the scale of business doesn't warrant a dedicated facility initially.

Why do we hold stock?

A supply chain with the minimum amount of stock within its pipeline is utopia. Unfortunately, this happens very rarely. Our society and our markets are not predictable and therefore we need to hold stock at various stages within the supply chain. Increased consumer demand for greater choice has resulted in a proliferation of product ranges and sizes leading to unprecedented demands on storage capacity.

Reasons for holding stock are as follows.

Uncertain and erratic demand patterns

Suppliers of ice cream, suntan lotion, umbrellas and the like will potentially experience erratic demand patterns based on the changeability of the weather. Other unpredictable sales can revolve around the launch of a new product and the progress of a team in a major competition such as football's World Cup or baseball's World Series events.

Trade-off between transport and shipping costs, justifying larger shipments

The ability to move product in large quantities tends to attract lower costs per unit. The trade-off here is between the cost of storing additional units compared with the higher cost of transport for smaller, groupage-type deliveries. If the transport cost is very attractive, then additional storage space will be required. There also has to be a strong conviction that all the items purchased will be sold.

Discounts via bulk buying

The possibility of reducing the unit rate through buying in greater quantities is always an attractive proposition for buyers. This can, however, have a negative effect overall if the company fails to sell all of the additional units purchased or has to sell at a loss to clear the warehouse. In this situation it is our contention that the whole-life cost of the item is calculated before the decision is made to purchase additional quantities. These costs will include additional storage and handling costs, obsolescence, damage, working capital interest, possible discounted sales and disposal costs. A trade-off exists between lower unit purchase costs and increased storage costs per unit. I'm sure there are many warehouses out there holding obsolete stock due to the overenthusiasm of procurement and sales staff!

CASE STUDY

A recent example was a company that had the licence to utilize the images from a well-known film franchise on its packaging. They had an issue with a lack of space within the warehouse, yet they were still holding packaging relating to episode one of the film franchise whilst episode four had just come out in the cinema. This packaging, which had been over-ordered due to a significant discount, was completely obsolete, although it could be sold to a recycling company, thus freeing up space and recovering at least some of the cost. Companies will always end up with surplus stock if they have forecasted incorrectly – it is how quickly this is resolved that makes the difference between an efficient operation and one with insufficient space.

Fluctuation in the price of raw materials and finished goods

Certain products fluctuate in price significantly and can also be affected by weather conditions. Companies might therefore buy significant quantities when the price is advantageous or when weather conditions dictate. This will necessitate additional storage capacity.

Distance between manufacturer and the end consumer

As mentioned earlier, the distance finished stock has to travel today requires a greater amount of stock to be held in the local warehouse. Lead times can be anything between four and eight weeks depending on the manufacturer's location. The trade-off here is between more expensive local suppliers and producers and increased costs in transport and inventory holding costs.

COVID-19 saw a significant increase in container shipping costs from the Far East due to delays at ports, a shortage of containers and a reduction in services.

Cover for production shutdowns

Many manufacturing companies and sectors continue to shut down their operations for vacations, machine maintenance and stock counts. As a result, retailers and wholesalers need to build up stock prior to the shutdown period to ensure stock availability for their customers. Manufacturers will also build up a stock of components to ensure that their production lines are not brought to a standstill as a result of supplier shutdowns.

Ability to increase production runs

Changing or adjusting production lines in order to accommodate changes in models, colour, design features, etc is expensive. The longer the production run is, the lower the cost per unit to produce. However, the trade-off here is between the lower cost per unit versus the additional cost per unit for storage.

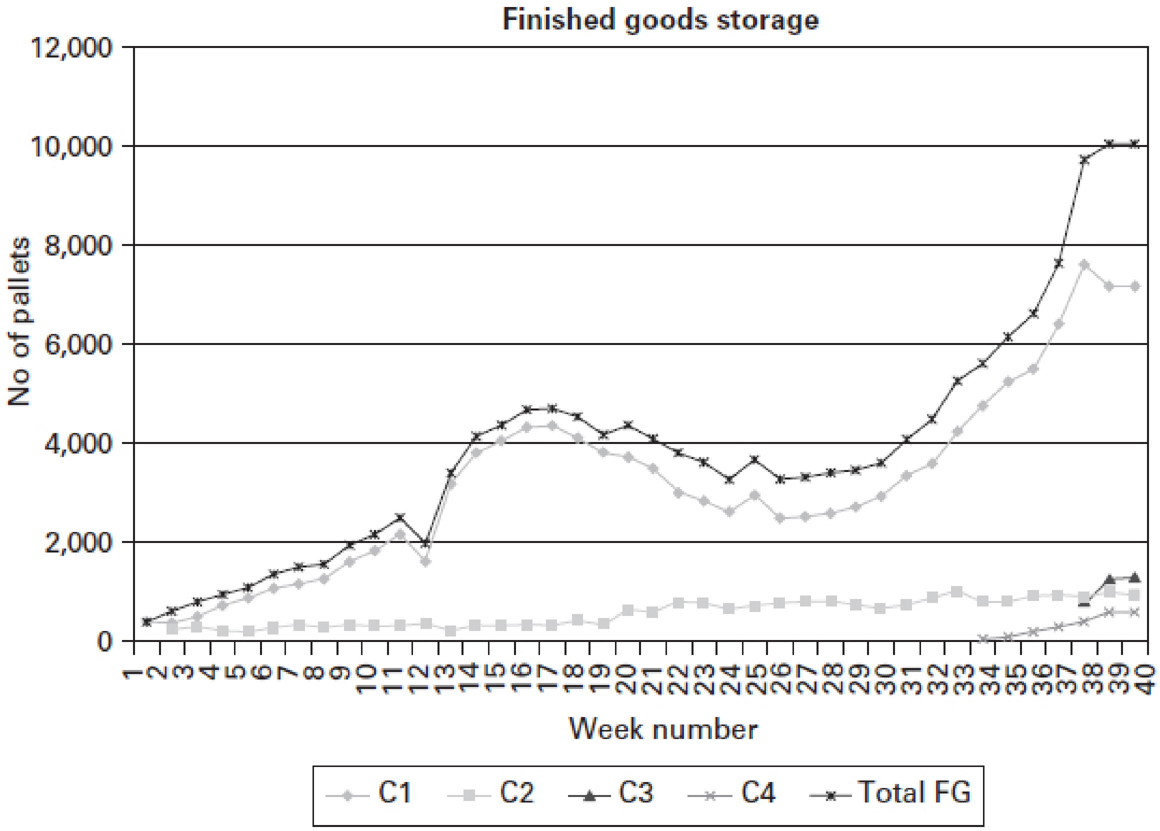
To manage seasonal production

Certain food and drink products are produced at specific times of the year and therefore need to be stored until required.

High seasonality

Seasonality can be a period of time such as summer and winter or a specific date in the calendar such as Easter, Valentine’s Day, Independence Day, Singles’ Day, Eid, or Chinese New Year. Figure 1.4 shows the stock build-up for a chocolate manufacturer in the run-up to Easter. As can be seen, pallet storage ranges from 500 pallets to a staggering 10,000 pallets at peak.

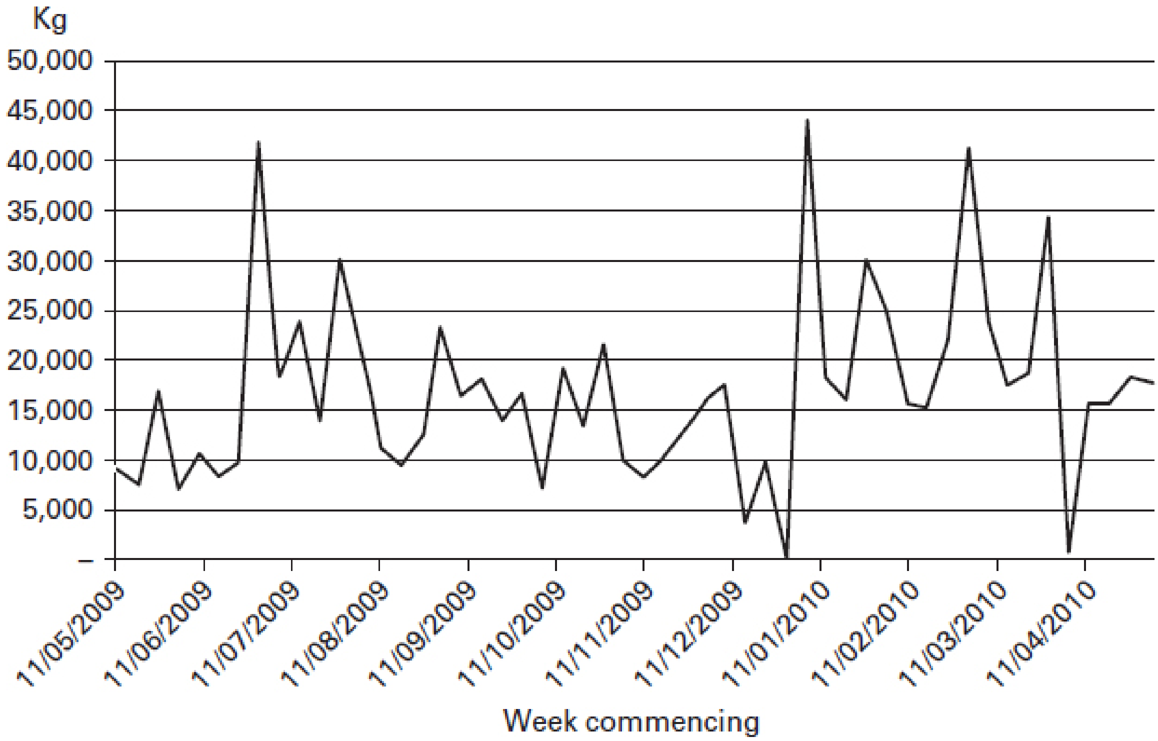
Figure 1.4 Seasonality: chocolate



▶ Figure 1.4 details

Large sporting events can also have an impact on the requirement for additional storage. This includes the World Cup, the Olympics, Super Bowl final and World Series baseball, etc. Figure 1.5 shows the activity of a clothing manufacturer leading up to the two distinct seasons of summer and winter collections.

Figure 1.5 Seasonality: apparel and equipment



▶ Figure 1.5 details

Spare parts storage or maintenance stores

To ensure an uninterrupted production line operation, manufacturers need to hold stock of spare parts just in case an item becomes defective. This can be expensive but the trade-off here is between the cost of the part together with its holding cost and the potential breakdown of the production line and the consequences that brings with it. This doesn't mean, however, that these items should not be reviewed regularly and decisions taken as to whether to stock them or not. The decision to stock the parts and in what quantities may well be managed by the supplier under a vendor-managed inventory (VMI) agreement. The supplier will decide on the type and quantity of parts to be stored based on historical usage information across a number of companies. Things to take into account include supplier lead time and machine failure rate. The advent of 3D printing could have a significant effect on this sector in the future.

In the meantime there remains a requirement for the storage of spare parts and therefore companies are looking at technology to reduce the cost of these types of operation where products are stored just in case rather than just in time.

An interesting example is the following case study where a company has used 5S techniques to find waste within their operation. Having done so they then needed to find a solution.

CASE STUDY ApexSupplyChain.com/Actylus (courtesy of Apex Supply Chain Technologies, Inc)

Munters: A global OEM's approach to process savings

Problem: Munters' old bin system required manual scanning and cost hours of labour each day. Solution: WESCO implemented the ACTYLUS™ Smart Bin System to eliminate manual scanning and stock-outs and recover valuable floor space.

Result: Munters recaptured 700+ employee hours/year and saved nearly $44,000 in labour costs.

Today's lean-focused OEMs are always on the lookout for ways to eliminate waste and optimize productivity. Many use the 5S method of workplace organization with its mantra, 'A place for everything, and everything in its place.'

For Munters, a global manufacturer of air treatment and climate control solutions, this focus on lean and 5S is a daily practice. Its Amesbury, Massachusetts, plant manufactures massive air treatment units for some of the world's largest and most demanding customers. Meeting their deadlines can have significant financial implications, so it's crucial that supplies for each project are always in the right place, at the right time.

Finding a better bin system

One process that Munters wanted to improve through the 5S method was how the company managed its OEM electrical inventory. Production workers were required to scan low bins on a daily basis, which meant they had to walk to a cabinet, pick up a scanner, walk back to their station, scan the bin's barcode, then make another round trip to return the scanner. At that point, a supervisor would have to enter those orders into the ERP system. This cost the company roughly 3½ hours of lost labour each day – that's 728 hours a year.

This process often led to over-ordering, since production workers were more focused on preventing costly stock-outs, not inventory carrying costs. This resulted in a significant amount of safety/reserve stock, excessive inventory costs and the need for extra storage space.

WESCO's Supply Chain Solutions team had recently learned about the ACTYLUS™ Smart Bin System from Apex (as seen in Figure 1.6).

Figure 1.6 Apex Corporation's ACTYLUS™ Smart Bin System

These cloud-based devices constantly monitor bin levels and send replenishment orders directly to WESCO's ERP system. Kevin Spearman, Materials Analyst Supervisor, Global Operations, decided to give them a try and track his results. A short time later, WESCO had implemented 10 ACTYLUS units to automate supply replenishment orders for Munters' production lines and panel assembly area.

Immediately, Spearman began seeing the results. The first obvious win was a reduction in wasted steps by the staff. Since the units are located near the point of use, employees can now pick up supplies in seconds. ACTYLUS eliminates barcode scanning and all those wasted steps, providing even more productivity gains.

In total, Munters employees will save more than 101,000 steps a year – that's 700 employee hours that can be channelled back into production. And since supervisors no longer manually enter orders into the ERP, they can now turn their focus to more productive tasks.

In all, Munters gained 108 square feet of productive floor space by reducing reserve stock. With real-time visibility into supply levels, WESCO can now help Munters achieve the lean cost savings and efficiency it needs to compete in the global marketplace. WESCO has also been able to reduce delivery runs from five days a week to four – a 20 per cent saving in the account's operational costs.

According to Spearman: 'ACTYLUS wasn't just a great fit for our 5S programme, we also saw ROI in 2½ months.'

A further enhancement with these bins is the use of infra-red beams to record whether the correct number of items have been extracted from the bins. Utilizing pick to light the infra-red system removes the requirement of turning the light off as this is done automatically as the picker's hand is removed.

Work-in-progress storage

Many companies will part-build products in anticipation of orders. The chocolate manufacturer mentioned above produces the two halves of the Easter egg prior to receiving any firm orders. This enables them to complete the process at a later date, once they know the type of packaging, style and insertions required.

Investment stocks

A number of products can increase in value the longer they are held in storage. These include fine wines and spirits, cigars, precious metals and stones, antiques and fine art.

Document storage

Both public bodies and private companies have an obligation to store documents over a period of time. These can include correspondence, invoices, accounts, contracts, etc. This can be a legal requirement. Other examples include evidence storage and patient records by the emergency services.

Maturation and ripening

Some products require longer-term storage in order to improve the quality or the maturity of the product. Examples include certain meats and cheeses.

Consignment stock

There are examples where manufacturers will utilize their customers' warehouses to store their goods. This is called consignment stock where the customer only pays for the stock once it has been used or consumed. This takes pressure off the supplier to hold more stock and ensure delivery on time whilst the customer has available stock within the warehouse but has yet to pay for it, thus increasing flexibility and improving cash flow.

Where customers are quite a distance away from the supplier this can reduce transportation costs significantly.

Warehouse location

With logistics operations becoming increasingly globalized a key factor in locating operations is the total cost of operating in any given market. Traditionally, it tended to be rent, local taxes and service charge costs that were taken into account; however, these factors can often mask other key factors such as the cost of labour employed in the warehouse, the cost of electricity and the cost of fuel for vehicles.

New data from Savills World Research as referenced in Figure 1.7 below demonstrate the effect of these non-property costs on the total operational cost. The data analyses warehouse costs in 54 markets across 21 countries.

Warehousing property costs are highest in the largest world cities where big populations and constrained land supply meet high demand from consumers and businesses. Four markets stand out above the rest: London, Tokyo, Hong Kong and Singapore. All have total costs well above $20 per square foot. A full list of land and tax costs can be found in Appendix I.

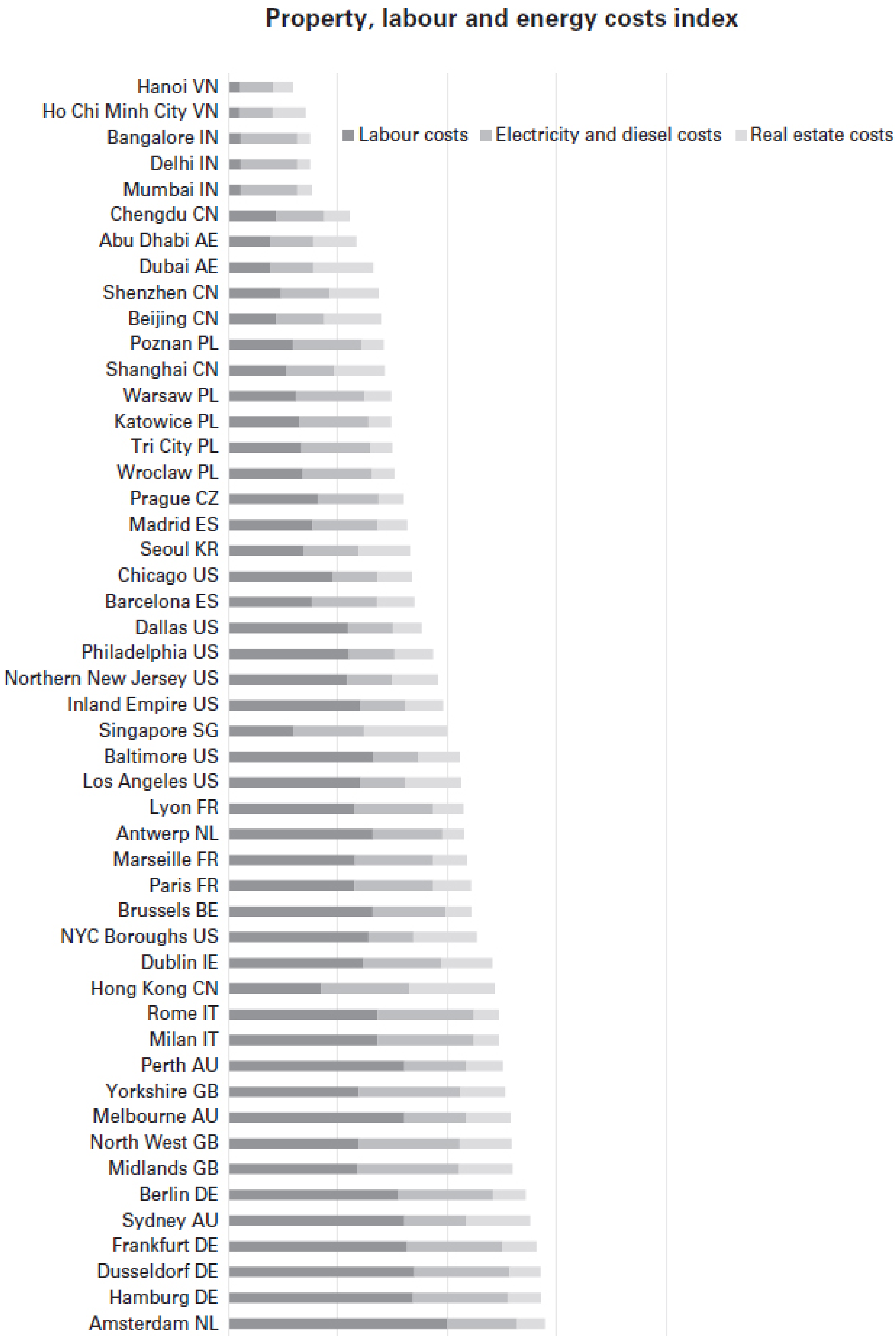
In Figure 1.7 we have combined property and tax costs with labour and energy to show total warehousing operational costs, having given a higher weighting to labour costs as the primary cost component for occupiers.

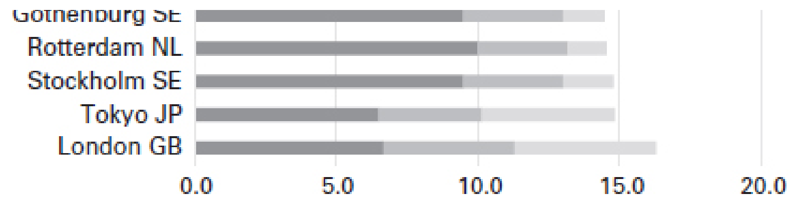
Low costs make Vietnam highly attractive to multinationals setting up operations in the country. India, where low warehousing property costs are offset by higher fuel costs, is the second cheapest location in the sample.

In the UAE, higher property costs (most notably in Dubai) are offset by very low energy costs, making it one of the cheapest locations for warehousing operations globally. The UAE has seen stable warehouse occupancy and rents, with take-up led by e-commerce companies.

Turning to Europe, labour costs are the key differentiating factor between Central and Eastern and Western Europe. Low labour costs in Poland mean total warehousing costs are comparable to those of China. In Western Europe, high labour costs in Sweden, the Netherlands and Germany, mean cities from these countries account for 7 of the top 10 most expensive locations by total cost.

Figure 1.7 Property, labour and land cost index (courtesy of Savills)


Property, labour and energy costs index
Labour costs
Electricity and diesel costs
Real estate costs
Hanoi VN
Ho Chi Minh City VN
Bangalore IN
Delhi IN
Mumbai IN
Chengdu CN
Abu Dhabi AE
Dubai AE
Shenzhen CN
Beijing CN
Poznan PL
Shanghai CN
Warsaw PL
Katowice PL
Tri City PL
Wroclaw PL
Prague CZ
Madrid ES
Seoul KR
Chicago US
Barcelona ES
Dallas US
Philadelphia US
Northern New Jersey US
Inland Empire US
Singapore SG
Baltimore US
Los Angeles US
Lyon FR
Antwerp NL
Marseille FR
Paris FR
Brussels BE
NYC Boroughs US
Dublin IE
Hong Kong CN
Rome IT
Milan IT
Perth AU
Yorkshire GB
Melbourne AU
North West GB
Midlands GB
Berlin DE
Sydney AU
Frankfurt DE
Dusseldorf DE
Hamburg DE
Amsterdam NL



▶ Figure 1.7 details

Locating a warehouse strategically and in the most cost-effective geographic location is one of the most important decisions a company will make. For example, in terms of fulfilment centres, because of the nature of deliveries, an important criteria is the need to be located near to the motorway/highway network and to the parcel hubs to delay the latest collection time from the parcel companies and therefore enable companies to introduce a later order cut-off time for next-day delivery.

For example, Shop Direct – the UK's second largest pureplay e-tailer – has its fulfilment centre on the same site as Yodel's parcel distribution hub.

Grocery retailers with online sales will have a requirement to be much closer to their customers due to the different temperature regimes of the products being delivered. As a result we are seeing some retailers bringing their e-com order fulfilment back in store.

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, is not as important as it would be when locating a retail outlet. According to a European survey carried out in 2016 by Prologis and EFT, the key factors shaping location choice included proximity to economic centres, transport and land costs, and the presence of modern and efficient infrastructure. Positioning to serve global trade routes is also important as is access to highly skilled staff.

Favoured locations include those within the Benelux countries and in Central and Eastern Europe (CEE). Many of these locations are oriented along international and global trade flows and are near Europe's major consumer markets. Other factors include transportation costs, land cost, skilled labour availability, travel minimization and overall cost of operation. The environment will also play a part in the decision-making process. The following are specific factors that need to be taken into account when deciding on a warehouse location:

- cost of land, rent and rates;
- access to transport networks;
- proximity to multimodal hubs;
- availability of affordable, skilled labour;
- languages spoken;
- 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 and airports;
- location of suppliers and manufacturing points; and the potential neighbours (eg proximity to oil storage depots can be a negative factor, as ASOS found out to their cost during the Buncefield oil disaster).

This criteria has ensured that, in general, the prime locations for warehouse deployment have not changed dramatically for decades. However, the rise of online retail has turned this model on its head.

In a Savills survey of the UK, the top nine requirements for e-retailing operations in terms of location were as follows:

- land/rent/lease costs;
- access to affordable labour;
- expansion space available;
- close proximity to parcel hub;
- close to motorway network;
- central location (covering all the United Kingdom);
- close proximity to consumers;
- government incentive; and
- close proximity to higher skilled labour.

Today, goods ordered online can be delivered directly to customers, same day, whether to their home or office (or increasingly to other locations such as lockers, click and collect in other retailers' premises and even the boot of your car), with no intermediate stages. Online retailers have relied heavily on the existing post and parcel network; however, some, like Amazon, are introducing their own network of courier deliveries.

CASE STUDY

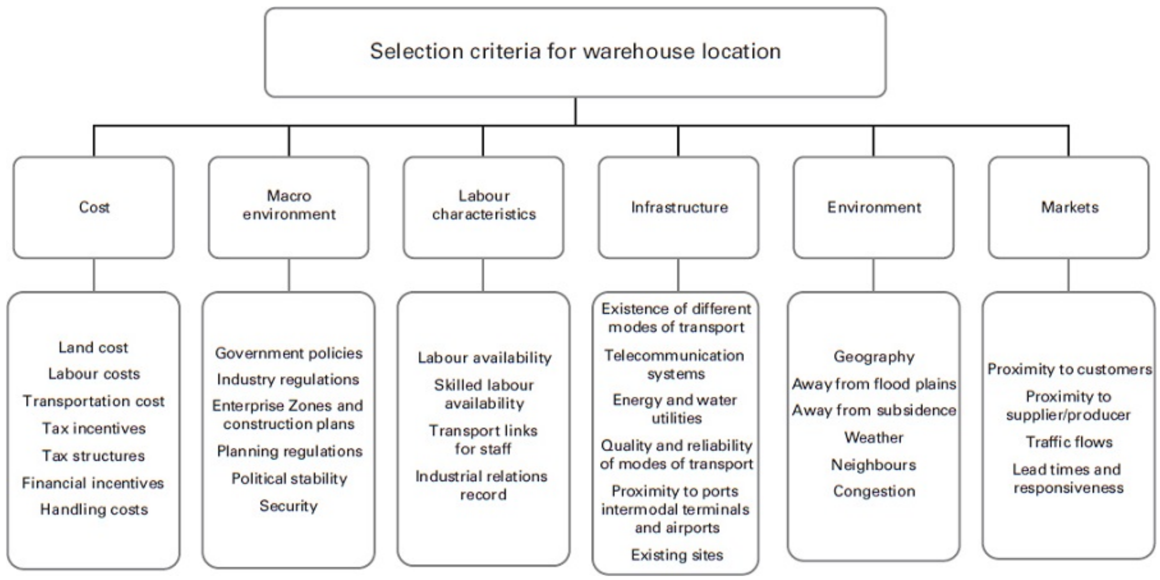
Amazon coped with a single logistics centre in Bad Hersfeld for seven years before opening a second in Leipzig in 2006. Amazon itself expedited this development with the launch of Amazon Prime in its home country, the USA, in 2005 and Germany in 2007. Users of this service, which include almost half of the 41 million households in Germany according to current estimates, receive their goods the next working day or the same day. To guarantee this service it requires larger warehouse inventories than previously and distribution centres located closer to the customers and hence in cities and conurbations. According to MWPVL, Amazon now has 73 warehouse units in Germany, including properties in surrounding areas of Berlin, Hamburg and Munich.

Amazon is not alone in requiring more logistics space in other locations in order to fulfil its service promise. The company established a sector standard so successful that it was adopted by other retailers. Consequently, these retailers now also require additional logistics space. In turn, Amazon subsequently went a stage further and introduced its Prime Now service in many major cities, which offers the delivery of a specific assortment of products within a time frame of a few hours. In Germany, this service launched in 2016 in Berlin and Munich and would be unthinkable without urban logistics space for the 'last mile' delivery. These units, which are even smaller than the regional distribution centres, are now the final link in the supply chain. Here, the goods are unloaded from lorries onto delivery vans, freight bicycles or similar and delivered to the address specified by the customer.

Another example of this is in Tel Aviv where a microfulfilment centre has been built in an old underground parking lot. It has been designed with three temperature zones. This underground dark store will store fresh, ambient, chilled and frozen food items and provide a one-hour grocery delivery service within Tel Aviv.

Demirel *et al* (2010) provide a comprehensive list of criteria for location decision-making (see Figure 1.8).

Figure 1.8 Factors determining the location of a warehouse



SOURCE Adapted and reprinted from *Expert Systems with Applications: Multi-criteria warehouse location selection using Choquet integral*, Tufan Demirel, Nihan Çetin Demirel, Cengiz Kahraman, May 2010, with permission from Elsevier

▶ Figure 1.8 details

Fortunately, the decision on where to site a warehouse does not have to be totally manual 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.

Many of these systems work on the basis of volume centre of gravity calculations that locate the warehouse at the centre of supply and demand by minimizing distances to customers and from suppliers.

A more accurate method is to utilize the cost centre of gravity calculation, which locates the warehouse at the centre of supply and demand by minimizing transport costs to customers and from suppliers.

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

Using software to determine warehouse location

The aim of facility location studies is to ‘optimize’ the logistics network. This is a complex mathematical problem because the number of facilities, their size and locations are all inextricably linked, even before considering the impact of factors such as land values. The optimum solution may be driven by cost, by service level or by aspects such as the capital investment available.

There are a variety of different software solutions available, ranging from the simple to the very sophisticated. They differ in aspects such as the number of product types and the different types of supply chain facilities that can be modelled, whether they can examine multiple different scenarios in batch runs, whether they can consider capacity constraints and/or influence supply choice, and finally whether they use the road network or crow-fly distances. The costs of using such software and the time required to set up more detailed models, vary considerably.

Because it is such a complex problem, any steps that can be taken to simplify the process without losing key attributes should be taken. For example, in deciding where to locate a warehouse within a particular country, it may be more appropriate to use landed cost at ports and airports, rather than replicating the international supply chain within the model. Another area to consider is the granularity of demand geography, the flows that are appropriate, and the difference that additional detail is likely to make.

The data required for this type of study includes: demand and supply locations along with measures such as volume, weight, number of deliveries/collections, product types and the different transit units (items, cartons, totes, pallets, sea containers) that are used in different parts of the supply chain; costs for warehouse facilities and the capacity of any existing locations; inventory costs, particularly if the number of locations is going to be reduced or increased; the balance between the costs of trunking and secondary distribution is key; and future volume forecasts for the expected lifetime of the facilities are also required. Other factors to be considered include order lead times, the inclusion of non-stocked locations such as cross docks, along with practical aspects such as land and staff availability.

Most of the different software solutions will be based on ‘pipeline’ modelling, that is on the average cost over a period, a year or a calculated average day, of transporting X amount of volume over Y one-way distance. It is important to double check input calculations as the resulting figures will probably not be familiar when compared with metrics from the daily operation.

In reviewing the results from any model, it will be appropriate to carry out ‘what-if’ analysis on assumptions made within the model, particularly sensitivity analysis with respect to external cost inputs such as fuel prices and exchange rates, and to use a vehicle scheduling package to confirm resource requirements. Other risk analysis may include business continuity if moving to a single stocked location.

Number of warehouses

A Prologis analysis from 2016 concluded, after taking all variables into account, that for each additional billion pounds in online retail sales, around 775,000 square feet of additional logistics space is required compared with traditional retail. Given the current sales of approximately EUR 70 billion, this means a logistics space requirement of more than 5 million square metres for Germany alone. However, current developments suggest that the Prologis estimate was too conservative with recent work from CBRE, a global property advisor, suggesting that 1.29 million square feet for every £1bn extra spent online is a more realistic figure given recent take-up levels. It will be interesting to observe how this metric evolves given the impact of COVID-19 on warehouse demand and also the level of online retail around the world.

Overall, this has meant that demand for warehouse space has grown significantly as the rate of online retail around the world has increased too. In Europe demand for warehouse space has increased by 102 per cent since 2012 with 2020 being a record year as new leases were signed on 293 million square feet of new warehouse space of which 25 per cent were in Germany and a further 17 per cent in the UK.

In the UK, where online retail growth has been the highest in Europe and reached 28 per cent of all retailing, the impact on warehouse demand has been most pronounced. Indeed, 2020 saw 50.1 million square feet of new leases signed, a new record, and 33 per cent of those new leases were apportioned to online retailers, also a new record in terms of the number of warehouses and overall costs.

In today's e-commerce world, customers tend to place significant weight on quick and cheap delivery. Delivery from a local fulfilment centre is almost always much quicker than shipping from a central location. As such, operating multiple warehouses can improve the customer experience. We can see from Table 1.1 that most costs are higher if multiple warehouses are chosen; however, all of these costs can be offset by a significant reduction in local transportation costs and improved service. As with most areas of the supply chain, there is a trade-off here.

With multiple warehouses you can draw on a buffer of inventory stock kept in another location if there is an issue with one of the other warehouses. For example, Ocado suffered a major fire at its Andover location in the UK, which destroyed the warehouse. Having another southern fulfilment centre in Erith, Kent, enabled the company to fulfil orders from there whilst they set up a temporary warehouse in Andover.

Table 1.1 Comparison between many and fewer warehouses

Skip table

Criteria	Many warehouses	Fewer warehouses
Inventory costs	Higher	Lower
Customer reaction time	Quicker	Slower
Facility costs	Higher	Lower
Inbound transport cost	Higher	Lower
Outbound transport cost	Lower	Higher
Systems cost	Higher	Lower
Risk	Lower	Higher

In terms of inventory, we need to be able to calculate by how much we will increase or reduce our safety stockholding when we change the number of warehouses operated.

One way of doing this is by using the Square Root Rule, which was first introduced by David Maister in 1976. Maister's rule enables companies to quickly calculate the reduction or increase in safety stock required when the number of warehouses is changed.

It states that the total safety stock in a supply chain is proportional to the square root of the number of locations at which a product is stored. The calculation is as follows:

$$\text{Reduction in stockholding (\%)} = [1 - (\sqrt{x} \div \sqrt{y})] \times 100$$

(y = original number of warehouses; x = proposed number of warehouses)

This calculation cannot be used in isolation. Other factors, such as supplier and customer lead times, the product itself (different types of electrical plug, for example), transport costs and distribution centre costs also have to be taken into account.

The rule is based on the assumption that the amount of safety stock in each existing warehouse in the system is approximately the same.

Supply chain trends affecting warehouses

This section examines current trends within today's supply chain and how these are likely to affect warehouse operations.

The e-commerce phenomenon will continue to grow both for business-to-business (B2B) and business-to-consumer (B2C) sectors. From a convenience point of view and under greater environmental pressure, grocery home shopping and delivery will also grow significantly.

This will necessitate more fulfilment centres and returns processing facilities.

Retailers and manufacturers will continue to look for further cost savings as markets become even more competitive. Warehouses will be expected to be more efficient and cost-effective, with the likely closure of inflexible buildings and inefficient operations.

Retailers will continue to take stock out of the supply chain, leading to increases in stockless depots, trans-shipment and consolidation centres and cross-dock operations.

The cost of transport and stock-reduction targets could potentially bring manufacturing closer to the consumer. Eastern Europe has recently become a centre for manufacturing within automotive and electronics and nearshoring is becoming a distinct possibility with US and

European companies bringing some production back to their shores.

The increase in port-centric logistics has resulted in companies building large warehouses as close to the ports of entry as possible. As mentioned, Tesco's 1.2 million square foot warehouse at Teesport, UK, is a typical example.

The miniaturization of products such as mobile phones, DVD players and computers, together with the increasing use of electronic media for listening to music and reading books via downloads, is likely to result in less space required for these types of products but greater security.

The sustainability agenda will also play its part within the supply chain. This will result in the development of further brownfield sites, linkages to rail and potentially canal and river networks, and self-sufficiency in terms of energy use.

Future warehouses will be expected to be carbon positive, which will be backed up by legislation in the future. UK retailer John Lewis built a new distribution centre in the United Kingdom with a view to significantly reducing its carbon footprint. Early results showed savings of 18 per cent in energy costs, 45 per cent in water usage, an overall reduction of 40 per cent in CO_2 emissions and a cost saving of circa £250,000 per annum.

It is expected that new warehouses will be targeted with having their own means of power generation, be it solar or wind, and may also convert waste into power. Greater collaboration within the supply chain, both vertically and horizontally, will lead to greater consolidation and an increase in shared-user operations. This is likely to lead to a reduction in the number of smaller warehouses and the construction of purpose-built centres.

The ability for companies to work closely with each other and trust each other will be a major factor as to how quickly this collaboration takes place. We are already hearing of UK retailers sharing transportation capacity for delivery to stores.

The growth of e-fulfilment and its effect on the warehouse

In 2020 e-commerce sales as a percentage of total retail sales in the US was 21.3 per cent, up 44 per cent on the previous year. In February 2021 e-commerce as a percentage of total UK retail sales reached 36.1 per cent, the highest on record. E-commerce sales are expected to grow from £34 billion in 2021 to £150 billion in 2024.

With regard to warehousing, pure internet traders have had an advantage in developing purpose-built facilities according to a recent TI report whereas existing retailers and manufacturers who are selling online need to adapt existing logistics systems and facilities to meet these new demands or create new ones to accommodate the move to multichannel retailing.

The report suggests that the tipping point for dedicated e-commerce fulfilment centres is approximately 200,000 orders and that warehouses are in the region of 20–60,000 square feet.

There are significant challenges for warehouse managers when operating an e-fulfilment warehouse.

First, these warehouses are significantly impacted by seasonality. The demand on staff and equipment varies tremendously with the seasons: large, bulky items such as barbecues and garden furniture during spring and summer and much smaller electrical products during the run-up to Christmas. These have very different impacts on handling and storage equipment.

Second, the wide range of products stored requires warehouse managers to efficiently process low-value, single-item orders. This is one of the main challenges facing all warehouses today but in particular those dealing with internet orders. Picking and packing low-cost items utilize the same amount of labour and equipment as for high-cost items but the margin is going to be significantly different.

Third, as consumers flex their muscles in the market, accuracy and on-time delivery become paramount if companies are to retain the loyalty of their customers.

Inventory management is another challenge for the warehouse manager. The increase in the number of product lines will put pressure on the number of pick locations whilst slow-moving and obsolete lines can take up much-needed space in the warehouse. From a picking point of view, the proliferation of product lines will result in warehouse managers having to look at alternatives to ground-floor pick locations such as mezzanine floors, flow racking and carousels.

In order to release vital space to the warehouse operation, stock turnover has to be managed well and decisions made quickly regarding the disposal of non-moving stock.

As discussed earlier, one of the main by-products of e-commerce is a large percentage of returns. This can be between 30 and 40 per cent of outward volume. Significantly, many of the returns are good stock that can be resold but have to go through a thorough quality check.

Mark Hewitt, ex-chief executive of iForce in the United Kingdom, sees this developing interest in returns:

> There will be a growing demand for outsourcing e-fulfilment to companies that can also offer returns processing from the same facility, as this will drive down costs by enabling a more efficient process for putting returned goods straight back into stock.
>
> (Supply Chain Standard)

A number of the third-party providers are now assisting their clients with the disposal of the returned goods through having their own eBay stores.

Other possibilities include rewarding consumers for taking returns back to the store where they can be processed by the store staff.

Next-day delivery is seen as the norm, which puts further pressure on the warehouse manager to balance speed with accuracy. Allied to this is the requirement to be able to integrate systems with couriers and customer services to be able to track and trace the progress of each order.

According to Savills, there is no current ‘blueprint’ for the optimum e-fulfilment centre design. Different retailers adopt very different strategies. We are already seeing this in terms of the different automation systems being introduced by retailers into their fulfilment centres. This is discussed further in Chapter 6.

Companies such as Amazon have developed unique systems that are capable of handling extremely large volumes of different types of products (ranging from relatively small in size to larger goods).

Smaller businesses will carry out fulfilment in their retail premises until the volume makes this unmanageable. Many small logistics providers and mail fulfilment firms now offer e-fulfilment, typically in general warehouse premises used for other aspects of the business.

A number of multichannel operators have developed dedicated e-fulfilment centres, once online sales volumes have become large enough.

Others have adopted a strategy of keeping e-retail volumes and traditional store volumes together, either as an opportunity to utilize spare capacity or due to minimal advantage in separating channels. Superdry have recently amalgamated their wholesale, store and e-commerce stock together under one roof.

To summarize, there are three types of fulfilment centre:

- integrated fulfilment, where internet sales are carried out alongside existing retail operations;
- dedicated fulfilment, carried out in a purpose-built facility; and
- store fulfilment, which involves picking online orders from existing retail shelves for separate delivery ex store. A same-day courier service provided by Shutl boasts a record delivery time of 13 minutes 57 seconds for an online order using this channel!

The third option has been favoured in the past for launching the service and establishment of e-fulfilment but is least favoured for a substantive operation.

However as IT systems become more sophisticated, we are now seeing an amalgamation of the above with the system deciding on whether to fulfil the order from the fulfilment centre, the store or even the supplier, whichever is in close proximity to the consumer.

In this next section we briefly discuss four specialist types of warehousing: customs warehousing, refrigerated storage, fashion logistics and hazardous goods storage.

Specialized warehousing

Customs warehousing by Barbara Scott and Gwynne Richards

This section is written specifically for the United Kingdom. However, most countries will have some form of customs warehousing or Free Trade Zones.

Operating a customs warehouse can bring huge benefits to an international trade business by delaying the payment of import duty and avoiding it altogether in the case of goods re-exported outside the UK. This is particularly useful if the company importing goods is unsure of the ultimate destination of the products, ie whether they will be sold on the home market (in which case the duty must be paid) or if they are to be re-exported (duty unpaid).

This section deals only with customs warehousing, which is a regime for the importation and storage of products imported from outside the UK that are liable to customs duty or anti-dumping duty. It does not deal with excise duty products – oils, alcohol and tobacco – which are covered by other specific regulations.

Customs warehouses are operated by warehouse keepers who must be authorized by HM Revenue & Customs (HMRC). There are basically two types of customs warehouse. There is a public warehouse, which is operated by a warehouse keeper who holds goods belonging to a number of companies. Customs responsibilities lie with the warehouse keeper who must ensure that the goods are not unlawfully removed from the warehouse and must keep accurate stock records showing at all times the imported goods held under the customs warehouse procedure. The depositor of the goods in the warehouse is responsible for correctly declaring the goods to HMRC. There is also a private customs warehouse authorization, which is granted for one importer to store his own goods in his own warehouse. No special security measures (eg barred windows, separate areas, etc) are required and there is no time limit for storing the goods in the warehouse. A number of warehouse sites can be included under the same authorization.

As an example of a private warehouse, consider a business importing forklift trucks that are manufactured in China. The rate of duty at importation would be 4 per cent of the landed cost, insurance and freight (CIF) value. If the annual import value is £20 million, the duty cost will be £900,000. By obtaining an approval to operate a customs warehouse (on the importer’s own site), the duty payments are delayed until such time as the forklift trucks are sold into the UK market. At that stage an import declaration is made and the duty is paid; by using the duty deferment scheme, up to a further six weeks of cash flow benefit can be obtained. If the forklift trucks are exported outside the UK, no duty is payable. The cash flow savings and duty saving opportunities are obvious and this has become more significant since the UK has left the EU.

It is true to say, however, that obtaining approval to operate a customs warehouse is not without its difficulties. HMRC effectively hands over control of the border to the inland warehouse keeper so has to be absolutely certain that import charges will be accounted for correctly and that there is no risk of goods being inadvertently placed on the UK market without duty being paid.

The customs warehouse operator may have to invest in a duty management system that interfaces directly with the HMRC's computer system known as CHIEF (Customs Handling of Import and Export Freight) to enable the discharge of the goods to be reported and any duties and VAT calculated. Additionally, if there are daily removals of goods from the customs warehouse, the operator is likely to also need to be authorized by HMRC to use Customs Freight Simplified Procedures (CFSP) and Entry in the Declarants Records (EIDR); without these approvals, a full customs declaration must be submitted to and accepted by HMRC before goods can be removed from the customs warehouse. For EIDR, the operator will also be required to obtain HMRC approval as an Authorized Economic Operator (AEO). An AEOC is a trader or international trade service supplier who, by satisfying certain criteria, is considered to be reliable and trusted in their customs-related operations. AEOS status is an internationally recognized quality mark indicating that a company's role in the international supply chain is secure, and that customs controls and procedures are efficient and compliant.

Customs warehousing can bring substantial benefits both in controlling the flow of merchandise and savings in tax. A first step is to look at the business case and determine the costs and benefits. The use of a customs expert in this area is strongly advised.

Of course, a customs warehouse is only for the storage of goods, although certain 'usual forms of handling' such as repacking or labelling, may take place. If the goods are to be processed, then another customs procedure may need to be used. Post Brexit, the UK government has decided to establish Freeports or Free Trade Zones within the UK with at least one Freeport in each nation of the UK opening in 2021. Freeports are tariff free zones that are considered to be outside a country for customs purposes, allowing goods to be imported, processed and re-exported without any duties or taxes being paid. The UK Freeport locations will be in the Thames region, Liverpool city, the Solent, East Midlands airport, Felixstowe and Harwich, Plymouth, Teeside and the Humber.

Temperature-controlled warehouses by Chris Sturman

The growth in the refrigeration market, due to demand for food that can retain its freshness as opposed to produce with a shelf life, has placed increasing pressure on cold and chilled store operators.

Temperature-controlled warehouses are in the main chilled (approx. +2°C to +8°C) or frozen (approx. –18°C to –25°C), although some specialist facilities for fresh produce can be slightly higher at around +8°C. There can also be a requirement for heated or air-conditioned facilities for some product storage such as chocolate.

The key function of a temperature-controlled warehouse is to maintain the temperature of products at the level at which they were received. Blast freezing and tempering chambers are used for managing any change of temperature required and these activities should take place away from the main storage areas to minimize the risk of temperature deviation (+/–) to goods being held in stock. Cold chain management, to adhere to food safety regulations and maintenance of food quality and safety whilst managing significant energy and materials handling cost levels, are priorities.

At the same time, boards of directors and management need to assess fire and other serious business continuity risks, which are major issues facing both the food processing and storage and distribution industries in the United Kingdom. In particular, adherence to regulations relating to the use of ammonia as a refrigerant need to be assured, along with the competence of the company's own staff and any contractors used for design, installation and maintenance. A business continuity and disaster recovery plan is a core requirement of the business health and safety and good operating proactive regime, with clear management processes and staff responsibilities being clearly identified and staff involvement and training being prerequisites.

Materials handling and storage in a temperature-controlled environment

A wide range of storage media is used, all with the intention of optimizing storage capacity with accessibility, given the high capital and operating fixed and variable costs prevalent in the sector. The most popular are:

- Wide, narrow and very narrow aisle racking. Used in faster-moving operations, particularly in order picking by case and by unit. These suit secondary distribution layouts, where access to a wide range of SKUs is required, and delivery lead times are short. Often reserve stock is held in a national or primary distribution centre (NDC or PDC).

- Drive-in racking. Used for bulk pallet storage and more frequently for longer-term storage, to suit seasonal or batch production and supply peaks or production/packaging operations to meet different packing formats.
- Mobile racking. Buildings must first be constructed with mobility in mind, as the building needs substantial steel runners set flush into the insulated cold-store floor surface. Popular with smaller companies that have higher volumes to store but also need accessibility for range and stock rotation.
- Automated storage. More common in continental Europe, although recent developments on behalf of multinational food processors in the United Kingdom have seen four further high bay stores built and commissioned for primary/national pallet storage and distribution with two more in the planning stage. These provide a very economical upstream solution for customers with volume related flows, and are best attached or contracted to a high-volume production plant. However, they are totally dependent on design and WMS software for operational capability and capacity/speed, and these demand high standards of presentation within the design pallet gauge. Reliability is key, with benefits in low manpower and energy costs.

Whilst mainly delivering full pallet quantities to the retail and foodservice supply chain, latest developments in automation include layer and case picking capabilities to meet specific customer requirements.

- Cross docking and urban consolidation – With the increase in internet shopping and e-commerce, we are seeing the development of micro hubs within or close to cities and large towns for last mile delivery, mainly to domestic consumers. Fast-moving, prepicked consignments move from inbound feeder vehicles to final-mile specialist delivery units, which can vary from light vans to cargo bikes and other technology-based distribution solutions. A similar materials handling approach is taken, aligned to those already in place within retail RDCs and 3PL temperature-controlled multi-customer networks.
- Recent innovations include inflatable and also modular units, which can be installed inside or outside an existing facility. Dawson Group in the UK provide 10 m^2 and 26 m^2 inflatable units. Each inflatable chill store can fit on just two pallets when deflated, eliminating many access issues and restrictions that could rule out other temperature solutions. The structure's height of 3.68 m allows for full forklift accessibility. Units can be linked together to increase capacity up to 60 pallets in total.
- Modular units can provide additional storage capacity. These can operate between temperatures of −60 to +85°C.

CASE STUDY

REWE Markt GmbH is one of the pioneers of digital food retail in continental Europe.

REWE decided to invest in the Scarlet ONE project – which has become the company's very first automated food fulfilment centre (FFC) – at their site in Cologne and equipped with innovative technology from KNAPP.

Customers can shop for their groceries in the REWE online shop and have them conveniently delivered to their door.

REWE's range of goods comprises over 20,000 grocery lines – from fruit and vegetables, dairy products and drinks to fresh, frozen and shelf-stable goods – offering customers a vast array of food and beverages online. The centre's high degree of automation allows gentle product handling and the cold chain is maintained across all areas, from incoming goods to delivery. All this allows customers to choose from a large selection of fresh groceries.

The 16,000-square metre FFC uses state-of-the-art technologies and optimum processes so that customer orders are prepared for same-day and next-day deliveries. The solution includes the following:

- OSR Shuttle™ for storing and picking fresh and shelf-stable goods;
- OSR Shuttle™ for sequencing, consolidation and shipping;
- Pick-it-Easy workstations for ergonomic and efficient grocery picking; and
- dolly loader for fully automatic stacking of order containers according to efficient delivery routes.

The OSR Shuttle™ provides access to every product and supplies just in time to the adjoining Pick-it-Easy workstations. The system guides employees through the process, no matter which area they are working in. Simple guidance and clear information allow efficient work processes, regardless of whether the employees pick fruit and vegetables manually or work at the semi-automatic Pick-it-Easy workstations for fresh and shelf-stable goods. System interfaces make intuitive interaction possible. The user can navigate quickly through the individual work steps using touchscreens.

Once picked the orders are optimally sequenced and stacked for shipment in perfect coordination with the departure times.

> *Our focus was not just on efficiency. Ergonomics also played an important role during the development of the installation. In manual picking, the goods are always directly accessible, which helps us ensure that they are supplied in the best quality. Thanks to their Pick-it-Easy work stations, KNAPP could fulfil our wishes and requirements.*
>
> (*Andreas Palmen, general manager*)

Key figures

Performance:

- 3,500 orders/day capacity (avg);
- 4,700 orders/day capacity (peak);
- 106,000 order lines/day capacity (avg);
- 150,000 order lines /day capacity (peak);
- 206,000 single units/day capacity (avg);
- 290,000 single units /day capacity (peak, without Christmas).

Picking:

- 4 Pick-it-Easy workstations for chilled food;
- 6 Pick-it-Easy workstations for shelf-stable goods.

Performance

- >600–700 picks/hour.

VIDEO 1iv REWE and KNAPP

In Video 1v Swisslog have introduced automated guided vehicles into United States Cold Storage and utilize cranes for automated put-away.

VIDEO 1v Connecting production and distribution in a deep freeze by Swisslog on behalf of United States Cold Storage

The most recently constructed frozen food facilities in the UK are highly automated sites, with high-density storage areas. These types of storage media result in less air circulation and as a result reduced energy usage.

The UK's pioneer frozen food logistics facility was opened in Wisbech, Cambridgeshire in 2010. The store, now operated by Lineage Logistics, has space for 77,000 pallets, operates at temperatures of –27°C, and measures 175 metres by 88 metres by 36 metres high. After the 2009–15 recession where only dedicated logistics facilities were built, two more shared use facilities at Wakefield (operated by NewCold) and Peterborough (operated by Lineage) have since been commissioned and overtook Wisbech during 2018. The Peterborough facility has a 92,000-pallet capacity. A further VLCS (very large cold store) from Newcold is close to completion in 2021.

The following video is one of Newcold's automated temperature controlled warehouses.

VIDEO 1vi Newcold

According to Avanta, built in 2014, 2800 Polar Way in Washington, USA. is the largest refrigerated warehouse in the world at 505,000 square feet. The facility is operated by cold storage specialists Lineage Logistics who have a combined worldwide capacity of 1.3 billion cubic feet.

The demand for new cold storage space in the UK has increased due to two key factors:

1. Replacement of life expired facilities for economic and environmental reasons (banning HFC refrigerants).
2. Stock holding solution to follow the exit of the UK from the European Union.

Density of storage is achieved by drive-in racking. This uses the cube of the building efficiently and is important in terms of economies for energy usage.

All these cold stores require specific types of MHE equipment, which are specially adapted by the manufacturer to be able to operate efficiently in chilled and sub-zero environments. Key aspects include:

- heavy-duty batteries designed for a minimum eight-hour shift life;
- special hydraulic oils to withstand sub-zero temperature levels; and
- electronic and electrical systems encased or coated to prevent moisture ingress.

In some cases, trucks are fitted with heated cabs to avoid driving staff having to wear special temperature-controlled clothing. This enables them to work longer since they no longer need the in-shift warming breaks (see Figure 1.9, courtesy of Translift).

Figure 1.9 Translift articulated truck for use in a refrigerated environment

Energy management and plant maintenance

Energy is a large proportion of operating costs, ranging from 12 to 40 per cent. The actual amount will depend first on the age and condition of the building, relative thermographic integrity and the age and management of refrigeration plant, and second on equipment management and maintenance.

Buildings flex naturally, but cold stores more so, because of the temperature and humidity range between the inside and outside environments. The most important area of focus is the avoidance of heat ingress into the cold space through panel joints, doorframes and structures. An annual thermographic scan with immediate attention to panels and joints is essential. The second priority is to ensure that no condensation settles on top of cold box structures, which, depending on the time of year, can repeatedly freeze and melt, with potential ingress through surrounding joints into the panel structure, thereby allowing delamination and subsequent structural strength decay.

The shifting of energy loads to more suitable and cost-effective periods, thereby reducing the tariff rate or alternatively agreeing to be cut off at peak load periods, are methods of energy-cost reduction. An alternative and latest version of this is to be paid to agree to have supply curtailed for a fixed period on a timed basis.

The focus on energy and carbon reduction has resulted in significant research in techniques by which to generate even greater improvement. These include:

- a reduction in cooling demand by ensuring that product enters at the correct temperature;
- improved plant design;
- improved operational management and maintenance;
- recovery of heat to use elsewhere in the business – hot water, space heating, etc;
- examination of the use of CHP (combined heat and power) – tri-generation; and

- consideration of low carbon electricity – wind, wave or hydro-electric.

In addition, there are more radical approaches, with more positive and closer store management attention. These are as follows:

- carefully review the cold-store room layout and thereby change the temperature flows;
- raise refrigeration evaporating temperature for a potential 11 per cent or more cost saving;
- reduce refrigeration condensing temperature;
- seasonally adjust refrigeration to take account of external ambient temperature;
- where fitted, split cold-store and blast-freezer refrigeration systems;
- install and use variable-speed drive fans; and
- focus on and manage more closely door opening design and operations.

Safety and risk assessment

There are two different types of refrigerants used in temperature-controlled stores. These are either hydrofluorocarbon/hydrochlorofluorocarbon (HFC/HCFC) or ammonia-based, with sometimes a brine or Freon secondary refrigerant, to minimize the ammonia charge.

HFC-based refrigerants are currently being phased down over a 15-year period under the F-Gas Regulations 2015. This EU legislation followed the adoption of the Montreal Protocol, to reduce Ozone Depleting Substances (ODS) or those with high Global Warming Potential (GWP).

The only economically realistic alternative is ammonia, a naturally available chemical. However, ammonia has dangerous and explosive attributes that require specific risk assessment and management (EU/UK ATEX/DSEAR Regulations 2002 or equivalent in other countries).

Additionally, legionella risk assessment and management of condensers are required to ensure the safety of workers and occupiers of adjacent properties.

Stock management and housekeeping

In addition to the normal stock-management processes found in conventional warehouses, the following specific processes can be found in the temperature-controlled sector:

- *Traceability*. EU 178/2002 sets out specific requirements for food safety, traceability and recall of unsafe foods. Warehouse operators should carefully consider whether they can be classed as food business operators (most public cold-store operators are) and register accordingly. Stores handling and storing products of animal origin also need to be approved by their Local Authority.
- Food Standards Agency Guidance Notes are available, which should be considered along with the Food Safety Act 1990 (Amendment) Regulations 2004 and the General Food Regulations 2004, along with requirements for marks and labels, which differ depending on whether the product has been prepared for final consumption. Food Labelling Regulations 1996 (Regulation 35) also need to be considered.

- Subsequently, EU Regulation 852 on the hygiene of foodstuffs and Regulation 853 laying down specific hygiene rules for food of animal origin require (inter alia) the maintenance of cold chain, implementation of procedures based on HACCP principles, consultation of good practice guides, and establishment of micro-bacterial and temperature-controlled requirements based on scientific risk assessment, albeit that this requirement applies to storage and transport but not to retail establishments.
- *Temperature checks*. All stores need to be fitted with temperature-monitoring equipment that is checked on a shift or am/pm basis and records kept for regulatory and operational analysis.
- *Product checks*. All products should be checked on intake to ensure that the product is sound and to specification. They should then be checked outbound to demonstrate to the collecting company and final receiver that they were at the specified temperature level on despatch. Care should be taken not to damage product at any time.
- *Segregation*. All damaged or unfit product should be labelled or marked and removed to ensure it cannot move further down the food chain.
- *Date codes*. Particularly with fast-moving chilled products, codes need particular attention to ensure correct rotation and 100 per cent acceptance at retail RDC or other final delivery point.
- *Product spills*. Need quick response, to avoid crushed product and packaging from spreading across the working space, and ingestion into the working parts of equipment.

(Note: The Withdrawal Agreement achieved as part of the UK exit from the European Union in 2020 has continued with the standards previously established in EU Directives and regulations and these will continue to apply until subsequently amended by UK legislation. This applies equally to Food Safety as well as Climate Change and the Environment.)

Health and safety issues

Additional hazards are particularly harsh at zero degrees or below, but can still apply in certain cases to the chilled chain.

Specific issues surround the effect of cold temperature and the cold environment on people, and will also vary by type and size of facility and operations being undertaken.

Specific hazards include:

- accidental lock-in risk, requiring alarms and quick-release equipment;
- the effect of cold on people and use of PPE require specific advice and training for staff to wear appropriate thermal clothing, drink lots of water, protect bare skin (particularly fingers, noses and ears), taking greater care if smokers or drinkers;
- accidental release of refrigerant, particularly ammonia;
- use of materials-handling equipment in slippery floor areas where ice build-up may occur, particularly around door openings. Slip and trip hazards are ever present along with the risk of skidding and overturning;
- ice build-up on panels presents an ice-fall hazard, and can, if left, cause roof panels to fall, risking injury to operators below;

- product falls from pallet racks, due to displaced product; and
- working at height: the use of non-integrated platforms using forklift trucks has effectively been eliminated from all stores other than in sub-zero temperatures, and the use of mechanized elevating working platforms (MEWPs) is obligatory. However, these items of equipment are not equipped for sub-zero temperatures. Here the practice is closely scrutinized as agreed between the industry and the Health and Safety Executive.

The Cold Chain Federation, British Frozen Foods Federation and Health and Safety Executive worked together to deliver a Supplementary Guidance (PM 28) during 2010 to help manage these risks.

Transportation issues

These revolve around the loading dock, where operational regimes need to ensure the maintenance of the cold chain, preventing temperature migration between the cold store, the outside temperature and the open vehicle whilst loading and unloading.

Solutions include the use of dock ports and shelters, with close-fitting seals around the door apertures of the vehicle, and air curtains to prevent the ingress of warm air.

Vehicles should be designed to maintain and record temperatures and operators trained to minimize hot air ingress into the load space, particularly in an urban environment. Here care needs to be taken to minimize the level of emissions caused by existing vehicles and refrigeration units after growing concerns about urban pollution and particulate emission levels.

Between 2018 and 2021 significant research and development has taken place regarding vehicle refrigeration units and has produced solutions that are no longer powered by fossil fuels. These initiatives have been introduced as a result of the government's intention to remove the taxation rebate on red diesel.

Summary

Overall, housekeeping regimes in any environment require the provision of a safe, clean, clear, unobstructed floor or work space to allow for the safe movement of goods, vehicle equipment and people. Extra care is required when handling food products that are intended for human consumption. The temperature-controlled environment also requires that extra care is taken to address condensation and ice build-up on equipment, floors and walls, and that operational spaces and processes are designed with the health and safety of people and product in mind.

Risk assessments, safe systems of work and operational methods and instructions need to be developed and communicated to all staff and visitors to the warehouse with that as the key priority.

Fashion logistics

With large and fast-changing product ranges, as well as dramatic seasonal fluctuations, the fashion industry has demanding logistics requirements.

The need to balance distribution capacity between replenishing retail stores, fulfilling online orders and dealing efficiently with returns is making warehouse automation an increasingly attractive option for the fashion industry.

Fashion products are either boxed or travel as hanging garments. This mix of items requires different handling capabilities and ensuring that expensive items of clothing are not creased or crushed in transit through the supply chain provides supply chain and warehouse managers with some interesting challenges.

Companies are able to store coats and dresses on movable rails within the warehouse; however, a more efficient and space effective method is to use some form of automation.

With e-commerce presenting the challenge of large numbers of orders that each have a small quantity of items, various companies have developed concepts that looks to bridge the gap between hanging and boxed product. These solutions allow flat-packed goods and hanging garments to be processed together, for the first time, on the same system. The system consists of hanging pockets – suitable for flat-packed clothes, shoes, accessories, books, DVDs or toys – that are conveyed to a matrix sorter so that they arrive at the packing stations in the correct sequence to collate each customer’s order. The pockets can be fitted with RFID tags and the solution can process up to 10,000 items an hour.

Figure 1.10 Sorter bag system

SOURCE Courtesy of KNAPP

The utilization of a hanging garment sorter means that the cube of the building can be fully utilized with rails travelling above the work and storage areas.

VIDEO 1vii KNAPP – Fashion warehouse

Storage of hazardous products

This next section provides a few guidelines with regard to the storage of hazardous products.

First, you need to identify what is and what isn't hazardous. The UN classification of dangerous goods provides a comprehensive list of items – commonly known as UN classification.

A number of hazards may be created when storing packaged dangerous substances. These hazards may affect people working within the storage site, the emergency services when dealing with an incident, the general public off site and the environment.

In a warehouse, fire is generally considered to be the greatest hazard. This is because many people can be exposed to dangers such as radiated heat, missiles such as aerosols, harmful smoke and fumes. There will also be other hazards within your storage area that you should consider. In rare cases, certain stored substances can undergo violent decomposition when engulfed in flame, and an explosion can result.

Common causes of incidents are:

- lack of awareness of the properties of the dangerous substances;
- operator error, due to lack of training and other human factors;
- inappropriate storage conditions with respect to the hazards of the substances;
- inadequate design, installation or maintenance of buildings and equipment;
- exposure to heat from a nearby fire or other heat source;
- poor control of ignition sources, including smoking and smoking materials, hot work, electrical equipment, etc; and
- horseplay, vandalism and arson.

As a result, the storage of hazardous products either requires a separate building or a separate zone within a building.

The following are specific requirements of a hazardous goods warehouse as outlined by Rushton, Croucher and Baker (2017):

- secure areas with restricted access;

- access doors fitted with restricted entry devices and lock-down capability;
- specialist extinguisher systems such as sprinklers;
- emergency lighting;
- automatic air ventilation systems;
- bunded storage area where spills are contained and prevented from leaking away (usually a low wall);
- racking with protective mesh to prevent the escape of products such as exploding aerosols;
- storage cabinets for flammable product storage;
- drench showers and eye wash stations for staff;
- storage area for appropriate personal protective equipment;
- safe escape routes for personnel, which are clearly signposted and illuminated; and
- audible and visible alarm systems.

Hazard classification

Packaged dangerous goods have their own well-defined hazards, often detailed on the material safety data sheet (MSDS), and a specified safe method of storage.

Certain types of packaged dangerous substances may give rise to additional hazards within a warehouse. These different types of dangerous substances should therefore be assessed when considering a risk control strategy to ensure there is sufficient segregation, etc. Interaction between different dangerous substances may create additional hazards.

Dangerous substances should be received into a chemical warehouse by a competent person who understands all the risks that they pose and can decide on where to store them and how to segregate them, having regard to their physical and chemical properties, the quantities concerned and the sizes of the packages.

Regulations require employers to assess the risks to workers (and others who may be affected by their work or business), which may arise because of the presence of dangerous substances within the workplace.

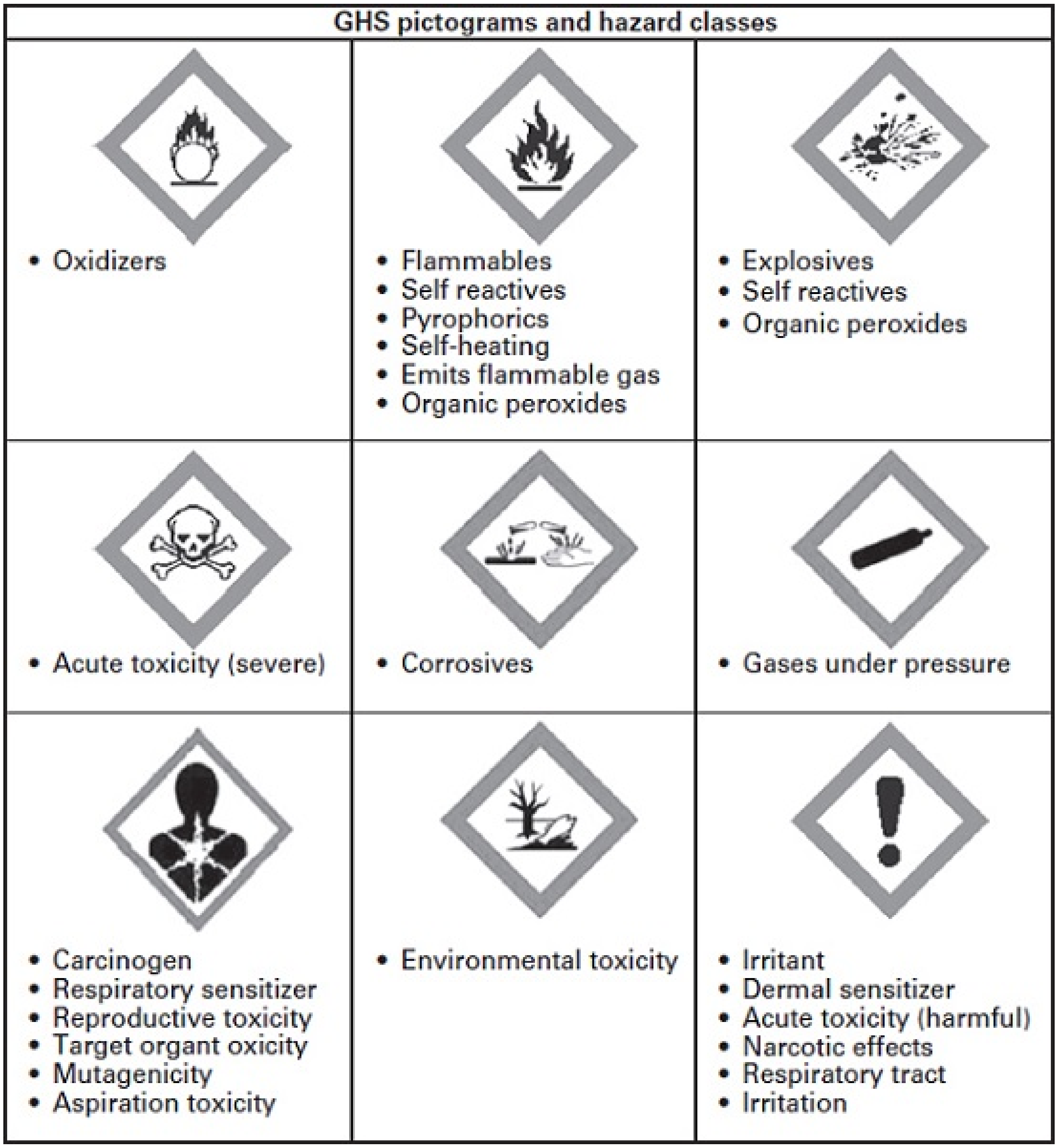
In completing the assessment, employers should consider the hazards arising from their work activity and the risks to employees (or others) and take steps to control these risks.

Risk assessment can be broken down into five steps:

- Step 1 Identify the hazards.
- Step 2 Decide who might be harmed and how.
- Step 3 Evaluate the risks and decide on precautions.
- Step 4 Record your findings and implement them.
- Step 5 Review your assessment and update if necessary.

Figure 1.11 shows the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Figure 1.11 Classification and labelling of hazardous products



SOURCE https://www.osha.gov/Publications/HazComm_QuickCard_Pictogram.html

▶ Figure 1.11 details

The storage of hazardous products is covered by a raft of legislation. This legislation is outlined on the Health and Safety

Executive website for the United Kingdom. It can be accessed at http://www.hse.gov.uk/pubns/books/hsg71.htm.

Other countries will have their own guidelines and legislation.

In the United States, details can be found on the OSHA website: https://www.osha.gov/Publications/warehousing.html.

Summary and conclusion

There are many types of warehouses operating within very different supply chains. No longer are they simply stockholding points.

The transfer of supply chain control from manufacturers to retailers in the 1980s and 1990s has seen a significant change in the operation of storage facilities worldwide. Warehouses are, in the main, no longer seen as static storage units. Concepts such as consolidation, cross docking and postponement have become commonplace with the ultimate goal of stock reduction and increased throughput within the whole supply chain.

Retailers are continually looking to move stock back through the supply chain, thus releasing more sales space in store. This requires more control over the supply chain, improved forecasting and accurate and timely information flow.

The advent of e-commerce has also changed the warehouse landscape appreciably, as has the necessity for cost reduction and the growing pressure to reduce the impact of logistics operations on the environment.

Companies are continually striving to reduce inventory within the supply chain and the continuing use of offshore manufacturing, increasing consumer choice and a predilection for instant gratification ensure that stockholding remains a necessity even in these days of JIT, ECR and QR.

Warehouses remain a crucial link within today's supply chains. As a result, warehouse managers and their colleagues need to be better equipped to manage a constantly changing environment and also need to work closely with their counterparts in their wider supply chains.

02

Role of the warehouse manager

Introduction

Today's warehouse managers no longer patrol the warehouse in brown coats clutching a clipboard and pencil. They are more likely to be in a suit or corporate uniform, use a personal digital assistant (PDA) and more often than not are seen hunched over a laptop deciphering the latest cost and productivity figures.

This chapter examines the challenges facing today's warehouse manager and the attributes required to deal with them. Each challenge is introduced to the reader and is further examined in detail in the remaining sections of the book.

One of the main challenges for the warehouse manager before we begin to look at the warehouse itself is whether they and their colleagues see themselves as the right person for the job.

Nick Weetman, commenting in *Retail Week* (2009), said:

> It is a neglected area. The effort expended on developing warehouse management is not proportionate to the importance of the warehouse as a business… We see a lot of warehouse management where people have just been promoted and don't really understand how to run warehouses. Those (retailers) that do have it in-house need to understand it's a critical part, and retail is just the end of the supply chain.

Although the quote is over 11 years old, it still rings true today. Warehousing still isn't seen as a career of choice for many graduates. Its image remains one of a ‘place to store things’ rather than a dynamic workplace where speed, accuracy and visibility is crucial for ensuring efficiency in today’s supply chains. Maybe we should rename all warehouses as fulfilment centres and take the emphasis away from storage.

A recent job description for a distribution centre manager required the following key skills and outlined core accountabilities that are typically sought from today’s senior warehouse managers: these included an ability to negotiate, information technology skills, basic finance and business acumen, people management skills and an ability to motivate and lead large numbers of employees through communication and engagement.

These are very much people skills and as Lee Iacocca (1984) said: ‘Management is nothing more than motivating other people.’

The job description and the core accountabilities were as follows:

- the provision of a responsive and cost-efficient warehouse that is aligned with the current and long-term requirements of the global business strategy;
- responsibility for the leadership and direction of the warehouse team;
- to ensure that the warehouse is capable of delivering the volume requirements of the business;
- to drive continuous improvement in the cost-efficiency of the operations;
- to set the long-term vision for the warehouse in line with the strategic plan and to ensure that future volumes and customer service requirements can be met;

- to safeguard the human and physical assets employed in the warehouse;
- the management of projects and introduction of new initiatives;
- to maintain strong relationships with suppliers; and
- the development and management of industrial relations within the warehouse environment.

Add to this the pressure to reduce the effect of the warehouse operations on the environment.

The people aspect is very important and a job description for a distribution centre manager produced by WERC suggested that the manager needs an ability to:

- develop and maintain a productive work team by creating programmes for hiring, training and professional development;
- match the skill and background of personnel to the work required;
- apply sound communication and motivational techniques, create programmes to supervise, counsel and discipline associates; and
- implement an appropriate performance evaluation system for recommending promotions, wage increases and terminations.

The warehouse manager has a number of operational challenges and is also expected to understand and implement company strategy in relation to warehouse activity.

Again, we see the trade-offs that the warehouse manager has to deal with. These include cost versus responsiveness and cost-efficiency versus volume throughput.

It is good to see that safeguarding human assets is included in the list of core accountabilities as this is a common worry for warehouse managers.

Today's manager has to maximize the effective use of his/her operational resources whilst satisfying customer requirements. This can be done effectively through motivating and managing staff effectively. As Richard Branson once said: 'Success in business is all about people, people, people. Whatever industry a company is in, its employees are its biggest competitive advantage.'

The above job description is reasonably typical of the requirements of a warehouse manager in today's fast-moving economic environment. The expectation is that the manager will achieve high customer service levels but also reduce cost through improved productivity and performance. Added to this is the constraint of lower inventory, reduced customer lead time and the pressure to ensure the safety and security of staff, equipment and stock.

The six basic principles of warehouse management can be summed up as follows:

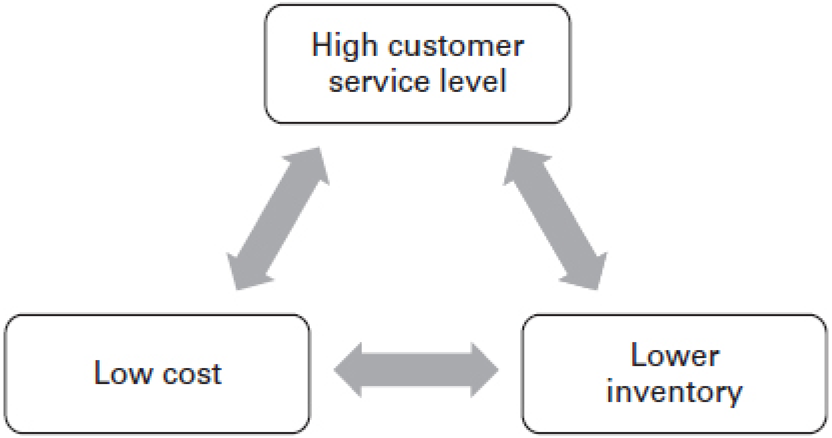
- **a**ccuracy;
- **c**ost control;
- **c**leanliness;
- **e**fficiency;
- **s**afety; and
- **s**ecurity.

Warehouse trade-offs

Managing trade-offs within the warehouse is fundamental to the role of warehouse manager.

The main trade-offs are shown in Figure 2.1.

Figure 2.1 Warehouse trade-offs



▶ Figure 2.1 details

Warehouse managers are also expected to recognize and balance other trade-offs within the warehouse, examples of which are as follows:

- increased throughput versus reduction in labour costs;
- increased service levels versus reduction in labour costs;
- storage density versus quicker pallet extraction;
- manual versus costly automated processes;
- increased pick rates versus accuracy;
- inventory holding costs versus cost of stock outs; and
- speed versus safety.

Today's challenges are many and varied and require additional skills from the warehouse manager.

The next section examines the specific challenges.

The warehouse manager's challenges

Pressure on today's warehouse manager comes from many different directions. These are both internal and external pressures.

A recent survey carried out by Intermec suggested the following:

- Nearly 3,000 hours per year are lost in warehouses and DCs through inefficient processes.
- 80 per cent of managers have been tasked with finding cost savings in existing operations.
- On average, managers have been tasked with finding nearly 20 per cent cost savings across their organizations.
- The majority of managers suggested the following areas were most inefficient:
    - inventory control (53 per cent);
    - picking (47 per cent);
    - put-away and replenishment (45 per cent).

Couple this with the cost of error in a warehouse amounting to at least US $59 per order and the pressure on the warehouse manager increases significantly. One surprising fact that came out of the survey was that one in six managers will not review their workflow processes until they receive a customer complaint (Intermec 2012).

The main pressures and challenges are as follows:

Pressure to reduce operating costs

Companies are targeting the supply chain as an area where costs can be reduced further and as a result, pressure is increasing on transport, logistics and warehouse managers to reduce costs whilst also increasing customer service.

This has resulted in companies evaluating outsourcing options as well as reviewing their own logistics operations.

Achieving the perfect order

A recent key performance indicator (KPI) introduced into the supply chain is the perfect order metric. A perfect order is deemed to be one that has been delivered on time (at the exact time requested by the customer), in full (the correct number and actual product initially ordered by the customer), in perfect condition (with no quality or damage issues) and accompanied by the correct paperwork (accurate delivery notes, invoices, customs documentation, etc). This metric includes many of the current supply chain performance measures and providing everybody uses the same parameters it can be adopted as one of the leading supply chain benchmarks and a differentiator between companies and supply chains. If we ever get to totally paperless transactions, we may need to re-think the fourth metric.

Shorter order lead times and stock availability

Order lead time is the length of time between the placing of an order and the receipt of the item by the customer. Order lead time can be a significant differentiator between competitors. For example, if your favourite cereal is not on the shelf of the supermarket, you are unlikely to wait for the next delivery but will look for it in another store or choose the closest alternative, whether from the same or different brand. Online consumers are likely to choose the quickest delivery method providing the quality and costs are similar.

The quality of products is such that competitive advantage is gained through fast, timely and accurate delivery. With the internet providing price transparency through a proliferation of price comparison websites, competitive advantage is now gained through offering the best service by whatever channel the consumer decides. We are now in an omni-channel world where customers are provided with a seamless shopping experience whether they are shopping online from a tablet, desktop or mobile device, by telephone or in a bricks and mortar store.

Thus, the most effective warehouses are those that have adapted quickly to these changing times and have reduced order lead times whilst maintaining quality at a reduced cost.

Some online retailers are now offering same-day delivery, which further increases the pressure on supply chains and more specifically, warehouse managers.

Delivery through multiple channels

Companies are increasingly selling via multiple channels to reach customers more effectively. The pressure on the warehouse is brought about through having to present goods in a variety of different ways.

These include direct delivery of single items to the end user or a collection point, multiple SKU orders direct to store and bulk orders to retail distribution centres. Each has its own different pick requirement and is likely to rely on different skills and equipment. Order lead times will also vary, as will the method of delivery.

Steve Smith of Manhattan Associates (*Supply Chain Standard*) summed this up when he said:

> Moving from a comparatively uncomplicated process of supplying and replenishing high street stores – with some added complexity around special promotions – to an online presence with fulfilment from either a

store or a warehouse, be that dedicated or part of an existing facility, creates complexities associated with ‘singles’ picking, small order volume, the number of deliveries, time limits, availability issues, and so on.

Smaller, more frequent orders

Manufacturers and retailers are continually striving to reduce inventory whilst retail stores are looking to increase floor sales space and thus reduce the amount of inventory held in stockrooms. Just-in-time (JIT) methods, increasing internet sales and initiatives such as efficient consumer response (ECR) and quick response (QR) are resulting in smaller, more frequent orders. This again necessitates changes in warehouse operations, with a move away from full-pallet picking to carton and individual-item picks.

Greater fluctuations in demand

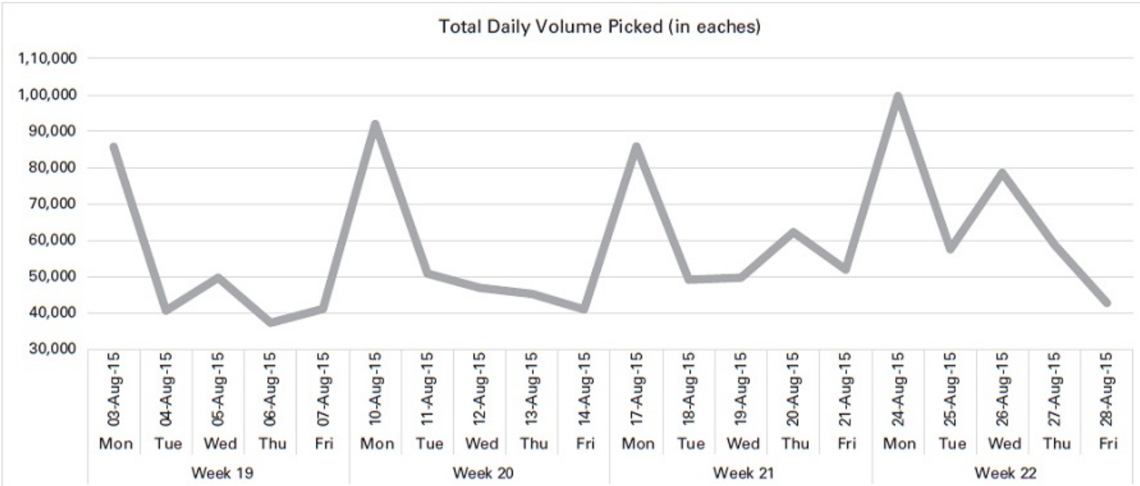
The days of predictable sales are long gone, with consumers rather than manufacturers flexing their muscles in the marketplace. Seasonality remains a factor in terms of market sectors such as fashion, whilst pre- and post-Christmas sales are now stretching warehouse resources to the limit as the rush to get product to stores intensifies. Retailers are also having to cope with ‘Black Friday’, ‘Cyber Monday’, ‘Singles Day’, Chinese New Year and many other holidays, which have become synonymous with heavily discounted sales and large volume throughput.

Companies have to be able to ramp up resources during the peak periods and have a much leaner operation during slower, quieter periods.

The clothing manufacturer shown in Figure 1.5 operates with a core team of seven warehouse staff, which can increase to over 40 during busy periods.

The retailer depicted in Figure 2.2 has very high daily fluctuations as can be seen in the figure below. Mondays are always busy as stores are replenished from the weekend.

Figure 2.2 Daily picked volumes UK retailer



▶ Figure 2.2 details

Increases in stock-keeping units

The proliferation of product lines gives the consumer choice; however, it is a major challenge for warehouse managers in terms of having sufficient, cost-effective pick locations. Once operators have to pick items at height, productivity rates reduce significantly.

Retailers continue to seek differentiation and as a result are continually looking to introduce product variants, not only in terms of the product itself but also in pack size, the type of packaging, labelling and product combinations. Retailers are also introducing more of their own-brand labels to provide consumers with even greater choice.

This has led to a number of companies introducing postponement into the warehouse. This entails holding stock of the basic product and only adding the ‘extras’ once orders have been received. Examples include loading specific software onto personal computers, adding additional memory or including extras such as monitors and keyboards – known as bundling. Other examples include labelling products in different languages for particular markets.

Labour cost and availability

During periods of high employment many countries are seeing labour rates steadily increasing and coupled with the fact that a number of countries have an ageing population it is becoming harder to source experienced warehouse operatives. Additionally, working in a warehouse is not seen as being the most glamorous of occupations and this deters a number of young people from entering the industry.

Warehouse managers need to come up with ways to attract new staff.

Many workforces have been supplemented with the introduction of staff from abroad. In these circumstances companies need to look at employing bilingual supervisors and contemplate the use of new technology such as voice-directed processes. The Lydia-Voice system has the capability of operating in 80 different languages. There is also the added challenge of health and safety, ensuring that international staff are able to read and understand instructions which are not in their native tongue.

Another way to attract staff is to be flexible on working hours. This can include shifts that coincide with school hours or with spouses' work hours, such as twilight shifts. The length of shift can also be varied to coincide with worker preferences. This can also attract student workers. Although potentially difficult to organize, this can prove beneficial in the long run.

Parkinson's Law suggests that work expands to fill the time allowed. This can be a problem in many warehouses when volumes are low. The introduction of annualized hours or even zero-hour contracts allow companies to match resource to demand as and when required. These types of contracts have to be fair to both sides – flexibility for the employer is one thing; however, it also has to work for the employee.

The introduction of apprentice schemes and closer interaction with local schools, colleges and communities will also assist companies in attracting more staff.

Finally, there can be a tendency, at times, to over-resource. This decision will generally be made by a first line manager either appointing a permanent member of staff or ordering labour from an agency. Many operations fail to have clearly defined rule sets for these decisions. If first line managers have too much autonomy to make resourcing decisions, they will over-resource. The reason for this is that the pain of service failure is more immediate than answering for an overspend.

Environmental issues

Warehouse managers are not only tasked with cost savings but also the reduction of the warehouse's impact on the environment.

This includes areas such as energy consumption, affecting areas such as lighting, mechanical handling equipment (MHE), cooling and heating.

Managers need to set examples by switching off lights and heaters when they are not in use and ensuring that MHE is operating optimally.

The issue of waste is also high on the environmental agenda. The warehouse can generate a great deal of waste in its daily operation. This includes stretchwrap, cardboard, tape, pallets, etc. These need to be closely controlled and, where cost-effective, recycled, reused or turned into energy. Ways of reducing a warehouse's effect on the environment is discussed in more detail in Chapter 15.

Data and information transfer

One of the warehouse manager's greatest challenges is how to manage data. Today's supply chain produces vast amounts of data and it is up to the warehouse manager among others to analyse this data and use it effectively.

A further challenge is ensuring that data is transferred to the correct location. It has been said that supply chains are all about the transfer of information and products are a secondary thought. The ability to track items throughout the supply chain is paramount, especially in the food and pharmaceutical market sectors.

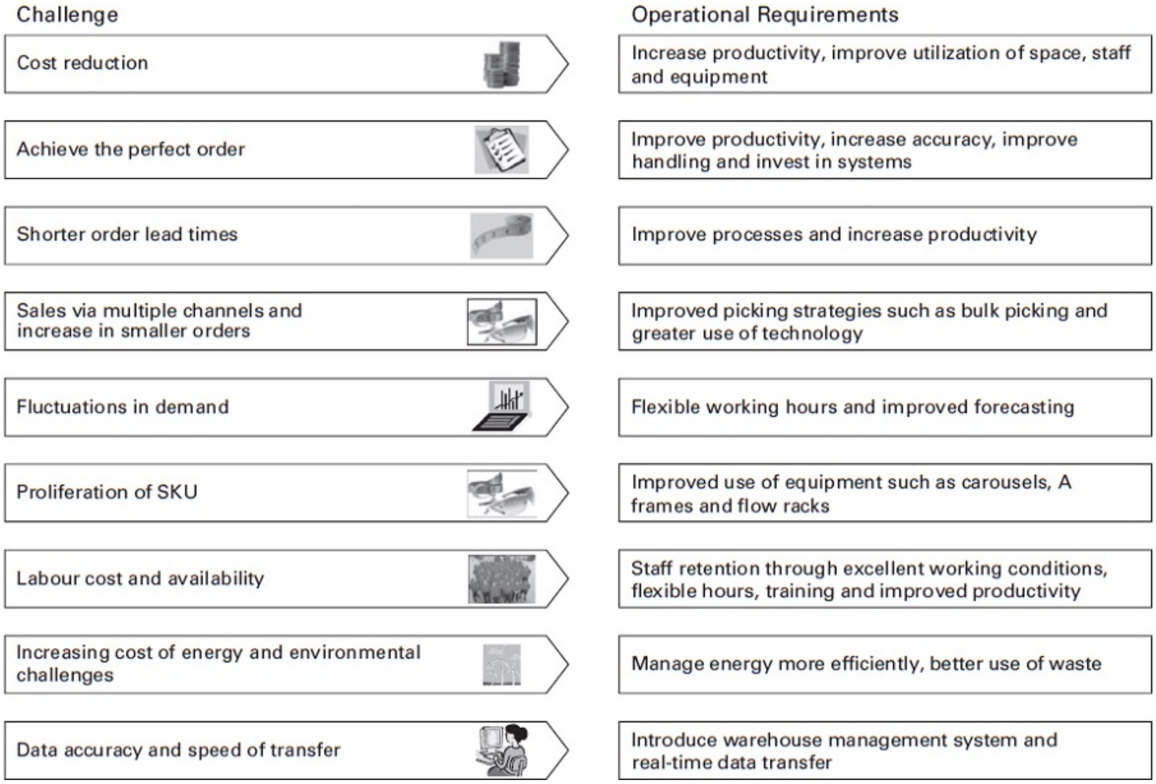
A lack of space

A number of my consultancy projects have revolved around finding additional space within the warehouse. This not only includes storage space but also inbound and outbound areas and an area to undertake value-adding services.

As discussed above, the increase in the number of product lines has resulted in a requirement for significantly more pick faces and as a result, space within the warehouse. Solutions to this challenge will be covered when we discuss equipment and layout.

As can be seen from this list and Figure 2.3, the role of warehouse manager has expanded significantly over the years and, as a result, the warehouse manager has become an important link within the supply chain.

Figure 2.3 Warehouse challenges (adapted from Dematic Corporation 2009)



▶ Figure 2.3 details

Lean warehousing

One way of overcoming some of the above challenges is the introduction of ‘lean’ concepts into the warehouse operation.

The concept of ‘lean’ comes from the manufacturing sector, more specifically the automotive industry, and is very much associated with Toyota and the Toyota Way.

‘Lean’ is now being applied not only in manufacturing but also within the public sector and the supply chain. The idea behind lean is to remove any activity that uses resources but doesn’t create any additional value.

In this short section we will look at how lean principles are likely to be applied within a warehouse operation.

According to Wild (2010), warehousing operations by definition are not lean. However, cross-dock centres and fulfilment centres can be, provided stock is moved quickly through the facility.

This is where lean techniques can be used within a warehouse environment. The idea is to identify the activities within the warehouse that absorb resources but don’t create additional value.

Waste can be found in many areas of the warehouse, none more so than in the use of space. Many managers will say they are running out of space and require additional storage facilities, yet when you walk around the warehouse you may see obvious signs of waste. During a recent warehouse audit we were told that space was at a premium, yet there were many examples of wasted space. These included:

- half-metre and one-metre-high pallets taking up space in two-metre-high locations;
- part pallets of the same product spread over a number of different locations;
- products overhanging pallets and taking up additional space;
- over 10 per cent of the stock was obsolete;
- unused space above the loading doors; and
- inappropriate choice of storage equipment.

In the first case there were opportunities to move the smaller pallets to other locations or alternatively invest in more rack beams to increase the number of low height locations.

In the second, providing there weren’t issues with FIFO, batch numbers or best before dates, the pallets could have been consolidated. Although there is a labour cost involved in transferring the pallets, it is more than compensated by the availability of more empty pallet locations. In the third case it was necessary to re-stack the pallets, which released more locations.

In the fourth case, the warehouse was storing software products that had been superseded by newer versions and were very unlikely to be sold. Decisions have to be made in conjunction with the finance department to dispose of obsolete product as soon as it is identified and deemed unsaleable.

In warehouses where there is sufficient height, a mezzanine floor can be erected above the dock doors providing additional storage and working space. A return on investment (ROI) calculation will need to be undertaken.

The use of drive-in racking was not conducive to storing small quantities of individual product lines resulting in many gaps in the racking.

Other potential areas of waste in terms of both space and time are at the receiving and despatch bays. If companies are confident about the service received from their suppliers and confident in the picking accuracy of their staff there should not be a requirement for product to be staged and checked before put-away or despatch. Exceptions might include very expensive items and pharmaceutical products.

Gooley (2013) talks about the seven wastes or muda that lean management seeks to eliminate.

This has been extended to eight with the addition of Skills. One way of remembering these wastes is to use the acronym

‘Tim Woods’. This can be adapted for the warehouse as follows:

- T – Transport – unnecessary movement of people, products, information and equipment such as empty running forklifts.
- I – Inventory – storing parts, pieces, documentation ahead of requirements or the storage of obsolete items.
- M – Motion – bending, turning, reaching, lifting. Ensure the fast-moving items are in easy reach.
- W – Waiting – bottlenecks at pick locations.
- O – Over-production – holding too much inventory.
- O – Over-processing – performing unnecessary steps such as relabelling and checking.
- D – Defects – time spent correcting errors such as miss-picks.
- S – Skills – under-utilizing capabilities, creativity and knowledge and delegating tasks with inadequate training. This can also include a failure to multi-task staff and therefore transfer them between processes at busy times.

Lean thinking revolves around having a clean and streamlined operation and removing non-value-adding processes. Waiting time is one of the biggest and most expensive wastes.

CASE STUDY (courtesy of SA Partners and Foodstuffs Inc)

This case study outlines how waiting time can be significantly reduced through the use of process improvement techniques such as ‘go – look – understand’.

The client and their challenge

A global producer of both liquid and solid fresh produce and home to some of the UK's leading brands, Foodstuffs Inc. is a multi-billion-euro turnover company with over 4,000 employees and 25 per cent market share. They make 4,000 deliveries to retailer regional distribution centres (RDCs) and stores each year.

There was a noticeable bottleneck in the logistics operation at peak return time every day that resulted in long queues of trailers in the yard. The challenge was to eliminate this particular problem to improve efficiency and effectiveness of the logistics operation and to reduce their variable operating costs.

Outline approach

The intervention focused on the Tools and Techniques section of the Lean Business Model, using problem solving and simple visual management tools to make improvements:

- SA carried out detailed diagnostics to understand the issues.
- SA carried out thorough 'go – look – understand' investigations of the operation.
- SA resolved bottleneck issues at root cause.
- SA aligned activity between operations and logistics to create capacity.
- SA challenged and created a case for changing the KPIs and measurements of the operation.

Approach in more detail

SA started by checking the current measures being used to monitor and drive performance. They found the way in which some measures were calculated hid a multitude of issues and inappropriate measures were being used at different levels of the organization.

They focused on availability as the driving measure to ensure the entire network was flowing effectively to maximize the use of the trailer and driver.

They found that the delivery drivers on average only spent 60 per cent of their time driving or on statutory breaks. They spent 25 per cent of their time waiting at customer sites and the remaining 15 per cent was spent waiting in the company yard.

SA found that after carrying out a 'go – look – understand' exercise, much of the yard waiting time was on return to site to refuel and drop off packaging (tetras). They found only two out of the four petrol pumps were working and two of the tetra off-load bays were always blocked with a forklift and a waste bin, left there when the operator went on his lunch break!

To resolve the issues the following took place:

- Process improvement work in the tetra unloading bay carried out to ensure that trailer turnaround was fully efficient and effective, and fully resourced at the right times of day. The other petrol pumps were also brought back into service.

- The introduction of more effective debriefing, whereby the driver had an opportunity to feedback where issues were occurring on his route that stopped him adhering to his schedule.
- Visual management at the key drop points on site that alerted drivers to call a number when certain conditions had not been met (ie queues too long) in order that a task team could identify the issues the moment they occurred and fix them.

Benefits

Financial

- reduction in overtime costs of £75k;
- 4 per cent increase in delivery capacity per shift; and
- elimination of two trailers resulting in annual savings of £54k.

Operational

- tighter control of existing working procedures; and
- improved measurement system to drive effective performance.

Ways of working

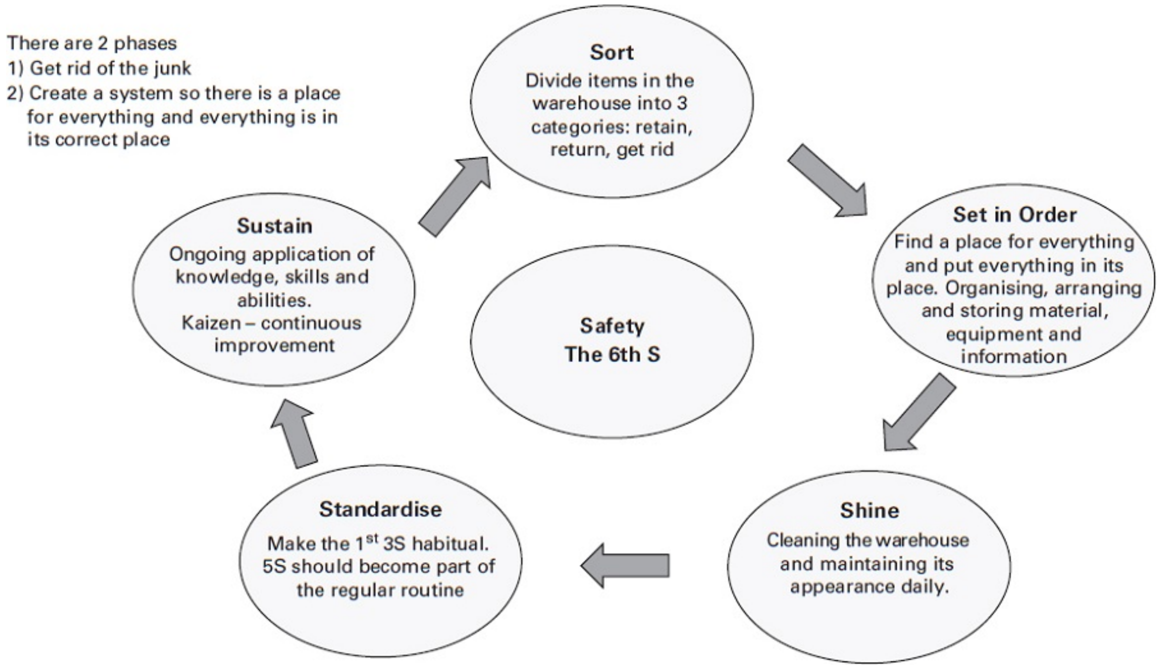
- within a month of activity SA had cured the incoming logistics operation of their bottlenecks and got the operations to a point of stability understood by all;
- cross-functional working between operations and logistics; and
- real-time problem solving.

Summary and next steps

Problems that had been building up and worsening over several months were found to be rooted in causes that were easy and inexpensive to fix. The measurement system was reviewed and changed. This allowed teams to have a much better understanding and control of performance enhancements.

Lean as a process is, in reality, common sense. As shown in the above example, simple things such as staggered lunch hours can improve equipment utilization and productivity. Figure 2.4 is a depiction of lean warehousing processes. It incorporates safety as a sixth ‘S’.

Figure 2.4 5S plus 1 (adapted from Cerasis)



▶ Figure 2.4 details

The 5S concept that underpins lean thinking can be easily applied to the warehouse as follows: 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.

You can also look to replace manual paper picking systems with radio frequency technology such as scanning, voice or pick to light.

Items marked for disposal can be put into a holding area until a consensus is reached as to what should be done with them.

The second S (Straighten or Seiton or Configure) focuses on efficient and effective placement of items, eg location labelling and putting frequently used items in easy to access locations. Directional signs in the warehouse are also part of this, as it should reduce the amount of time taken to find items. The use of ‘shadow boards’ for the location of equipment is also a good idea. See Figure 2.5.

Figure 2.5 Shadow boards (courtesy of Fabufacture)

Areas should be set aside for the storage of equipment such as scanners and voice terminals together with parking areas for handling equipment with reminders to staff to put the equipment on charge if required. Items such as empty pallets and packaging should be placed in easily accessible areas close to the point of need.

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 defective 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 rack to capture wastepaper, packaging and broken pallets and making brooms and dust pans easily accessible.

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.

The fifth S (Sustain or Shitsuke or Custom) 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.

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 and the admin office.

5S methodology is all about establishing an orderly flow, eliminating waste and organizing the workplace.

There are two phases:

1. Get rid of the 'junk'.
2. Create a system so there is a place for everything and everything is in its correct place.

People management

During the past few years, as I've been running warehouse management courses, one of the main topics of discussion has been how to attract, manage, retain and motivate staff.

The Deloitte Human Capital Trends Report (2017) found that 78 per cent of today's business leaders rate employee engagement and retention as one of their top concerns.

This section therefore concentrates on what we believe to be the lynchpin of the warehouse operation: the people. Technological advancements have brought increased productivity and higher accuracy into the warehouse operation; however, warehouse managers still rely heavily on their staff to ensure a cost-effective and efficient operation.

In all industries, companies face identical workforce management challenges. These include:

- identifying, attracting and retaining good supervisors, first line managers and team leaders;
- attracting and retaining employees;
- an ageing and constantly changing workforce, including the introduction of international staff;

- identifying training needs;
- the need to provide safe, comfortable working conditions;
- employment contract negotiations;
- introduction and management of incentive schemes;
- compliance with employment and health and safety legislation;
- staff discipline; and
- security issues.

People challenges

Warehouse supervisors are seen as the cornerstone of warehouse operations. They can be in charge of large numbers of staff within a warehouse depending on the type of work carried out, the size of the warehouse and the capabilities of the supervisors and their staff.

In our experience, a ratio of one supervisor/team leader to 12–15 staff members is the optimum. Any higher and supervision becomes less effective, whilst any lower, costs increase and there is more onus on the supervisor to assist in the tasks. This is not always a bad thing as it provides the supervisor with a greater insight into the job at hand and facilitates progression. However, it can reduce overall effectiveness.

According to a 2016 report by Tiny Pulse, employees with managers and supervisors that respect their work and ideas are 32 per cent less likely to think about looking for a new job. Managers play a significant role in an employee’s likelihood to stay with or leave their company.

As discussed previously, the role of the warehouse and that of its staff has changed appreciably over the last 10 years.

Warehouse staff roles are changing to include more tasks that were once undertaken by staff in administration, inventory control and customer service.

McMahon *et al* (2007) undertook research into the various logistics functions and found that warehouse supervisors work in the difficult middle. They must understand and often do the work of operators and clerical staff but also perform management tasks. These jobs are complex, calling for frequent decisions and almost constant activity.

In today's warehouse, supervisors need a comprehensive knowledge of the operation along with significant management skills.

These changes have altered the way companies hire, train and develop warehouse supervisors. They require higher education standards, language skills, better training and ongoing personal development.

Supervisors are the people at the sharp end as the warehouse managers are usually found at their desks in front of computer screens evaluating reports and planning future activity.

Warehouse supervisors therefore need high-level supervisory, training and interpersonal skills. They also need to know about supplier and customer procedures that affect warehouse operations.

Supervisors also need to manage by example. A previous director of mine was often seen picking up litter within the warehouse, setting an example to the rest of the staff. This simple task shows how important housekeeping is within a modern warehouse. Having been around warehouses all my working life, I have yet to find an untidy warehouse that is likely to figure within the top 10 best-performing warehouses in the country.

Taking pride in the way the warehouse looks tends to mean that staff take a pride in their work, leading to an efficient warehouse.

According to Ackerman (2000), effective supervisors and managers encourage an open exchange of ideas and have frequent discussions with their staff and peers. They should have nine critical attributes:

1 Excellent communication skills

The ability to receive and convey messages clearly and explicitly. Mis-communication leads to confusion, wasted effort and a missed opportunity.

2 An ability to delegate effectively

This is a hard skill to master but very effective when achieved. Once a task is delegated, managers and supervisors must not oversee the task too closely but neither should they abrogate responsibility. They need to monitor how the task is progressing and give feedback on performance.

3 Motivational skills

Supervisors and managers need to understand their staff and adapt their approach to motivation and feedback according to each person's needs. Providing staff with consistent feedback when they are performing well, is as important as the feedback to less well-performing staff.

According to Gavin Chappell, former supply chain director at Asda Walmart in the United Kingdom, ‘if you get the culture right and the atmosphere, structure and progression right it’s not that difficult to get a motivated team’ (2009).

4 Problem-solving skills

Problem-solving and decision-making skills are closely aligned and each requires a person to identify and develop options, and having done so, act decisively.

When walking around your warehouse, look for staff who are waiting for something to happen before they can do their own job – find out what’s causing the bottleneck and change the process.

According to Goldratt and Cox (1984), every operation has some kind of constraint that stops it from operating optimally – the weakest link in the chain. You need to identify the constraint and change the way you work to overcome it.

The five steps in the process are as follows:

- identify the constraint;
- exploit the constraint (get the most that you can out of the current situation);
- subordinate everything to the constraint (avoid producing more than the constraint can handle);
- elevate the constraint (focus on eliminating it); and
- identify the next constraint.

Congestion at a pick face can be an example of a bottleneck:

- identified by people waiting in turn to pick items;
- try to maximize productivity under the current situation;

- don’t overload the system by sending too many pickers to the same location;
- increase the number of pick locations for that product.

If cured, return to step 1.

5 Flexibility

Supervisors in today’s fast-moving warehouse environment need to be flexible, react quickly to urgent requests and shift priorities easily. They are asked to oversee and undertake many different tasks and they need to be able to handle stress caused by the pressure to meet deadlines.

6 A comprehensive knowledge of company processes and procedures

Warehouse supervisors need to have a comprehensive understanding of the company’s policies and procedures in order that they can effectively train warehouse operatives and coordinate their work. Supervisors are likely to be called upon to oversee and undertake many different tasks within the warehouse. As such, they need to spend time in all sections to get a working knowledge of all operations within the warehouse.

Supervisors need to be involved in and be party to the compilation of warehouse procedures and processes. They need to know both the administrative and operating procedures.

7 Ability to train others

Supervisors need to be able to pass on their knowledge effectively to their staff to ensure consistency and continuity. Well-trained staff are more likely to stay and provide the supervisors of the future.

8 Be customer oriented

Today supervisors need to be fully aware of customer requirements and manage the operation in such a way that customer satisfaction is achieved within the parameters set. However, they also need to be mindful of costs and the potential trade-offs involved.

9 Teamwork skills

Supervisors need to be able to set out the goals of the company to their team and outline how the team is going to contribute to these goals.

Team-working skills and capabilities include:

- ability to work in a group;
- ability to build relationships;
- ability to cope under pressure;
- negotiating skills;
- ability to cooperate;
- coordination and allocation of tasks;
- influencing skills;
- ability to compromise where necessary; and
- ability to make decisions.

Supervisors are paramount to the success of any warehouse operation. They are the liaison between employees and management. Needless to say, they also need to receive suitable, ongoing training.

One pitfall to avoid is not to promote your best-performing operative without assessing their supervisory abilities. Many companies use promotion to reward ability; however, the best person in a particular job is not always management material. This is sometimes called the Peter Principle, where staff are promoted as a result of their capability in particular job aspects. This can have a number of consequences. For example, by promoting your best picker not only are you taking them away from the shop floor but you may also be promoting them to a position at which they are no longer competent (they have reached their 'level of incompetence'). Here they stay – or may leave, being unable to earn further promotions and potentially harming the company's operations.

Attracting and retaining warehouse employees

Competition between companies in high-density warehouse areas can be fierce with staff moving between companies for very little increase in hourly rates of pay. This puts a great deal of pressure on management. Recent surveys in the US suggest that warehouse staff turnover can be up to 39 per cent. Skilled warehousing jobs are expensive to replace. The cost of turnover for warehouse workers can reach 25 per cent of salary.

Although many firms see monetary incentives as being key to staff recruitment and retention, a number of surveys – including one by TINYpulse (2016) in the United States – gave five main reasons for staff either staying or leaving their employment:

1. Employees with managers that respect their work and ideas are 32 per cent less likely to think about looking for a new job.
2. Employees with low levels of peer respect are 10 per cent less likely to stay on board.
3. Employees that give their workplace culture low marks are 15 per cent more likely to think about a new job than their counterparts.
4. Employees that feel burnt out think about quitting more often.
5. Employees are 10 per cent more likely to stay with their organization if there are growth opportunities to be had.

Other suggestions include active employee involvement in productivity improvement, management commitment to staff, job security and a sense of community.

Flexible hours, recognition of a job well done, clean and safe working conditions, access to training and open communication are all seen as crucial to attracting and retaining staff. Other areas include staff benefits and bonus payments. The opportunity to follow jobs through to their conclusion can also give staff a sense of ownership and a greater understanding of the business.

Surveys have shown that the primary reasons for staff leaving their employment isn't pay but employee discomfort with, or misunderstanding of, the corporate culture and the general lack of a sense of belonging.

As Chappell (*Retail Week* 2009) puts it:

> Having motivated, engaged individuals working in warehouses is a must if you want to be cost effective. However, it's also about service. If you need the warehouse to work above and beyond in times of peak or change, would you want a team who is just doing it for the extra

overtime or one who is doing it because they want the business to succeed?

An ageing and constantly changing workforce

This is a challenge faced by many warehouses throughout Western Europe and the United States and is beginning to emerge in China also. Experienced staff are nearing retirement age with fewer trained staff to replace them as the position of warehouse operative is not seen as attractive for today's youth. A survey by Motorola suggested the construction of elder-friendly warehouses to encourage staff to stay in employment longer.

In order to overcome the challenge of staff shortages, organizations are visiting schools to teach pupils about the role of logistics in today's society and trying to burst the myth that warehouses are cold, dirty, noisy places in which to work. As warehouses become more technically advanced, this will also attract a new breed of warehouse employee – those with an interest in technology and automation.

Attracting younger workers and increasing their job satisfaction early on can be key to early integration into the organization, which in turn can lead to improved attitude and job performance. Apprentice schemes are ideal in this situation.

Companies are also utilizing agency workers in greater numbers; this provides cover not only during seasonal peaks but also during periods of absence and holiday cover. The use of agency staff can also provide flexibility during new contract start-ups. The ideal situation is to build up a relationship with local agencies and train their staff in the way the company operates. This ensures increased productivity if the same staff are utilized on a regular basis. As work increases these staff can then be converted into full-time employees.

As discussed previously, the use of flexible working hours and annualized hours will attract staff who would not normally consider working in this environment.

Remuneration

As of October 2020, the average warehouse operative earned approximately £18,466 per annum (US $24,130) and a warehouse supervisor around £23,867 ($31,187). In the United States, according to Payscale Inc, the median annual rate as of October 2020 was US $35,169 (£26,911). Compare these rates with Chinese wages at around US $7,960 per annum.

Operating hours

The legislation that surrounds working hours within the warehouse will vary country by country. This section outlines some of the options available to the warehouse manager in terms of working hours. However, these need to be checked against local legislation.

The operating hours of the warehouse will very much depend on the throughput and customer requirements. It can also depend on local regulations and restrictions.

The classic three-shift system is still used widely; however, with the increasing requirement for 24/7 working, many warehouses have adopted different shift patterns.

The classic shift pattern is as follows:

- Shift 1: 0600–1400 hours;
- Shift 2: 1400–2200 hours;

- Shift 3: 2200–0600 hours; and
- Shift 4: 0900–1700 hours.

This shift pattern works on an eight-hour day with 24-hour coverage. However, one of the drawbacks is that there is no overlapping shift for the handover of information.

Within these shift patterns we also see staff taking breaks at the same time. Studies differ on the effect of group breaks on productivity. Some suggest that staff interaction at break times is positive and leads to increased productivity whereas others will argue that having equipment inactive and orders stacking up can be detrimental to overall performance and adds increased pressure on the staff. I tend to lean towards the latter.

With the introduction of 24/7 working, a number of companies have adopted a four-day working week for staff based on a 12-hour day on a rotating basis. See Table 2.1.

Table 2.1 Warehouse shift patterns (adapted from Ackerman 2000)

Skip table

	Team 1	Team 2	Team 3	T
Monday week 1	0600–1800	1800–0600		
Tuesday	0600–1800	1800–0600		
Wednesday	0600–1800	1800–0600		
Thursday	0600–1800	1800–0600		
Friday			0600–1800	180
Saturday			0600–1800	180
Sunday			0600–1800	180
Monday week 2			0600–1800	180
Tuesday week 2	0600–1800	1800–0600		

Other companies have utilized part-time workers with flexible shifts, working around school hours with staff working between 0930 and 1430 hours, for example, in order to supplement full-time staff.

Where 24/7 coverage is not required, typical shift patterns are as follows:

- Shift 1: 0600–1400 hours;
- Shift 2: 0900–1700 hours; and
- Shift 3: 1400–2200 hours.

There can be variations on the above theme. The ideal situation is to ensure that peaks in activity are covered as much as possible. This can include the arrival of inbound trucks in the morning and the normally busy period of picking and despatch during late afternoon and early evening.

When shift working is adopted, public transport and catering facilities need to be available for the staff.

Other considerations include potential congestion during shift changeovers and the effect on nearby residential housing of vehicle movements, noise and light pollution. In a seasonal business, the system of annualized hours can be used to cover periods of unpredictable demand.

In an annualized hours system an employee works a certain number of hours over the whole year but with a certain degree of flexibility about when those hours are worked. Normally, a period of regular hours or shifts forms the core of the arrangement, with the remaining time left unallocated and used on an ‘as needed’ basis (ACAS 2016). The adoption of this system provides increased flexibility, reduces the need for agency staff and temporary labour and ensures sufficient labour cover when demand is high, as a result providing better customer service. Through its flexibility and by working with staff, it can also contribute to higher levels of employee retention.

Under most annual hours systems, overtime is removed and consolidated into basic pay. This system can work efficiently with the cooperation of staff. Whereas overtime relies on the goodwill of the employee and their commitments at the time, a system of annualized hours should benefit both parties equally. In terms of disadvantages, employees may be required to work extra hours at short notice, which may disrupt planned leisure time; therefore, a successful annualized hours system depends on good design following consultation with employees and their representatives and adequate time to prepare for its introduction. Another disadvantage is the capture of all the data and the possibility of under-utilization of the hours, leaving the staff with excess hours.

Temporary labour is expensive, not only in terms of the hourly rate but also in terms of training, supervision and the likelihood of lower productivity. Where temporary workers are utilized it is always a good idea to strike up a relationship with a local agency that can provide staff who have received training specific to your company's requirements and have also received some form of induction.

Training

A whole book can be written on this topic. However, in this section we will cover the basics of warehouse staff training.

First, managers need to ensure that all staff receive an induction. For example: 'At Boots we set up a three-day induction programme for colleagues joining the warehouse, the highlight of which was a day's stint working in store, seeing a delivery being made and working the stock to shelf. It really helped colleagues connect what they do with the store operation' (Chappell 2009). A simple process flow map showing the end-to-end supply chain and how each step impacts the final customer will engage warehouse staff and make them feel part of the bigger process.

Second, the manager needs to undertake a training needs analysis to identify which staff require specific types of training. There are always areas in which staff need to be trained – the trick is in identifying them.

Effective training helps to engage staff and should be an ongoing process. Training across disciplines not only provides the operator with a sense of progression but builds flexibility into the operation.

From a productivity, but more importantly a safety, point of view, all staff operating mechanical handling equipment must be trained on each individual piece of equipment and obtain a licence from the authorities.

Staff must also be shown how to lift heavy items without causing injury as back injuries tend to be one of the most common reasons for absence from work.

The Chartered Institute of Logistics and Transport (www.ciltuk.org.uk) provide courses in Warehouse Management and the United Kingdom Warehousing Association has introduced a Warehouse Manager's Certificate of Professional Competence.

Warehouse audit

In order to assist the warehouse manager to improve processes we have produced a warehouse audit, which can be found in Appendix II.

These lists of questions are not exhaustive and can be added to by the user to mirror their own operations. Audits should be undertaken by an independent person either from within the company or an outside consultant.

The purpose of the audit should be explained to staff and a timescale agreed to introduce the improvements. Results need to be shared with all the staff and staff need to take ownership of the results and the improvements necessary.

The audits that are concerned with the internal processes are based on what the authors see as best practice in a warehouse.

An Excel version of these audit forms can be purchased and downloaded from www.howtologistics.com.

Quality systems

Finally, in this section we have provided a list of quality standards that warehouse managers may deem necessary or advantageous for their operations.

These are as follows:

- ISO 9001 – a standard of requirements against which your Quality Management System can be evaluated;
- ISO 14001 – a standard of requirements that defines and establishes controls to reduce your company's impact on the environment;
- ISO 50001 – a standard of requirements that deals with the energy impact of your warehouse operation;
- OHSAS 18000 – a family of international standards relating to occupational health and safety management. It consists of two separate parts:
- OHSAS 18001 – the Occupational Health and Safety Management Systems Specification;
- OHSAS 18002 – provides guidelines for the implementation of OHSAS 18001;
- ISO 27001 – a standard of requirements that deals with all aspects of information security (this is particularly useful in the case of outsourced warehousing); and
- ISO 28000 – specifies the requirements for a security management system, including those aspects critical to security assurance of the supply chain.

Summary and conclusion

If a warehouse is going to operate effectively and efficiently it needs an experienced, knowledgeable, well-trained manager and a motivated team of supervisors and operators.

An ageing population and difficulty in attracting new staff pose more challenges for today's manager, together with increased environmental pressures.

The warehouse manager's challenges are therefore many and varied, not least the requirement to reduce costs and inventory levels whilst increasing customer service.

A comprehensive and ongoing training programme is essential for both managers and supervisors. The warehouse should not be seen as a black hole but as an essential part of the supply chain, and the role of its staff in this chain needs to be recognized and understood.

Quality of service is what sets companies apart these days and the introduction of audits and quality systems into the operation will enable managers to continually assess, evaluate and improve their service both internally and externally.

The next section of the book examines in detail the processes within the warehouse and suggests where the manager can increase productivity and look to reduce costs.

03

Warehouse processes

Receiving and put-away

Introduction

As Peters says, improvement comes from simplifying processes and procedures. These processes need to be aligned and working optimally if we are to improve efficiency and, as a result, reduce cost within the warehouse operation.

Detailed process documents need to be produced and made available to all employees. These need to be continually reviewed and updated. According to WERC (2010), companies who exhibit good to best practice processes are those which define and publish process descriptions and assign ownership of the processes to responsible individuals. Supplementing written instructions with photographs also improves understanding.

In the next five chapters we examine in detail each of the processes associated with a warehouse operation. Although warehouses differ in terms of size, type, function, ownership and location the fundamental processes remain.

These processes include pre-receipt, receiving, put-away, storage, picking, replenishment, value-adding services and despatch. We also include a section on cross docking where products are moved from inbound to despatch without actually going through the put-away process. Other warehouse processes such as stock counting and inventory control, although undertaken as part of the mainstream day-to-day processes, are included in the section on housekeeping.

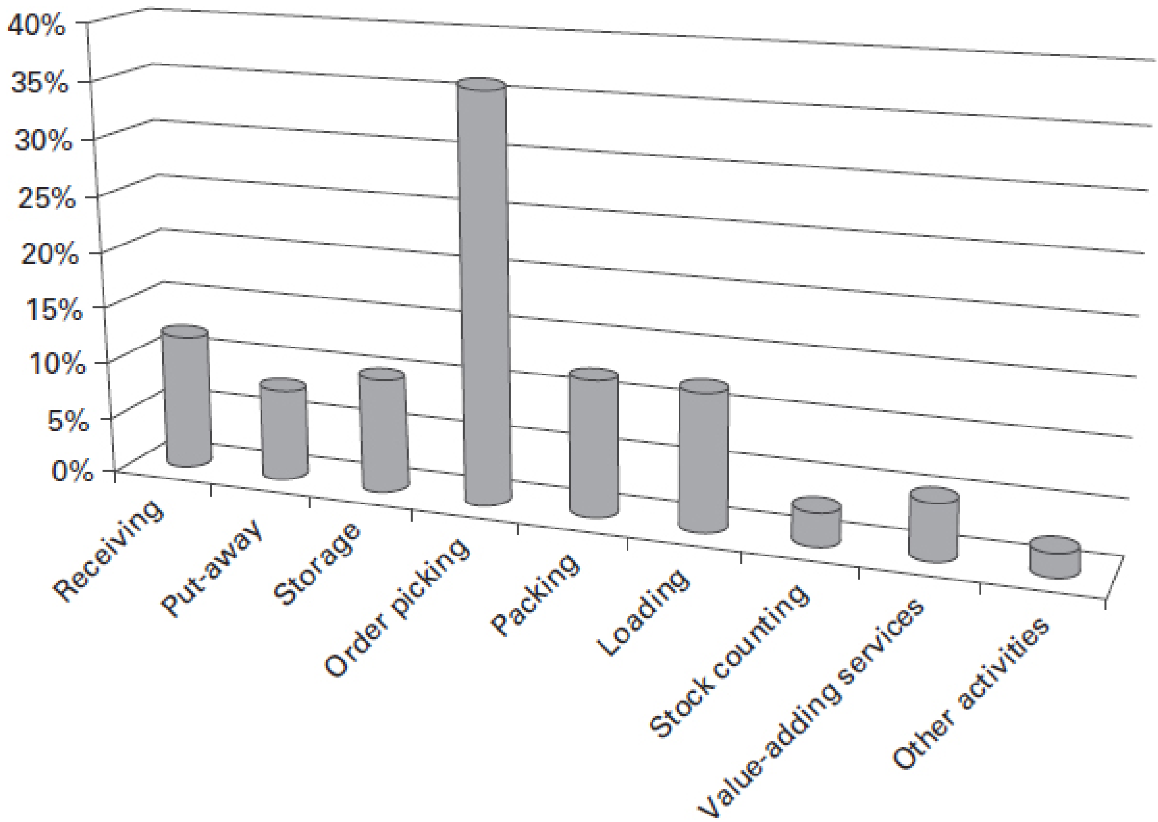
By ensuring that the correct processes are in place and operating optimally, companies cannot only improve accuracy and efficiency but also take advantage of the new technology available.

Many books on the subject of warehousing will concentrate on the picking process as this is the most labour- and cost-intensive process and has a direct impact on customer service.

This section is no exception; however, we also recognize the importance of pre-receipt and the receiving process. Receiving the wrong products or putting products in incorrect locations can result in errors just as easily as picking the wrong item.

Figure 3.1 shows each main warehouse activity as a percentage of cost, emphasizing the importance of the pick, pack and despatch operation. These figures will vary significantly depending on the type of operation.

Figure 3.1 Warehouse activities as a percentage of total cost

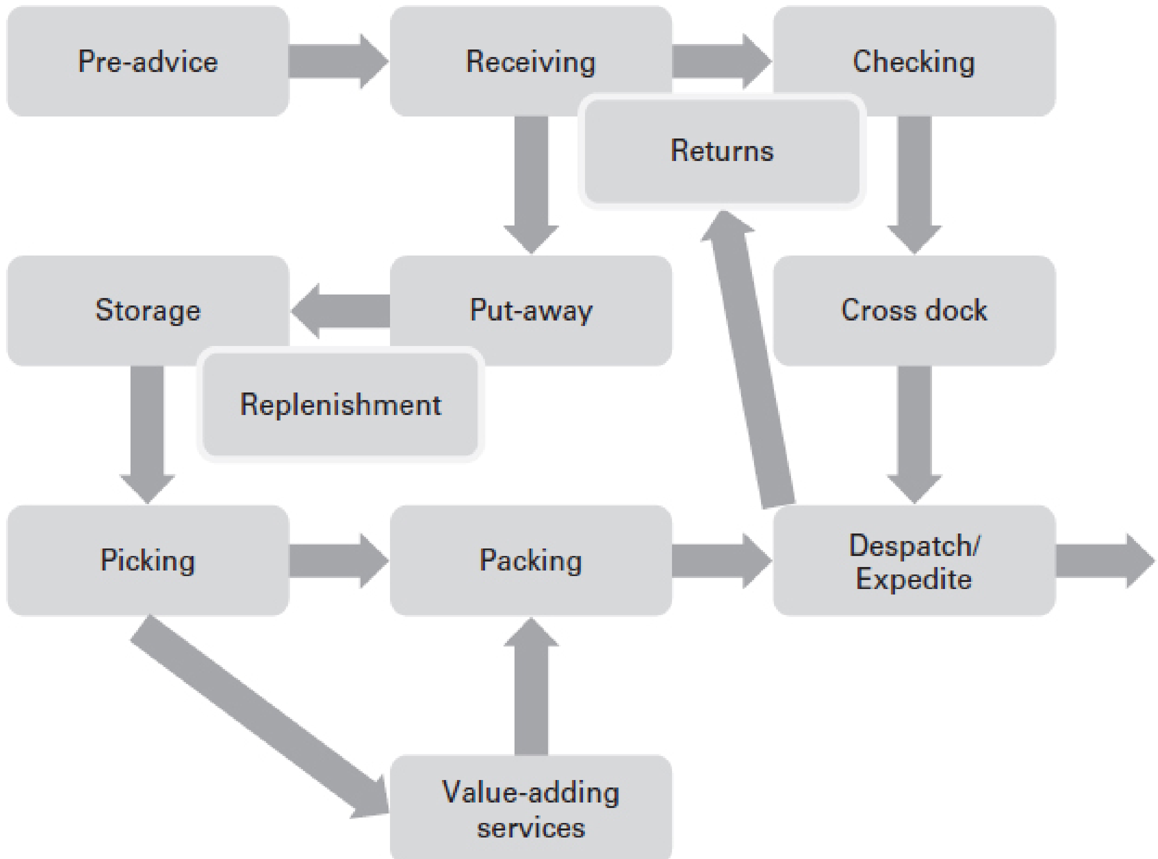


▶ Figure 3.1 details

For example, companies that are under pressure to speed up throughput are likely to use concepts such as cross docking, thus reducing the amount of time spent on put-away, picking and retrieval.

The main activities mentioned above are shown in Figure 3.2 together with their relationships.

Figure 3.2 Warehouse processes



▶ Figure 3.2 details

Receiving

Receiving, goods-in or in-handling is a crucial process within the warehouse. Ensuring that the correct product has been received in the right quantity and in the right condition at the right time is one of the mainstays of the warehouse operation. These elements are often termed supplier compliance.

However, it is our contention that once goods have arrived at the warehouse it is usually too late to rectify most receiving issues. We believe there are many steps that need to be taken before the actual act of receiving takes place.

Pre-receipt

First, we need to ensure that the supplier presents the products to the warehouse in the most appropriate way. It is normally the buyer who specifies the product and therefore may not have knowledge of the goods-receiving operation.

Our suggestion here is that the warehouse manager also gets involved in specifying and agreeing the packaging, items per carton, cartons per pallet, TiHi (cases per layer, layers per pallet) and any specific labelling required, together with size of pallet and the mode of transport to ensure that the products ordered are compatible with the storage facility.

All too often we see items arriving at warehouses in unsuitable packaging that overhang pallets, have incorrect or badly positioned labels and with goods packed in quantities that do not relate to selling-pack quantities. Our proposal here is that samples are ordered and despatched in their transit packaging to ensure full compliance.

All these problems take time to resolve and are better handled at the supplier prior to delivery.

Areas that need to be discussed both internally and externally prior to the order being placed should include:

- size and type of cartons;
- type of transit packaging – cardboard, plastic totes, metal stillages, roll cages, pallets;
- palletized, slip sheeted or non-palletized delivery of product;
- size (length, width and height) and type of pallets, eg euro pallet (1200 × 800 millimetres), industrial or UK pallet (1200 × 1000 millimetres), two-way entry, four-way entry

(note that different countries use different pallet sizes as can be seen in Table 3.1);

- specific labelling such as product description, barcode and quantities;
- position of label(s) on carton and pallet;
- carton quantities (inner and outer carton quantities, for example); and
- mode of transport, delivery quantity and frequency of delivery.

Delivery in the standard selling quantity is also crucial in assisting the manager to increase the speed of throughput and simplify picking. For example, many companies still place orders on their suppliers in multiples of 12, yet most customers order in multiples of 10 thus causing considerable extra work in computing quantities, opening cartons and re-packing.

The method of delivery needs to be compatible with the unloading equipment available at the warehouse. The lack of loading bays, for example, will necessitate the use of tail-lift-equipped or side-(un)loading vehicles. Warehouses might also need to invest in container ramps, for example.

The transfer of much production offshore has resulted in a significant increase in container traffic. The decision here is whether to loose-load or palletize the cargo. Another option is to use slip sheets.

The benefits of palletizing product include protection from loss or damage during handling and transportation and a reduction in the number of people required to load and unload containers. The process of loading and unloading is speeded up whilst space required at the loading and despatch bays is also reduced.

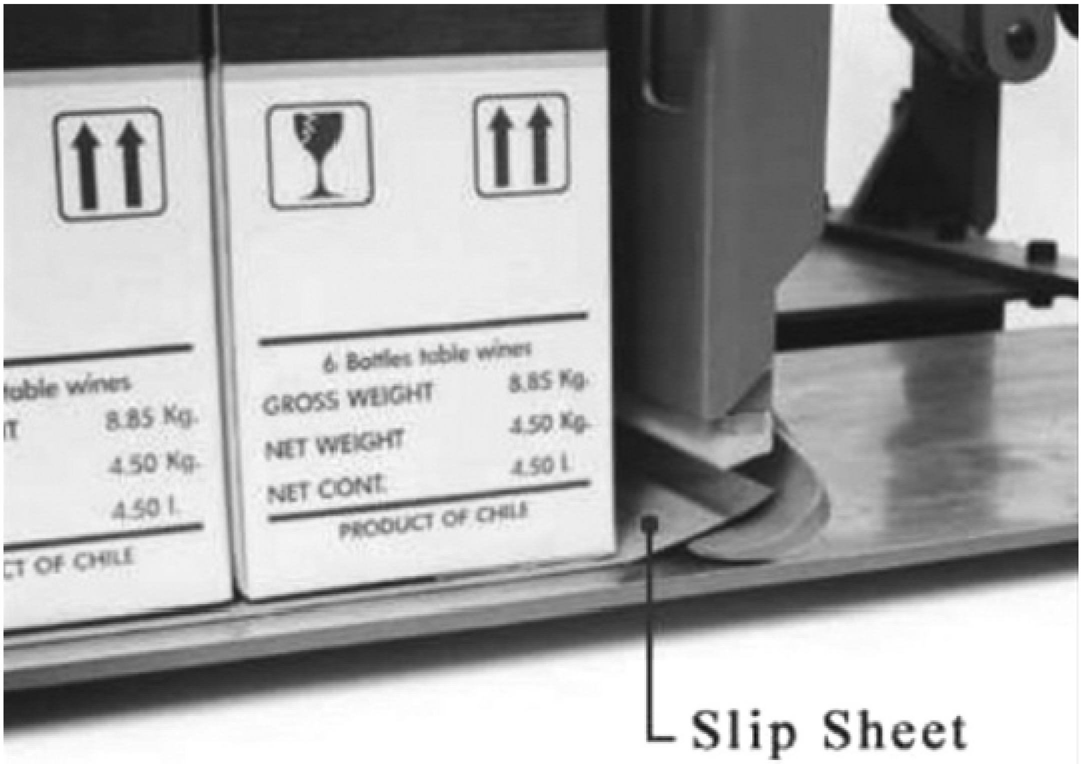
The trade-off is the reduction of space utilization in the containers. Depending on the number of pallets used, this can be up to 10 per cent of the space for the pallets alone. Couple that with the required clearance height for the pallet and the possibility that pallets cannot be stacked and resulting space utilization will be significantly reduced.

One potential method of reducing the trade-off effect is the use of slip sheets in place of pallets. Slip sheets are constructed from fibreboard, thick cardboard or thin plastic in the shape and size of the unit load. The thickness of the sheet is approximately 2 centimetres.

The load is placed on the slip sheet, loaded onto the container and on arrival at the final destination the slip sheet together with its load is removed by means of a specialist forklift attachment and placed on a pallet for storage.

The increasing legislation (FAO ISPM 15) on the use of wooden pallets makes slip sheets a viable option for the transport of goods in shipping containers. They increase the loading cube within the container, reduce the time taken to offload and are easier to clean. They do, however, require both despatch and receiving warehouses to purchase a special attachment for the forklift truck.

Figure 3.3 Push Pull image



SOURCE B&B Attachments Ltd

VIDEO 3i Slip Sheet operation from Rehrig Pacific

Depending on the load configuration, shipping costs can increase between 15 and 33 per cent when using pallets. However, there are notable savings made at the point of delivery plus the reduction in potential damage to products and injury to staff.

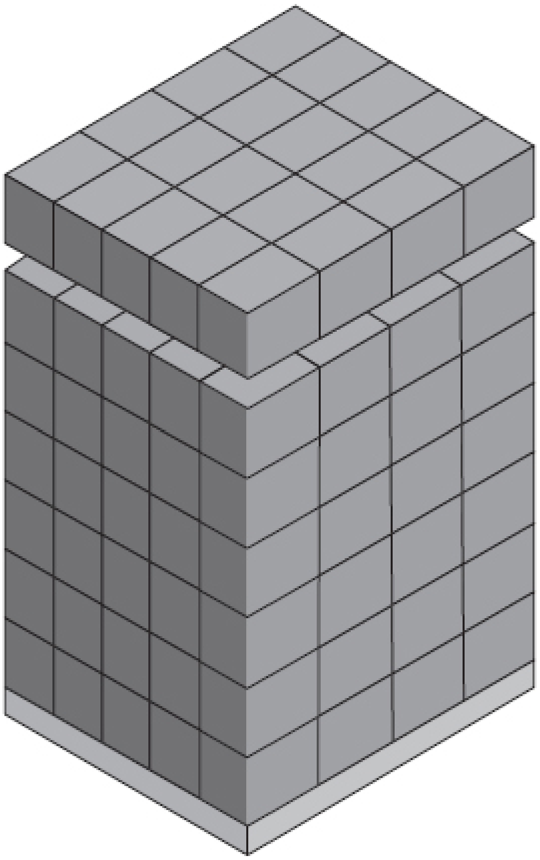
The introduction of high cube containers has provided additional internal height and therefore the double stacking of pallets becomes more feasible, providing the products are not easily crushed.

Finally, containers with large numbers of product lines will still need to be sorted at the receiving bay whether they are palletized or loose loaded. In order to reduce in-handling time the supplier needs to be instructed to keep the same product lines together in the container.

If products arrive loose loaded in a container, they will need to be palletized prior to being put away in the racking. Where possible these cartons need to be constructed in such a way that there is no overhang and no potential for crushing when they are arranged on the pallet and that as many cartons as possible can be accommodated within the cubic capacity of the pallet space.

For example, for a 1,200 millimetres × 1,000 millimetres (48 inches × 40 inches approx.) pallet with a clearance height within the pallet location of 2,000 millimetres (80 inches), the cartons weighing 5 kilograms, each measuring 300 millimetres × 200 millimetres × 250 millimetres , for example, will give a total potential pallet capacity of 140 cartons if we allow 15 centimetres for the height of the pallet and 10 centimetres clearance between the top of the pallet and the underside of the beam. Each layer will have 20 cartons and will be stacked seven high as shown in Figure 3.4. There is no overhang on the pallet on either side and cartons are not turned on their sides. The following website provides a tool to calculate TiHi: www.onpallet.com.

Figure 3.4 Onpallet.com TiHi calculation



Used by manufacturers, retailers and service providers, unit loads are key cost drivers. Developing more efficient unit loads is critical to the success of efficient consumer response and is estimated to save 1.2 per cent of the retail sales price.

As can be seen in Figure 3.5, the size of the outer cartons does not allow the warehouse operation to optimally stack the pallet and can result in increased damage.

Figure 3.5 Example of incorrectly sized cartons

Utilizing off-the-shelf software can potentially further improve the load-building capability both on a pallet and within a trailer or container where the carton dimensions are not so straightforward. Not only do the pallets look neat and tidy but the products are less prone to damage.

Currently, there is no universally accepted standard for pallet dimensions. Different market sectors and organizations utilize many different pallet sizes around the globe.

The International Organization for Standardization (ISO) sanctions six pallet dimensions, detailed in ISO Standard 6780: Flat pallets for intercontinental materials handling – principal dimensions and tolerances. These are shown in Table 3.1.

Table 3.1 Pallet dimensions (ISO)

Skip table

Dimensions in mm (W × L)	Dimensions in inches (W × L)	Country of use	Unused floor space in a 40 ft ISO container
1016 × 1219	40.00 × 48.00	North America	3.7%
1000 × 1200	39.37 × 47.24	UK and Asia; pallet commonly referred to as a UK or industrial pallet	8.1%
1165 × 1165	44.88 × 44.88	Australia	8.1%
1067 × 1067	42.00 × 42.00	Most countries	11.5%
1100 × 1100	43.30 × 43.30	Asia	14%
800 × 1200	31.50 × 47.24	Europe; pallet commonly known as a euro pallet	15.2%

The introduction of the smaller euro pallet was as a result of the need to fit through domestic doorways in crowded cities.

Other pallet sizes are seen in the chemicals and printing industries to accommodate drums and printer reels, etc. We previously worked with a client who received stock on single-use American pallets, which they had to 'slave' (put on top of another pallet) to enable them to place them in their racking safely. This not only requires additional labour but also reduces the cubic capacity of the storage location. Another client has two different pallet sizes: 1200 millimetre × 1000 millimetre and 900 millimetre × 650 millimetre. This makes it very difficult to configure storage racks and decide on optimum locations within the warehouse. This required the use of mesh or wooden decking in the racking to safely stow the pallets, which can be expensive.

The size of pallet to be stored determines the rack configuration. Where companies store different sizes of pallet the configuration needs to be suitably flexible. For example, UK companies needing to store both UK and euro pallets will be forced down the route of having their racking set at 1100 millimetres deep with each 2.7 metre bay accommodating either two UK pallets or three euro pallets.

Other factors to take into account when specifying pallets include whether they are two-way (stringer) or four-way entry (block), the type of timber used (certain countries have restrictions, such as Australia where wood is required to be treated) and the type of nails used.

ISPM 15 is the regulation that requires heat treatment for wooden pallets, also known as pest control. It applies to transport between the EU and the rest of the world. ISPM15 regulations apply to all pallet wood, wooden collars and boxes. As of 1 January 2021, companies will have to meet this international standard for every pallet going in and out of the UK, as the UK is now classed as a third-party country.

Certain types of MHE are not able to operate with block pallets, reducing warehouse flexibility. These include pallet stackers.

Recent innovations in the pallet sector have included iGPS's plastic pallets that are said to be 100 per cent recyclable as well as being 30 per cent lighter than wooden pallets.

iGPS also claim that their pallets are 'vastly better for the environment' and 'do not absorb fluids that can cross-contaminate food'. One concern that has worried food manufacturers is the treatment of wood pallets with pesticides and fungicides. iGPS's plastic pallets do not need treatment, so they claim they are more suitable for moving foodstuffs in the warehouse. As with plastic totes and trays used for the movement of food items, they do need to be cleaned regularly. These pallets are also said to be far more sanitary than wooden pallets and ensure FDA (Food and Drug Administration) food safety standards are met.

The plastic pallets also have embedded RFID tags to enable tracking to take place and there are also barcode and alphanumeric identifiers. The pallets measure approx. 48 inches × 40 inches (1,200 millimetre × 1,000 millimetre) and are four-way entry (logistics.about.com).

The automotive industry has tended to use metal stillages to transport and store automotive parts.

Products delivered in outer cartons need to be labelled in such a way that they can be easily identified. Information can include barcodes, which need to be compatible with radio frequency (RF) equipment and which hold data such as product code, description and pack quantity. Ease of identification speeds up the in-handling process.

With regard to carton quantities, many suppliers continue to supply units in multiples of 12, yet customers who have grown up with the metric system tend to order in multiples of 5 and 10. There needs to be consistency within the supply chain in terms of pack quantities supplied, pack quantities stored and pack quantities sold.

The pack quantities will depend on the value, weight and volume of the product and, although there is no legal limit in the UK, outer cartons should not weigh in excess of 20 kilograms (44 pounds) from a health and safety point of view.

Individual unit sales will always necessitate opening cases to satisfy orders; however, the fewer times this occurs the more productive the warehouse.

There also needs to be consistency by product line to ensure accuracy during stock counts and reduce picking errors. I have come across many instances where different suppliers of the same generic product pack in different quantities. This leads to inaccuracies and delays on receipt, picking, stock counting and despatch.

Discussions between the warehouse, procurement, customer services and the supplier should alleviate many of these problems.

The premise is to discuss requirements with the supplier and if you need them to do things differently then you need to take the initiative. There may be an additional cost; however, this needs to be weighed up against the additional costs incurred within the warehouse. The supplier may surprise you by changing the way they present things to you. In fact, there may be occasions when this is also advantageous to the supplier. The old adage of 'If you don't ask, you don't get' is very true.

Another truism to bear in mind is the 80/20 rule as it applies to suppliers. Not only is it likely that 20 per cent of your suppliers provide 80 per cent of your stock, but it is likely that 20 per cent of your suppliers cause 80 per cent of your goods-in problems.

You need to put measures in place to identify the suppliers who are not performing to standard and work with them to introduce improvements. You can be reasonably sure that your suppliers aren't deliberately causing you problems. The issues arise because they are not aware of the effects of their actions on your operation. You will benefit more from a hands-on approach to the problem and work with the supplier to improve the situation.

In-handling

One of the main challenges for a warehouse manager is to match labour hours with work content. Handling a product for the least amount of time possible (labour touch points) leads to reduced labour hours and as a consequence, reduced cost.

Depending on the operation, labour can be the single biggest cost within a warehouse. It can be between 48 and 60 per cent of the total warehouse cost depending on the amount of automation utilized. It is also the most difficult cost to control.

In-handling makes up approximately 20 per cent of the total direct labour cost within a retail warehouse.

Preparation

Prior to the actual receipt, a number of processes need to take place. The first step is to ensure that suppliers deliver into the warehouse when you decide, not when it suits them. There will be exceptions to this. For example, it is difficult for parcel delivery companies to adhere to booking times because of the nature of their deliveries; however, pallet and full-load delivery companies expect to be given specific delivery times, albeit this is not their preferred option.

By providing delivery times for each supplier or their subcontractors, you are in control and able to match your work hours to work content. A booking-in or dock-scheduling system needs to be introduced. Many of today's warehouse management systems (WMS) have a dock-scheduling module; however, an Excel spreadsheet will suffice if this isn't the case – see Table 3.2 as an example.

Table 3.2 Excel spreadsheet denoting delivery truck booking times by door

Skip table

DOOR one				
Time slot	**Supplier**	**Units**	**Unit type**	**Time e**
0700	ARCO	24	Pallets	45 mir
0750	TCO Deli	10	Parcels	10 mir
0805	SBH Ltd	12	Pallets	24 mir
0835	Delta ltd	24	Pallets	45 mir
0925	Argo.com	1000	Cases	3 hour

Initially, you need to decide on when you are going to receive products into the warehouse. Are you going to have deliveries throughout the day or limit them to a morning shift, for example?

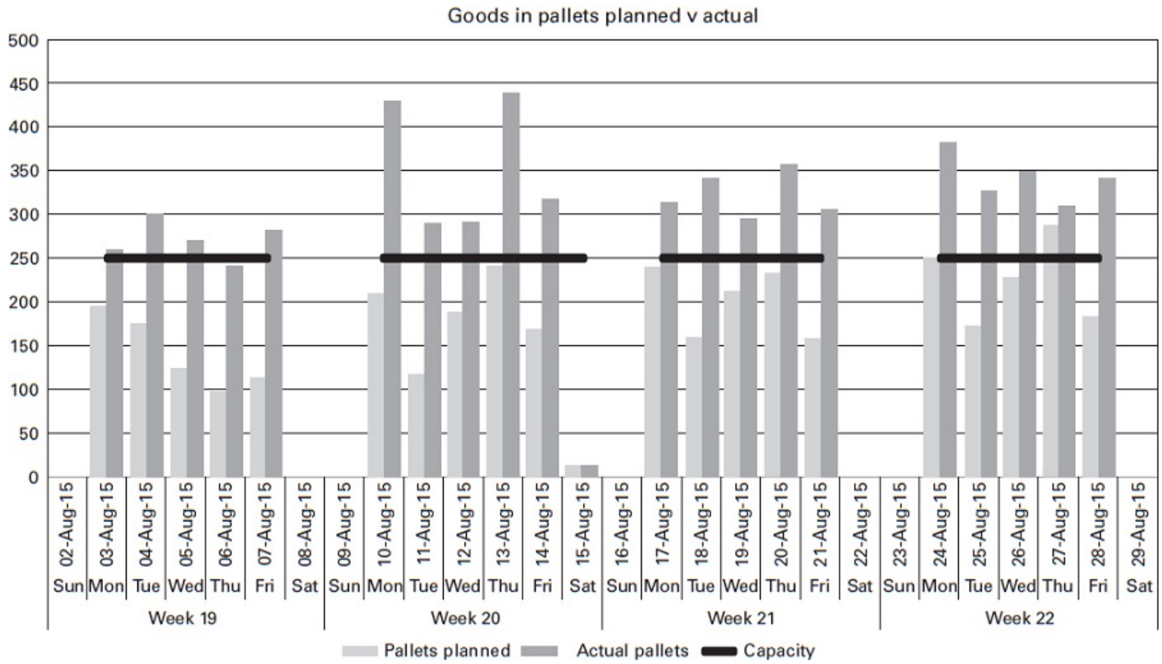
You then need to match the length of the time slots to the time estimated to fulfil the task. Standard time slots do not work, as each delivery is likely to be different. For example, it could take 30 minutes to offload a 13.6 metre (45 foot) palletized trailer and a further 15 minutes to check and move the pallets to the storage area, whereas a loose-loaded 20 foot container could take up to three hours depending on the number of SKUs, cartons and staff deployed.

You need to keep records of the time it takes for each type of delivery and share this information with your booking-in team. This will give you the amount of labour and equipment required to undertake the task, thus making planning a great deal easier.

By introducing a dock-scheduling system you are able to allocate accurate time slots, measure productivity, organize labour and also check demurrage and penalty charges.

Figure 3.6 shows a retail inbound operation where calculations have been made regarding expected deliveries and the actual situation. Note that on certain days, arrivals exceed capacity (black line), suggesting that a number of unauthorized deliveries have taken place. This highlights why an accurate scheduling system needs to be introduced to avoid excessive overtime.

Figure 3.6 Retail operation goods in planned v actual graph



▶ Figure 3.6 details

Warehouse staff need to be aware of the products being delivered, the type of vehicle and the equipment required to offload. Once this has been ascertained and the time calculated, a suitable booking slot is allocated and a booking reference given to the supplier.

Details of any pallet exchange agreements also need to be ascertained. The use of pallets within a rental system such as Chep, IPP Logipal, LPR, iGPS and others requires both parties to accurately record movements within the system.

Pre-advice of the products being delivered is also advisable so that the details can be entered into the WMS. This is normally in the form of an Advanced Shipping Notification (ASN). An ideal method of receipt is to accept the contents of the ASN as correct into the system as soon as possible through the use of RFID, voice, vision or barcode scanning. Some WMSs will use this information to pre-allocate pallet locations for the products prior to arrival (system directed put-away) and also specify which pallets need to be cross-docked. The information is also used to check the delivery. Issues can arise when multiple deliveries are received against one purchase order and therefore each purchase order needs to be broken down by actual delivery to avoid confusion. To overcome this Superdry decided to track per individual carton.

Yard management

The arrival and departure of a significant number of vehicles each day requires the use of a yard management system to ensure that there is sufficient space to park the vehicles and that each vehicle is allocated to the correct dock door. Vehicles with goods for specific areas within the warehouse need to be allocated to those dock doors closest to that area. The same is true for vehicles collecting from the warehouse.

Where trailers have been pre-loaded for despatch, incoming vehicles can uncouple their loaded trailers either in the yard or at the dock door and they can be moved by a 'shunter' once unloaded. Shunters are vehicles that are used solely within the confines of the yard to move trailers on and off the loading bays. They are normally equipped with RF screens and operators are directed as to which trailers to move and when.

The use of closed-circuit television cameras will allow yard controllers to manage the movement and parking of vehicles efficiently.

Yard management systems are now being incorporated into many WMS. Software programs are also available to simulate the movement of vehicles in the yard.

VIDEO 3ii Yard management from Körber Supply Chain

Offloading

On arrival, the vehicle details need to be checked against the booking reference, the delivery notes checked against the ASN and the vehicle allocated a loading bay or location in the yard. Any vehicle seals need to be checked against the delivery paperwork to ensure the load has not been tampered with on route.

Prior to offloading temperature-controlled vehicles, the temperature history of the vehicle whilst in transit needs to be checked, together with the current temperature of the goods.

Once the vehicle has backed onto the appropriate bay or has been positioned in the yard for offloading from the sides, the in-handling team should have appropriate labour and equipment to hand, to efficiently manage the offloading process. A photograph of the load can be taken prior to offloading just in case there are any disputes regarding the load at a later stage.

Where vehicles are unloaded in the yard this usually necessitates the use of two lift trucks, one to unload the trailer and another to put the product away within the warehouse.

The introduction of articulated forklift trucks that can work both inside and outside the warehouse is going some way to reducing the requirement for two different types of truck for the latter operation. Counterbalance trucks are also able to undertake both tasks providing they are operating in wide aisle pallet racking and the lift height does not exceed 8 metres.

The most common method of unloading palletized vehicles onto a loading bay is with a powered pallet truck, hand pallet truck or pallet jack. Some companies utilize counterbalance forklift trucks or reach trucks; however, the weight of the truck, driver and load on potentially weak or damaged container or trailer floors can be an accident waiting to happen. Thorough checks need to be carried out before unloading takes place.

Unloading times will vary depending on the equipment used and whether the load needs to be staged prior to put-away.

In order to speed up this process, equipment companies have introduced automatic unloading systems, which means that a 26-pallet trailer can be unloaded within five minutes of arriving at the dock. Unloading methods include the use of rollers, tracks (as seen in Figure 3.7) and slip chains whilst others use loading plates or giant slip sheets. These tend to be operated in high volume situations between production plants and off-site storage locations.

Combine these with conveyors or automated guided vehicles (AGV) and the requirement for labour within the receiving operation reduces significantly.

Figure 3.7 Automated unloading (courtesy of Joloda)

VIDEO 3iii The JoLoda system in action

Unloading loose-loaded containers has always been a time-consuming operation. This normally necessitates having at least two people unloading within the container and placing the items onto a pallet. A third person is usually waiting for the pallet to be stacked before taking it to the checking area before put-away. This is very unproductive as the staff within the container wait for full pallets to be replaced with empty ones whilst the forklift driver is waiting for the pallet to be built.

There is no guarantee that the same product is together within the container, therefore more sortation needs to take place on the unloading dock. This is very inefficient and can be hazardous to the staff, who are continually bending and stretching within the container and are in close proximity to the MHE. Lighting is usually poor and conditions are not conducive to fast, accurate work.

Added problems arise if the warehouse is not equipped with loading bays and is dependent on a container ramp. There are situations where a forklift truck with an operator standing on a pallet is used to unload the first few cartons from the container. This is totally unacceptable and breaches health and safety protocols.

Figure 3.8 shows a boom conveyor unloading cartons from a container. These can be static or can be moved between loading doors as required.

Figure 3.8 Boom conveyor unloading cartons (courtesy of Best Conveyors)

Placing cartons onto a conveyor means that sortation can take place outside the container, there is less bending and twisting involved as the conveyor is at a manageable height and it provides a continuous, uninterrupted flow.

VIDEO 3iv Caljan boom conveyor

The person within the container can also utilize a vacuum lift to prevent injury through bending, stretching and lifting heavy cartons. Video 3v shows an operator unloading using vacuum lifting technology.

VIDEO 3v Tawi vacuum lift with conveyor

The system can increase productivity through reducing fatigue and is likely to help with staff retention, and reduce injuries. Lift capacity ranges from 50 kilograms to 270 kilograms.

Pallets or stillages can be laid out either side of the conveyor and can be stacked with the correct item. These pallets can be placed on platforms that rise and fall according to the build height of the pallet, thus reducing the amount of bending and stretching by the operators. The conveyor can also be extended into the trailer or container as the cartons are unloaded reducing the amount of operator travel.

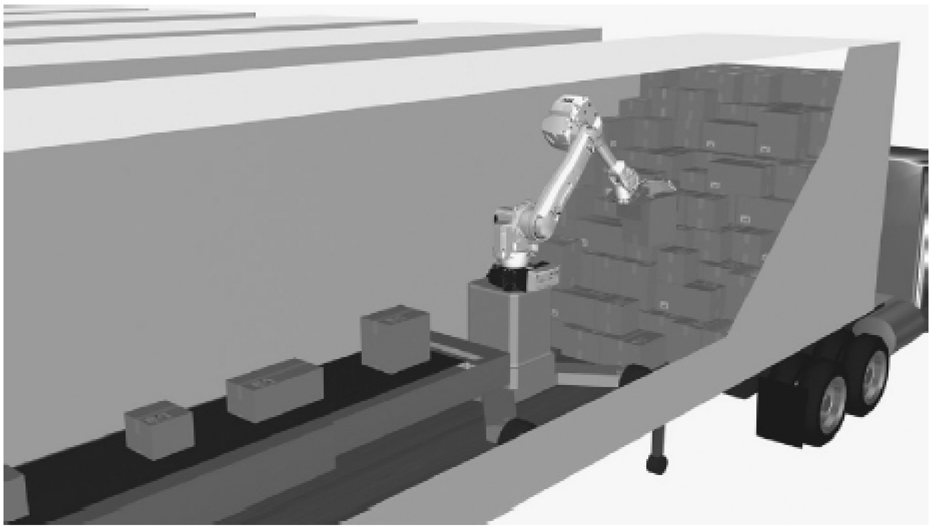
In order for this operation to run smoothly, the supplier needs to be instructed to load the same items together in the container. There is the potential of increasing productivity by up to 50 per cent using this process.

With the increase in automation, there is a greater emphasis on uniform cartons as robots are now utilized for building pallets both on intake and for despatch (an example can be seen in Figure 3.9).

Figure 3.9 Robotic palletizer (courtesy of Bastian Solutions)

In certain operations robots have replaced the manual unloading of containers as can be seen in Figure 3.10.

Figure 3.10 Robotic unloading of container with boom conveyor (courtesy of Bastian Solutions)



The following videos show semi and fully automated container unloading.

- **VIDEO 3vi Semi-automated container unloading from Copal**
- **VIDEO 3vii Automated trailer unloading from Trapo**
- **VIDEO 3viii Cartonmover**
- **VIDEO 3ix Actiw Loadplate**

Other equipment includes forklift trucks with clamp attachments for offloading items such as white goods and de-layering pallets, rams, booms or poles for offloading carpets and similar items, rotating clamps for barrels, drums and tyres, and forklift trucks with slip sheet attachments for unloading containers. Other attachments include double pallet handlers, fork extensions, telescopic forks and weighing systems.

Checking

Once the goods are offloaded, you need to decide whether they need to be checked before put-away. The ideal scenario is to move inbound goods directly from the loading bay to the storage area or despatch area if goods are cross-docked.

However, trust is an issue here and unless you are 100 per cent certain that your suppliers are totally accurate with their deliveries on every occasion, some form of checking will need to take place.

This can, however, take the form of a random check of certain product lines rather than checking the whole consignment. A count of total pallets may be sufficient.

CASE STUDY

During a recent assignment, I was assisting a company with improving their maintenance stores operation. They received multiple deliveries per day ranging from nuts and bolts through to large engines and gearboxes.

Products such as nuts and bolts, fasteners, washers, etc were received in plastic bags within an outer carton.

The operator opened each box, removed each plastic bag and ticked the relevant box on the delivery note showing receipt of that particular item.

The operator proceeded to count each item within the plastic bag. This was very time-consuming and when distracted he had to start the count again.

The operator could have weighed each bag to ensure that the correct quantity was delivered, which would have been much quicker; however, the telling fact was that when asked how accurate the supplier deliveries were, he said that he had not witnessed any errors over the last two years.

Therefore, in this situation there was no requirement to check the whole consignment especially given the value of the items in question. These are the areas that warehouse managers need to be aware of and act accordingly.

A number of retailers have introduced GFR (good faith receiving) where products are accepted into the distribution centre or store without checking on arrival. Random checks by third-party auditors are undertaken and any discrepancies found are charged to the supplier on a pro rata basis. The auditors check a statistically robust number of pallets, across a three-month period and identify the pick accuracy. They use this to determine a Gross Error rate used to calculate the monetary deduction from every invoice. So, if the client delivers with 99 per cent accuracy, 1 per cent of the total value of goods is deducted from the invoice.

GFR was introduced to compensate chilled suppliers for retailers' inability to count mixed pallet deliveries accurately, which was costing suppliers £30–40 million pa but has now been reduced by 90+ per cent by GFR following a supplier-led campaign and the intervention of the Grocery Code Adjudicator, for a breach of 'delays in payment' under GSCOP rules.

This enables drivers to continue to deliver without delay and encourages suppliers to increase the accuracy of their shipments to minimize deductions. Furthermore suppliers are paid to terms, in full, against their delivery notes, which also significantly reduces claim administration for both supplier and retailer. Even if GFR is not introduced, by measuring supplier performance a warehouse manager can decide on the regularity and comprehensiveness of inbound product checks. The rate of checking can be based on the accuracy of recent deliveries.

A client we worked with checks 10 per cent of the lines on each incoming shipment. If they find a discrepancy they will check a further 10 per cent. Further discrepancies result in the whole load being checked.

Where new suppliers are concerned it is likely that you will want to check the whole of the consignment initially until you are confident of the accuracy of the supplier.

Table 3.3 Inbound product quantity checklist

Skip table

Supplier	Product code	Operator count	Expected quantity Office use only	Discre Office
ACME	85052	*56*		

There is a trade-off here between the time it takes to check inbound deliveries, the delay in the product being entered onto the system and available for sale, the number of discrepancies found and the time it takes to deal with them.

Another decision to be made is whether the delivery notes are used to check off the delivery or whether a 'blind' count is made (in which operators are not made aware of the quantities expected until the count has been completed) and the actual delivery cross-checked against the paperwork once the whole load has been received into the warehouse.

From experience, although it is likely to take longer, it is more accurate to count the product and then compare it with the delivery paperwork than use the paperwork as a checklist.

The utilization of barcode scanners has speeded up the process significantly and improved accuracy. Products can be scanned and the details compared in real time (if wireless enabled) with the expected quantities to determine any discrepancies. Once scanned, the goods can be moved directly to the next staging point, be this quality control, a forward pick face, reserve storage or the despatch bay for cross docking. Voice and vision technology can also be programmed in the same way.

The introduction of RFID will further reduce checking time at the receiving bay. Products that have tags fitted can be recognized and counted immediately on entry via a portal into the warehouse and details passed in real time to the WMS.

Other equipment can include weighing scales for products that are not easy to check or are stored and sold by weight.

Recording and reporting discrepancies both internally and externally are a fundamental part of the receiving process.

Table 3.4 shows an example of a goods received non-compliance report, not only recording quantity discrepancies but also other non-compliances.

Table 3.4 Goods received non-compliance report

Skip table

Date received	Supplier	Product code	Purchase order no	B re
03/04/21	ACS	48145	266460	1
03/04/21	ACS	104658	266460	1
10/04/21	BFP	113144	261688	1
10/04/21	QRS	102258	267456	1
14/04/21	QRS	115119	267456	1
21/04/21	Tco Deli	110002	287547	1

Cross docking

The goal of most warehouses is to increase throughput rates and reduce the amount of stock held. Cross docking is a process where products are moved directly from goods-in to the despatch bays. This replaces the need to place the product into storage and any subsequent picking operation.

Cross docking needs the full support of suppliers as to how they present the product. This includes clear labelling and advance notice of arrival together with accurate, on-time delivery. The supplier is required to deliver the product in time for the departing vehicles to be loaded. As each departing vehicle may be taking cross-docked items and items from the warehouse, this needs to be coordinated properly and the goods consolidated accurately.

Where cross-docked products are for multiple store deliveries a pick-by-line system can be used where items are picked from a pallet and allocated directly to a store. Each store will be allocated a line of cages or pallets in front of a despatch door.

Cross docking requires systems to identify the product that needs to be cross-docked and a process needs to be in place to recognize and alert the staff.

Once checked in, the products should be taken directly to the despatch area and their floor or temporary rack location recorded on the system, alerting staff that the product is now awaiting despatch. The details must be recorded in order to provide an audit trail.

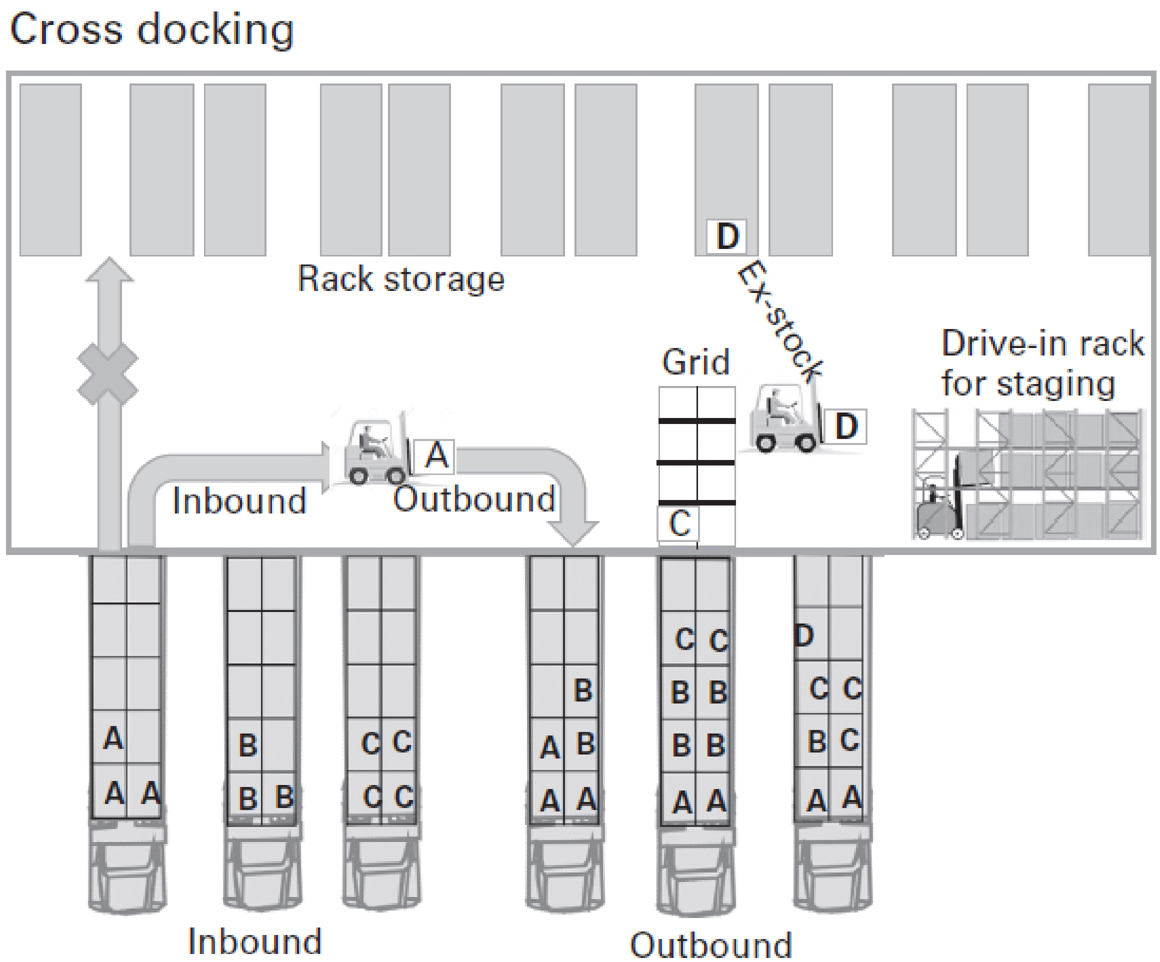
Other points to take into account include the amount of space available at the inbound and outbound areas. Sufficient space is key to moving products quickly and safely. Any congestion in these areas will slow up the process appreciably and lead to tension between teams. There also needs to be a well-marked staging area where the products can be placed prior to despatch. An area of drive-in, push-back or flow racking can assist in marshalling loads for particular collections. This uses more cubic space within the warehouse rather than having all the pallets on the warehouse floor.

Cross docking is used significantly in the movement of perishable goods through the supply chain and retailers use this system in their distribution centres where they receive products from multiple suppliers and sort and consolidate them for onward shipment to different stores. It has been said that

Walmart in the United States delivers approximately 85 per cent of its merchandise using a cross-docking system. This system is prevalent in many retail operations today.

Just-in-time systems also rely on cross docking where manufacturers deliver parts to a cross-dock or sequencing centre where they are consolidated and delivered line-side in sequence.

Figure 3.11 Example of cross docking



▶ Figure 3.11 details

Cross docking does have its disadvantages in that more space is required in and around the despatch bays, suppliers may be asked to deliver in less than truck load quantities. This increases transportation costs and it can result in stock being held further up the supply chain, which could result in overall delivery delays.

Recording

Depending on the product, there could be a requirement to record more than just the standard data such as product code, description and quantity on arrival. Other information could include batch or lot numbers and serial numbers. Barcode scanning and vision technology, which we will look at in the following chapters, are ideal for this type of data capture.

Quality control

It is accepted that certain products will require more stringent checking on receipt. These include high-value items, food, hazardous goods, temperature-sensitive product and pharmaceuticals. New suppliers will also fall into this category. I did some consultancy for one of the emergency services and they quarantined the uniforms on receipt, in order to go through a QC process before being allocated to the staff.

Superdry have introduced a QC check (operated by third-party companies) in consolidation centres in the countries of manufacture to overcome the issue of returning product long distances if found to be sub-standard.

An area close to the receiving bay should be set aside to spot-check items on arrival. This needs to be done as promptly and as efficiently as possible so as to avoid congestion and to get the products onto the system quickly. If there are issues, the items need to be taken to a specific quarantine area or, if space is an issue, to the storage area – but must be identified as defective or awaiting the results of tests. Most WMSs are able to block access to products on the system, making them unavailable for picking until cleared for sale. A physical sign at the location is an additional failsafe.

Put-away

Many of today's WMSs allocate product locations in advance and instruct the operator as to where to place the goods. This can be directly to the despatch area if the product is to be cross-docked as discussed above, to the pick face as a form of replenishment or to a reserve or bulk-storage location.

In order for this system to work effectively, a great deal of information needs to be programmed into the system. This includes the following:

- size, weight and height of pallets and cartons;
- results of an ABC analysis or slotting, where fast-moving goods are placed closest to the despatch area (an area we will cover later);
- current order data;
- family product groups;
- actual sales combinations – product affinities;
- current status of pick face for each product;
- size of pallet and shelf locations; and
- weight capacity of racking and shelving.

The use of pick and drop stations on the end of the racking allows forklift operators to continue with the put-away process whilst another truck can transfer pallets from the inbound area to the rack area.

Distance of the locations from the receiving and despatch areas

In circumstances where there is an absence of system directed put-away, the warehouse manager needs to calculate the optimum location for the goods and instruct the operators accordingly.

Another decision to take is whether products are placed into fixed or random locations. In utilizing fixed locations you are designating a specific location for a particular product. A random location is, as it states, where the pallet is placed in the most efficient slot available.

Fixed positions enable the picker to memorize the actual location and speed up the put-away and picking process. However, if there is no stock for that particular product at any time, the slot remains empty and pallet storage utilization reduces significantly. Having to memorize locations is becoming a thing of the past for many companies with the introduction of WMS; however, I recently worked with a client who didn’t operate a WMS and had the products located by product code so the staff could find items reasonably easily. As a consequence, slow-moving items were mixed with fast movers which isn’t an efficient way of operating a warehouse.

Factors to bear in mind when locating product include their specific characteristics. For example, hazardous items need to be stored in an appropriate area. Items of high value will also require special storage conditions, which might mean a lockable cage or the use of a secure carousel.

When locating cartons, the fastest-moving items should be placed in the middle row of shelving so that the order picker doesn’t have to spend time bending and stretching. Slower-moving items should occupy the lowest and highest shelves.

The warehouse manager also needs to take into account that items should be stored in groups by similarity. For example, within an automotive environment, gearbox parts should be stored together in the same area. Added to this, products that often appear together on a pick list should be located side by side. For example, a ½-inch bolt needs to be stored next to a ½-inch nut rather than the bolts stored together in one area and the nuts in another.

Finally, some warehouse systems will combine put-away with pallet retrieval. This is termed task interleaving or dual-cycling. The system will instruct the operator to put away a pallet en route to collecting a picked full pallet or one that is required for replenishment.

Summary and conclusion

The receiving and put-away processes are crucial to the efficient and effective operation of the warehouse.

The following steps should help to improve productivity in the receiving and put-away area:

- allocate the supplier a time for delivery;
- estimate time to unload, check and put-away;
- allocate sufficient labour and MHE for unloading;
- check if load requires special handling;
- check for any special handling instructions (hazardous, fragile, temperature control, etc);
- unload and check quality of delivery;
- record variances;
- have a system in place to prioritize inbound goods, eg prioritize critical low-stock items, back orders and promotional items;
- attach label or ID tag (sometimes referred to as a licence plate);

- clear dock area and ensure goods are on the system as quickly as possible and therefore available to pick – dock-to-stock time is crucial;
- locate items effectively using system-directed put-away – areas include quarantine, cross dock, pick face, reserve storage;
- check stock rotation policy;
- consolidate stock in locations if FIFO rules allow;
- record stock against the location;
- undertake task interleaving or dual-cycling – put-away and retrieve in same movement; and
- cross dock as much as possible.

04
Warehouse processes
Pick preparation

Introduction

Order picking is normally the most costly activity within today's warehouses. Not only is it labour intensive, but it is challenging to automate, can be difficult to plan, is prone to error and crucially has a direct impact on customer service. Typical errors include omitting items from the order, sending the wrong item and sending the wrong quantity of items.

Companies target the picking operation as the area in which productivity improvements can make a significant difference to overall costs.

The trade-off in this instance is between speed, cost and accuracy. Managers are looking for quick response times, high accuracy rates and high productivity at least cost.

Satisfying these factors will determine the types of picking systems and processes chosen.

The picking operation has changed significantly over the past 20 years. Previously, full-case and pallet picks tended to be the norm. Today, concepts such as just in time, the growth in online shopping and significant reductions in order lead times have resulted in smaller order quantities and more frequent deliveries.

This type of picking is referred to as item, eaches, broken-case or split-case picking.

In a 2020 benchmarking survey, WERC used the key performance measures shown in Table 4.1 to distinguish best-in-class picking operations.

Table 4.1 Best-in-class: picking (WERC)

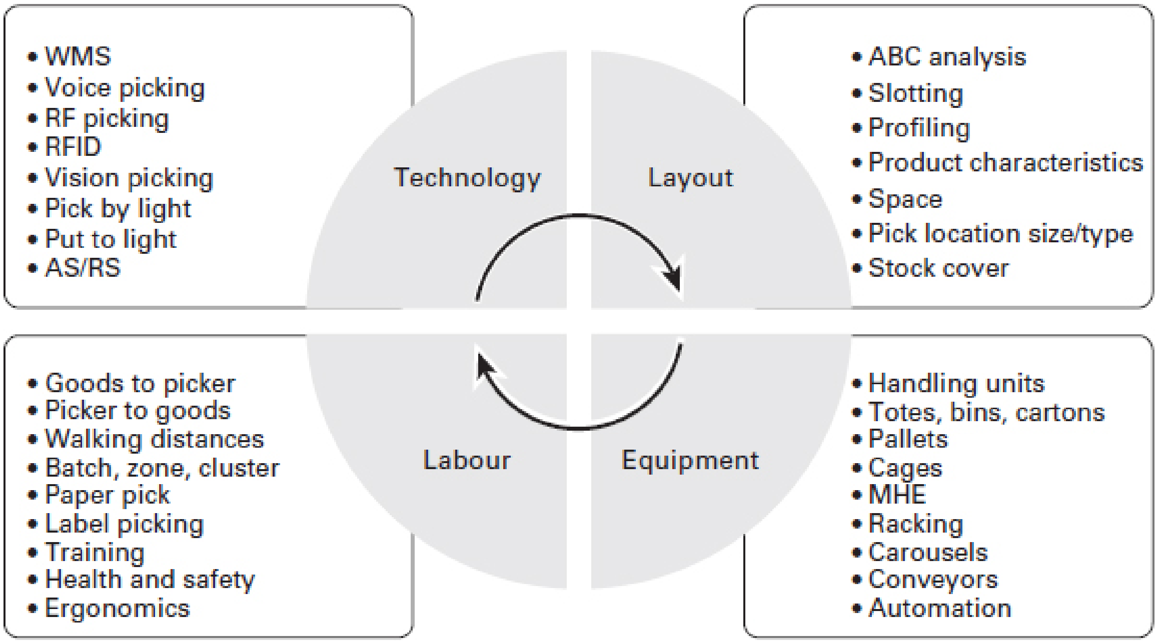
Skip table

	Best-in-class	Median	Major opportunity
Percentage of orders picked accurately	≥ 99.9%	99.5%	< 98.0%
Percentage of orders shipped on time and complete to customer request; or on time, in full (OTIF)	≥ 99.04%	96.19%	≤ 86.23%

The imperative here is to ensure that picking accuracy is checked before the order leaves the warehouse so that incorrect items do not leave the warehouse, operatives can be informed of their performance and additional training instigated if required.

So how does the warehouse of today achieve best-in-class standards? As can be appreciated, there are many interrelated decisions that need to be made and aligned for companies to be effective in this area. Figure 4.1 shows the interrelationship between labour, technology, equipment and warehouse layout.

Figure 4.1 Picking interrelationships



▶ Figure 4.1 details

Preparation

As with any logistics process, preparation is a key element.

According to Frazelle (2002), less than 15 per cent of stock-keeping units (SKUs) within a warehouse are assigned to the most efficient location, resulting in a 10 to 30 per cent cost increase in travel time and underutilized locations.

In order to prepare the warehouse for an efficient pick operation, we need to follow a number of steps. These are based on 5S methodology.

The first step is Sort.

Sort is all about dividing items in the warehouse into three categories: retain, return and get rid.

So, the first tool I want to introduce is an ABC–DE analysis.

We need to produce a stock file that shows the product code, description, quantity in stock, units sold and the last date of sale during a particular time period – a full year of data is preferable.

We also need the number of orders received for each item.

We can then analyse the data and categorize each product line or SKU as follows:

A refers to the most popular items that are constantly being ordered by customers. These are items that we classify as fast movers or runners.

B items are what we term medium movers and are sometimes classified as repeaters.

C items are items that are slow movers or strangers.

D items are items that are better served by being sent direct from the supplier rather than being held in stock and

E items are those items that are the non-movers and need to be removed or exited from the warehouse. However, before the final act of removing the items, you need to ensure that there is no likelihood of future sales. Initially, items can be heavily discounted, returned to suppliers, sold to jobbers or discount stores, sold on platforms such as eBay, given to charity, discounted to staff, recycled or, as a last resort, destroyed.

The quantity sold during the year and the current stock quantity can tell us how many days/months/years of stock we're holding in the warehouse. As a consultant I've had instances where companies have been holding over 20 years' worth of stock of particular items. One example was of first aid kits where there was 12 years' worth of stock held in the warehouse based on current usage yet most of the items within the kits had earlier use by dates. When a CEO or CFO sees you have over 20 years' worth of stock of an item in store it soon concentrates the mind.

Table 4.2 Annual stock usage report

Skip table

Item ID	Total QOH	M 1-12 usage	Days' stock	Yea
SE041-002-02R	39	1	14235.0	
HN031-020-01	77	3	9368.3	
ZN80	24	1	8760.0	
EC211-001-01	96	4	8760.0	
0285263	92	4	8395.0	
MF551-S11-13	64	3	7786.7	
MB041-011-01	20	1	7300.0	
0218293	19	1	6935.0	
EC121-033-01	16	1	5840.0	
0378818	47	3	5718.3	
0415982	15	1	5475.0	
AC99-R	30	2	5475.0	
AD99-R	28	2	5110.0	
HN071-078-01	25	2	4562.5	
0009398	12	1	4380.0	
0314786	12	1	4380.0	
BPGA	12	1	4380.0	
0206719	35	3	4258.3	
0318915	23	2	4197.5	
0270423	11	1	4015.0	
CA121-002-02	21	2	3832.5	

As consultants we worked with a chocolate manufacturer who still had Easter egg packaging in the warehouse that related to the first *Pirates of the Caribbean* film, rendering them totally obsolete as the fourth film in the franchise had already been released. These pallets of cardboard took up valuable space in the warehouse at a time when empty pallet locations were scarce.

Understanding ABC classification begins by understanding Pareto's Law or the 80/20 rule. This states that roughly 80 per cent of effects come from 20 per cent of causes. This rule is not universal, but it is surprising how often it can apply. The idea therefore is to concentrate time and resources on the important 20 per cent or the 'vital few'.

Examples of the 80/20 rule in relation to the warehouse include the following:

- 80 per cent of sales come from the top 20 per cent of product lines;
- 80 per cent of sales come from 20 per cent of customers;
- 80 per cent of profits come from 20 per cent of customers – not necessarily the same customers as above;
- 80 per cent of profits come from the top 20 per cent of products;
- 80 per cent of the cube usage within the warehouse comes from 20 per cent of the products;
- 80 per cent of the inventory value is in 20 per cent of the products;
- 80 per cent of problems come from 20 per cent of your suppliers;
- 80 per cent of complaints come from 20 per cent of the customers; and
- 80 per cent of staff problems come from 20 per cent of your workforce.

It is commonly suggested that the A product codes tend to account for 20 per cent of the stock items, producing 80 per cent of the orders. The B items make up 35 per cent of the stock lines producing 15 per cent of the orders whilst the C, D and E items make up 45 per cent of the stock lines but only 5 per cent of the orders. This is a good exercise to carry out on your own product lines to see how close to the mark this is.

An 80/20 split isn't always the case. One previous client's profile showed that, based on our calculations 80 per cent of the total units sold came from only 5.9 per cent (144) of the total SKUs (2,443 product lines). A further 202 SKUs (8.3 per cent) provided another 10 per cent of the units sold whilst the remaining 85.8 per cent of lines made up the remaining 10 per cent of sales.

These analyses allow you to identify not only the highest-selling products but also items that are not selling and may be prime candidates for disposal.

Note that an ABC analysis shows movement over a specific period. An item that has recently been introduced into the stock portfolio could be a new stock item and therefore has no stock movement recorded. This should not be removed from the warehouse until you build up its stock history.

This ABC–DE analysis should be undertaken on a regular basis, especially if your company has a significant amount of seasonality.

The second S is set in order

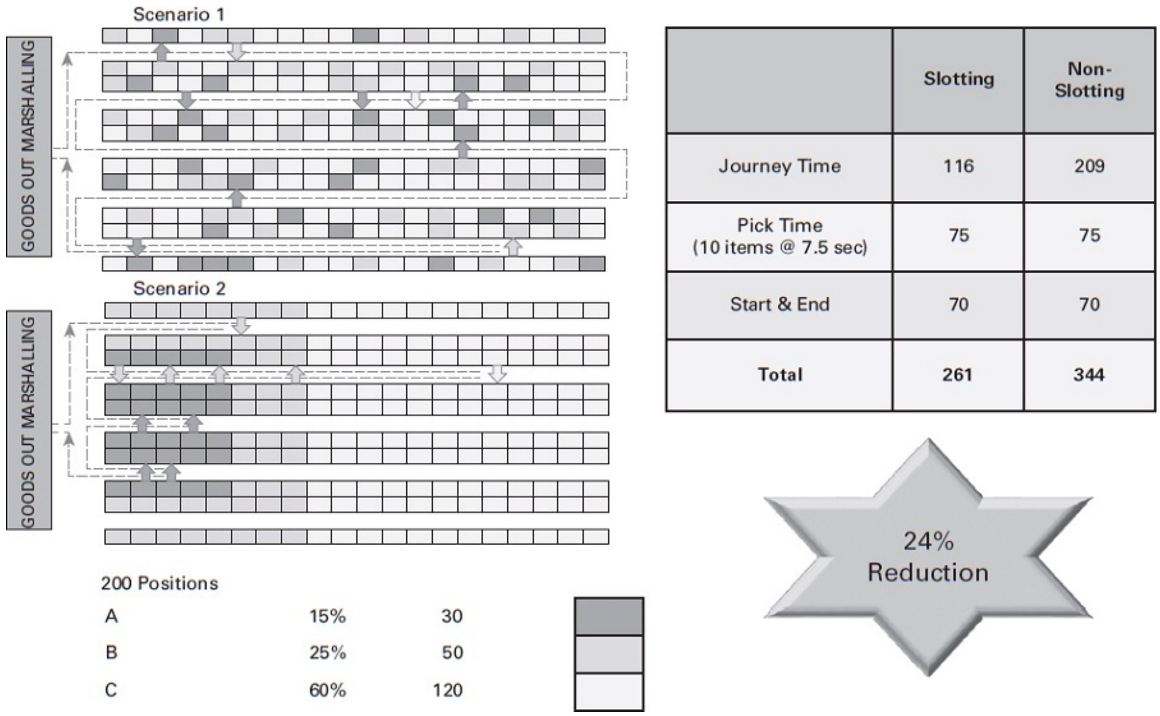
Not only does an ABC analysis assist you in deciding which stock items to keep and which to remove from the warehouse, but it can also assist you in determining the most efficient location for that stock.

Although there is a cost in rearranging stock within the warehouse this is more than compensated for by the reduction in overall movement whilst picking. It's been said that travel accounts for up to 50% of a pick operation in a manually operated warehouse. For example, a DIY retailer will have its summer sales products at the front of the warehouse during the spring and will replace these lawnmowers and garden furniture with Christmas decorations towards the end of the year.

Figure 4.2 demonstrates the importance of ABC analysis and its relationship with travel in the warehouse.

Note that in Scenario 1 products are placed randomly throughout the warehouse irrespective of the number of times they are picked. In Scenario 2 the items are located based on their frequency of pick. As can be seen, the A items are now closest to the despatch area and this has resulted in a 24 per cent reduction in overall time taken to pick the orders.

Figure 4.2 Benefits of ABC analysis (courtesy of Körber Supply Chain)



	Slotting	Non-Slotting
Journey Time	116	209
Pick Time (10 items @ 7.5 sec)	75	75
Start & End	70	70
Total	261	344

▶ Figure 4.2 details

Note that ABC can also be used for locating pallets in the reserve storage area with the fastest-moving products on the ground floor. As soon as you go into the air, the operation slows down appreciably. When locating items on shelving ensure you use the middle shelves for the fastest-moving items – a quicker and safer pick, reducing the amount of stretching and bending for the operative. Keeping A items on the same and adjacent shelf levels within a carousel is also time efficient.

Even within automated systems the fastest-moving products will be closest to the pick stations to speed up the pick process.

Many companies will use an ABC analysis to produce a warehouse layout. However, the traditional ABC analysis using total item sales will only provide a snapshot of the current situation based on one parameter – the level of sales by product, the idea being that the A items, as the highest sellers, are placed at the front of the warehouse, closest to the despatch area. This is not efficient!

Using this analysis alone can lead to a reduction in productivity. For example, compare the following two products in Table 4.3.

Table 4.3 ABC comparison

Skip table

	Sales	Number of orders
Product A	10,000 units	4
Product B	1,000 units	200

Although product A is the highest-selling item, it is only picked four times during the period, whereas product B appears on 200 orders, necessitating 200 visits to the pick face. Under these circumstances, in order to reduce travel distances and time, it is product B that should be closest to the despatch bay. With regard to warehouse layout, we are more interested in the number of times a product is ordered not the actual quantity ordered, although knowing the quantity can also determine the size of pick faces.

With client Y we carried out an analysis based on frequency of pick per product line. Here we found that 80 per cent of picks came from 15 per cent of the product lines. In fact, the top 20 most popular lines by order frequency made up 39 per cent of the total picks as can be seen in Table 4.4 below.

Table 4.4 Order frequency analysis

Skip table

SKU code	No. Orders	Cumulative	Cumulative %
XZ214	1600	1600	4.94
XZ208	1166	2766	8.55
XZ216	1099	3865	11.94
YR301	1055	4920	15.21
XZ114	731	5651	17.46
YR028	728	6379	19.71
YR010	715	7094	21.92
YR031	626	7720	23.86
ST977	549	8269	25.56
ST976	547	8816	27.25
XZ116	521	9337	28.86
XZ109	521	9858	30.47
YR296	501	10359	32.01
YR300	355	10714	33.11
ST978	352	11066	34.20
YR302	343	11409	35.26
XZ217	343	11752	36.32
YR011	315	12067	37.29
YR503	312	12379	38.26
YR012	285	12664	39.14

It is our contention that the picking area layout should be based on the number of pick-face visits taking into account size and weight of the product and any special circumstances such as high security items.

There are sophisticated software programs available to enable you to produce these results. However, if you are looking for a quick analysis, utilizing the ‘sort’ feature within Excel will give you reasonable results as can be seen from Table 4.4.

Another analysis to undertake alongside the ABC analysis is the number of times an order is completed with a single product line. Table 4.5 is an ABC analysis, which also shows how many orders are completed with a single order line.

Table 4.5 Product popularity by order frequency

[Skip table](#)

SKU	# containing orders	# completing orders	% order completions
CC01-0002AB	353	44	12
SE021-001-01	287	17	6
284568	168	9	5
CC01-0001AB	156	10	6
ZM01	149	47	32
SB11-09	129	20	16
SB11-10	127	26	20
ARSA-R	120	3	3
AOMS-R	120	0	0
SE021-017-01	114	19	17
AMSA-R	111	0	0
AWSS-R	111	0	0
SB11-08	102	24	24
32986	93	44	47
CC021-010-01	90	30	33
OAS-8100YS	86	38	44
ZM02	86	27	31
MF01	83	3	4
DCVB	80	15	19
10123	76	38	50

As can be seen in Table 4.5, over 40 per cent of orders for product codes 10123, OAS-8100YS and 32986 are single-line orders.

ABC is part of the slotting process within a warehouse. Slotting is a tool that calculates the optimum location for products within a warehouse. The tool is used to reduce the amount of travel time for operators by not only placing fast-moving products close to despatch but also placing items that frequently ship together next to each other in the pick-face area.

For example, in a maintenance stores environment the natural storage method for nuts and bolts is likely to be by family and product code: all the nuts in one area and the bolts together in another area, although reasonably close by. Our suggestion is that the same-size nuts and bolts are stored next to each other. This is for two reasons: one, they are normally sold together, and two, it provides a separation between two similar-sized products, eg 3⁄8-inch nut from a ½-inch nut. This should lead to a reduction in travel time *and* potential errors.

Table 4.6 is an example of a simple slotting analysis carried out for a client, which shows how often the same products appear on a pick list. This only looked at pairs of items. More sophisticated software can look at multiple items. In this maintenance stores example we see items appearing on orders regularly together.

As we can see, item codes CC01-0002AB and SE021-001-01 appear on the same order 186 times even though they are not in the same family of products. These items should be located as close to each other as possible, if feasible, in order to reduce travel time within the warehouse.

Table 4.6 Example of product slotting tool

Skip table

Product affinities			
SKU 1	SKU 2	#-containing orders	#-completing orders
CC01-0002AB	SE021-001-01	186	1
284568	CC01-0002AB	117	3
AOMS-R	ARSA-R	116	3
AMSA-R	ARSA-R	111	0
AOMS-R	AWSS-R	111	0
AMSA-R	AWSS-R	111	0
AMSA-R	AOMS-R	111	0
ARSA-R	AWSS-R	111	0
CC01-0001AB	CC01-0002AB	110	7
284568	SE021-001-01	107	1
CC01-0001AB	SE021-001-01	85	1
MF01	ZM01	66	16
CC01-0002AB	SE021-017-01	60	0
SE021-001-01	SE021-017-01	57	1
ZM01	ZM02	55	16
346538	DCVB	52	15
284568	CC01-0001AB	46	0
CC01-0002AB	SE021-001-03	46	1
CC01-0002AB	HH01	44	1
CC01-0002AB	SB11-09	40	3
CICA-R	TSSA-R	39	15

The system can also identify small groups of products that can complete a large number of orders. By examining the popularity of the items combined with the orders that they complete, these items can be identified and stored within a specific area in the warehouse. In Table 4.6 note how often product code CC01-0002AB is paired with other items.

Slotting can also determine how many and what size of pick face is required for each product line. Very fast-moving lines will require multiple pick faces to avoid a bottleneck at a single location. These need to be spread efficiently across the front of the racking nearest the start and finish of the picking run. Larger pick faces can also be produced by utilizing a full bay or even adjacent bays, thus reducing the need for frequent replenishment.

Slotting will also take into account seasonality and suggest product transfers such as moving garden furniture from the front of the warehouse, where it is stored during spring and summer, to the rear of the warehouse during winter. Although there is likely to be a reasonable amount of additional handling involved, this should be outweighed by an overall reduction in travel, having moved the more popular winter products to the front of the warehouse.

The system can also take into account other parameters such as value, cube, weight and crushability. Retailers can also set up the system to pick in sequence, tailored to store layout, thus minimizing the time spent handling the product at store.

This software is integrated within many of today’s WMSs but can also be sourced separately; payback is normally less than one year.

By profiling the activity of items and orders received into the warehouse, we can determine which pick method to use, how much space to allocate and therefore where and how to store the product.

Slotting optimization determines the best location profile for your warehouse, and enables you to make timely, intelligent decisions as ordering trends change.

It asks the following questions:

- Are fast-moving items in the most accessible locations?
- Are slots allocated in the most efficient manner according to product size and weight? When picking, you want to be able to pick the heavier items first.
- Is your storage capacity optimized for your current stock? For example, are your rack slots configured and take into account the heights of your pallets. Ensure you don’t have half height pallets in full pallet height locations.
- Are items that sell together close to each other?

We can analyse orders in a number of different ways. One of the most common is lines per order. This examines how many different product codes make up an order, and as a result we can calculate how many pick locations we will visit for each order.

Table 4.7 shows the number of lines (SKUs) per order on average for different family groups and also the average number of units per line for a manufacturer in the fast-moving consumer goods (FMCG) sector.

Table 4.7 Order analysis: FMCG manufacturer

Skip table

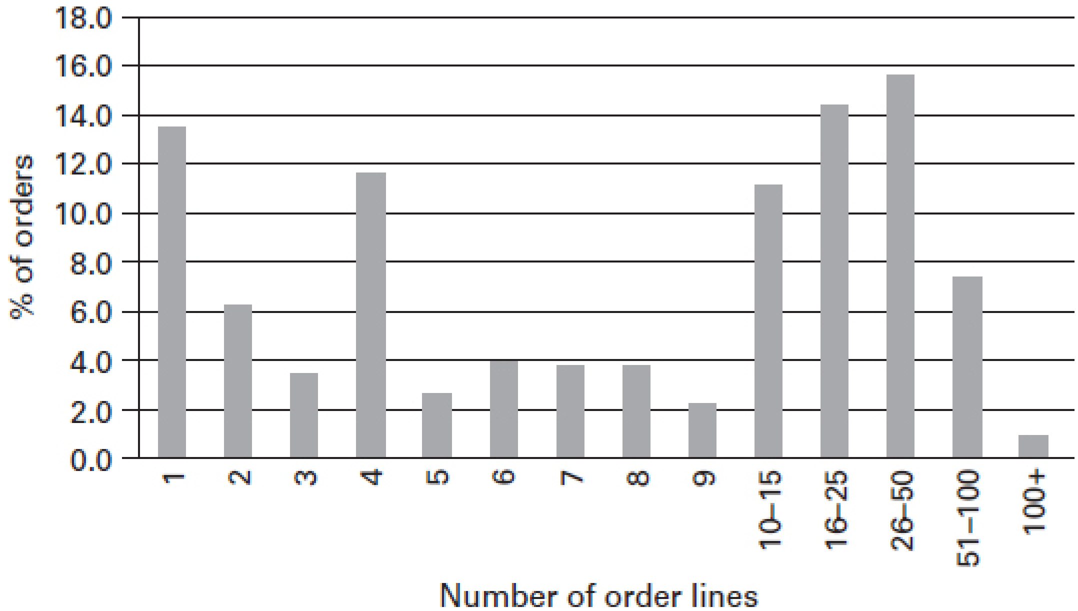
	No of orders	No of units	No of SKUs	Units
Family group 1	4,783	65,552	29,501	
Family group 2	6,955	81,857	34,386	
Family group 3	1,892	25,596	12,165	
Family group 4	52	817	110	
Family group 5	2,555	13,654	4,287	
Family group 6	12,974	667,558	189,898	
Family group 7	6,067	112,218	55,704	
Family group 8	1002	1,603,200	40,080	
Family group 9	62	25,270	643	4
Overall	36,342	2,596,172	366,774	

As can be seen in Table 4.7, the family groups of products have different profiles. Family groups 8 and 9 have full-carton picks; however, the other family groups are predominantly item picks.

This information can help in determining the type of pick operation and also the type of storage medium to be used.

If we take family group 6 as an example, we can see in Figure 4.3 that there are a larger number of single-line orders together with some large orders with multiple lines. Using averages in these circumstances can therefore be misleading.

Figure 4.3 FMCG manufacturer: order analysis



▶ Figure 4.3 details

With such a large number of single-line orders we also need to determine whether these are standard orders or possibly back orders.

If they are standard orders then a batch pick (discussed later) is probably the most suitable method of picking. Examples of this type of order profile include internet sales, small-parts distribution and engineering spares.

Where items are picked from cases, this suggests that the items could potentially be decanted into smaller receptacles and placed in a specific area within the warehouse where picking operations can be consolidated. It is more efficient to decant product at inbound than having to do it during the order pick process. Note the operation in the first iHerb.com video. Time tends to be more critical on outbound.

Allied to the lines-per-order calculation is the ‘cube per order index’ (COI), which calculates the ratio of a product line’s space requirement at the pick face to the number of picks per day.

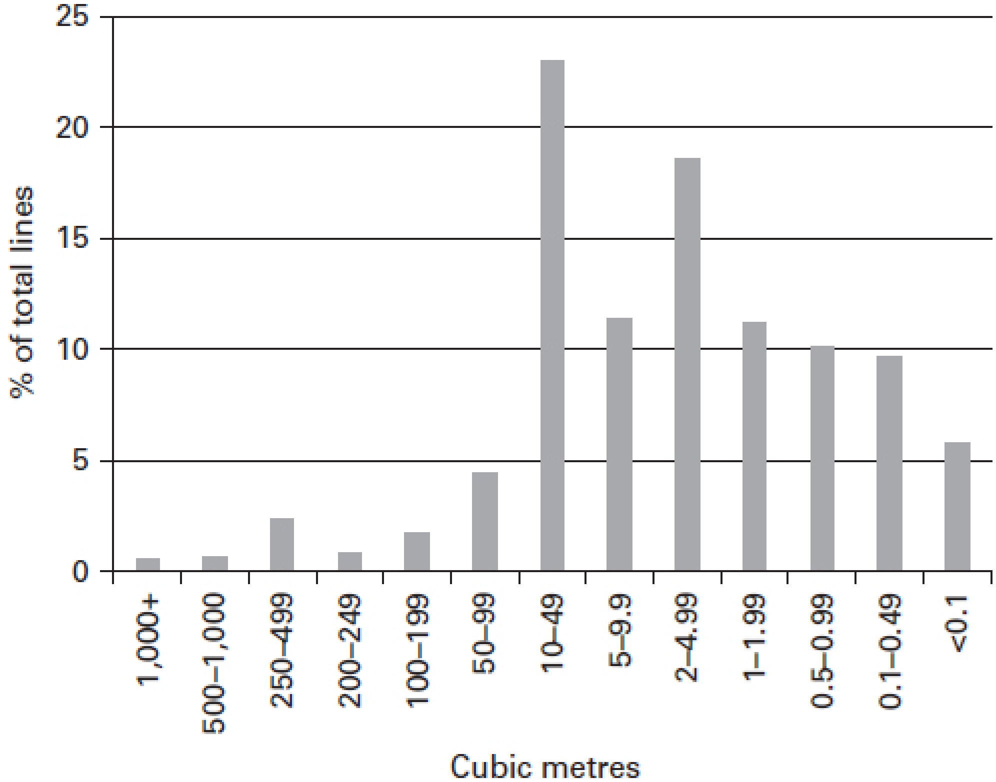
This ratio enables you to decide on which position in the pick run a particular item should be placed. The lower the COI, the better the space utilization of the product and, therefore, it should be placed nearer to the despatch bay at the front of each run of racking.

By combining the two measures we are able to determine the method of picking. Multiple orders with a small overall cube can be picked by means of a roll cage or trolley whilst larger cube orders will require pallet trucks or pallet jacks, for example.

In order to decide on the method of storage for individual product lines we need to examine the cube movement distribution. By detailing the items that fall into specific cube movement ranges we can decide on the most appropriate storage mode.

Figure 4.4 shows an example of cube movement distribution. Approximately 15 per cent of the total items ship less than 0.5 cubic metres per month, which suggests bin, shelf, flow rack or carousel storage, whereas 12 per cent of the items ship in excess of 50 cubic metres per month. This points in the direction of some form of pallet storage.

Figure 4.4 Product cube picked and despatched per month



▶ Figure 4.4 details

Demand variation distribution enables you to determine the size of the pick face and the quantity held for each type of product, the idea being to limit the number of replenishments that take place during a day. The ideal is not to replenish but have sufficient stock in situ to cover demand over a shift. An approximate figure can be derived by calculating the average daily demand and the standard deviation for each item.

Table 4.8 is an example of a client's pick operation that utilizes flow racking and has a mixture of full carton and item picks from carton.

Table 4.8 Example of pick-face analysis

Skip table

Product code	Av. Units picked per day	Equivalent carton pick	Average number of visits to pick face per day	Carto rack
989533	886.1	11.1	13.3	
989133	942.3	10.5	16.2	
881043	522.2	8.7	6.4	
978003	5,804.3	7.3	14.4	
989333	309.8	6.2	13.4	
881033	405.7	5.8	4.3	
881053	141.8	4.7	3.7	
989122	554.1	3.7	12.0	
812833	158.8	3.5	11.6	
989144	194.6	3.2	8.8	
989322	277.7	3.1	9.1	

As can be seen from this example, the number of cartons stored in the pick faces is nearly optimum providing there is no significant deviation from the average.

The issue arises when there is a significant daily deviation in the number of items picked. For example, if we take product code 989533 with daily pick quantities of 11, 13, 19, 5 and 7, although the average pick per day is 11 there is a wide variation across the week. In order to accommodate an average day's demand with a low possibility of replenishment, we need to store the average number of cartons picked plus two standard deviations for a 5 per cent chance of replenishment and three standard deviations of demand for a 1 per cent chance of replenishment during the day. This suggests the pick face should contain either 21 or 26 cases for this product.

To calculate the standard deviation using Excel, enter each of the pick quantities into adjacent cells. In an empty adjacent cell go to statistical formulas and choose STDEV.P. This should highlight all of the pick quantities and once you press enter this will produce the standard deviation. For two standard deviations multiply this number (for the above example it is 4.9) by two. Add this number to the average pick.

The issue will be whether there is sufficient space available to accommodate this amount of stock in the picking area.

The amount of space made available to the pick operation will very much depend on the total available cubic capacity of the warehouse, the floor space and the amount of reserve stock needing to be stored.

To summarize, the following analyses need to take place in order to accurately determine the type of pick and storage medium required:

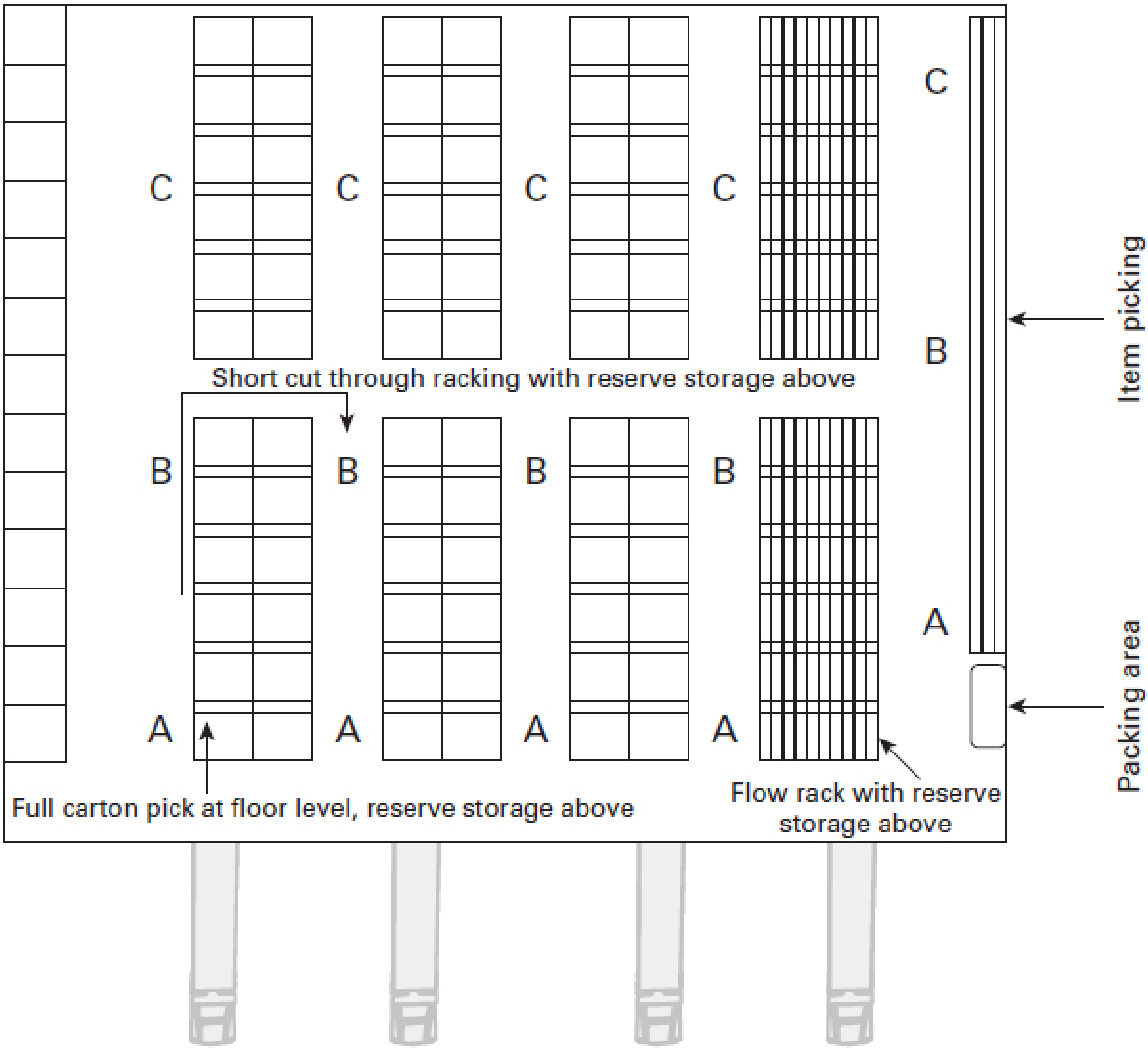
- order profile – percentage of orders from each family grouping;
- lines per order;
- units per order;
- cube per order;
- lines and cube per order; and
- item order completion rate.

Warehouse pick area layout

Having produced a comprehensive profile of the products and orders, we are ready to tackle the layout.

Figure 4.5 depicts a very basic layout that has used an ABC analysis based on the frequency of pick-face visits. The next step is to minimize the amount of travel through the warehouse when picking an order.

Figure 4.5 Basic warehouse layout based on ABC classification



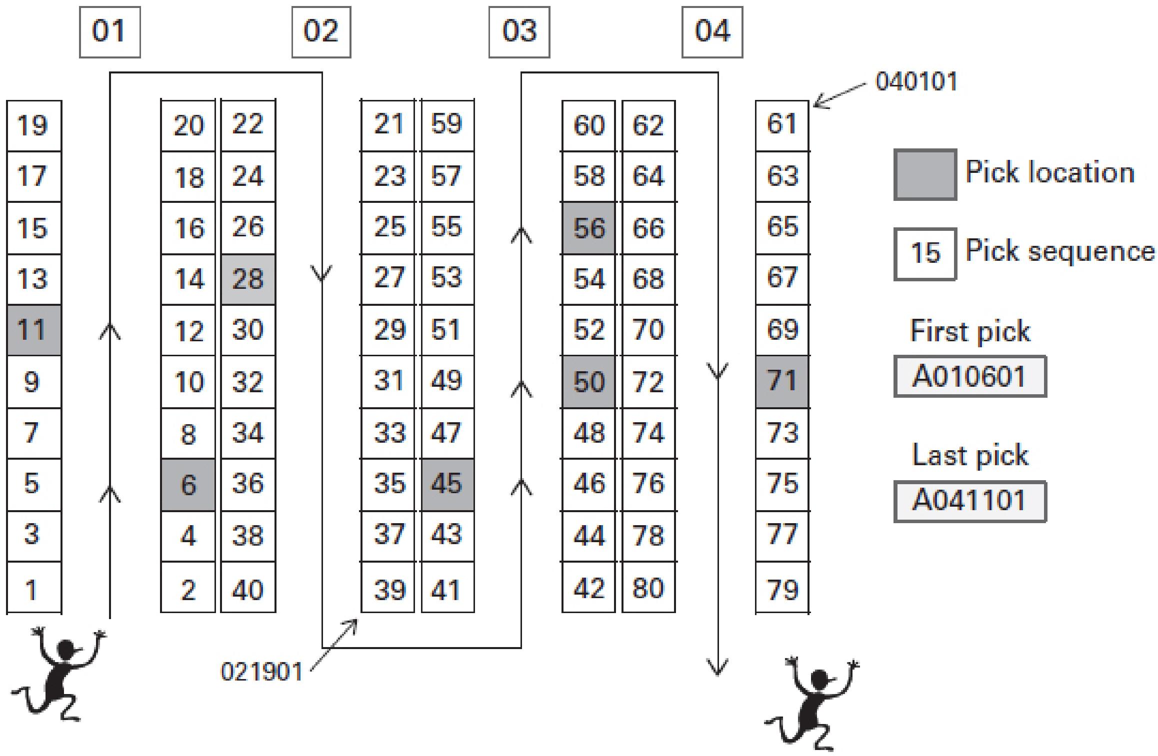
▶ Figure 4.5 details

The route followed by the picker when assembling the order needs to take into account the following:

- The pick instruction will have each pick sequenced as per the most effective route beginning and finishing at the front of the racking nearest the despatch bays.
- Heaviest items are picked first.

- The picker should be able to pick from both sides when moving up and down the aisles (see Figure 4.6). In this example the aisles are numbered, not the rows of racking, which means that the picker can move from side to side as opposed to travelling up the length of the racking and back down the other side.
- Shortcuts are programmed into the system to minimize travel. For example, a break in a long length of racking (as shown in Figure 4.5) enables the picker to shorten the travel distance but allows the storage of reserve product above the pathway.
- A photograph of a rack tunnel is shown in Figure 4.8.
- The picker ends up as close to the despatch area as possible. If the picker is not operating in real time the picker may need to return to the start point to pick up a new assignment. This is not ideal.
- Multiple pick locations for the most popular items need to be set up to avoid congestion at the pick bays.

Figure 4.6 Rack and shelf layout (adapted from J P van den Berg, 2011 and reproduced by kind permission)



▶ Figure 4.6 details

An alternative layout can be seen in Figure 4.7. Rather than traverse up and down each aisle a number of side aisles can be positioned at right angles to the main aisle.

Figure 4.7 Alternative rack layout with racks at right angles to the main aisle

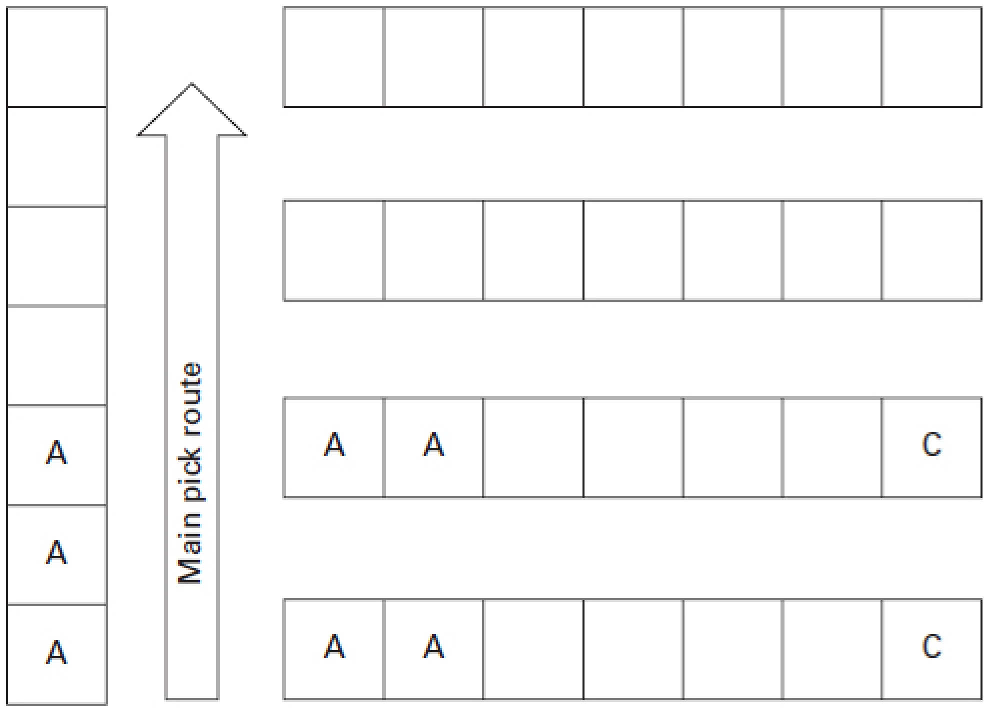


Figure 4.8 Rack tunnel (courtesy of Nene Storage Equipment Ltd)

A typical warehouse layout will operate with a reserve pallet storage area (racked or free standing), which may or may not be above the individual pick faces. Whether the storage area is separated from the pick area or not will depend on the number of SKUs and the amount of floor space available for both reserve and pick locations.

This enables the picker to pick full pallets of a product if the order demands it. The picker must not be directed to pick a full pallet from the pick location as this will increase the amount of work required, as that pallet will have to be replaced by another through replenishment immediately.

The worst-case scenario is where the picker takes 30 cartons from the pick face and a further 30 cartons from a pallet of 60 cartons in the reserve storage area to complete a full pallet order of 60 cartons of the same SKU. Unfortunately, some WMSs still work on the principle of emptying the pick face first, irrespective of the size of order. A manual intervention by the picker normally takes place to overcome this situation.

If during the item and order profiling we see that families of items regularly appear on orders together and fulfil a large percentage of these orders, it may be cost-effective to establish a separate area within the warehouse for these products. In effect a warehouse within a warehouse. Examples are large customers who only order a specific number of products or customers who have bespoke products with their own labelling and packaging such as retailers who sell own brand items but are manufactured by another company. A mezzanine floor may be constructed to increase the number of pick locations, specifically for smaller, slower moving items.

Third-party shared-user warehousing is a typical example where a number of clients share the building but the picking activities are typically segregated.

Where small quantities of items are picked, the warehouse will also have an area of shelving where the product may be held in bins or totes to make individual-item picking easier. Gravity-fed shelving or flow rack further enhances the picking process, where product is fed in at the back of the shelf and as the carton, bin or tote is emptied another slides into its place. The key to this type of storage is to ensure maximum utilization of the flow rack and timely replenishment as discussed above.

Depending on the height of the building, these may be situated on a mezzanine floor, thus increasing the cubic utilization of the building and minimizing contact between MHE and the pickers. Although there is a tendency to use mezzanine floors for slow-moving items the floors can be linked by conveyors to quicken up the pick process by using a pick by zone method.

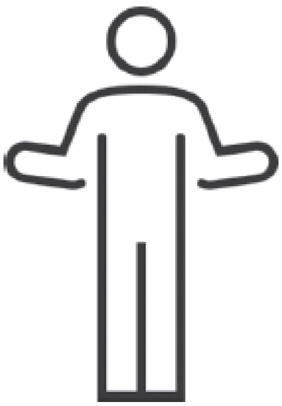
An alternative to shelf locations are carousels, which are described in greater detail in Chapter 5.

When determining the pick layout, you also need to take into account the requirement for space to undertake value-adding services such as labelling, kitting, packing, shrink wrapping, promotional packing, etc. This area needs to be close to both the picking and despatch areas to avoid excessive travelling and handling. It also needs to be segregated from MHE movements to safeguard the staff. Again, a mezzanine floor is ideal for this type of work. Constructed above the inbound and outbound doors not only ensures proximity to the despatch area but also utilizes 'dead' space.

As picking is a labour-intensive operation, the welfare of the operator has to be taken into account when choosing the most appropriate method of picking. This includes safe and comfortable MHE, ergonomically designed storage modules, workstations and equipment. Figure 4.9 below shows items placed at a height which minimizes bending and stretching for the operator.

Figure 4.9 ABC locations on shelving

Product location on shelves by ABC



C	C	C	C	C	C
A	A	A	A	A	A
A	A	A	A	A	A
A	A	A	A	A	A
B	B	B	B	B	B
B	B	B	B	B	B

Ensure A items are located between the hips and shoulders to reduce bending and stretching.

We will discuss how to approach warehouse layout and the choice of equipment in greater detail later.

In the next chapter we determine the most appropriate picking system based on the data we have compiled. Information required to determine the most effective picking system includes:

- dimensions and weight of the product (item, inner carton, outer carton, pallet);
- product group (hazardous, temperature sensitive, high value, etc);
- total number of SKUs by category (ABC);
- total number of orders in a period;
- total number of deliveries (there is a difference – orders can be consolidated into fewer deliveries);
- mode and average number of lines per order;
- mode and average number of units per line;

- cube per order;
- pick-face visits per SKU;
- item, case or full-pallet picks by SKU;
- typical family groupings; and
- items which are sold together frequently.

This data should be gathered during the profiling exercise. Having compiled the data, we can now proceed to determine the most effective picking systems.

Summary and conclusion

In order to be productive and efficient in the picking process, a great deal of preparation needs to take place. This includes having a comprehensive understanding of the products and their sales patterns and the data available to produce ABC analyses.

Placing products in the most appropriate location reduces travel distances and strain on operatives and as a consequence leads to improved productivity and overall cost reduction.

According to OPS (2009) the 'Ten Commandments of picking' are as follows:

- Design for flexibility and scalability – things change – build for today, design for the future.
- Keep pickers picking… not waiting or undertaking other tasks such as carton erection, packing, labelling, etc.
- Minimize travel.
- Minimize product touches. If you have expert pickers you shouldn't need to check their work.
- Never let pickers arrive at an empty location.

- Measure, measure, measure (productivity and accuracy but also product dimensions).
- Pick logically, slot intelligently.
- Pick accurately – get it right first time.
- Continue to learn and explore.
- Advocate continuous improvement.

I will add one more to this list: ensure that you make it easy and comfortable for the operator by providing:

- good lighting;
- ergonomic equipment;
- equipment aids (scanners, voice, RFID, vision);
- assistance with heavy items;
- placement of product – in easy-to-reach shelf locations; and
- clear and unambiguous labels.

In the next sections we will look at the different picking strategies.

05
Goods-to-person and person-to-goods picking

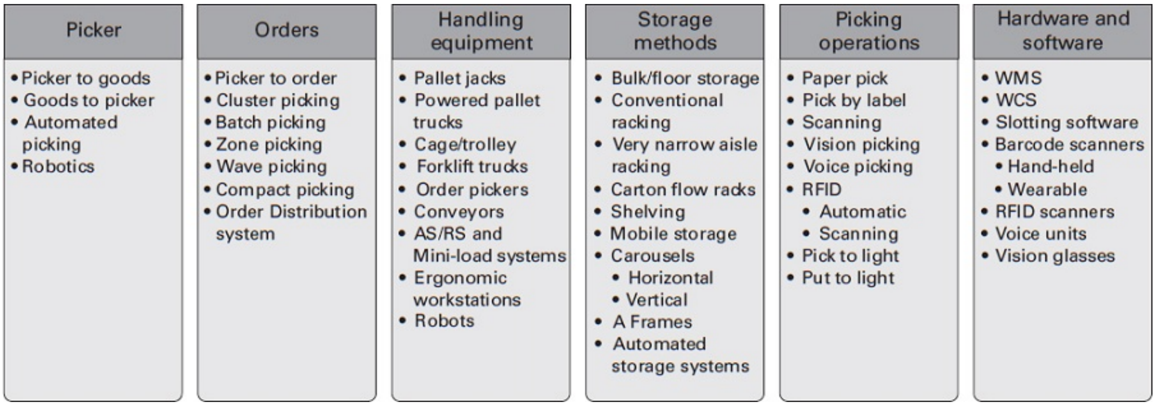
Introduction

In this chapter we examine the different types of picking strategies available to warehouse managers including goods-to-person and person-to-goods picking.

One of the main cost areas within the picking operation is the movement of people and equipment between pick locations. Depending on the operation, this can account for up to 50 per cent of a picker's time. To increase productivity and efficiency the aim is to reduce this travel time significantly. Congestion at the pick face is also an issue as it can convert travel time into waiting time. This chapter examines the different methods of picking and the equipment and automation utilized to attain these goals of reduced travel and waiting time.

There are a number of dimensions to the picking process. These include how and when the orders are presented, how the items are stored, how the actual items are picked and the equipment required. These dimensions are shown in Figure 5.1.

Figure 5.1 Picking strategies and equipment



▶ Figure 5.1 details

What we can see from Figure 5.1 is that there are many interrelationships and many options. For example, if we decide on a picker-to-goods operation this can either be done by, for example, picking individual orders, batch or cluster picking, utilizing trolleys or pallet trucks and a choice of paper, voice, vision or scanning.

The first point to mention here is that in terms of picking there is no ‘silver bullet’ or ‘one size fits all’ solution.

In today’s e-commerce world companies are more likely to use advanced pick methodologies such as batch, zone and cluster picking as opposed to individual-order picks. However, each company has different requirements and these strategies may not suit everyone. We are also seeing a significant increase in automated solutions.

A picking operation may require full-pallet picks, pallet-layer picks, outer-carton picks, inner-carton picks or individual-item picks. In most cases the warehouse will be required to pick a combination of the above and, at times, these combinations can occur on the same order.

Many managers see advanced technology and automation as the silver bullet where picking is concerned; however, they may well be overlooking basic improvements that can be introduced initially to enhance order picking efficiency and also the potential lack of flexibility that accompanies automation in certain operations.

During many of the warehouse management courses I run I tend to find that the majority of attendees do not use ABC analysis and order profiling. There are many opportunities therefore to improve basic pick operations before introducing automation.

Basic techniques such as profiling, slotting, pick-route planning, pick-face sizing, accurate and timely replenishment, proper equipment selection and documented processes will all help to enhance pick efficiency without having to introduce technology and automation in the short term. The growth of e-commerce, however, is challenging this. 'E-fulfilment requires scalable operations and highly flexible systems to address these inherent challenges,' according to Roland Martin from Swisslog. Challenges include shorter order lead times, large numbers of small orders for single units and a need for extreme accuracy.

Companies are likely to operate a number of different order-picking strategies and techniques depending on the nature of the product, the quantity of items to be picked and the size of order.

There are usually five types of pick requirement within a warehouse. However, they do not always occur individually and can be included on the same order. These are as follows:

- piece, each, unit, item or broken-case pick;
- inner-carton pick;

- full-case or carton pick;
- layer pick; and
- full-pallet pick.

In the following sections we will look at each of the pick strategies in turn and discuss their interrelationships.

Pick strategies can be split into three categories. These are:

- picker to goods;
- goods to picker; and
- automated picking.

Picker to goods

The majority of small- to medium-sized warehouses continue to operate with minimal automation and picker-to-goods operations prevail.

Pick to order (individual order pick or discreet order pick)

Here the picker takes one order or part of an order (assignment) and travels through the warehouse either on foot with a cage or trolley or using a pallet on a pallet jack or forklift truck, collecting items until the whole order or assignment is completed.

Orders can be for individual items, inner cartons, full cartons, pallet layers, full pallets or a combination of these.

The picker follows a route or pick path designated by reading a paper pick list, looking at a roll of labels, reading instructions on a radio data terminal or following voice commands. New technology recently introduced includes vision picking where the operator follows directions via a see-through display on a pair of glasses.

All order lines are picked in sequence for a specific customer order. Depending on the size of the items, piece pick items are likely to be stored on shelf locations, in carousels or on flow racks for example. Full cartons can be stored on pallets in pick locations, on shelving or in flow racking.

The advantage of picking individual orders is the minimum amount of handling involved as the product moves from storage to despatch in one handling movement. It is also excellent for urgent order requests.

This remains the most common method of picking. However, orders with multiple SKUs and long distances between picks can be very labour intensive.

There can also be a requirement for a second person to check the order before it is despatched. This requirement for checking is discussed in greater detail in the chapter on despatch.

Cluster picking (sort whilst picking)

In order to reduce overall travel time, operators can take a number of orders out into the warehouse at the same time and pick into individual compartments on their trolleys or cages. Some operations will utilize powered pallet trucks that can carry two pallets at a time or utilize tugs or tractors that can move multiple pallets through the picking aisles as can be seen in Figures 5.11 and 10.24.

Figure 5.2 shows a pick cart with put-to-light technology used for cluster picking.

Figure 5.2 Cluster pick cart (courtesy of Inther)

VIDEO 5i Actemium cluster pick to cart

CASE STUDY Lightning Pick and Capacity USA

3PL warehousing and fulfilment service provider Capacity LLC stores, picks, assembles, kits and ships orders on behalf of its customers, which include both household names and global brands. The company sought to implement a semi-automated order fulfilment system to improve picking speed and accuracy, as well as overall throughput rates. One of the goals was to minimize touches, explains Capacity's Chief Strategy Officer Thom Campbell, 'With our paper picking environment, we had six eyes on each order: a picker, a packer and a quality control (QC) supervisor who confirmed that the right units were picked,' he explains.

Lightning Pick engineered a two-part solution including mobile pick-to-light carts for cluster picking of required stock-keeping units (SKUs) and put-to-light put walls for sorting and organizing picks into discrete customer orders prior to pack out. Associates could take one cart out and pick 16 batches at one time, then bring those batches to a sorting area equipped with put walls for the fast sorting required of a high-volume e-commerce fulfilment operation. At the start of the cluster picking process, a Capacity team member registers pick destination totes to a pick cart. Light modules on each cart indicate the required SKU's storage location within the warehouse. The picker guides the cart to the first item location and scans its barcode. This prompts specific light modules on the cart to illuminate, displaying the number of units to be picked. Picked units are placed into their corresponding totes and the picker presses a button on the light module to confirm the pick.

The same process is repeated until all picks for that batch are complete. Once all the units have been picked, the cart is wheeled to the sortation area for distribution into individual customer orders. At the put wall, a Capacity team member scans each item, which triggers the illumination of light modules in front of each put wall cubby, indicating orders requiring that item. Upon placement of the item into each put bay, the operator presses a button on the light module to confirm placement.

Once all the required products are sorted on the sortation side of the put wall and an order is complete, a corresponding light illuminates on the other side of each open-ended put bay. This alerts packers to start the pack out process for that order. Capacity team members then scan the boxes for fulfilment, remove the units from the bays, and pack the units for shipment.

When previously picking from paper-based lists, Capacity's fulfilment associates could process around 2,500 orders in a normal workday. Now, with the new light-directed fulfilment systems in place, the teams can handle 12,000 or more orders in a normal shift – and even more during extended shifts. 'We are just beginning to mine the data surrounding our productivity, but on a maximum throughput day when we are working shifts around the clock, we are getting as many as 1,000 e-commerce orders through the put wall in any given hour,' says Campbell.

A similar system is shown in the initial iherb.com Video 1ii.

Although having the advantage of being able to pick several orders at the same time and reducing overall travel, it does need experienced pickers if a put-to-light system is not utilized. There is a possibility of putting the wrong product or wrong quantity of product into a container and therefore a check system needs to be in place to ensure picker accuracy.

Cluster picking can also be used with conveyors, where a partitioned tote or multiple totes divert into a pick zone. As the tote passes a barcode reader its unique ID is read and all the picks for the current tote are displayed on the individual pick-to-light terminals.

Each terminal indicates both the quantity to be picked and the tote location where it is to be placed. A pick of eight pieces into the B compartment would be displayed as B8. When all picks for all compartments in the current zone are complete, the tote is returned to the conveyor belt and it proceeds to the next zone, where additional picks for any compartment are required (elogistics101.com).

Both scanning and voice can also be used with a conveyor and zone pick system as can be seen in Video 5ii.

VIDEO 5ii Voice and scanning cluster pick example from Vocollect

The number of orders per cluster will depend on the number of lines, units per order, total cube and the capacity of the totes, cages or trolleys.

The next video shows a DHL operative utilizing a vision system to operate a cluster pick.

VIDEO 5iii Cluster picking with vision technology

As seen above we have a combination of technologies and pick strategies.

Batch picking

Batch picking is where operators pick products for a number of orders at the same time. This is similar to cluster picking; however, rather than have a cluster of separate orders, these orders are consolidated into one pick list and once picked are later broken down into their constituent orders. Pickers can be sent to the reserve storage area to pick full pallets or layers of pallets to satisfy the order quantities.

There are two alternatives: pick by line and pick to zero. Pick by line may result in excess items being returned to stock where full pallets or cartons have been picked. For example, a batch of 10 orders may require 100 units to be picked in total. A full pallet holds 120 units and is brought to the order consolidation area. Once the 100 units have been picked the remaining 20 units are returned to the reserve storage area or possibly transferred to the forward pick area. In the case of pick to zero the correct number of items (the 100 units in this case) are picked and allocated to customer orders until the lines and units are exhausted. This is also termed bulk picking.

Advantages include less travel and potentially increased accuracy as two people are involved in the pick and allocation process. The disadvantage is that it is a two- or even three-stage process and cannot easily manage time-sensitive orders. There is also a requirement for additional space at the despatch area for sortation and there may be a delay as the system waits for sufficient orders to come through before it produces a batch pick.

The batch system can also be utilized within a cross-dock operation where products can be picked and allocated on arrival at the warehouse. This removes the put-away and replenishment tasks and increases throughput and accuracy.

Orders can be batched in a number of different ways. For example, mail order or e-commerce operations may well batch by single order lines or single items. A typical usage is in television home shopping such as the QVC channel. Different products are promoted at certain times of the day and orders are placed for them. This results in a large number of orders for a single product line. Each order is likely to be for potentially one or two units. It makes sense to consolidate these orders into one pick list and pick large quantities of the product in one pass. It is then simply a case of attaching a shipping label onto each item for despatch.

Orders containing similar items can also be batched together. Finally, orders can be split, based on where the products are in the warehouse.

Batching orders together can be done manually; however, most warehouse management systems (WMSs) today have this capability.

Technology such as put-to-light systems and put walls can be used to help ensure accuracy. As the bulk picked products are brought to the sorting or consolidation area, each product line is scanned in turn and lights will indicate how many of each product should be placed into a tote or container for shipment. This can be used successfully for multiple retail store delivery with each store having its own shelf location, cage, tote or despatch area. Put walls are a typical example as we can see in Figure 5.3.

Figure 5.3 Put wall courtesy of Lightning Pick

VIDEO 5iv Put wall video from Lightning pick

As we can see, put walls are a shelving system, such as ‘pigeon holes’, fitted with LED lights. Each shelf slot represents an order for a customer or part of a store order in a retail operation. Items are picked in bulk, from active locations (pick modules or racks) and conveyed to the put wall area.

Goods are then scanned using the put-to-light system and sorted into the positions assigned to the orders in the wave. The LED display will also show the quantity to be placed.

Once an order is complete, the light associated with the shelf position lights up on the reverse side of the shelf where a packer retrieves the goods and packs it at a station. The packer then sends the order to a shipping lane.

Batch picking using put walls can significantly increase the number of lines picked per hour; however, as mentioned this is a three-stage approach (pick, put and pack). There are a number of touch points but it can be very effective.

Zone picking

In zone picking, products are picked from defined areas in the warehouse and each picker is assigned to a specific zone or zones and only picks items from within those zones. The level of activity will determine the number of zones/pick locations allocated to each picker. It can also be described as a pick-and-pass operation.

Orders are moved from one zone to the next as each zone completes its pick. This movement can be undertaken by a cage, trolley or pallet being passed from one operator to another, but is more commonly done by conveyor. The conveyors may be powered or use rollers or gravity to move the cartons or totes between the zones.

More recently we have seen the introduction of AMRs to move items between zones.

Orders can be picked simultaneously within the zones and consolidated later or they can be picked sequentially. Separate pick instructions are produced by the WMS for each zone for simultaneous picking.

Zone picking tends to operate with a pick-to-light system; however, it can also be operated manually. For example, a single pick list will travel with each order for sequential picking. The drawback is the requirement for a further step in the process, having to bring the partial picks back together to complete the order.

Zone picking can also be undertaken using hand-held barcode scanners and voice-activated picking. Zone picking can be seen in Video 5ii above with the tote being passed from one operative to the next. Note also the use of voice here.

The volume of orders sent to each zone needs to be controlled so that each sector has an equivalent number of picks. The potential for bottlenecks can be high, with staff having to wait for orders to arrive.

Zones are usually sized to accommodate enough picks for one or two order pickers. A picker may look after two zones or more if the volumes are reduced on a particular day or time of day.

Zone picking can be effective in operations with large numbers of SKUs, multiple orders and low to moderate picks per order. Mobile phone and computer games retailers are typical examples.

As mentioned, the most popular picking method utilized in the zones is pick by light. As an operator scans the next order to arrive in the zone or as the tote passes a barcode reader on the conveyor, a number of lights illuminate in the section. A digital display denotes the number of items to be picked. Once the pick is completed the light is turned off and the picker goes to the next illuminated location.

Some companies will also scan the barcode on the product prior to placing it in the tote to ensure that the correct item has been picked.

Advantages include the reduction in travel and an increase in the speed of pick as multiple lines can be picked at the same time compared with pick by order.

This system can be used by companies where there are different zones for product families such as pharmaceuticals, hazardous products and food items.

The use of a pick-to-light system does require accurate put-away as the actual product is not usually identified for the picker.

Wave picking

In wave picking, orders are combined and released at specific times during the day or are associated with vehicle departures, replenishment cycles, shift changes, product locations, product commonality, value-adding service requirements and priorities. The use of wave picking can also balance workload by time or by area by logically grouping and releasing orders.

Orders can be released at different times to different zones based on how long it takes to pick the orders.

Goods to picker

Significant benefits can be realized with the use of a goods-to-person system. Even though there are many variations on how a system can be configured, most of the designs allow the following benefits, according to Dematic (2009):

- *Eliminate picker travel time, use less labour.* Order pickers do not need to roam the warehouse walking to and from the pick faces. Travel time is the largest time component of a traditional order picker in a person-to-goods arrangement. By minimizing this time component, productivity is increased and labour to operate the facility is reduced.
- *Omit the dedicated pick face.* Typically, a goods-to-person system involves storing the inventory in crane-operated, very narrow aisle racking, on shelving transported by

AMRs, in grids such as AutoStore or in a mini-load or AS/RS system. Each SKU is retrieved as and when it is required. The system dictates when the item is picked and it is less important where it is in the warehouse, although having the fastest-moving items closer to the workstation will further improve efficiencies.

- *Reduce system footprint.* The space required for a goods-to-person design is much less than conventional person-to-goods systems. If the storage medium is high density, significant space savings can be achieved. A typical footprint may be 30 to 50 per cent less than conventional storage. In the case of AMRs taking shelves of product to the picker, this will require multiple floors to ensure the full cubic use of the building.
- *Product security.* When the product is placed into a high-density automated system (AS/RS), it is secure and not accessible by staff. Product security is important to maintain inventory accuracy, reduce theft, and assure first in, first out principles.
- *Ergonomic workstations.* The pick stations can be designed for employee comfort. Working heights, range of motion and environment (lighting, temperature) can be optimized for the employee. Some designs omit the requirement to move and lift totes/cartons. Furthermore, workstations can be outfitted to support employees with special needs, thereby allowing universal access.
- *Speed in order selection.* The pick station design results in high worker productivity. Since there is little or no travel time and the item to be picked is ergonomically served to the worker, high rates of order selection are achieved.

Most operations obtain rates of 500 to 1,000 lines picked per hour per operator. The goods-to-person system allows fast- and slow-moving SKUs to be treated equally, which removes the need for separate pick areas based on SKU velocity. This is important for applications where SKU velocity changes on a daily basis.

- *Accuracy*. Order picking using a goods-to-person station tends to be more accurate because operators are typically handling one SKU at a time, making errors less likely. Most goods-to-person stations utilize put-to-light technology to indicate quantity and location to place the item, further enhancing accuracy. The picking process is performed by one person, thereby improving traceability. Accuracy during the inbound process is paramount.
- *Decoupled workstations*. Staff can work in parallel, unaffected by each other. Stations can be opened and closed according to business volume on a particular shift of operation. There is redundancy in this configuration since items can be processed at any location as the workstations are completely decoupled. The requirement for social distancing as a result of COVID-19 has highlighted this advantage.
- *High-utilization workstations*. Work flows into the pick station smoothly and consistently. Order pickers are highly utilized, since they do not need to wait for work. Worker productivity is not affected by the structure typical of a traditional pick module (high activity in one zone, little activity in another zone, pace issues in a pick-and-pass environment, etc).

- *Sequencing.* When building a customer order, a precise sequence of SKUs can be achieved. For example, items can be presented to the order selector by weight (heavy to light). Or, in another example, orders can be built in sequence by family group or to match a retail store layout.
- *Order profile.* The system is not affected by changes in order profile. For example, single-item orders and multi-item orders are accommodated with equal efficiency. This means that trends such as more orders with fewer order lines do not compromise productivity. This feature adds to the ability of goods-to-person systems to accommodate change as order profiles change in the future.
- *Efficiently accommodates SKU growth.* If more SKUs are added, the storage system can absorb the new loads (if sized for growth) or the system can be expanded with additional automated storage modules, existing modules can be extended or by the addition of more AMRs.

Types of semi-automated picking

Carousels

Carousels are designed for medium- to high-throughput environments. They are also ideal for small, high-value items. There are two types of carousel: horizontal and vertical.

Horizontal carousels

Horizontal carousels work on a similar principle to a merry-go-round. The carousel can be made up of shelves, bins or garment holders. These rotate and are controlled by an operator who uses a computer keypad to type in the location, product code or order number, depending on how the software has been set up. If an order number is keyed in, the carousel will stop at the operator station in pick sequence.

An operator may look after more than one carousel (pods) in order to limit the amount of down time waiting for each carousel to rotate. Goods-to-operator systems are designed to keep the operator working as much as possible and reduce the amount of travel time.

Horizontal carousels vary significantly in length depending on the nature of the product to be stored. They can also range in height from 2 to 8 metres, necessitating the use of a platform to access the product or the introduction of automatic extractors.

Horizontal carousels are ideal for storing and picking high numbers of SKU, small individual items, medium to large cartons and products including hanging garments. They are especially effective in low-headroom areas.

According to OPS (2009), a multiple pod (three or more) can be used to pick between 200 and 400 lines per hour.

Horizontal carousels are expensive and are limited by the amount of time they take to rotate. Cubic space utilization can also be an issue, as can safety if the carousel is not enclosed. It is difficult to replenish when picking and they are limited in terms of the number of operators. They are also very system driven.

Figure 5.4 Horizontal carousel

VIDEO 5v Horizontal carousel by Modula

Vertical carousels

Vertical carousels are enclosures that have shelves that rotate in either direction similar to a Ferris or big wheel at a fun fair, bringing a requested item to the operator at a suitable working height. They allow you to use the maximum height available within the building, providing the best use of space within a very small footprint. Where there is a restricted height within the warehouse an option is to build a tall, attached exterior enclosure to house the vertical carousels and punch an access opening through an existing exterior wall according to Kardex Remstar. Another option is to have part of the carousel below ground. Vertical carousels are ideal for small- to medium-sized parts. The carousel takes up a much smaller footprint than a horizontal carousel. The shelving can be adjusted and sub-divided to handle different sizes and weights.

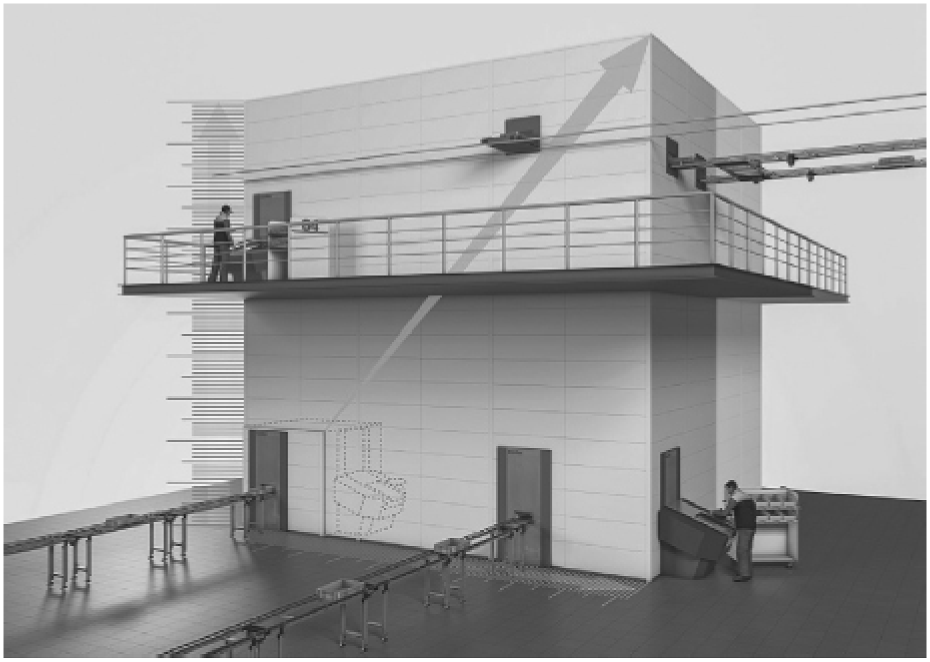
Vertical carousels provide added security. However, their effectiveness is tempered by the speed of movement. Here the trade-off is between the height of the system and therefore its greater storage capacity and the length of time it takes the shelves to rotate.

The software provided with vertical carousels can manage the stock within the carousel, pick in sequence, work with pick-to-light systems and provide accurate reporting. The system can also work with scanners to confirm the correct item is picked every time.

In both examples operators may look after more than one carousel, as can be seen in Figure 5.5, thus reducing downtime. Vertical carousels can also operate with two or more openings so that staff at different levels can access the parts stored, as can be seen in Figure 5.6.

Figure 5.5 Vertical carousel (courtesy of Kardex)

Figure 5.6 Kardex Remstar LR 35



Pick rates vary from 100 to 300 lines per hour. As in the horizontal carousel it requires ongoing maintenance and is very system reliant. Overall, the horizontal carousel is the least expensive option per cubic foot/metre stored.

VIDEO 5vi Vertical carousel by Kardex Remstar

Vertical lift module (VLM)

Similar to a vertical carousel, a VLM is an enclosed storage system consisting of two columns of extractable 'trays' each able to hold multiple cartons, totes or bins. A computer-controlled insertion/extraction device between the two columns automatically locates and retrieves the tray containing the item to be picked. Trays are delivered to an access window for the picker. A pick-to-light system will normally indicate the quantity and the item to be picked, whilst slotting software controls the location and number and size of items per tray. As with the vertical carousel, multiple VLMs or pods reduce the amount of dwell time by the operator (OPS/WERC 2009).

A similar system to the VLM is Kardex Remstar's Shuttle XP system.

CASE STUDY (Courtesy of Kardex Remstar)

Flowtechnology UK's primary objective is to be the most efficient provider of Fluid Power Products in the markets that they serve. They have built a reputation as a distribution innovator in the Fluid Power Industry and have supported customers throughout the UK.

With so many new products being added to the company's portfolio, warehouse expansion was becoming an issue. Although they were able to expand laterally with their existing storage, they soon realized that upwards would be the way to go. According to Marc Borland, Logistics Director at Flowtechnology UK: 'We realized that after the addition of new products for the next catalogue, space would become a problem and in 2001 our original 20,000 ft2 warehouse was expanded by a further 40,000 ft2.'

Solution

Phase 1 started with five 12-metre high Shuttle XPs being installed. They chose bespoke tote boxes for the components and loading commenced. A bespoke back-office software suite optimized the picking routines and developed efficient 'tours' – the routes used by individual picking operators. Upon receipt of picking data from the back-office system, the shuttle units work in pairs so, as one part is being picked at the first Shuttle, the next part is being indexed and positioned at the other Shuttle. Upon delivery of the items, barcode bag labels are printed and the software is updated on completion of the tour.

Borland states:

> *In the past we could achieve a rate of about 30 manual picks an hour. The addition of RF technology, bar coding and tour management has increased this to 40–45 picks an hour, but we must then compare this to the automated Shuttles which are giving us 90–100 picks per hour. These advantages are further enhanced by much quicker replenishment.*

The combination of the new technology and Flowtechnology UK's own back-office suite means that not only is auditing simpler but, thanks to the optimization of the tours and the stock control, picking accuracy is greater than 99 per cent – based on an error rate of just 0.21 per cent. The company is looking to further invest in conveyor systems and enhanced inspection and packaging bays with touch screens and scales.

Efficient picking of small parts

With up to 500 order lines per picking station per hour, the Kardex Remstar LR 35 (Figure 5.6) is ideal for picking small parts quickly. A station can consist of one or more units. Its energy efficiency and easy integration in existing systems make it a highly economical storage solution.

VIDEO 5vii Kardex Remstar VLM

A-frames

These machines are similar to vending machines but on a much bigger scale. They are ideal for high-volume items of uniform size and weight. This sorting and picking equipment operates most efficiently in an environment where these two characteristics are present. Typical products include cosmetics and pharmaceuticals.

The products are placed in magazines on a frame resembling a letter A and are automatically dispensed via a computer-controlled trigger system into a tote or directly onto a conveyor as it passes through the tunnel created by the frame. A section of the conveyor is allocated to each order. As the order reaches the end of the A-frame it drops into a tote or carton and is then conveyed via conveyor to another picking area if the order is incomplete or to the packing area. Whilst the machine is operating, manual replenishment activities can be performed with no impact on the dispensing operations.

A-frame systems are capable of filling orders quickly: up to 750,000 units per day, 3,000 lines per hour, depending on capacity and the replenishment capability. They can be highly accurate, with operations recording over 99.95 per cent accuracy.

However, this system does require manual replenishment and inaccuracies can occur when filling the channels.

VIDEO 5viii A-frame storage and retrieval system

The requirement for increased speed, accuracy and productivity has pointed managers towards automation as a realistic option in today’s competitive automated equipment market. A high-volume item pick operation is an area where automation can have a high impact. An operation where the despatch of upwards of 3,000 cartons per day is worth consideration in terms of automation.

The advantages of automation include the following:

- increased space utilization and reduced space requirement;
- high bay, narrow aisle systems (up to 40 metres high);
- random storage;
- higher density storage for refrigerated products, leading to cost reduction through lower energy requirements;
- improved control;
- pallet tracking through enhanced WMS;
- labour and energy savings;
- no heat and light requirement unless required for product integrity;

- minimum supervision required;
- continuity of performance;
- 24 hours, 7 days per week operation;
- product security;
- use of first in, first out principles;
- less human intervention;
- increased safety;
- elimination of manual handling;
- reduction in accidents;
- ability to cope with hazardous/harsh environments such as refrigerated storage;
- fully integrated;
- coordination of product flows, avoiding bottlenecks;
- constant performance levels; and
- continuous review.

Compact picking system

The goods-to-picker-based compact picking system by Vanderlande is ideal for slow-moving products in retail and wholesale warehouses. It is also cost-effective for warehouses handling parts and components for sectors such as the automotive industry which have a large range of SKUs and very high service levels.

For example, in a manufacturing warehouse, product is retrieved from the automated storage and retrieval area and taken by conveyor to the operator's workstation. There it is consolidated with other items that do not fit the profile such as exhaust systems, gearboxes, body panels, etc. They are then placed in a shipping carton, a crate or on a pallet for despatch. The use of ergonomic workstations enables operators to achieve a constant high order picking performance (up to 1,000 order lines per operator per hour) over a prolonged period of time, without risk of work-related injury.

VIDEO 5ix Vanderlande Industries – CPS with PICK@EASE

Order distribution system

An order distribution system is ideal for business processes where a large number of order lines are fulfilled from a relatively small number of SKUs. Totes or cartons of single-line products are transported to operators who distribute goods into order totes controlled by put-to-light displays. This concept works efficiently in mail order and e-commerce sectors.

In both the above operations the workstation plays a major part in the overall system. The main features include:

- optimal ergonomics because of horizontal order picking (one level);
- ideal height for the operator using a movable platform;
- operator learning curve of only 15 minutes;
- constant productivity level through fatigue-free working; and
- high accuracy and safety by pick-to-light displays, detection light grids and a touch screen.

Mini-load AS/RS systems

A mini-load automated storage and retrieval system handles loads that are contained in small containers or totes, with load weights typically falling in a range of 40 to 250 kilograms. The capacity range can go to 350 to 1,000 kilograms at the high end.

The system is ideal for storing small quantities of large numbers of SKUs. ‘Slave’ trays can also be used to transport shipping cartons to reduce the amount of decanting within the warehouse.

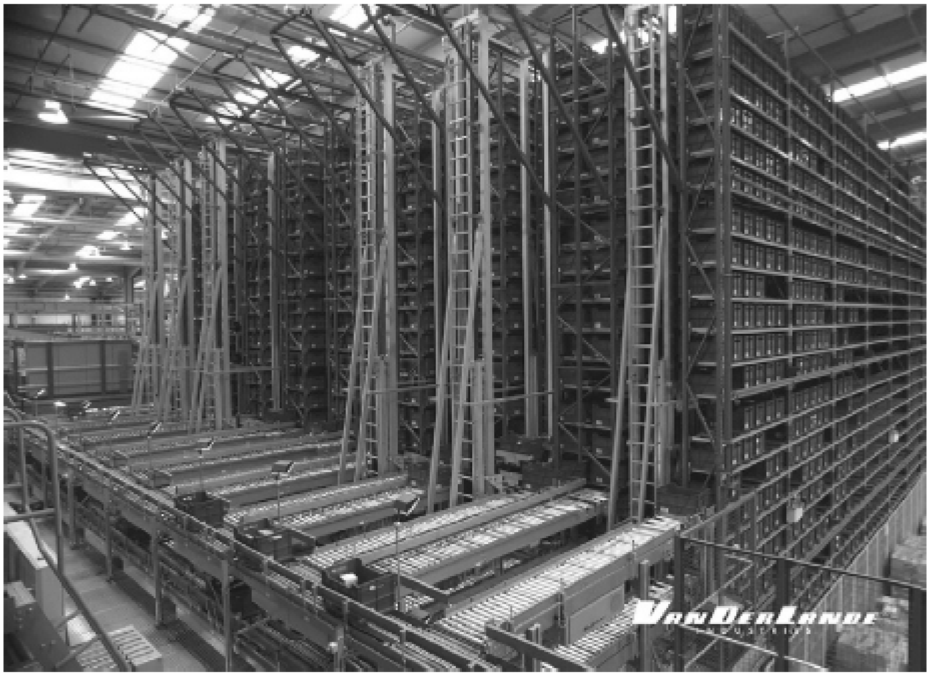
One key feature of a mini-load system is that it maximizes the cube of the warehouse, saving space whilst increasing throughput. Recent innovations include double-deep locations thus further increasing space utilization.

Product is put away in random locations and the system manages the put-away and retrieval of the product. Dynamic slotting enables fast-moving products to be located in the most accessible locations. When a product is required, the system will identify the location and the tote or tray will be transferred to the operator, who is standing at a pick station located in front of the rows and columns of storage bins.

Once the item has been picked from the tote, it is returned to a position in the racks. Different SKUs can be stored in each tote providing the operator has the ability to distinguish one product from another. Picking is normally managed by pick-to-light and put-to-light systems, which denote the quantity and into which outgoing tote to place the item. Some systems can provide a photograph of the item on screen to ensure further accuracy as seen in the Opex/iHerb.com video – 1iii.

Each pick station can have multiple totes arriving and leaving at the same time, ensuring an effective flow of goods and increasing productivity. This is similar to batch picking by line (350 to 700+ lines per hour) (see Figure 5.7).

Figure 5.7 Mini-load system (courtesy of Vanderlande)



3D shuttle technology

Although an AS/RS system, the Cimcorp 3D shuttle™ uses gantry robot technology, combined with an innovative shuttle device integrated into the gantry, to store and retrieve goods in plastic crates, totes, bins and containers required for order fulfilment. The system creates stacks on entry to the storage area. These stacks are then collected by one of the gantry robots and deposited somewhere within the robot's working envelope.

When a particular SKU is required to fulfil an order, a robot retrieves the corresponding tote and deposits it on the shuttle device. The shuttle travels along the gantry and transfers the tote to the outfeed conveyor, which then transports it to a conveyor line that feeds the picking stations.

Once picking from a tote is complete, it is conveyed back to the entry point to the storage area.

The system's advantages are as follows:

- up to six times more efficient than a manual solution;
- productivity of up to 1,000 totes/hour;
- low investment cost;
- excellent cost/storage capacity ratio;
- no racking required resulting in significant cost savings;
- optimum space utilization with no space wasting aisles; and
- exceptionally high storage density.

Example 3D shuttle cell (two robots)

Throughput capacity: up to 5,000 totes in or 1,000 totes out per hour by one cell/two shuttle robots (stacks in/single totes out). Average throughput: 500 totes in and out/hour.

Storage capacity of 31 totes per square metre, tote size (L × W × H) = 600 × 400 × 250 millimetres, storage size 25,000 totes per cell.

The advantage of this system is that it doesn't require any racking or grid structure with 80 per cent of the operational time feeding the pick stations.

Figure 5.8 Cimcorp 3D shuttle

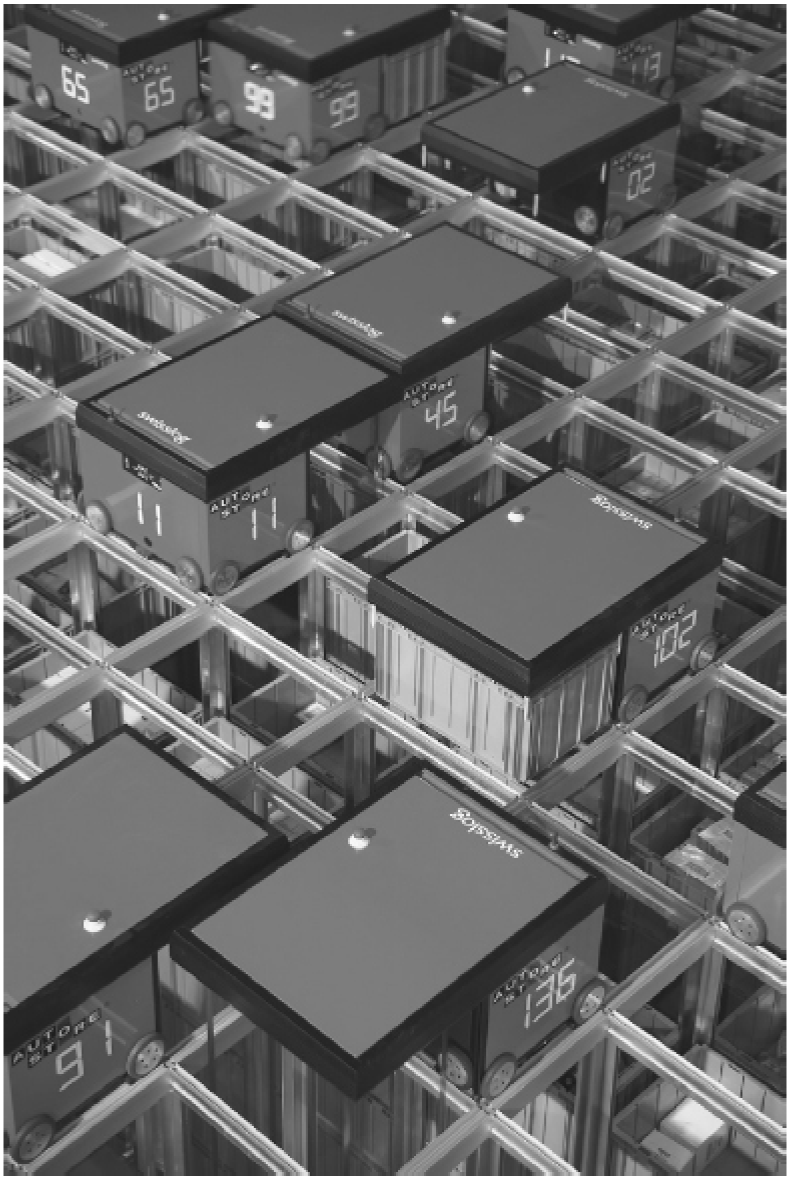
VIDEO 5x Cimcorp 3D shuttle for automated storage and retrieval

AutoStore

AutoStore is an AS/RS system that stores goods in bins that are stacked directly on top of one another in a self-supporting aluminium grid. The grid not only guides the bins but also serves as rails for the robots to travel on. The battery-operated robots are controlled using a wireless system and manoeuvre the bins within the grid. They also transport the bins to and from workstations for goods to be decanted or picked. Bins containing fast-moving products are stored at the top of the storage system whilst slow-moving stock is stored in the lower sections. Once the goods are placed in the bins they are ready for picking and despatch.

The system uses less energy than a mini-load system and is scalable.

Figure 5.9 AutoStore robot



CASE STUDY Asda Stores

Founded in the 1960s, Asda is one of Britain's leading retailers with over 180,000 dedicated Asda colleagues serving 18 million customers. It is the second largest supermarket chain in the United Kingdom, holding around 18 per cent market share.

Asda is unsurprisingly a leading proponent of warehousing innovation. The business is constantly looking at ways to improve the use of space within its existing distribution centres. Asda selected Swisslog's AutoStore solution to handle a range of its products in a more space efficient and productive way. An intelligent storage and retrieval system for small case lines, the solution provides Asda with flexibility for its future expansion. Swisslog worked with Asda at each phase of the project from the initial design to the installation and ongoing support. Work started onsite in 2012. Before installation of the AutoStore system could commence a robust mezzanine level was built on which the new solution would be constructed. Once the preparation work was completed, installation and commissioning took place in a matter of months, as the rest of the IDC was in full operation.

The operation:

1 Decant

Pallet loads of inbound goods are conveyed automatically to one of six ergonomic decant stations. An Asda colleague working at each station transfers products from a pallet into AutoStore bins, whilst lift tables eliminate the need for bending, thereby making the whole process highly ergonomic. Each station also has a chute for colleagues to dispose of waste.

2 Picking

The AutoStore robots always work ahead of colleagues to ensure a constant stream of bins are presented at the picking port. Reaching required bins usually involves a digging process, which temporarily stores those above the required bin on top of nearby stacks.

The solution includes carousel picking ports, designed for high-throughput operations. These ports have three rotating arms, which are able to carry three bins simultaneously in order to provide seamless delivery to colleagues. With 10 ergonomic picking stations, where orders are collated for store delivery, the site is able to process a large quantity of orders. They're also aided by the robots delivering the bins in sequence. Each colleague has a touch-screen computer instructing on how many of each product line to pick for particular orders, moving them from the captive AutoStore bin into the store consolidation tote. Once all items for a store are picked, colleagues push the tote onto the conveyor for shipping.

3 The benefits

From the outset, the system enables Asda to manage several thousand different product lines, whilst allowing further phased investments to accommodate more bins, in line with the retailer's developing requirements. AutoStore's key benefit is that of space efficiency, allowing for maximum utilization of the area, in this case bolstered by its installation on a mezzanine level. This leaves the ground level available for other operations.

4 Fact file

- number of robots: 140;

- number of bins: 44,860;
- number of pick stations (ports): 10;
- number of decant stations (ports): 6;
- bin presentations 335/hour per pick station;
- length of grid 48.8 metres;
- width of grid 29 metres;
- height of grid 6.8 metres;
- height of mezzanine approx. 6.5 metres from ground level.

VIDEO 5xi AutoStore solution

An interesting development in this area is that Japanese investment giant SoftBank Group Corp. will acquire 40 per cent of the Norwegian robotics and software firm AutoStore AS for $2.8 billion. A significant investment in this market.

Robotics

Robots are a common sight in manufacturing operations and on automotive production lines. However, they have rarely been seen operating in warehouses, until now.

According to Fortune Business Insights, the global logistics robotics market stood at $4.70 billion in 2019 and is projected to reach $14.95 billion by 2027. Some reports suggest an even greater rise to $18.58 billion.

Robots in the form of automated guided vehicles utilized for transferring pallets within the warehouse have been in use for a number of years, but they have been a rarity within picking operations.

These AGVs or driverless forklift trucks are not only used to transfer pallets between warehouse areas but they are also used to assist pickers within the aisles as shown in Video 6iii in the next chapter.

Robot arms have been adapted to pack items into boxes and stack those boxes onto pallets in the most efficient way. An example of collaborative robotic arms is Swisslog’s AutoPiQ system. This fully automated picking station teams humans with robots, enabling direct cooperation between the picker and the robot. AutoPiQ intelligently complements light, goods-to-person systems. AutoPiQ is equipped with state-of-the-art sensor technology and a seven-axis gripper.

The AutoPiQ solution is designed for repeated single-item picks for fast fulfilment of orders. It is based on a shared picking principle. The robot picks the items that it is able to pick – which can be up to 95 per cent of the product range – and an operator finishes the order. Both can pick into the same bin or split orders into two lines depending on requirements. Innovative 3D vision technology is used for object recognition in the source bin. It consists of a 3D camera detecting a point cloud as well as a 2D camera identifying the product contours.

Static robots are also being utilized in greater quantities with the use of robotic arms fitted with suction pads and an optical reader being used to pick items from a conveyor and deposit the items into their respective containers as can be seen in Figure 5.10.

Figure 5.10 Robot picking (SSI Schaeffer)

▶ **VIDEO 5xii KNAPP robot pick**

Increases in the use of these robots are in areas where labour is scarce or very expensive, where the tasks are reasonably straightforward and monotonous or where the operation is undertaken in hazardous conditions where manual handling is deemed dangerous.

The appearance of COVID-19 and the need for social distancing together with the phenomenal growth in e-commerce has accelerated the growth in the use of AMRs and CMRs.

A popular use of AMRs is the movement of free-standing shelving (pods), arranged in rows and columns in a grid, from a storage area to pick stations. The AMR are capable of independent navigation around the warehouse through mapping and/or utilising 2D or QR barcodes located on the floor of the warehouse. Communication is via Radio Frequency (RF).

When a consumer submits an order, the robotic drive units deliver the relevant shelving units to workers who pack the requested items in a box and ship them off, utilizing other drive units, to the despatch bay, allowing workers to fill orders three to four times faster than they could with conventional methods. Each pick station is equipped with a pick-to-light and put-to-light system. The drive units can work in parallel, allowing dozens of workers to fill dozens of orders simultaneously.

The robotic system is also faster because the entire warehouse can adapt, in real time, to changes in demand by having the robots move shelves with popular items closer to the workers, where the shelves can be quickly retrieved whilst items that aren't selling are gradually moved farther away. This becomes a very sophisticated slotting system. This is all controlled by radio frequency with floor labels providing the drive units with the location coordinate information they require to navigate the warehouse. Suppliers include Grey Orange, Swisslog, Geek plus, Eiratech and hikrobot.

The racks are adjustable and not limited to a bin size as with a shuttle system.

It is ideal for medium and slower moving SKUs, where the picker used to travel the greatest distances between picks. This is where picking productivity will see its greatest gains – the shelves are doing the walking instead of the picker. It takes all of the picking travel out of the equation.

This system allows companies to scale the performance incrementally by adding single robots/workstations to the existing system. This is especially of value in e-commerce as growth is hard to predict.

It can also be moved easily to another warehouse location if required and can be quickly installed within less than four months.

The system, depending on the supplier, can be leased, rented or paid on a per pick basis. The system can also be integrated into an existing warehouse operation.

VIDEO 5xiii CarryPick system from Swisslog

VIDEO 5xiiib Grey Orange AMRs

Figure 5.11 Eiratech robotic system

There are potential issues that have been highlighted recently. With the increase in throughput – up to four times the productivity – warehouses in the US have seen an increase in muscular injuries to staff.

There is, of course, the moral issue as well. What happens to the staff that are displaced by increased numbers of robots within the warehouse?

The utilization of floor space by these AMRs is high because of their ability to move omni-directionally thus reducing the aisle space required in the storage area. However, unless the storage area is in a low height facility then cubic space is not fully utilized. This can be overcome, however, by operating with multiple mezzanine floors and a lift system as seen in the DIY retailer – Sodimac's warehouse in Chile – a system provided by Grey Orange.

CASE STUDY Superdry

Superdry is an iconic, global fashion brand operating through 768 store locations in 65 countries. Since its foundation in Cheltenham in 1985, the business has experienced phenomenal growth and in 2019 reported revenue of £871 million.

As an omni-channel retailer competing in the fast-moving fashion sector, maintaining high product availability, efficient fulfilment and the rapid processing of returns is essential for ensuring the best possible customer experience across multiple channels – retail, wholesale and e-commerce. Critically, all of these competitive differentiators depend upon the fast, accurate and efficient picking of products from across Superdry's extensive range of over 60,000 SKUs, held at the company's three regional distribution centres in the UK, Europe and USA.

In a significant departure from the company's traditional approach to warehousing, where mainly manual processes have been used, Superdry has launched a major initiative to roll-out intelligent goods-to-person robotic systems across its international network of regional distribution centres. The robots work in unison with manual pickers, automatically selecting and lifting modular pick walls and transporting them to pick-to-light stations where a predetermined pick face is presented to the operative. Under the guidance of pick-to-light technology, items are manually selected scanned and placed for maximum speed and accuracy. Walk-time is eliminated, giving a design capability to offer up to 600 picks per hour, with 99.9 per cent accuracy.

Superdry deployed a fleet of 26 Hikrobot carriers to handle continental e-commerce returns at its European DC in Belgium run by Bleckmann Logistics.

In the UK, Superdry's ecommerce returns rate is around 25 per cent; however, in Germany and other EU member states, that figure is far higher.

Picking performance

Significant benefits have been realised through the introduction of robots. At the Burton-upon-Trent facility, put-away of returns have dramatically risen from under 100 units per hour to rates of 300–350 per hour. Some 99 per cent of returns can now be processed and re-despatched within 24 hours, with many being re-despatched within an hour. Present volumes allow for 180 picks an hour from mixed SKU locations, double that of the previous manual operation; however, with higher volumes, single SKU bins will enable picks of around 300 items per hour or more when taking multiples from the same bin.

Other benefits from the robotic goods-to-person system include: increased accuracy, reduced cost per pick, no major infrastructure changes, low Capex, enhanced flexibility and scalability, as well as greater storage density, which has reduced warehouse space requirements.

The UK robotic operation now handles the entire picking and put-away of womenswear for retail, ecommerce and wholesale. Over 80,000 square feet of the warehouse has been set out with 1,000 transportable pick-wall modules and the area is equipped with a total of 12 pick-to-light stations. The robots follow QR codes on the floor.

Flexibility and scalability

The simplicity of the robot guidance system allows for fast and flexible layout changes and the inherent flexibility of this modular approach facilitates easy expansion of the system. Should more robots be needed to boost capacity, they can be simply added.

Menswear will follow later with an estimated requirement for 60 more robots and expectations are for the further deployment of Hikrobot carriers in Belgium and the USA.

Endorsements

Gordon Knox, Director of Logistics at Superdry, said: 'The adoption of robotics has come about through a requirement to cut operating costs and to reduce our reliance on labour. The headcount we needed to attract during peak periods was resulting in us having to adjust our pay structure beyond what we ideally wanted to pay.'

Interestingly, the use of robots did not feature in Superdry's initial thinking when it came to the use of automation. A few years ago, faced with an issue of mounting returns from stores, the business considered investing in an automated storage and retrieval system. The project would have required a commitment to heavy equipment being bolted to the floor and so was not seen as being flexible enough for any future changes that may occur in the business. As it happens, it was the right decision – the business model changed and store returns were dramatically reduced.

Superdry partnered with UK-based warehouse solutions provider, Invar – supplier of Hikrobot systems in Europe.

Mr Knox went on to say: 'The more we looked at the capability and flexibility of robotic systems the more we could see how they could be used within our operations. We found that inventory accuracy was significantly improved and the tests far exceeded our expectations on throughput and productivity.'

VIDEO 5xiv Superdry

The second type of system features CMRs, which travel to a zone where operatives are waiting. Items to be picked can be communicated to the picker via voice commands or a screen on the CMR. Locus Robotics has recently installed this type of system in the Boots warehouse in the UK. In this system the crucial aspect is the utilization of the pickers. The pickers need to be dynamic and move between zones if required. In many of today's automation systems, control of these operations is in the cloud and utilises artificial intelligence (AI) to ensure the system runs as efficiently as possible. The increased use of AI will ensure that items are placed in the most effective location based on the sales data received.

Some of the advantages of these systems over traditional automation include the following:

- lower investment including a pay as you use system for peak;
- faster implementation and deployment;
- modularity and scalability;
- ability to relocate operation reasonably quickly if required.

These systems also enable deployment around obstacles such as roof columns.

CASE STUDY 6 River Systems and NLS

National Logistics Services is Canada's leading retail logistics provider. A user of 6 River Systems since 2018, NLS provides wholesale, retail and ecommerce fulfilment to top-name retail stores. A forward-thinking company, they are always looking for ways to innovate and improve the services they provide to their customers.

The challenge

Prone to peaks in volume across their network of distribution centres, NLS often shifts labour between large sites, at times staffing upwards of 200–300 additional temporary people in a building to help meet demand from their retail customers and ever-rising direct-to-consumer activity.

The 3PL wanted to introduce a flexible automation solution to improve work for their fluctuating labour force, increase picking accuracy and efficiency, minimize training time and to adapt quickly to demand spikes, especially those from ecommerce orders.

NLS has Chucks (collaborative robots) deployed in three sites, with plans to prepare multiple sites to receive any number of their robots at a moment's notice.

Whilst they have 27 Chucks available to them year-round, NLS rents an additional 15 Chucks to support holiday volumes across their network of warehouses.

Seasonal rentals and site preparedness enables them to easily customize their robotic fleet by size and location to best support the needs of their associates at any operation.

Benefits and results

- 58 per cent improvement in pick productivity;
- deployment of robots between buildings in 1.5 hours;
- training time: one pick cycle.

Since 2018, NLS has seen a 2× increase in business volume, year over year. By allocating their robotic fleet between buildings to meet peaks in demand, NLS found that they could increase their throughput by 3× where and when it mattered most.

Prior to peak 2020, NLS increased their picking associates by 2.3×. When order volume increased threefold, their newest hires were trained and ready to perform – reaching 80 per cent of FTE performance within one shift.

By treating Chucks as resources to share between different warehouse sites, NLS is able to maximize the efficiency of their teams as well as their budget. No changes to infrastructure, no changes to layout, no changes to robot configuration. Just the allocation of their fleet.

> *This solution is such a good fit for our business. The returns are significant – even without a huge capital investment.*
>
> (*Gordon Brown, Director of Engineering and Innovation, NLS Logistics*)

Utilizing the same system DM Fulfilment has seen:

- ↑ 38 per cent in pick velocity;

- ↑ 17 per cent in order volume;
- ↓ 50 per cent in employee turnover;
- new associates achieve picking performance goal in 15–20 minutes.

VIDEOS 5xv and 5xvb 6 River systems CMR

An interesting concept is that provided by Exotec, which has been taken up by retailers including Gap and LeClerc.

In the following videos we see how the system works and a spokesperson from LeClerc explains why the company turned to Exotec.

In terms of cost, Exotec provide the following guidelines:

- For an operation utilizing 10 robots, 10,000 totes and picking 2,500 order lines per day the cost is in the region of €1.5 million.
- Increasing the number of robots to 500 with 80,000 totes and 12,000 tote movements per hour the cost is circa €30 million.

VIDEOS 5xvi and 5xvib from Exotec

A similar system to the above is the bionic Hive; however, this robot is able to access conventional racking.

VIDEO 5xvii Squid from Bionic Hive

A recent study by McKinsey Global Institute that looked at the impact of automation including robotics, machine learning, and AI, forecasts that these technologies will raise productivity growth globally by 0.8 to 1.4 per cent annually through 2065. That study also predicts that automation should help create more jobs – rather than take them away – because of stronger economic growth and new, emerging job roles. This will necessitate re-training but it is questionable whether all warehouse operatives will find new employment in this new technical world. However, the introduction of these systems also coincides with a shortage of warehouse operatives. A recent CBRE report suggested that significant growth in e-commerce could result in a shortage of up to 452,000 warehouse staff in the United States. We are also seeing a significant take up of warehouse space resulting in less overall space availability. These systems require significantly less floor space than current manual operations.

With less need for fixed infrastructure with today's robotics and the ability to work collaboratively with humans to scale up output, these solutions are less costly and more flexible to dynamic e-commerce fulfilment needs than the automation of the past.

According to Swisslog's Tony Buckley (2017): 'Robotics today are different than the robotics of the past. On the hardware side, costs have come down, so that makes them more cost-effective to implement in more situations. Second, the type of robots we have now are different, with smaller collaborative and mobile robotics.' There is an argument that robots can't always adapt to changes in the work environment whereas humans can analyse the situation and use their intelligence, past experience and critical thinking to come up with solutions.

The new intralogistics robots make use of vision-based navigation, sensors and machine learning to allow them to do things such as working safely alongside humans and moving through warehouses in efficient, safe patterns. Rather than being fixed to the floor, today's intralogistics robotics can come in the form of smart, wheeled carts that navigate the warehouse using minimal guidance infrastructure. A collaborative picking robot knows it needs to stop when touched by a human, and the software guiding a robotic cart will adjust its path if an aisle is blocked.

‘Traditionally, robots had to be instructed on each task through costly programmatic means, but with machine learning, a picking robot essentially can “learn” new picking tasks on its own without programmatic instruction,’ says Swisslog’s Schultz. ‘Machine learning is bringing the vision and gripper systems of our picking robots closer to the level of what eye/hand coordination can accomplish.’

These vision systems are likely to play a significant role in the future of warehouse operations, providing much greater speed and accuracy.

KNAPP uses a Cognex imager to drive a very high-speed robotic piece picker. The Cognex vision system looks into a carton and takes images with something like a million data points. This can be seen in Video 5xi above.

In a recent report on Promat, Dan Gilmore discusses a company called Iam Robotics, which uses a stored 3D image of each item to help its piece picking robot traverse aisles of static storage and pick items into a tote using an AGV with a small robotic vacuum arm. The system in effect ‘sees’ the item on the shelf to confirm it is the right SKU and determine its approach.

A similar system has been introduced by RightHand Robotics.

VIDEO 5xviii RightHand Robotics

The KNAPP-Store is an innovative storage and picking system that can be used along the entire pharmaceutical supply chain, whether in wholesale or for online pharmacies. The KNAPP-Store can store diverse articles effortlessly and occupies minimal space. It automates a wide spectrum of articles that would normally require a great deal of manual processing, with manageable investment costs and low costs per storage location.

VIDEO 5xix KNAPP-Store system

Ergonomic workstations

As with all goods-to-person systems the comfort and safety of staff are paramount. Ergonomic workstations are therefore used in conjunction with goods-to-picker solutions.

The workstations are designed to enable continuous, sustainable performance. The goal is to counter the risk of repetitive strain injury (RSI) and fatigue, thus increasing effective operator time.

These ergonomic workstations are also important from a disability worker point of view. Many warehouse and distribution centres such as those operated by M&S in the United Kingdom and Walgreens in the United States are designed with disabled staff in mind. As discussed above, there can be issues with staff standing in one location for a long period of time. If we continue to see increases in muscular injuries as a result, this will need to be addressed.

Figure 5.12 Ergonomic workstation (Dematic)

VIDEO 5xx Ergonomic workstations from KNAPP

Automation enablers

Conveyors

Conveyors carry goods by power or gravity. They are an integral part of zone picking and goods-to-picker systems as they transfer cartons and totes between zones and to the operator workstations.

Powered conveyors tend to be used for transferring goods over longer distances and utilize belts, chains, slats and rollers.

Gravity conveyors can be used to transfer picked items from a mezzanine floor to the despatch area for consolidation with other picked items or along short distances within zones.

Conveyors can have non-powered or powered rollers or belts. The latter tend to be less expensive than powered rollers and have the advantage of being able to move all types of boxes and bags without fear of jamming up the conveyor.

The disadvantages of conveyor systems include high capital cost, less flexibility, regular maintenance requirements and they are an obstruction to both pedestrians and trucks.

Figure 5.13 Conveyor systems (courtesy of Dematic Corporation)

Figure 5.14 Autocruiser from SSI Schäfer

An alternative to conveyors is SSI Schäfer's Autocruiser, which represents a less expensive and more flexible alternative to a conventional conveyor system. It consists of transport carriers operating on rail structures, which are easy to extend and modify, making it a versatile and scalable solution.

Other alternatives also include the AMRs and CMRs as discussed above.

CASE STUDY

Creativ Company is a major global supplier of hobby and educational items. With regard to the implementation of a new, extensive logistics system, Creativ Company opted for a combined Autocruiser and VLM solution from SSI Schäfer. At the core of the solution are eight LogiMat storage lifts, each six metres in height and in total amounting to a storage area of 1,000 m2. On a 300-metre-long track, 27 SSI Autocruiser waggons transport 300–450 units per hour. The idea was to create a semi-automated solution using the SSI Autocruiser whereby the waggons – controlled by the warehouse management system – transport the

SKUs to the different picking zones. The SSI Autocruiser system is used to connect picking zones with the goods out area.

Sortation systems

In situations where there is a high degree of commonality in terms of orders with a known number of delivery locations such as retail stores, a pick to belt system can be used effectively. Here products are picked in bulk using the batch picking method and the items are placed on a conveyor belt. As each item passes a barcode reader it is identified and diverted to a particular location on route. The items can either drop into a bin or slide down a chute. Here the items are consolidated and packed into a shipping carton, a cage or loaded directly onto a vehicle. Examples are cross belt, narrow belt, bomb bay and tilt tray sorters. Productivity can range from 6,000 to 20,000 units per hour.

A new parcel sortation system has been introduced by Tompkins Robotics. t-Sort is a material handling system that has applications for both unit and parcel sortation. It performs much like a traditional automated sortation system, such as a tilt tray or crossbelt sorter. However, the unique difference is t-Sort uses completely independent robots.

At only 15 inches wide, the robots take up a minimal amount of space. They can move in any direction and are easily programmed to meet unit and parcel sorting needs. The robots recharge automatically by returning to a charging station when needed. See Video 5xxi.

VIDEO 5xxi Parcel sortation system from Tompkins Robotics

Summary and conclusion

There are many different picking strategies that can be utilized within a warehouse operation. Each one will depend on the nature of the product, the velocity of throughput and the company budget.

Picker-to-goods strategies remain the most utilized method within today's warehouse operations. However, goods-to-picker methods are gaining ground as automation becomes more sophisticated and also more affordable.

It is likely that multiple strategies will be used in today's warehouses as they look to cope with multichannel and omni-channel distribution requirements.

Note how, in the Novaltia video many of the above technologies come together under one roof. These include the OSR shuttle, A-frame, conveyors, carousels, robotic arms and AMRs.

Figure 5.15 provides some guidelines to the type of picking and storage equipment to use, based on product size, number of orders, speed of throughput and size of inventory.

Figure 5.15 (Part 1) Pick module selection matrix (courtesy of OPS Design)

PICK MODULE SELECTION MATRIX

	Manual – Conventional					
	High Density Drawers	Bin Shelving	Decked Rack	Carton Flow Rack	Pallet Rack Position	Pallet Flow Rack
Picking Type						
Piece	♦	♦	◊	♦	◊	
Inner Pack	◊	♦	♦	♦	◊	◊
Full Case		◊	◊	◊	♦	♦
Full Pallet					◊	♦
Security						
High	◊					
Medium	♦	♦				
Low	♦	♦	♦	♦	♦	♦
Pick Unit Size						
<0.0005 Cubic Ft.	♦	◊	◊	◊	◊	◊
0.0005–0.015 Cubic Ft.	◊	♦	◊	♦	◊	◊
0.015–0.125 Cubic Ft.		◊	♦	♦	♦	♦
0.125–1 Cubic Ft.			♦	◊	♦	♦
1–5 Cubic Ft.			◊		♦	♦
5–10 Cubic Ft.					♦	♦
>10 Cubic Ft.					♦	♦
Daily Hits						
<0.05	♦	♦	♦		♦	
0.05–0.2	♦	♦	♦		♦	
0.2–1	♦	♦	♦	◊	♦	◊
1–5	◊	♦	♦	♦	♦	♦
5–10		♦	♦	♦	♦	♦
10–50		♦	♦	♦	♦	♦
>50		♦	◊	♦	♦	♦
Daily Cubic Velocity						
<0.005 Cubic Ft.	♦	♦	♦		◊	
0.005–0.1 Cubic Ft.		♦	♦	◊	◊	
0.1–0.5 Cubic Ft.		◊	♦	♦	♦	
0.5–5 Cubic Ft.			♦	♦	♦	◊
5–10 Cubic Ft.			◊	◊	♦	◊
10–25 Cubic Ft.					◊	♦
25–100						♦
>100						♦
Average Inventory Cube						
<0.125 Cubic Ft.	♦	♦				
0.125–2 Cubic Ft.		♦	◊	◊		
2–5 Cubic Ft.		◊	♦	♦		
5–10 Cubic Ft.			♦	♦		
10–25 Cubic Ft.			◊	♦	◊	
25–250 Cubic Ft.				♦	♦	◊
>250 Cubic Ft.				♦	♦	♦

♦	OPTIMAL
◊	FEASIBLE

▶ Figure 5.15 details

Figure 5.15 (Part 2) Pick module selection matrix (courtesy of OPS Design)

	Mechanized – Automated				
	Automated Dispensing System	Vertical Lift Module or Carousel	Horizontal Carousel	Mini-Load AS/RS	Pallet Load AS/RS
Picking Type					
Piece	♦	♦	♦	♦	◊
Inner Pack	♦	♦	♦	♦	◊
Full Case	◊	◊	◊	♦	♦
Full Pallet					♦
Security					
High		♦	◊	♦	♦
Medium	♦	♦	♦	♦	♦
Low	♦	♦	♦	♦	♦
Pick Unit Size					
<0.0005 Cubic Ft.	♦	♦	◊	♦	◊
0.0005–0.015 Cubic Ft.	♦	♦	♦	♦	◊
0.015–0.125 Cubic Ft.	◊	◊	◊	♦	♦
0.125–1 Cubic Ft.				♦	♦
1–5 Cubic Ft.				◊	♦
5–10 Cubic Ft.					♦
>10 Cubic Ft.					♦
Daily Hits					
<0.05		◊	◊	◊	◊
0.05–0.2		◊	◊	◊	◊
0.2–1		♦	♦	♦	♦
1–5		◊	◊	♦	♦
5–10				◊	◊
10–50	◊				
>50	♦				
Daily Cubic Velocity					
<0.005 Cubic Ft.		♦	♦	◊	
0.005–0.1 Cubic Ft.	◊	♦	♦	◊	
0.1–0.5 Cubic Ft.	◊	◊	◊	♦	
0.5–5 Cubic Ft.	♦			♦	
5–10 Cubic Ft.	♦			◊	◊
10–25 Cubic Ft.	♦				◊
25–100	◊				♦
>100					♦
Average Inventory Cube					
<0.125 Cubic Ft.		♦	♦	◊	
0.125–2 Cubic Ft.	◊	♦	♦	♦	
2–5 Cubic Ft.	♦	◊	◊	♦	
5–10 Cubic Ft.	♦			♦	
10–25 Cubic Ft.	♦			◊	
25–250 Cubic Ft.	♦				♦
>250 Cubic Ft.	♦				♦

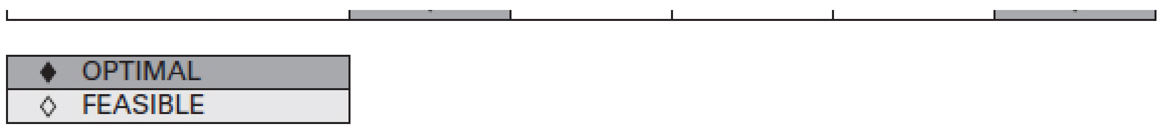


Table 5.1 provides a comparison between the different picking strategies.

Table 5.1 Comparison chart – order pick strategies

Skip table

Pick method	Typical applications	Benefits	Disadvantages
Pick by individual order	Most operations	Single-stage operation Flexible Quick implementation Ability to isolate urgent orders Picker able to decide pick path if paper-based Utilize manual or technology systems	Low pick rate Very labour intensive Can result in bottlenecks at the pick face Training can take some time depending on the tools used
Cluster picking	Most operations, smaller items typically	Multiple orders picked at the same time Reduce travel in the warehouse Reduce overall pick time	Training can take some time Accuracy can be an issue if no technology involved Urgent orders cannot be separated easily Requires equipment to hold multiple orders Requires low cube items in the main Requires system assistance to combine orders Can result in bottlenecks May require second stage to pack orders

Pick method	Typical applications	Benefits	Disadvantages
Batch pick to zero	e-commerce Retail store orders	Multiple orders picked at the same time Very effective for e-commerce orders where 100s of orders for single-line items Reduced travel Increased accuracy Can be used successfully in a cross-dock operation	Urgent orders cannot be separated easily Requires system assistance to combine orders into a single pick list Batch pick to zero will take longer than with pick by line Requires sortation area and additional staff Re-packaging required
Batch pick by line	e-commerce Retail store orders	Multiple orders picked at the same time Increased accuracy Very effective for e-commerce orders where 100s of orders for single-line items Reduced travel	Urgent orders cannot be separated easily Need to return unallocated items to stock Requires sortation area and additional staff Re-packaging required

Pick method	Typical applications	Benefits	Disadvantages
Zone pick	Situations where there are large numbers of SKUs and low number of items per order line	Less travel for operator Orders can be picked simultaneously or sequentially Can accommodate different families of items on orders such as hazardous, temperature controlled, etc.	Normally requires conveyors Cost of equipment Normally combined with pick/put-to-light systems Can lead to idle time if work is not balanced between zones
Wave pick	When orders are released on a timed basis or to meet departing trucks	Ability to schedule work efficiently Orders are picked in time for a production run or vehicle departure	Urgent orders cannot be separated easily Requires a WMS to manage the allocation
Goods to picker	High-intensity pick operations	High pick rates High accuracy Equipment moves, operators stay in the same place Reduced space requirement Product security Ergonomic workstations Training is less intensive	High equipment costs Higher energy costs Potential system failure High opportunity cost Standardized unit loads required Limited to smaller items in the main Possible increase in muscular injuries

06 Order-picking methods

> *Fast is fine but accuracy is everything.*
> (WYATT EARP, 1848–1929)

Introduction

This is the area in which advances in technology have transformed the picking operation and improved accuracy and productivity significantly. The introduction of barcoding, voice and vision technology and pick-by-light systems is not only improving warehouse picking operations but also producing an acceptable return on investment.

The following picking methods are currently in use in today's warehouses:

- paper pick lists;
- pick by label;
- pick by voice;
- pick by vision;
- barcode scanning;
- radio frequency identification;
- pick by light/pick to light;
- put to light; and
- automated picking.

Paper pick lists

A paper pick list will normally detail the order number, location, product code, description and quantity to be picked. If utilizing a WMS, each product location will be shown in sequence, enabling the picker to travel the most efficient route around the warehouse and ending up as close to the despatch bay as possible. The operator is at liberty to choose a different route if it is felt that it is more direct. The fastest-moving items should be placed close to the despatch area to minimize travel. Stock-control systems and manual applications may not have this ability and therefore some form of manual intervention is required to reduce the amount of pick travel undertaken.

The picker will utilize a trolley, cage, pallet truck or possibly a forklift truck depending on the size of product and quantity of items. The advantage of using a forklift truck or a low-level order picker is that the pallet can be lifted to a suitable height as the picker continues along the route in order to reduce the amount of bending and stretching.

Any discrepancies are written onto the pick list. When the pick list is returned to the supervisor, the discrepancies should be checked immediately and alternative locations provided if there are shortages. Details of the pick are entered manually into the system. This can lead to errors if the writing is illegible or there is confusion over the way a number is written. This all adds time to the operation. Paper picking requires little investment; however, it can have low accuracy and may require order validation.

Once an order has been picked the operator has to return to the office for further pick lists or instructions. It is not a real-time system. From an environmental point of view, it also wastes a great deal of paper.

Pick by label

In this system, pick lists are a series of gummed labels on a sheet, which are printed in pick order. The picker attaches a label to each item picked. Once all the labels have been attached that should be the end of the pick for that order. If there are any labels left over (as a result of no stock being available in the location) they need to be returned to the supervisor's office. Any discrepancies are checked immediately and additional labels printed if the stock is available elsewhere in the warehouse. This can eliminate a step at the despatch area as address labels are already attached. It's also more accurate than paper picking as you can soon tell if there has been a miss-pick in terms of line quantity.

Pick by label is not a real-time system, as the WMS has to be updated at the end of each pick.

Paper pick and pick by label are both very manual operations and rely on the operator, supervisor and administration clerk all playing their part to ensure accurate information is recorded.

These manual forms of operation and low levels of productivity and accuracy have led to an increase in the use of technology within the warehouse.

Pick by voice

The use of voice technology is gaining ground in warehouses globally, particularly for order picking, although other processes such as cycle counting, put-away and replenishment also utilize the system. Many companies are moving directly from paper picking to voice and bypassing barcode scanning.

Operators are issued with a headset and a microphone together with a small terminal that is attached to a belt or can be worn on the wrist or upper arm. The WMS sends messages to the computer via radio frequency (RF) transmissions, utilizing transmitters installed throughout the warehouse, and these messages are converted into voice commands. The operator also uses voice to communicate back to the system. In Video 6i operators are not required to use headsets as the voice system is incorporated into a wearable vest. The freedom of movement this gives to users is particularly helpful during processes that require greater physical exertion. The most recent voice systems work on the basis of neural networks and guarantee reliable voice recognition – even in challenging conditions.

Voice was first employed about 30 years ago for cold-storage applications where gloves and extreme temperatures made it difficult to use scanners and paper-based systems.

The benefits listed are stated as being very comprehensive. They include:

- increased accuracy;
- increased productivity;
- reduction in paper usage;
- reduction in errors through elimination of re-keying data;
- improved safety through hands- and eyes-free operation;
- reduction in damage to product and equipment;
- real-time stock updates leading to fast and accurate replenishment;
- real-time updates regarding potential shortages;
- increased operator time on the warehouse floor;
- reduced training times;

- multilingual, accommodating a diverse workforce;
- potential reduction in employee turnover; and
- normally a quick ROI.

In a survey by ARC Advisory Group and *Modern Materials Handling* magazine, nearly 60 per cent of respondents saw productivity gains greater than 8 per cent in their picking operations when they adopted voice, whilst another 26 per cent saw productivity gains of between 4 and 8 per cent.

More than 83 per cent of the companies who had implemented voice reported that their investment had met their financial hurdle goals.

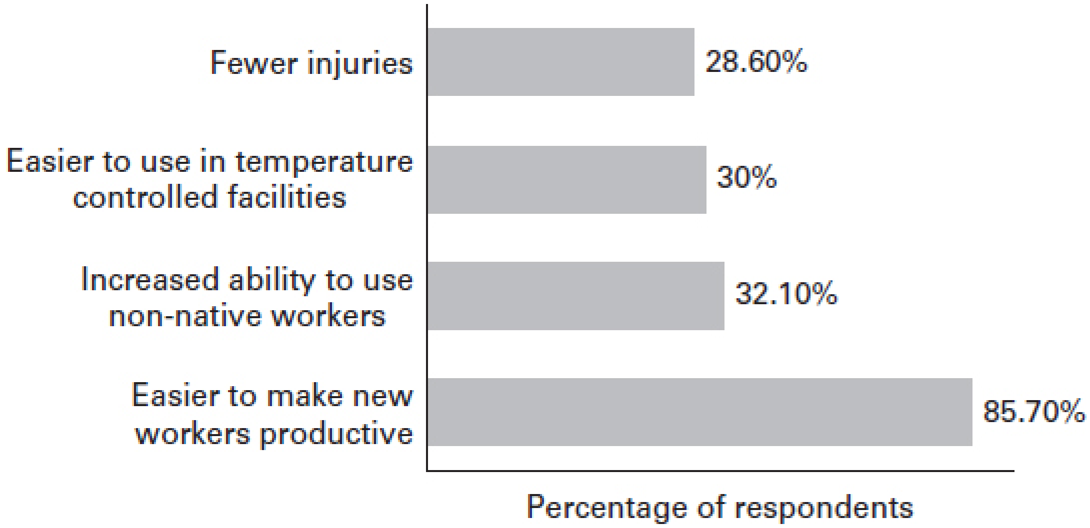
The following two videos discuss the advantages of voice picking compared to paper pick and scanning.

VIDEO 6i Voice pick video at Simba Dickie

VIDEO 6ii Voice pick video at Lifeway

Figure 6.1 shows other benefits identified by the survey.

Figure 6.1 Benefits of voice picking (courtesy of ARC Advisory Group)



▶ Figure 6.1 details

Voice has become prevalent in the food service and grocery retail sector. It is particularly suitable for both chilled and frozen environments where gloves hamper the use of radio data terminals (RDTs) and paper, whilst the hands-free aspect of the system has major advantages over paper pick lists, labels and barcode scanning.

Increased accuracy can negate the need for additional checks at despatch. The reduction in picking errors is significant in most of the companies who have adopted this technology. Some companies have, however, introduced a failsafe by scanning the item once picked or getting the picker to speak the last three digits of the barcode to confirm the correct item has been picked.

Lydia® offer a combination of pick by voice and pick by vision. In addition to voice communication, a display – for example on a smart watch, a tablet or via smart glasses – is used to display additional visual information. By displaying additional information such as product images, article quantities, navigation instructions or article numbers, you ensure that customer orders are executed without errors.

For high-volume operations, even small improvements in accuracy can produce a substantial payback. For example, a warehouse that picks half a million cases per week with a 99.8 per cent accuracy level (two errors per thousand) incurs 52,000 errors per annum. Increasing accuracy to 99.96 per cent or 4 per 10,000, for example, will reduce errors by 41,600 per annum.

If we accept that the global cost of a miss-pick is approximately £48 ($59) based on a recent Honeywell report (2015), this can be an overall saving of £1,996,800 ($2,454,400).

Other surveys suggest the cost of an error could be as much as $300.

When UK retailer Waitrose introduced voice into its picking operation it recorded an increase in accuracy from 98.68 per cent to 98.88 per cent based on sample audits.

Companies that have invested in voice systems are seeing increases in accuracy rates of up to 99.9 per cent and a number are recording reduced staff turnover and training time.

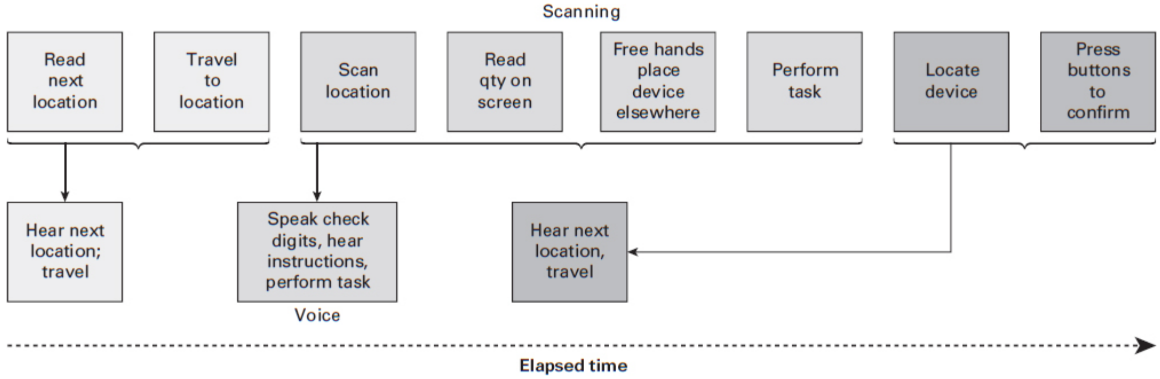
According to Marc Tremblay, logistics director at South Shore Furniture who introduced the latest Lydia® voice system, ‘The only training we need to do with temporary personnel is to explain the warehouse structure and storage locations to them. Then we explain how the communication with Lydia® works. It is very easy for them to learn. It may take 10 minutes until the employee can work independently.’

Perhaps most importantly, voice solutions demonstrate direct benefits to the bottom line: payback is typically less than one year. This can be achieved through accuracy alone.

According to Gale (2017), machine learning AI has led to even greater accuracy in this area. It is suggested that these voice systems have the same accuracy rate as humans and are also able to understand language as we use it. This will negate the need to ‘train’ the system in individual voice recognition prior to deployment.

As can be seen in Figure 6.2, voice can eliminate a number of steps in the pick process, leading to increased productivity and accuracy.

Figure 6.2 Why voice outperforms scanning



▶ Figure 6.2 details

CASE STUDY Lifeway (courtesy of Körber)

Lifeway provides 160 countries with everything from bibles and biographies to journals and CDs, all distributed out of a 350,000 square foot DC in Tennessee. There are 15,000 unique SKUs and 3,000 orders per day.

Lifeway was keen to update its existing paper method for multi-pick and multi-put workflows to improve accuracy and efficiency. The pick accuracy at the time was 91.17 per cent.

By introducing a hands-free voice solution, Lifeway achieved the following:

- 79.2 per cent reduction in carton errors;
- 69.8 per cent reduction in line errors;
- 83 per cent decrease in training time;
- 6.5 per cent increase in productivity.

> *We are much more accurate, much faster and we're able to utilise our workers to do more… The most surprising outcome was the system's ability to handle any language, accent or dialect.*
>
> *(Justin Sullivan, manager of supply chain and systems – Lifeway)*

When considering the introduction of voice technology, this is a list of Dos and Don’ts as follows:

Do:

- visit other operations to assess impact of introduction;
- work in partnership with these companies where possible;
- get a full understanding of the potential technology issues;
- ensure sufficient RF coverage throughout the warehouse;
- ensure the management team fully understands the benefits and has a full understanding of the system;
- consult and gain full acceptance from your staff;
- explain fully the advantages of voice and allay fears regarding safety and any ‘Big Brother’ issues;
- appoint super users to respond to and react quickly to issues;
- ensure training standards and procedures are maintained at a high level;
- provide choice to the users in terms of headsets and voices;
- provide opportunities for staff feedback;
- measure productivities before and after implementation and ongoing;
- continually assess and review the processes.

Don’t:

- think it’s easy to implement and manage;
- assume staff will accept it unconditionally;
- implement other systems at the same time.

The main advantages to date for many companies include:

- improved health and safety as a result of the hands-free operation;

- a safer working environment as staff are able to concentrate fully on the job in hand;
- improved productivity;
- greater accuracy;
- quicker staff training compared with paper- and RDT-based picking;
- ability to use many nationalities in the same operation.

In order to calculate the benefits of any technology, you need to measure productivity levels before and after implementation.

Increases in productivity can be measured in terms of the average cases per hour picked by each worker. Take the cases picked per day divided by hours per day worked (eg 7.5 actual hours) divided by number of pickers (in this case 35):

> 36,000 cases ÷ 7.5 hours per day ÷ 35 operators = 137 cases per hour per operator. A 10 per cent productivity gain would raise the cases per hour to 151.

To calculate the reduction in operators:

> 36,000 cases ÷ 151 cases per hour ÷ 7.5 hours per person = 32 operators (Rounded up)

In this example that means three fewer operators are needed with the switch to voice-directed selection based on a 10 per cent improvement in productivity.

Further savings can be made in terms of stationery, the labour involved in administrative tasks, the training of personnel, improved safety, reduced sickness levels and potential compensation claims together with quicker, more accurate stock checks.

Time to full productivity for a new worker using scanning methods is typically two to three weeks; with voice it can be as little as three to four days.

In terms of expected return on investment, this will vary significantly from company to company. It will depend on:

- the current level of productivity and scope for improvement;
- the current method of picking;
- the number of staff;
- the amount of checking within the system;
- the number of picking shifts within the system;
- the current level of RF infrastructure; and
- whether the WMS or ERP system can support voice.

Voice on its own may not work in all environments. Where companies require the capture of data such as serial numbers or batch codes, voice needs to be supplemented by some form of scanning or image-capture technology.

Voice technology, unless used in conjunction with scanning, may not be 100 per cent accurate. It does rely on the correct product being placed in the right location. Some companies have supplemented voice confirmation of quantity with product recognition by repeating the last three/four digits of the barcode, for example.

Voice can also be combined with scanning. To continue with the hands-free aspect a compact scanner weighing just 4 ounces / 114 grams can be comfortably worn on the back of the hand. The scanner is activated automatically via an optical proximity sensor or alternatively via gesture control. It can also be voice controlled when paired with a voice system.

Overall, voice technology can provide a reasonable return on investment by improving accuracy, increasing productivity and improving ergonomics and safety, thus reducing staff illness and, as a consequence, improving customer service.

In Honeywell's (2015) survey they found that nearly 25 per cent of distribution centre workers around the world do not speak the local language, requiring a need for technology solutions that support multiple languages and facilitate rapid training of new workers. Lydia® Voice is currently available in over 50 languages.

On a recent visit to a UK retailer's DC it was found that 60 per cent of the operators were non-UK born citizens with a majority coming from Eastern Europe.

Potential disadvantages of voice include working in a very noisy environment and it is also very reliant on the wireless technology within the warehouse.

Taking things a step further, a number of manufacturers have introduced a combined voice and automated guided vehicle (AGV) or laser-guided forklift truck system.

The AGVs feature a laser navigation steering system that charts the picker's route. At the first location the voice system instructs the picker as to which item should be loaded onto the empty pallet. The picker informs the system as to what has been picked and loaded and the truck continues to the next location without the operator having to control it although some systems utilize a trigger to move the AGV forward.

Once the truck is fully loaded it transfers to the loading bay while the picker moves on to the next order, arriving at the first location where another AGV with an empty pallet has just arrived (see Figure 6.3).

Figure 6.3 Laser-guided AGV with voice (courtesy of Toyota)

VIDEO 6iii Toyota Automated guided vehicle for picking

By implementing both systems simultaneously, the Swedish Co-op reported that it had improved productivity by up to 70 per cent.

A further addition to the system is the ability for supervisors to communicate directly with the operator via VOIP.

If you would like to give voice a try yourself, you can download the Lydia Voice app for android from the Google Play Store. https://play.google.com/store/apps/details?id=de.topsystem.lydiavoicedemo&hl=en

Barcode scanning

A barcode consists of a series of vertical bars of varying widths that represent letters, numbers and other symbols. Barcodes are used to identify products, locations in the warehouse, containers (totes, cartons, pallets), serial and batch numbers.

As with many areas of logistics, there is no conformity and thus no universal barcode. This can make it difficult to transfer products between companies and countries. The main barcode standards include EAN-8, EAN-13 and Code 128.

Recent developments include two-dimensional barcodes or QR codes, the advantage being that you can store a greater amount of data within a much smaller space (see Figure 6.4).

Figure 6.4 One-dimensional and two-dimensional barcodes

ADDR0010C62620AE

A current debate is whether the pharmaceutical industry should be investing in 2D technology or radio frequency identification (RFID) tags. Both are able to hold more information than a standard linear barcode; however, certain types of RFID tags are rewritable, which can be a significant advantage given the current cost of the tags. Currently, there is a significant difference in price between barcodes and RFID tags.

Barcode readers come in many different forms. They can be hand-held, static, truck-mounted or wearable.

The hand-held scanner has a screen and a trigger. It scans the barcode, deciphers it and stores or transmits the data to a computer. These scanners have the ability to read a number of different types of barcode, although this will depend on the manufacturer, model and cost. Some PDAs and mobile phones also have scanners and cameras able to read one-dimensional and two-dimensional barcodes. This is leading to a reduction in cost; however, there is the issue of how robust these readers are compared to the industrial barcode scanners.

Information is normally transferred in real time via RF.

A pen or wand scanner can also swipe the barcode through contact and reads and transfers the information to a computer or screen.

Barcode scanning, utilizing hand-held scanners with real-time data transmission, has made data collection faster and more accurate in today’s warehouse environment. It has also increased productivity by ensuring that operators don’t have to return to the office for instructions each time they complete a task. The instructions are on screen in the form of text which the operator scrolls through and advances by choosing specific commands.

However, barcode scanning with hand-held devices does have drawbacks. These include having to set down the reader whilst tasks are carried out or struggling to hold the unit and carry out the task at the same time. Errors tend to occur when using hand-held scanners if they are holstered or put down on a surface. This movement can cause the picker to pick from the wrong location or miscount the items. There is potential for greater damage if scanners are dropped or mishandled. Safety is also an issue as operators try to read the instructions whilst in motion.

A stationary scanner will read the barcode as it passes by on a conveyor or belt sorter, for example. This requires the barcode to be easily visible, intact and in a uniform position on the item. Recent advances in this area include the introduction of hands-free, wearable computers that enable the operator to handle product with both hands as opposed to having to hold a barcode scanner, paper pick list or roll of labels.

A wireless-enabled, wearable computer allows operators to receive instructions in real time, scan barcodes, enter data and transmit in real time. Wearable computers are typically worn on the wrist or lower arm and feature a screen and a small keyboard or touch screen, with the option of a finger-mounted scanner that either plugs into the unit or communicates via Bluetooth technology. These have gained in popularity within warehouses where heavy items require both hands free to execute a task.

Companies choose wearable solutions for a variety of reasons. Wearable computers require very little change to existing warehouse operations that currently use hand-held computers. Wearable computers also require little re-training of staff and usually no software modification.

Workers simply need to adjust to putting the wearable components on, to the feel of the computer on their wrist, and if chosen, to the use of a ring scanner. Today's wearable units typically weigh just a few ounces, so fatigue and comfort are typically not an issue. Power is usually supplied from a battery pack worn on the arm or at the small of the back. See Figure 6.5.

Figure 6.5 Wearable RDT with finger scanner (courtesy of Vanderlande)

By using wearable computers, one task is eliminated, thus making the pick process quicker and potentially reducing errors. Productivity and accuracy improvements can quickly add up to substantial savings.

The computers can also be supplied with easy-to-read touch screens and two-dimensional imagers. They can be configured to be voice enabled, allowing pick operations to be even more accurate as items can be scanned to ensure the correct item has been picked from the location.

Other advantages include less damage to equipment and less strain on the user. Figure 6.6 shows an operator carrying both a scanner and a box. Not all his fingers are around the box, making it more difficult to grip. This compares with the operator in Figure 6.7, who is using both hands to hold the box.

Figure 6.6 Picking with hand-held barcode scanner (courtesy of LXE)

Figure 6.7 Picking with finger scanner (courtesy of LXE)

Figure 6.8 ProGlove – smart glove scanner

CASE STUDY TTI Europe

The ProGlove smart glove scanner has been in use for several years at TTI Europe. Since deploying ProGlove's barcode scanners, the electronics distributor has unlocked multiple productivity efficiencies through its ergonomic handling, reliability and robust industrial design. Overall, the time saved due to the introduction of streamlined barcode scanning exceeds 10 hours per day.

The setup at TTI for its outgoing goods includes more than 8,000 order lines, with 4,000 parcels and 100 pallets per day – with 250 pallets of incoming goods. TTI Europe has always been keen to explore ideas and solutions that would deliver valuable improvements and efficiencies to its operations.

ProGlove was first introduced to TTI in 2016. Prior to engaging with ProGlove, TTI had relied on conventional mobile barcode scanners. However, the limitations of this technology were considerable right from the start. The scanners first had to be picked up before each scan and then put down again. Moreover, no satisfactory solution could be found for certain areas. For example, employees operate up to four lean lifts per order. But this requires a level of flexibility that cannot be guaranteed with traditional mobile scanners. Further, the reliability of the mobile scanners was not up to standard because they were not designed for the rough use in the warehouse, and quickly suffered irreparable damages.

ProGlove's glove scanners presented a completely different approach: Not only did the rugged industrial design withstand the demanding environment, but it was also perfectly compatible with the warehouse situation as a whole. Employees always carry their scanner on a glove or cuff, depending on their personal preference. If required, they can trigger it at the touch of a button and can also easily log on to a new workstation via the access point and an encrypted radio connection, or via Bluetooth Low Energy (BLE). This not only keeps workers' hands free at all times, but also eliminates the inefficiencies and restrictions of the old systems.

Today, there are 150 ProGlove systems in use at TTI Europe in the warehouse and shipping department. The smart glove has delivered a rapid return on investment for TTI. Given the 8,000 order lines that are required to be scanned, the time saved exceeds ten hours per day.

'ProGlove has paid for itself incredibly quickly,' Michaela Fritz sums up with satisfaction. 'The device is also easy to handle, reliable in use and, above all, more durable than many of the conventional mobile solutions that we often had to replace after only six months.'

One of the main disadvantages of barcodes is their potential to be damaged, thus making reading difficult and/or potentially inaccurate.

A recent advance in hand-held units by companies such as Tecsys is visual logistics whereby instead of lines and lines of text, operators are being presented with a visual warehouse location map to quickly guide them to the assigned pick location and a visual guide as to the exact carton or tote into which to put the selected products, eliminating the wasteful and time-consuming process of searching for the pick slot. They are also being presented with product-specific images to enable a visual validation and to ensure that the appropriate quality assurance checks are performed.

According to Tecsys, the time to pick a product line can be reduced by up to 30 seconds. Workers are empowered to access critical information to make faster decisions and accelerate their workflows, particularly in environments where literacy is an issue. It also reduces training time.

In this next video we see a combination of vision pick and ProGlove's scanner.

VIDEO 6iv ProGlove and Picavi

Radio frequency identification (RFID)

RFID is a means of uniquely identifying an item using radio waves. Data is exchanged between tags and readers and depending on the frequency, ie high frequency, ultra-high frequency etc, may or may not require line of sight. Common uses in today's world include library books, toll passes and access ID cards.

Its use in the supply chain has been limited until recently. However, high-profile projects within the US military, Marks & Spencer, Walmart and Tesco have increased awareness. Superdry has recently introduced RFID on its products to increase accuracy and improve productivity. The tags cost approximately 5 cents each when bought in large quantities. Accuracy between the warehouse and the stores has improved appreciably.

The system enables the simultaneous reading of multiple items as opposed to barcodes, which need to be read individually.

There are two types of RFID tags: those that are passive, have no power source, limited data storage capacity, are read only and have a limited read range, and those that are active, have their own power source, have a larger data storage capacity, have a read/write capability and are readable from a greater distance.

Passive tags hold little actual data but are able to identify an item to a database where more comprehensive data is stored. For example, a conveyor-based sortation system can identify the item and interrogate the database to receive routing instructions. These tags are powered by the electromagnetic energy transmitted from an RFID reader.

Active tags have a higher capacity and can have their item's status updated once a task has been completed. They have a shorter writing range than reading range and the internal power source is likely to burn out within three to five years.

Frequency is an important factor in transmission range and speed. Not all frequencies are available for use globally, which can cause issues from a supply chain perspective.

- Individual-item-level tracking for the majority of products is unlikely to happen during the next 10 years or so due to the cost of implementation; however, unit-load identification is possible and potentially cost-effective. The tracking of roll cages, pallets and returnable packaging such as totes, kegs, barrels and trays can be made simpler and cost-effective through the use of RFID.
- The difficulty faced by proponents of RFID is that barcodes are so cheap to produce and remain an accurate and cost-effective method of identification.
- The cost of operating an RFID system will vary tremendously depending on the application, the size of installation, the frequencies used and the quantity of tags purchased. As take-up increases, the costs will reduce.

- The following items are required to introduce an RFID application:
    - RFID readers (from $400 to $2,000);
    - RFID tags (from $0.05 to $55.00 upwards depending on the frequency and method of application to the item);
    - middleware;
    - systems upgrades; and
    - RF network within the warehouse.

In terms of use within the warehouse, tags can not only hold product data but can also record:

- the length of time an item has been kept in storage;
- the number of occasions stock has been accessed;
- inventory status, such as ‘awaiting pick up’, ‘held for customers’ etc.

Current disadvantages of RFID include:

- reading issues when in close proximity to liquids and metal;
- dead areas in the warehouse where signals are weak;
- overlapping or tags in close proximity being read as one item;
- tags can be damaged by liquids, static discharges and magnetic surges; and
- intermittent data capture, with the possibility of some tags not being read.

The following video, although 17 years old, describes how Metro, the German retailer, planned to introduce RFID throughout its whole supply chain.

From a warehousing point of view the speed at which data is captured is a significant advantage over barcodes. Both inbound and outbound operations can be speeded up through the use of portals as you will see in Video 6v.

VIDEO 6v Metro RFID envisaged system

Pick by light/pick to light

Light travels at a speed of 186,000 miles per second (299,792,458 metres per second) whereas sound travels at 0.2 miles per second (343 metres per second), therefore the human eye can see a light faster than it takes the brain to interpret a voice command.

Pick to light or pick by light uses light-indicators, LED or LCD modules mounted to shelving, flow racks, pallet racks or other storage locations.

This system tends to be used in conjunction with zone picking.

To begin the process an operator scans a barcode on an arriving pick tote or shipping carton, which denotes the next order number to be picked. This communicates to the system that the operator is ready to pick. The system then sends a message to the zone in which the operator is stationed and all the pick locations for that particular order light up at once.

A digital display tells the operator the quantity to pick as can be seen in Figure 6.9 on page 201; once picked, the operator turns the light off to confirm the pick. The operator can then move on to the next location indicated. The pickers continue until the pick in their area is completed. Some systems allow the operator to scan the item before placing it in the shipping carton to further ensure accuracy. This does, however, slow down the process but is a check on the accuracy of the put-away process. Other systems provide an image of the product to be picked to increase accuracy. The tote is then passed to the next zone for the rest of the order to be picked. This is a typical pick-and-pass method of picking.

Figure 6.9 Yankee Candle pick to light (courtesy of SSI Schäfer)

All information is exchanged in real time with the enterprise resource planning (ERP) or WMS system.

Unlike scanning and voice picking, which are sequential in nature, all locations are indicated to the operator at the same time. This means that the operator can choose the best pick path within the area.

Pick by light necessitates operators being stationed in zones looking after a certain quantity of SKUs. The order tote moves between zones on a conveyor, cart, CMR or other transportation method.

As operators are based in a specific area, this reduces the amount of walking required within the warehouse.

At the end of the pick an operator will check the order number, possibly check the weight of the consignment, attach an address label, add the delivery documentation and signify the carrier if multiple carriers are used.

This occurs with a sequential pick. There may be a situation where large orders are divided into sections and the order is picked on a simultaneous basis in different zones as opposed to on a sequential basis.

This will require the consolidation of the picks from each zone at the despatch area.

By getting the operator to the right location each time, the picking process is greatly improved and productivity increased. Training is relatively simple and is conducive to the use of temporary labour and seasonal employees. Some companies have introduced portable pick-by-light systems that can be moved around the warehouse as required or to a temporary warehouse to cover peaks in business.

As with voice, there is very little upheaval when implementing the system. The lights can be retro-fitted onto shelving and racking. The system can also be used in conjunction with carousels.

In terms of systems integration, pick to light is relatively simple. It requires the downloading of a file with the order number, product codes, locations and quantities. It can easily deal with part cases and individual items.

VIDEO 6vi Pick to light video from Lightning Pick

Put to light

This system is particularly prevalent in retail store replenishment operations; however, its use is now significant for e-commerce orders.

For store replenishment the WMS will consolidate all the store orders for a particular group of stores. This might be done by region or despatch times from the distribution centre (DC). The system needs to ensure that each group of stores has similar volumes where possible.

Depending on daily volumes, staff can increase or decrease the number of locations (stores) that they look after. Cages or pallets for large-volume stores may be situated in a number of different zones with the totes/containers being consolidated at the despatch area.

Individual product lines required by the stores will be batch picked in bulk and transferred to the correct operator station by cart, pallet truck or via a conveyor. Each store will have either single or multiple totes, cages or pallets assigned to it.

Once the SKU has arrived at the 'put' station the operator scans each item and a flashing light displays at each location indicating which containers (relating to a particular store) require that product and how many items are required. Confirmed 'put' results are uploaded to the system in real time to update the WMS.

With pack-to-light or put-to-light systems there is a requirement to set up a central processing area, which can result in the design of a new layout and the introduction of further equipment.

In terms of retail replenishment systems, put-to-light technology requires order consolidation and a batch pick of products. Part pallets or cases will need to be returned to stock if stores do not order in complete cases or the total number of units ordered does not equate to full case or pallet quantities. This is called pick by line. Pick to zero means that the picker collects the correct total quantity of products rather than a full pallet or case, which might not be fully required.

Pack or put to light can be more dynamic and works well with cross-dock operations where product can be received, allocated, picked and despatched on the same day if required. An example of that is in a chilled food environment.

In the following video of Rocky Brands we see an omni-channel operation that has been enhanced through the use of a put-to-light sortation system.

VIDEO 6vii Put to light at Rocky Brands

CASE STUDY

Put to light

A UK clothing retailer installed a put-to-light system at one of its DCs. Twenty stations were installed, each with a capacity of up to 24 stores. Product is automatically delivered to each station, utilizing an automated storage and retrieval system.

The light display at each location indicates how many items must be placed into each of the order totes, which means that a single operator can look after 24 store orders at the same time.

Once an order tote is full, the display instructs the operator to push the tote onto a conveyor system, which takes it to the despatch area.

The high-rate put stations (up to 1,000 items per hour, depending on order profile) significantly reduce the time taken by staff travelling between store orders.

Operators are fed with a continuous supply of products and each workstation is ergonomically designed.

Vision pick

As the name suggests it’s a vision-based system where instructions are sent over a wireless network from the WMS, via specialist software, to the operative wearing a head-mounted display and portable PC. Each operative can see a digital picking list in their field of vision and are guided through the warehouse by a navigation system to optimize routes and distances travelled. The position of the operative is permanently recorded by a tracking system. Products to be picked and order information are visually displayed enabling the operative to undertake visual checks. With the advent of vision picking, even faster, hands-free and error-free picking is being made possible through augmented reality (AR) combined with wearable technology, such as smart glasses. AR combines the very best in vision and voice-guided instructions and merges virtual images and information with an operator’s environment. So, the operator wears the glasses, follows the commands given and scans product barcodes all within the glasses’ display, with information sent back to the WMS. What is clear is that vision picking is easy and intuitive to use, thus requiring minimal operator training. It’s language independent, which is good news for companies employing lots of non-native workers and offers true hands-free operation. It can be used in virtually all warehouse environments without structural modifications and will certainly become more popular for operations in the future according to Chess Technology (2016).

Companies including DHL, Ricoh, Samsung and SAP are currently investing in this technology.

There are some issues according to LogistikKnowHow as follows:

- Low battery life – external battery packs required.
- Seamless WLAN coverage required (100 per cent).
- Lack of acceptance among older employees.
- There may be a health hazard due to dizziness induced by the integrated displays.
- Eyeglass wearers require additional expensive lenses.
- It takes practice to fix the scan exactly to the spot (barcode). If several barcodes are affixed next to each other, it becomes increasingly difficult to detect the matching one.

There are also reports of stiff necks and headaches as operators try to scan the items.

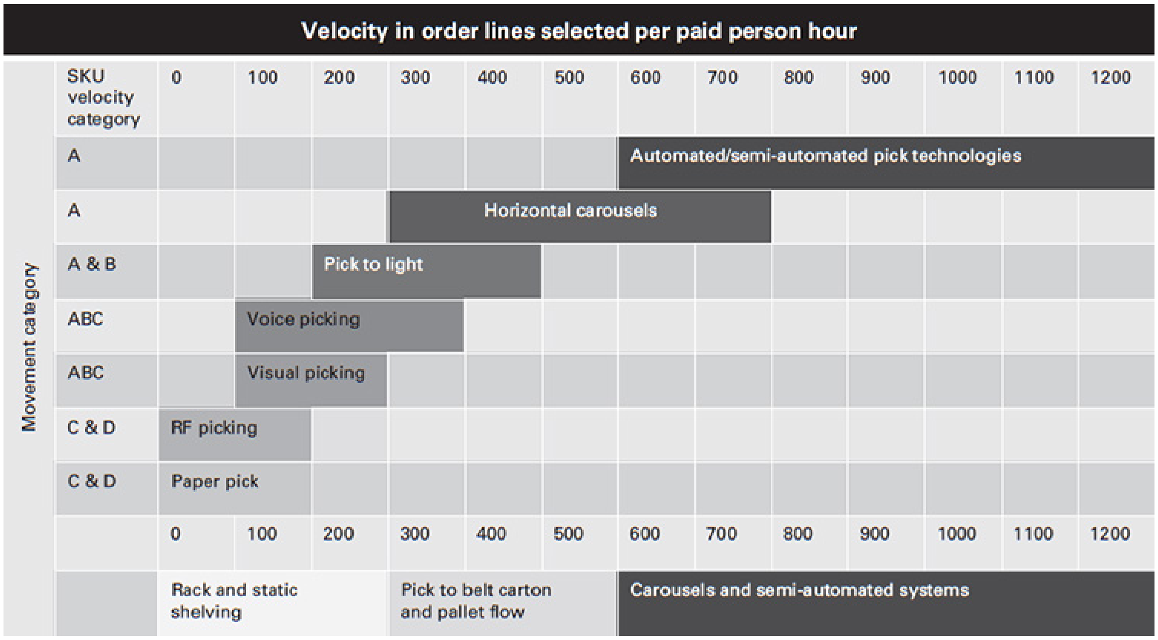
Video 6viii shows a combination of vision and voice technology.

VIDEO 6viii SAP vision and voice warehouse system

Comparisons

Table 6.1 shows the various methods of picking utilized within today's warehouse. These show a combination of picker to goods and goods to picker. In section one we tend to have a single-pick operation where the picker collects all the items for a particular order and then takes it to despatch prior to picking the next order. Picks can be made from a floor-level pick face or, if there are significant numbers of SKUs and too few floor locations, from a higher-level pick face. In this situation the productivity reduces significantly as soon as the operator has to go up into the air.

Figure 6.10 Pick rate comparison for the various pick technologies (Wulfraat 2013)



▶ Figure 6.10 details

Table 6.1 Pick method comparison (adapted from CILT Warehouse Management course)

Skip table

	Method	Equipment	Speed	Accur
Pick faces in aisles	Picker to goods	Low level with hand pallet truck, jack or roll cage	Medium	Paper: RDTs: Voice: Vision
	Picker to goods	Low level with PPT/CBT	Fast	Paper: RDTs: Voice: Vision
	Picker to goods	High-level order-picking truck	Slow	Paper: RDTs: Voice: Vision
	Zone pick	Pick to light	Fast	High
Bulk pre-pick (batch)	Pallet to picker followed by picker to tote/pallet	By RT/CBT	Medium–fast	Paper: RDTs: Voice:
	Put to light	Cart, pallet truck or conveyor	Medium–fast	High
Mainly automated	Goods to picker	Carousel	Medium	High
	Picker to goods or goods to picker	Conveyor or sorter (A-frame)	Fast	High
	Goods to picker	AMRs	Fast	High
	Goods to picker	AS/RS to pick station	Medium–fast	High

KEY PPT – Powered Pallet Truck; CBT – Counterbalance Truck; RT – Reach Truck; AS/RS – Automated Storage and Retrieval System; RDT – Radio data terminal AMR Autonomous Mobile Robot

In section two we have a two-stage process where product is picked in bulk, for example by batch, followed by a sortation process into individual orders. Although in two stages, the pick rates are reasonably high and it also includes a double check of items and quantities, thus improving accuracy. Put-to-light systems use batching to collect all the items for specific orders.

In section three we have the use of carousels, conveyors, AMRs and fully automated AS/RS systems.

Utilizing this form of picking, we see pick accuracy rates increasing together with the ability to handle large numbers of SKUs and items.

Table 6.2 provides a comparison between the different pick methods in terms of advantages and disadvantages.

Table 6.2 Pick system advantages and disadvantages

Skip table

	Applications and pick rate	Benefits	Drawbacks
Paper picking	• Most operations • Where there is very little systems support • Low-cost areas • < 100 lines per hour	• Low cost • Single-stage picking operation although two-stage update operation (need to key data into system) • Flexible • Quick • implementation • Ability to isolate urgent orders • Picker able to decide pick path • Low maintenance • Suitable as part of a contingency plan	• Low pick rate • Not hands-free • Low accuracy • Duplicated tasks • Not real time • Training can take some time • Requires manual update of system from written instructions • Requires return to desk for further instructions • Paper waste

	Applications and pick rate	Benefits	Drawbacks
Pick by label	• Most operations • Where there is very little systems support • Low-cost areas • < 100 lines per hour	• Low cost • Reasonably accurate • Single-stage picking operation although two-stage update operation • Flexible • Quick implementation • Low maintenance	• Low pick rate • Not hands-free • Duplicated tasks • Need to print labels • Not real time • Training can take some time • Label information may be difficult to read • Can damage product if mistakes made • Requires return to desk for further instructions

	Applications and pick rate	Benefits	Drawbacks
Barcode scanning with gun	• Most operations • < 100 lines per hour	• Improved accuracy • Paperless • Flexible • Real-time stock update** • Ability to deal with multi-SKU locations	• Low/medium pick rate • Not hands-free • Can take longer than 1st stage paper picking • Cost of hardware • Requires barcode on every item • Barcode standards • Requires system interface • Real-time system requires wireless receivers throughout warehouse • Requires maintenance

	Applications and pick rate	Benefits	Drawbacks
Wearable scanners	• Most operations • < 150 lines per hour	• Paperless • Flexible • Improved accuracy • Improved productivity • Hands-free • Less strain on operators • Damage reduction • Real-time stock update • Ability to deal with multi-SKU locations	• Cost of hardware • Requires barcodes on product • Issues with international standards • Requires system interface • Real-time system requires wireless receivers throughout warehouse • Requires maintenance

	Applications and pick rate	Benefits	Drawbacks
Voice picking	• Most operations • Ideal for temperature-controlled areas • Heavy, awkward items • 100–250 lines per hour	• Paperless • Flexible • Fewer processes • Improved accuracy* • Improved productivity • Quick training • Hands-free/eyes-free • Improved safety • Less strain on operators • Damage reduction • Real-time stock update	• Cost of hardware • Difficult in noisy environments • Requires system interface • Requires maintenance • Problem with multi-SKU location • Serial number capture is an issue • Accuracy issue if product in incorrect location • Unsure of long-term health issues
Voice picking plus finger scanning	• Most operations • Ideal for temperature-controlled areas • 125–250 lines per hour	• Paperless • High accuracy • Good productivity • Hands-free • Less strain on operators • Damage reduction • Real-time stock update • Ability to deal with multi-SKU location	• Cost of hardware and software • Requires barcode • Requires system interface • Requires international standards • Unsure of long-term health issues

	Applications and pick rate	Benefits	Drawbacks
Pick to light	• High no. SKUs high frequency sales per individual item mail order/ e-commerce, maintenance stores • approx. 250–450 lines per hour	• High accuracy* High productivity • High pick rate • Easy to train staff • Staff can choose pick sequence • Real-time stock update • Hands-free • Improved safety • Damage reduction • Simultaneous or sequential picking • Can be used for goods-to-person and person-to-goods picking (zone)	• Cost of hardware • Requires system interface • System failure • Cost of maintenance • Low flexibility • Long implementation time • Limited in terms of product types • Cannot have multi-SKU locations • Difficulty with batched or clustered orders

	Applications and pick rate	Benefits	Drawbacks
Put to light	• Retail store operations • Cluster picking	• High accuracy • High productivity • Damage reduction • High put rate • Easy to train • Real-time stock update • Can be used for goods-to-person and person-to-goods picking (zone)	• Cost of hardware • System failure • Limited in terms of product types • Cost of maintenance • Two-stage operation
RFID	• High value goods • Items requiring accurate traceability • 200–300 lines per hour	• Very high accuracy • High productivity • Real-time stock update • Track and trace throughout warehouse	• Cost of hardware • Cost of tags • Requires suppliers to attach tags/labels • Read distances very short • Requires international standards • Requires system interface • Cost of maintenance • Issues with certain types of products (liquids, metals)

	Applications and pick rate	Benefits	Drawbacks
Vision picking	• Most operations • Ideal for temperature-controlled areas • Heavy, awkward items • 100–250 lines per hour	• Paperless • High accuracy • Good productivity • Hands-free • Less strain on operators • Damage reduction • Real-time stock update • Ability to deal with multi-SKU location	• Cost of hardware and software • Requires barcode • Requires system interface • Requires international standards • Unsure of long-term health issues

NOTE *High accuracy is dependent on accurate put-away. Can be supplemented by reading out last four digits of barcode or scanning.

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

Cost of errors

It is an accepted fact that increased errors lead to increased costs.

There are many calculations for the cost of a miss-pick. The elements involved in an incorrect pick include:

- cost of recovering the item;
- labour cost of in-handling and checking the item on its return;
- cost of put-away;
- cost of picking the replacement item;
- cost of repacking;

- cost of redelivery;
- administration costs of handling queries and credit claims, etc;
- cash flow with reference to non-payment of invoice;
- potential loss of sale for the product incorrectly despatched;
- potential ‘knock-on’ effects on other orders;
- cost of checking processes and retraining staff; and
- possible stock write-off if the returned product is outside an acceptable shelf life or has been damaged in transit.

In addition, if the error is an under-pick then it could result in a lost sale and the associated margin. If it’s an over-pick and is reported, there is the cost of transport to collect the item and labour costs as above or potentially a loss of margin in persuading the customer to keep the item. If not reported, the cost becomes the loss of the product and margin.

If this happens too often then it can mean the likely loss of a customer.

Estimations of the cost of miss-picks range from £48 ($59) to £75 with £48 being seen as a significant underestimation. This will, of course, depend on the type of product and market sector.

Finally, there is also the environmental impact of increased transportation and additional handling and packaging.

Deciding on type of picking system and equipment

This is quite a dilemma for warehouse managers today as they grapple with labour shortages and pressure to reduce costs yet increase accuracy, productivity and service levels.

The following factors must be taken into account before you make your final decision:

- *The return on investment and payback periods* for major capital investments will greatly influence the decision as to whether or not to choose automation over more manual processes. A three- to five-year payback or better is considered a reasonable period when investing in warehouse operations; however, in today's climate finance directors are looking for even shorter payback periods.
- *Ergonomic and green issues* are also playing their part in decision making within this arena. A greater concern over energy usage and potential taxation on environmentally unfriendly equipment is a factor that needs to be taken into account.
- *The long-term strategy* of the company will have a bearing on the decision to invest in new equipment. Any potential relocation of the business, changes in product profile or distribution channel suggests that any investment in hard automation needs to be carefully considered. The dismantling and re-installation cost of this equipment is likely to be prohibitive.
- *High volume due to seasonal peaks* such as the pre-Christmas period is not a signal to fully automate the processes. iForce, a UK-based fulfilment centre, decided against large-scale investment in automation. In a recent article, ex-CEO Mark Hewitt said that peak issues may negate the use of technologies such as hand-held data terminals because it would mean a large number of units

sitting redundant for the majority of the year. However, the opportunity to rent these items, including voice units, makes technology more accessible and appealing. It is also true to say that customer demands for shorter delivery times is taking companies down the route of automation and technology. This is certainly the case with AMRs and CMRs.

- *The availability of labour* is also a major factor in determining the level of automation. The availability of a large and stable workforce of skilled and non-skilled operators at reasonable wages enables you to be more flexible, saves on investment and improves cash flow significantly.

Flexibility and automation tend not to go hand in hand, although this is beginning to change and therefore a thorough review of your pick operations and a discussion regarding future operations are paramount.

Computer simulations can assist in this review. Different types of pick operation can be evaluated and both soft and hard automation can be compared quickly and without disrupting the existing operation.

Simulating different types of pick operation enables you to determine which one is best suited to the operation. It is cost-effective and provides instant results.

By comparing picking solutions, such as pick-to-light and voice picking, for example, the simulation software is able to determine performance indicators such as operator pick rates and overall order throughput and, based on the results, suggest the most cost-effective method. Each of the scenarios is undertaken in the risk-free environment of a computer screen.

Suppliers include Class, Logistics Simulation Ltd and many of the mechanical handling and equipment suppliers.

Finally, it is not always a case of having one method per warehouse. Most companies will use a combination of pick technologies to further increase accuracy and productivity as we have seen in many of the videos. A typical example is the use of voice technology together with finger scanning. This combines hands-free picking with accurate data collection. The i-Herb.com Hebron warehouse uses a combination of pick-to-light and automated storage and retrieval systems.

Summary and conclusion

You should not under any circumstances automate a bad or broken process. Always ensure that your warehouse operation is working as efficiently as it can without the use of technology. It is only when you are at this stage that you should contemplate using technology to further enhance the operation. Processes need to be as streamlined as possible and any unnecessary steps eliminated.

Continuing to do what you've always done but more quickly and with less paper is not going to improve your overall performance.

There is a plethora of suppliers in this market and all are capable of helping you make the right decision for your company. They want a sale but they also want a satisfied customer – take advantage of their expertise.

Finally, staff resistance to change is a potential barrier to the successful implementation of any new system and therefore all parties need to be on board before major decisions are taken.

07
Warehouse processes from replenishment to despatch and beyond

Introduction

In this chapter we examine the remaining processes within the warehouse. These include replenishment, value-adding services and despatch, together with the peripheral but essential tasks of stock counting and housekeeping. We also look at security measures that can be taken within the warehouse.

Replenishment

In order to ensure a smooth and efficient picking process we need to ensure that the right products and quantities are in the correct pick location at all times. This is replenishment.

As in the case of replenishing overall inventory to ensure customer satisfaction, the warehouse also has to replenish its pick faces regularly to ensure picker satisfaction. An empty picking slot, just like an empty shelf location in store, can mean a lost sale. The result of a poor replenishment process is order shortages, increased picking times and therefore increased cost per pick and an overall reduction in service level.

Real-time WMSs will recognize the need to replenish pick locations through real-time data transfer. These systems are also able to identify the total actual order quantities and therefore replenish before the next wave of orders arrive on the warehouse floor.

There are three distinct methods for warehouse replenishment:

1. Demand-based: Inventory is only moved on an as-needed basis. This cuts down on wasted time but can require extensive planning, with plenty of room for uncertainty. This is related to the Kanban system – use one, replace it!
2. Routine: Replenishment is triggered only when a product reaches a minimum threshold at the point of picking. Routine-based replenishment can work well for seasonal products with predictable demand. However, it may require more space in both upstream storage and downstream picking areas. This will rely heavily on timing as orders that have generated pick lists may not actually have been picked and therefore replenishment has been triggered early. Late replenishment can result where staff have picked out of sequence, for example, and emptied the pick bays before the replenishment team have had an opportunity to top up the location. Timing is crucial. An early instruction to replenish can cause as many problems as late replenishment, with potentially overfull pick faces and issues with FIFO.
3. Top-off: If activity in one area is temporarily slow, top-off replenishment could be put in place to take advantage of these fluctuations. This gives warehouse managers flexibility in shifting work around the warehouse to

increase efficiency at peak times whilst taking advantage of demand troughs.

If product can be moved directly to the pick face from the inbound section this cuts out a number of processes. This will require a certain amount of pre-planning to ensure that pick faces are not overfilled. Pallets can be de-layered to correspond with expected pick quantities.

In the absence of a real-time warehouse management system the warehouse manager will need to first ensure that the pick faces are designed to take the optimum quantity of product based on predicted sales per day or per shift, cubic capacity of the pick location, and staff need to be trained to identify replenishment requirements and inform either the supervisor or the forklift truck driver, depending on how the process has been set up.

One other point to note here is that although real time dictates that replenishment and picking can occur simultaneously, there are issues of worker safety if forklift trucks and pedestrian pickers are working together in the same aisle. It can also lead to confusion if both are at a location at the same time.

This can be alleviated by incorporating multiple picking locations for the same SKU, the utilization of A-frames, carton live storage or flow racking where product is replenished from a separate aisle. The two activities can also be carried out at different times of the day if feasible. For example, receiving and replenishment can take place in the morning whilst picking takes place in the afternoon. Carousels and areas where forklift trucks are in constant use must be replenished at different times to avoid slowing down the operation and endangering staff.

Alternatively, replenishment can take place during breaks or after picking has been completed for the day. This mirrors what happens at retail stores where shelf replenishment takes place when stores are closed overnight.

Value-adding services

Many warehouses have introduced areas where value-adding services can be carried out. These are common in both dedicated and shared-user or public warehouses where third-party logistics companies are providing an all-encompassing service to their customers.

These value-adding services include the following:

- (re)labelling;
- pricing;
- tagging and kimballing;
- (re)packing;
- bundling, as in ‘buy one, get one free’ (BOGOF) offers;
- reconfiguration;
- sub-assembly;
- repair and refurbishment.

Undertaking shop-floor-ready labelling, tagging, bundling and pricing in the warehouse removes the task from the retail assistants who can spend more of their time selling.

More sophisticated services include some form of production, as in the case of postponement where items are added once the customer’s order is known. This can include the inclusion of graphics cards and the loading of software in the case of personal computers and laptops. It can also include the fitment or inclusion of a particular part for a specific market. The UK electrical plug is a typical example as it differs from the rest of Europe.

Postponement can be described as a delay in the completion of an item until an actual order is received from a customer. Postponement not only saves time but also reduces inventory holding by reducing the total number of SKUs held in stock.

Value-adding services can also include returns processing and a repair service. This area is covered in more detail at the end of this chapter.

Sufficient space needs to be made available for these tasks, with access to power and being close to the despatch area, thus reducing any unnecessary movement. An ideal location, if the height of the warehouse allows it, is above the despatch bays on a mezzanine floor.

An interesting example and one where logistics companies are seeing potential is Walker Logistics in the United Kingdom, which has opened dedicated units for customer rework operations.

Some of the processes they manage are;

- performing additional quality control (QC) and component testing to ensure 100 per cent compliance;
- managing sales and marketing stock including point of sale items and tester conversion;
- customized product assembly service including labelling, kitting, bar-code application and instruction leaflet insertion;
- product launches, planning months in advance, handling large volumes, fast turnaround receipts, cross docking and

multiple rework projects to very tight deadlines;
- bespoke returns management programme including QC;
- dedicated Amazon ‘bagging’ and rework services to meet strict SLA guidelines for Fulfilled by Amazon (FBA);
- on-demand or long-term kit collation consisting of re-packed products or grouping into kit format.

Using a full-service supplier reduces double handling and transport to and from an external service supplier, therefore saving costs.

An example of value-adding services being undertaken in a third-party warehouse can be seen in the video below.

VIDEO 7i Batch pick, put wall and VAS courtesy of Paula’s Choice

Indirect activities

There are many support activities that occur in warehouses and are crucial to the efficient operation of the warehouse. These are, in the main, undertaken by supervisory staff, specialist teams and the housekeeping team. These activities include:

- ensuring optimum staffing levels and providing a pool of suitably trained staff for peak periods;
- on the job training;
- managing the allocation of labour for value-adding services;
- ensuring optimum space utilization;
- monitoring work flow and congestion;
- provision, allocation and maintenance of equipment;
- identification and replenishment of fast-moving items;
- identification of non-moving stock;

- stock integrity and dealing promptly with non-conforming, lost or found stock;
- managing cycle counts and organizing full stock checks;
- security of high-value or hazardous stock; and
- ensuring the cleanliness of the warehouse and the safety of both staff and visitors.

The above tasks can be separated into three distinct sections:

- the management of labour, space and equipment;
- the control of stock; and
- the security and safety of stock and people.

Stock management

Inventory or stock management and warehouse management tend to be two very distinct roles.

Warehouse managers are in a position to advise their inventory colleagues on levels of safety stock and the specific movements and characteristics of particular stock items. However, they tend to stop short of determining stock levels.

This function is a major part of a company's operation and the theories and practices are covered in many books on the subject of inventory management.

Although the majority of warehouse managers are not involved directly in the choice, purchase and replenishment of stock, they can play a role in the identification of fast-, medium-, slow-, non-moving and obsolete stock.

This can be done using one of the mainstays of a warehouse manager's armoury – an ABC classification. The information can normally be obtained from the WMS and, as mentioned in

Chapter 3, a simple spreadsheet can categorize stock items by volume and frequency of sales.

A warehouse manager can extend the normal classification to include non-moving and obsolete stock together with identifying stock that may not require storage in the warehouse but can be despatched direct from the supplier to the end customer where the lead time is in line with the customer's requirement.

The classification might look something like that shown in Table 7.1.

Table 7.1 Stock classification

[Skip table](#)

Classification	Description	Approx % of stock items
A	Fast-moving stock	20%
B	Medium-moving items	35%
C1	Slow-moving items	45%
C2	Very slow-moving but required for cover or customer-specific	
E	Obsolete or non-moving stock	
S	Special or one-off purchases	
X	Non-stock or non-standard items	

The percentages will vary significantly by company and by market sector. Maintenance stores are likely to have a high proportion of their stock in the C to X categories.

The goal is to identify the items in the C to X categories and act accordingly. Obsolete or non-moving stock needs to be analysed and one of the following tasks undertaken:

- return to seller if the contract allows;
- sell to staff at a discount;
- sell the item at a highly discounted rate either through normal channels or via companies who specialize in selling overstocks and obsolete items;
- assess whether it is cost-effective to break the item down into its constituent parts;
- donate to charities; or
- dispose of the product as cheaply as possible. This may incur charges but it will release space to store other faster-moving product in its place.

A quick and easy way of ascertaining whether there is an excess of slow-moving stock in the warehouse is to calculate the stock turn:

> Stock turn = cost of goods sold ÷ average cost of goods stored

or:

> Annual throughput in units ÷ average number of units held in stock

For example, an annual throughput of 1,200,000 units with an average stock-holding of 100,000 units gives a stock turn of 12. That is, the stock turns over once per month.

A low turn in most operations suggests that stock sits in a warehouse for far too long, implying that the safety stock level has been set too high.

Typical examples of stock turn within companies are as follows:

- 150 +: world class using just-in-time techniques;
- 120 +: chilled foods;
- 16 +: retail;
- 10–30: European manufacturing;
- < 3: maintenance stores.

The higher the figure, the better the company is performing in terms of inventory management. UK food retailers Sainsbury's and Morrisons have average stock turns of 16.74 and 25.61 respectively. Maintenance stores will always have low stock turns through having to hold stock in case of breakdown.

Stock or inventory counting

All warehouses are obligated to undertake some form of stock count. It depends on the law of the country and accounting requirements as to how frequent and comprehensive the count is.

We have seen over recent years a move towards cycle counting or perpetual inventory counts as a replacement for an all-encompassing annual count of stock in the warehouse.

A full stock count usually necessitates the closure of the warehouse for a period of time when all inbound and outbound movements are suspended. A significant drawback of a single annual count is the difficulty in reconciling the discrepancy as it could have occurred over 11 months ago.

The count is normally carried out at the company's year-end. Some companies will carry out quarterly or possibly half-yearly checks depending on the stipulations laid down by the auditors.

More recently, providing the company can prove that its cycle counting is accurate, auditors have agreed in some cases that if each stock line is counted and audited at least once per annum that will be sufficient for their needs.

Providing the cycle counts are considered to be accurate, the year-end stock figures will be taken from the WMS.

Cycle counting or perpetual inventory counts

When undertaking cycle counts it is prudent to use an ABC analysis to ensure that your fast-moving and high-value items are counted more frequently than your slow-moving, inexpensive items.

Miss-picks are more likely with fast-moving goods, and high-value items are prone to pilferage.

It is suggested, therefore, that fast-moving and high-value items are counted monthly, medium sellers are counted quarterly and slow-moving items either once or twice a year. The following percentages can be used to ensure a comprehensive count:

- 8 per cent of A items counted weekly (ensures each SKU is counted approximately once per quarter);
- 4 per cent of B items counted weekly (counted twice per annum); and
- 2 per cent of C items counted weekly (counted at least once per annum).

The accuracy of the counts will also determine the frequency. A high error rate should result in more frequent counts until the accuracy improves. Each discrepancy needs to be investigated and procedures put in place to ensure that there is no repeat of the problem.

Increasing the frequency to daily ensures a more accurate count; however, this will depend on the number of product lines, available resource and the cost of that resource.

The trade-off here is the cost of the error against the cost of discovering it in the first place.

Cycle counting can take place during the pick itself with staff being prompted to count the items in the location once a pick has taken place. This is termed a 'left on location' check. This can only work in real time through the use of scanners, voice or vision technology. Operators will normally be prompted once the stock level falls to three or below to avoid delaying the pick.

As mentioned previously, a number of auditors will be happy (or as happy as they can be) if stock in the warehouse is counted at least once, preferably twice during the year.

The count itself

All stock counts require organizing. You need to know who will undertake the stock count, what you are planning to count, when you plan to undertake the stock count, what tools and equipment you need and the timescale allotted. For example, items that require measuring or items that need to be brought to ground for counting will take much longer than counting in situ. Also, if you are counting at height you will need to ensure the safety of the warehouse staff. If you are using forklift trucks a suitable safety cage needs to be provided. Under certain health and safety legislation and company rules the use of cages on forklift trucks are deemed unacceptable and therefore specialist equipment is required such as elevated work platforms (cherry pickers). Portable scales for counting items such as nuts, bolts and fasteners for example are a necessity.

Prior to the start of the count ensure that all items have been put away in their correct location and try to despatch as many items as possible prior to the stock take. Second, ensure that any obsolete units are disposed of before the start of the count. There is no point in counting stock that shouldn't be in the warehouse.

Some companies will affix a different coloured label on pallets during each year's count. One way of identifying non-moving or slow-moving stock is to look for the labels from the earliest stock count. In the past we have identified stock items that have gone through a significant number of counts and the pallets or cartons have never moved.

It is normal to have a counter and a checker for each section if you are using a paper-based system. If you are scanning locations and products, one person per section should be sufficient. An auditor is likely to be present during a full count to make random checks of locations to verify the count is accurate.

In order to complete a full stock count in the shortest possible time to minimize disruption to sales, companies will inevitably use staff who are unfamiliar with the products. As these counts normally take place at weekends or over the Christmas and New Year vacations, their motivation to do a thorough job might also be suspect.

Where there are a significant number of locations and a number of open cartons and individual items to be counted, it is likely that additional staff will need to be employed from agencies to assist in the count to ensure it is completed in time. However, completion on time is rarely the case as the number of discrepancies can take days to resolve. As a result, operations resume so as not to let customers down, but this tends to compound the problems. This is why a number of companies are turning to cycle counts as opposed to full-blown stock counts.

Outside agencies who are experienced in stock counts can be employed as an alternative but can be expensive and the issue of product familiarity is also a factor.

Any discrepancies between the system figures and the count figures should be checked immediately by a supervisor and this continues until you arrive at two matching figures, be they the last two counts or the count and the system figures.

The likelihood of finding the reasons for a discrepancy are low, as a year’s transactions have passed through the warehouse since the last count. The root cause of discrepancy is seldom discovered and as a result cannot be eliminated.

With a paper system it is usual to provide staff with details of locations and product codes but with the quantities removed. Quantities are written on the sheets together with any changes to the product codes and other comments such as damage are recorded.

This can lead to further inaccuracies as the administration staff try to decipher each person's writing whilst typing the results into a spreadsheet or database.

This system of counting is fraught with problems and if agreed by auditors a perpetual inventory counting system should be introduced to replace the single annual count.

In terms of performance measures companies need to record the number of errors found, not the difference in monetary value as this can hide a number of problems. A difference of a few hundred dollars may seem acceptable; however, there could be hundreds of errors within the system such as the following:

- products in incorrect locations;
- too many items of one product; and
- too few items of another product.

These may balance out but they need to be logged, measured and corrected before operations recommence.

In today's technologically advanced world we are seeing the introduction of drones to assist companies in counting their stock. These unmanned autonomous vehicles (UAV) are still in their infancy. There are a number of advantages, not least the reduction in staff levels.

Figure 7.1 Stock counting drone – supplied by FlytWare

These UAVs are ideal for counting one deep, full pallet, single SKU locations. They can also be used to identify empty locations and confirm correct put-away.

They do, however, require pallets to be labelled clearly with front-facing barcodes.

They can also be used in chilled and frozen environments and in very narrow aisle racking where ground operated forklift trucks as opposed to VNA Turret trucks are used.

FlytWare has recently introduced the use of these drones into an IAG facility in Spain.

VIDEO 7ii Drone deployment – IAG Spain

Given the relatively high frequency of pallet movement and the wide variety of barcodes in an air cargo warehouse, inventory scans using drone fleets can be an ideal solution for fast, high-frequency, cost-effective cycle counts.

In order for these drones to operate efficiently, there are a number of requirements:

- out of hours operations or segregated areas;
- automatic triggering of overhead, motion-activated lights;
- a comprehensive indoor radio frequency (RF) range;
- operational improvements to ensure all pallet barcodes can be successfully read;
- optimal location of the ground station and charging pads for the drones.

There are a number of disadvantages, however when it comes to counting boxes on part pallets, opened cartons, poorly labelled items and multiple product lines in a location. There is also the safety aspect and the short battery life.

Some of these disadvantages can be overcome by the introduction of RFID tags applied to each item; however, cost remains an issue with very few companies adopting comprehensive tagging of individual items. Overlapping tags, the presence of liquids and metal can also affect accuracy.

Although a recent technology, a number of high-profile companies are either using these drones or at least contemplating their use.

Security

Security of product within the warehouse is paramount. The warehouse manager is responsible for the integrity of all the products under his or her care, whether they are owned or stored on behalf of other companies as a third-party contractor.

This can be achieved through good housekeeping, the use of security cages and carousels for storage, CCTV and thorough vigilance by staff.

Poor security costs companies in lost inventory, higher insurance premiums and personnel turnover.

Loading docks and platforms tend to be the most vulnerable areas – they're very easy places for a thief to remove stolen property, often in partnership with an outsider, a delivery driver, for example. Security systems tend to be designed to protect your facility from people breaking in – but many thefts are perpetrated from within.

Closed-circuit television at strategic points throughout the warehouse is a significant deterrent; however, unannounced inspections and walkabouts are also effective and much cheaper.

With regard to the loading bays, one common-sense recommendation is that you separate them from employee parking areas, making it much more difficult to remove items from the warehouse. Searches on entry and exit, whether instigated by staff or by a random system of lights, are also very effective.

Not only is product security important but also the protection of data. WMSs hold a large amount of sensitive data that needs to be protected. Internally this can be done through the use of password protection for different access levels and firewalls for external protection. The data needs to be backed up daily and the backup files stored offsite. A mirror system is an even better backup providing it can react quickly to the main system failing.

Protecting data from being stolen or copied is also paramount. Equipment such as servers, computers and laptops need to be protected. These items need to be locked with key or code access, and personal computers need to be password protected and those passwords changed regularly.

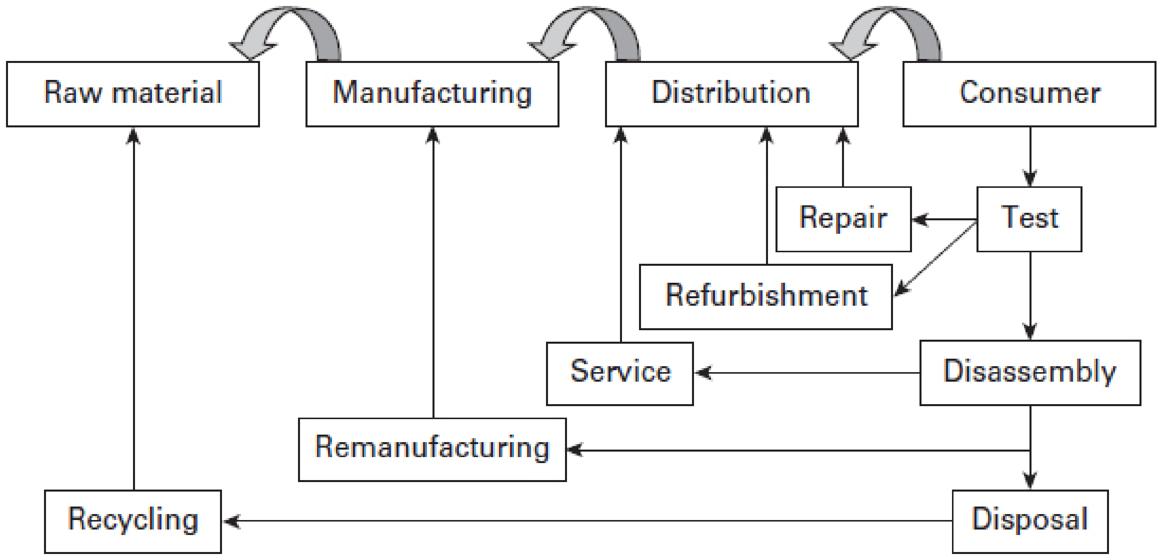
The core attributes of security within a warehouse are as follows:

- appropriate recording of inbound and outbound products;
- authorizations for all despatches;
- accurate audit trails;
- regular stock checks;
- the use of appropriate storage equipment; and
- vigilance.

Returns processing

Returns processing, or reverse logistics as it has become known, involves the handling of product returns, transit packaging and surplus items. The processes associated with this operation include repair, reuse, refurbishment, recycling and disposal. See Figure 7.2.

Figure 7.2 The returns cycle (courtesy of University of Huddersfield)



▶ Figure 7.2 details

Reverse Logistics has been described as:

> The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal.
>
> (Rogers and Tibben-Lembke, 1999)

The processing of returns has gained increasing importance in the warehouse over the past few years. There is now an increasing awareness of the economic value of reusing products and the effect on cash flow of perfectly serviceable items that can be repackaged and made available for sale. There is also the possibility of fines if products and packaging are not disposed of in an environmentally friendly way.

Doing nothing about returns costs money. They take up space, are difficult to count during stock takes, difficult to value and, more importantly, could be back on sale rather than taking up much-needed space within the warehouse. The alternative is ordering further stock with all its inherent costs.

In a recent EFT survey, 54 per cent of global retailers take more than a week for returns to be added back to inventory. This represents a significant amount of lost sales time as well as possible stock-outs of popular products. However, just under 24 per cent of respondents were getting their returns back to inventory in three days or less.

There has also been a greater environmental awareness backed up by legislation such as the Waste Electrical and Electronic Equipment (WEEE) Directive, hazardous waste disposal legislation and more stringent waste packaging directives.

The WEEE Directive came into force in January 2007 in the EU. Its aim is to both reduce the amount of electrical and electronic equipment being produced and to encourage everyone to reuse, recycle and recover.

The WEEE Directive also aims to improve the environmental performance of businesses that manufacture, supply, use, recycle and recover electrical and electronic equipment.

The increase in e-retailing has also seen a significant increase in the level of returns into the warehouse. This has grown even further as a result of COVID-19. Catalogue retailing has always had significant amounts of returns, especially in terms of textiles and clothing. These retailers have, in the past, set up returns-processing areas to not only receive the items but also clean them, iron them and pack them for resale. In Germany the percentage level of returns for fashion is in excess of 50 per cent.

Other such returns include products despatched on a sale-or-return basis and those where customers are given the option of a 14-day returns policy. These items are likely to be good stock and can be returned to stock almost immediately.

In this respect, the WMS has to ignore the FIFO principle and ensure that these ‘good’ returns are despatched as quickly as possible rather than ending up at the back of the queue in terms of despatches based on its current receipt date. Ideally, the return item should be placed directly into the forward pick location.

Other groups of returns include reusable packaging such as barrels, kegs, bins, cages, trays, totes and pallets.

Product recalls are also a significant area, needing to be handled carefully. These products need to be quarantined on return so that the company can ensure, first, that all items have been received and are no longer a potential danger to the public – which is normally one of the main reasons for recall – and second, that they are not mixed with good product and sent out in error.

Recently introduced legislation, the cost of landfill both in money and environmental terms and the realization that returns can be an expensive area to neglect have triggered the growth of reverse logistics programmes and the establishment of warehouses built specifically to handle the returns process.

This type of warehouse needs to be set up very differently from a stock-holding facility. Space needs to be set aside for sortation, inspection, repair, refurbishment and disposal. The idea behind returns processing is to either return stock into the supply chain as quickly as possible in whatever format, be it finished goods or spares, or dispose of it efficiently.

Returned items shouldn’t remain in the facility for too long.

Should you decide to operate the returns function within an existing warehouse operation then you are likely to set up a warehouse within a warehouse. This needs to be carefully planned to avoid cross-contamination – for example, when dealing with damaged or defective items, chemicals and hazardous products.

Prior to making any decision regarding a reverse logistics operation you need to calculate the following:

- percentage and value of goods returned directly to stock and to vendor;
- percentage of goods refurbished and returned to stock;
- percentage of goods dismantled and used for spares;
- percentage of goods destroyed or given away to charity, etc;
- percentage of goods returned due to manufacturing defects; and
- percentage of goods returned due to sales department, warehouse or consumer error.

With regard to the last two points above you need to look at the causes in more detail before putting processes in place. For example, with consumer error it could be that the operating instructions are not clear enough.

In order to justify a returns processing operation, the following needs to be calculated:

> Total cost of returns processing + cash flow impact versus purchasing/manufacturing new + cost of disposal and cash flow impact

KPMG suggest that ‘It can cost double the amount for a product to be returned into the supply chain as it does to deliver it.’

There are estimates that returns logistics costs can account for about 5 per cent of turnover.

A final decision to make with regard to reverse logistics is whether to operate the function in-house, within the warehouse or at the store or subcontract to a third-party specialist. This decision very much depends on the following factors:

- level of returns;
- available space;
- available expertise;
- cost;
- control and efficacy;
- capacity and capability of third parties; and
- lead time from return to available to ship.

You need to determine how many hours per week you are likely to expend on returns processing and how much space you require. You need to calculate the amount of space required at peak, which is more than likely the period after Christmas or highly discounted sales days such as Black Friday and Singles Day.

With regard to disposal, companies will need to produce the relevant certification to prove that products and packaging, if not recyclable, have been disposed of properly.

Reverse logistics has gained momentum recently and has gone from being driven by environmental concern to becoming a corporate cost-reduction programme.

According to Stock/WERC (Stock 2004), ‘the keys to any successful product returns programme are having the right combination of people, policies, procedures and priorities.'

They go on to say that best practice in terms of returns management requires the following:

- decision-making process before product is physically returned;
- the use of returns authorization notes;
- ongoing measurement of product return cycle time;
- training of employees in returns handling;
- cross-training of staff in warehouse operations and reverse logistics;
- use of software to monitor and evaluate product returns;
- time slots allocated for receipt of returns;
- two-stage approach for returns handling – initial processing to identify quick wins followed by in-depth examination;
- use of detailed product return process maps;
- availability of packaging material to re-box product;
- undertake regular audits; and
- achievement of higher recovery rates (> 80 per cent).

CASE STUDY

A typical example is XPO Logistics, which was awarded a contract with Costco Wholesale UK Limited to manage the company's reverse logistics for its 28 warehouses in the UK.

Under the terms of the agreement, XPO receive and unload vehicles carrying store waste, handle and load shipping containers with old corrugated cardboard (OCC) and 98:2 plastic, and securely dispose of electrical and electronic waste. In addition, XPO process returnable transit packaging, recycle scrap metal and hard plastics, and dispose of recycled office materials and waste wood.

A number of companies have attached RFID tags to products to assist with the sortation of returns, including Superdry who have seen a significant increase in productivity in this area.

VIDEO 7iii SSI Schaeffer returns processing with RFID

Despatch

The order cycle time or lead time from order receipt to despatch is continually shortening and there is increased pressure on the warehouse manager to coordinate all activities to ensure that product is despatched on time and complete.

Packing – pieces/items/eaches

Once product has been picked there is the question of how it is packaged for despatch. As previously discussed, with individual order picks the operator may well package the product immediately, attach shipping labels and where required insert despatch documentation and invoices.

This reduces the number of touch points in the warehouse but does take the operator away from the prime task of picking.

Where there is the possibility of damage in transit, material can be added to the carton such as polystyrene and foam pellets, shredded paper, corrugated paper, air-filled bags, etc. This again increases time at despatch and puts the onus on the customer to dispose of the excess packaging on receipt.

Figure 7.3 shows a typical packing area for an online retailer.

Figure 7.3 Outbound workstations (courtesy of Joe Fogg)

Where possible this material needs to be recyclable. The use of carton erectors that cut the cardboard to fit the contents is one way of overcoming this problem.

The trade-off here is the cost of the machine versus the labour and material cost of doing it manually and the cost to the customer together with the specification of the WMS, which needs to hold all the product dimensions accurately. Automated and semi-automated case erectors have a compact footprint and can drastically speed up the erection and sealing of a wide variety of cartons, boxes and cases.

Tape application machines automatically seal the top and bottom of the boxes. Being easy to adjust for different case sizes and mobile enough to use flexibly, they speed up sealing on different packing stations, on demand. This frees up packing operatives, and not only makes the assembly faster, but also much safer.

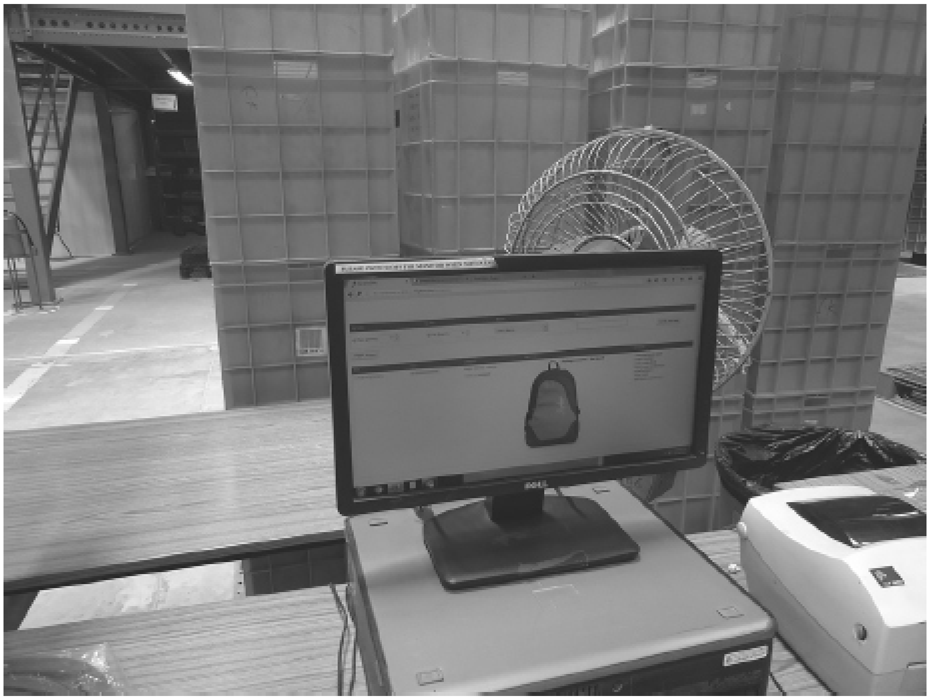
The following video shows how the despatch process can be automated in terms of checking, via camera technology, leaflet insertion, packing and labelling.

VIDEO 7iv KNAPP handling systems at L'Oréal featuring automated leaflet insertion

If orders are required to be checked on despatch this is an ideal time to add the paperwork and affix labels. In terms of checking, items can be removed from the pick container, checked against the order and returned to the original carton or if the order was picked into a tote it can be transferred to a shipping carton.

A visual comparison of the product through the use of screens at the despatch area can also increase accuracy as can be seen in Figure 7.4.

Figure 7.4 Despatch desk



Other methods of checking include weighing the carton and comparing this weight with a system generated weight. This is preferable, providing the information held in the system is 100 per cent accurate. This also reduces the labour required in this area and assists with load planning.

The need to check every order before it leaves the warehouse may well be a requirement for very high-value products and products such as pharmaceuticals, but I have to question the need to check every despatch order when it comes to other products.

Companies need to measure the accuracy performance of their pickers and base the amount of checking on this figure. A picking team that is constantly achieving > 99.9 per cent accuracy requires minimal checking. Random checks will suffice. Where there is a drop in accuracy the amount of checking can be increased for a time but so should the training of the operators until the accuracy is restored.

There is a trade-off here between the cost of the operators who are checking every order and the overall cost of miss-picks. There is no point in spending £20,000 ($31,400) on a checker per annum to save £3,000 ($4,710).

KNAPP is using its vision technology to ensure accurate despatch of product especially in the pharmaceutical market sector. The following videos show how cameras are used to ensure total pick accuracy.

VIDEO 7v KNAPP vision desk

VIDEO 7vi KNAPP vision check system and A-frame

The introduction of automation into this area of the warehouse enables companies to use equipment to automatically insert paperwork into a shipping container, attach a lid and label it correctly.

Packing – cartons

Full-carton despatch is somewhat easier to manage. Individual cartons may require the attachment of a shipping label, which may be generated from the WMS or from a carrier system such as those operated by UPS, FedEx, USPS and the Royal Mail, for example. In terms of multiple carton despatch, first there is a need to establish whether it is more cost-effective to despatch via a parcel network or a pallet distribution or LTL carrier.

This will decide the means of shipment – loose cartons or a palletized load.

If palletized, the decision here is how to stabilize the cartons on a pallet for despatch. Many companies will use stretchwrap to do this. Some companies will stretchwrap manually whilst others utilize an automatic stretchwrap machine as shown in Figure 7.5. The trade-off here is the cost of the machine versus the cost of labour and the reduction in the use of stretchwrap material.

Figure 7.5 Automatic stretchwrap machines

Velcro has introduced pallet straps to secure cargo. These are more environmentally friendly than stretchwrap, but there is the added complication of tracking and returning the straps for reuse.

The use of returnable packaging is also growing under environmental pressure. The use of plastic totes and pallets, slip sheets and collapsible cages is growing; however, there is a trade-off here between the initial cost of these items and the cost of returning them to the shipper versus the cost in money and environmental terms of cardboard packaging and one-way pallets.

Loading

The efficient loading of containers and trailers is crucial in today's environment of rising fuel prices. 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. It also needs to be robust enough to travel.

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 not only assist with pallet configuration but also container and trailer loading. The software can optimize packing within a container and trailer, on a pallet and even within an individual carton.

This sophisticated software optimization not only takes into account the cube of the products but also their load bearing strength and location within the container.

The latter ensures ease of off-loading 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 items. Examples include Tops, Cubemaster and CubeDesigner. A free TiHi calculation for pallets can be found at www.onpallet.com

The following video shows automatic loading of vehicles.

VIDEO 7vii Automated loading of vehicles by AFB

VIDEO 7viii Automatic loading of vehicles by Bastian Solutions

Figure 7.6 Boom conveyor – tyre unloading and loading

Shipping

Many operations are now taking orders late into the evening and despatching that same night for next-day delivery. Next, a retailer in the United Kingdom, has a cut-off time for internet orders of 10 pm for next-day delivery. We are also seeing orders delivered on the same day further reducing the internal order lead time.

Work plans are now centred around the latest despatch time for orders, and managers work backwards from this ensuring that all processes are completed and both labour and equipment are made available at the right time to meet these deadlines.

The despatch process has to be managed precisely and be aligned with most other activities within the warehouse. If, for example, receiving and despatch share the same doors, a daily schedule needs to be drawn up to ensure that labour and equipment are utilized as efficiently as possible, the work content is matched to the number of doors available and congestion is avoided in the dock area.

In many operations, receiving tends to take place in the morning whilst picking and despatch occur during the afternoon and evening as order cut-off times continue to be stretched later into the evening.

Depending on the method of picking and the company's procedures regarding checking product before it leaves the building, sufficient space needs to be available at the loading bays to stage the loads and allow for whichever checking method is applied – be it full-carton checks or random checks.

If coordinated correctly, the picked orders should arrive at the loading bay in the sequence in which they will be delivered. That is, the last delivery from the vehicle will be the first order to be loaded.

Collecting vehicles should be assigned a bay closest to where the orders have been accumulated. This requires close coordination between the gatehouse and the despatch supervisor.

Many companies have grids marked out on the warehouse floor at the despatch area to replicate the floor area of the largest vehicle. For example, a UK warehouse handling industrial pallets solely will currently have a grid equivalent to 26 pallets. The introduction of longer vehicles in the future with greater cubic capacity will necessitate an increase in the amount of floor space set aside for marshalling outbound orders. Warehouses handling euro pallets will extend this to 36 pallets. The introduction of drive-in racking between or to the side of the loading doors can accommodate more pallets by using the cubic capacity of that area. A shuttle system above the dock doors can also be utilized to reduce congestion in front of the doors.

Where vehicles are delivering multiple orders, a system needs to be in place to segregate these orders and make them easily identifiable to the loading team. This can be a simple handwritten pallet label or a barcode label.

Companies with sufficient yard space and available trailers can load product directly into them and park them up, awaiting collection.

As discussed in the section on inbound, companies need to manage the arrival and departure of trucks for outbound goods. A yard management system (YMS) can improve inbound and outbound scheduling, increase visibility of trucks and trailers, manage cross docking, reduce congestion and delays and ensure the safety and security of both vehicles and operators.

There are both stand-alone and modular versions of yard management systems.

Where full pallet loads are despatched it may be that pallets are pulled directly from the bulk or racked area and immediately loaded onto the vehicle. This minimizes the amount of double handling and requires precise coordination.

Once the despatch team is ready, vehicles can be called forward onto the despatch bay. This can be done either by the driver of the load or a shunt driver who is loading trailers in readiness for collection by drivers returning from earlier deliveries or operating a second shift.

As with the receiving process, the driver's paperwork needs to be checked to ensure that they are collecting the correct load. Loading a vehicle with goods bound for Alaska on a truck scheduled to deliver in Florida will be a very costly mistake.

The trailer should also be checked to ensure that it is fit for purpose, ie clean and watertight, doesn't have any odours that could contaminate the product, is at the correct temperature if loading refrigerated product, and finally that the floor is damage-free.

Before the vehicle leaves the premises it is a good idea to take a photograph of the load just in case there are any disputes regarding the load at a later stage.

Where products are loose loaded onto a container or trailer, the use of telescopic boom conveyors will assist the loading process significantly.

A tyre manufacturer recognized a number of advantages after introducing three telescopic booms into the operation. These conveyors can also be moved sideways to cover a number of dock doors. The advantages are as follows:

- safer working conditions;
- cleaner working area with better visibility;
- separation of forklifts and operators;
- improved ergonomics: no more rolling of the tyres, no more lifting of the tyres;
- improved quality of the tyres;
- fewer claims, having introduced a counting and video system on the conveyor; and

- improved productivity: 42 per cent increase on tyre loading, 32 per cent increase on tyre unloading.

ROI and payback can be significant in terms of labour saving, increased accuracy and less damage.

Other companies will use automatic pallet loaders as discussed in the section on inbound, whilst the majority of companies will use hand pallet jacks or powered pallet trucks if loading from a despatch bay. Counterbalance or articulated forklift trucks are normally used if loading outside the warehouse.

The increasing use of double-deck trailers presents its own challenge to warehouse operations, with some loading bays having to be adapted to accommodate the variable heights.

Where loading bays cannot be adapted there are products such as Transdek's double-deck lifts that can be retro-fitted. The product operates with a hinged lift platform that doubles as a dock leveller in order to provide a direct run-through for product from the warehouse to both single deckers and the bottom deck of double-deck vehicles.

The lift platform also raises up to 3,000 mm to carry product to/from the top deck of double deckers.

Documentation

Finally, despatch documentation and labelling needs to be completed to ensure compliance with customer requirements and government legislation. Different countries will have different requirements and these will also differ if shipments are within country or for export.

Any errors in the export paperwork can result in non-shipment, seizure, fines or delays. This is currently very topical in the UK with deliveries significantly delayed as a result of Brexit and confusion over the paperwork required.

When shipping hazardous material it is essential that products are labelled accurately and have the correct documentation.

Typical despatch paperwork depending on ultimate destination includes the following:

- advanced shipping notice;
- manifest;
- shipping labels;
- Bill of Lading/Airway bill;
- commercial invoice;
- shipper's export declaration;
- export packing list;
- certificate of origin;
- export licence;
- inspection certificate; and
- insurance certificate.

As mentioned above each country will have its own requirements in respect of the documentation needed.

Role of the driver

In situations where companies operate with their own transportation there are no issues with what the driver's role is in the actual loading process. However, when third-party contractors are used there is the age-old dilemma of what to do with the driver whilst the loading process takes place.

Some companies insist on the driver assisting with the loading and checking the contents of the load, whilst other companies have health and safety issues with external staff being on the loading bay. If the latter is the case then the driver has to be accommodated elsewhere, preferably not in their cab. The possibility of the driver moving off the despatch bay whilst the vehicle is still being loaded is just as real.

There is also the question of what the driver should sign for once the vehicle has been loaded. If they have not seen the products loaded onto the vehicle and the vehicle has been sealed prior to leaving the despatch bay, then it is reasonable to suggest that they are at liberty to sign the document and preface it with the word 'unchecked'. A time limit needs to be agreed in terms of how long the collecting or receiving company has, to report any discrepancies.

If the vehicle is sealed, the seal number needs to be recorded on the delivery paperwork and any other relevant documentation such as hazardous data sheets handed to the driver.

Summary and conclusion

This chapter has examined replenishment, value-adding services, support functions and despatch.

We have already suggested that both receiving and picking are crucial roles; however, within the warehouse, the above operations are no less important.

Well-timed replenishment will ensure an efficient pick operation whilst a timely and accurate despatch ensures that customer lead times are achieved or at times surpassed.

The warehouse’s ability to undertake value-adding services enables the manufacturer to postpone certain activities until the order arrives, resulting in fewer stock codes, and it enables retailers to transfer activities from the retail store back to the warehouse, freeing up valuable sales time.

Stock counting and security are fundamental to the integrity of products stored in the warehouse and are crucial to maintaining credibility whether an in-house or outsourced operation.

08
Information systems in the warehouse

GWYNNE RICHARDS AND LYNN PARNELL

Introduction

IT and related issues of data and data security are vital factors in today's world. IT can deliver business critical benefits in reducing lead times, improving operational efficiency, productivity and accuracy. Data generated from the software that is running logistics services, reported properly, can support decision-making and transform visibility.

The choice of technology deployed can have a significant effect on the efficiency, service levels and cost of a logistics operation. Increasingly, end-customer experience is based on IT as expectations for lead times, pick accuracy and order fulfilment visibility are driven by leading edge technology companies such as Amazon, ASOS and Uber. The experience that supply chain managers and customers have as consumers themselves in the B2C market is also driving B2B expectations. These expectations cannot be met without effective IT and this pace of change is increasing.

As customers become more sophisticated, requiring accurate, secure, fast data exchange and as the competition becomes more intense, companies need to have the information technology tools to support the business and build reliability, speed, control and flexibility into the warehouse operation. The ability to communicate in real time is crucial in today's fast-moving technological world.

Paper-based warehouse management systems or even spreadsheets can fulfil a need and manage stock accurately if managed well. However, I still find it incredible that companies can operate a warehouse without a location system, relying on staff knowing where the items are located in the warehouse. I'm currently providing consultancy to such a company.

Other warehouses have stock-control systems that tell you where the stock is and how much there is of it but don't provide optimum pick paths or slotting functionality.

If a company is going to compete effectively, it needs to introduce a real-time warehouse management system.

The cost of these systems has reduced significantly over the past few years and, today, companies are able to rent systems on a month-by-month basis using software as a service (SaaS) and cloud computing, where you can pay as you use, share resources and only use the functionality you require.

Warehouse management systems (WMSs) can be stand-alone or can be part of enterprise resource planning (ERP) systems supporting the latest technological advances within the warehouse including automation, RFID and voice recognition.

The question that is usually posed is whether to go for 'best of breed', which means finding the ideal software solution for warehouse management, and to connect it to other company systems through interfaces or 'best-in-suite', an all-in-one solution with many functions that covers all the various processes within a company including production, finance, warehousing and transportation.

Although there has been some consolidation within the WMS marketplace, there continues to be a myriad of systems to choose from including from the automation equipment suppliers who have produced their own warehouse management systems, which not only manage the automated equipment but all other aspects of the warehouse operation.

This chapter looks at the process of choosing a WMS and the functionalities that assist companies in improving productivity and reducing costs. It goes on to look at more recent IT developments such as machine learning.

Why does a company need a WMS?

Although companies operating with paper-based systems are able to introduce some best practice into the warehouse such as improving warehouse layout and minimizing travel time by having the fastest-selling items closest to despatch, they can improve even further and become more productive by introducing software technology into the warehouse.

Customers are becoming increasingly demanding and the ability to communicate via electronic data interchange, have online visibility and receive instant replies to queries is more of an expectation than a need. A WMS can be part of this solution.

Sales and marketing teams are also desperate for real-time information, whilst finance departments are chasing data constantly.

Before we discuss the advantages of a WMS, we need to point out that a stock-control system is not the same as a WMS. We have come across many companies who have purchased an inventory management system in the belief that it will operate the warehouse efficiently. Stock-control systems will manage the inventory at stock location and quantity level, but the majority of these systems will not manage productivity within the warehouse.

In our opinion, in order to be productive, warehouse systems need to be able to work in real time, manage all the processes within the warehouse and have the ability to communicate with other company systems.

A WMS can process data quickly and coordinate movements within the warehouse. It can produce reports and handle large volumes of transactions as experienced in e-commerce operations.

The introduction of new technologies into your operation not only improves your competitiveness in a challenging market but can also be instrumental in meeting ever-increasing customer demands.

The potential benefits of having a WMS in place include the following:

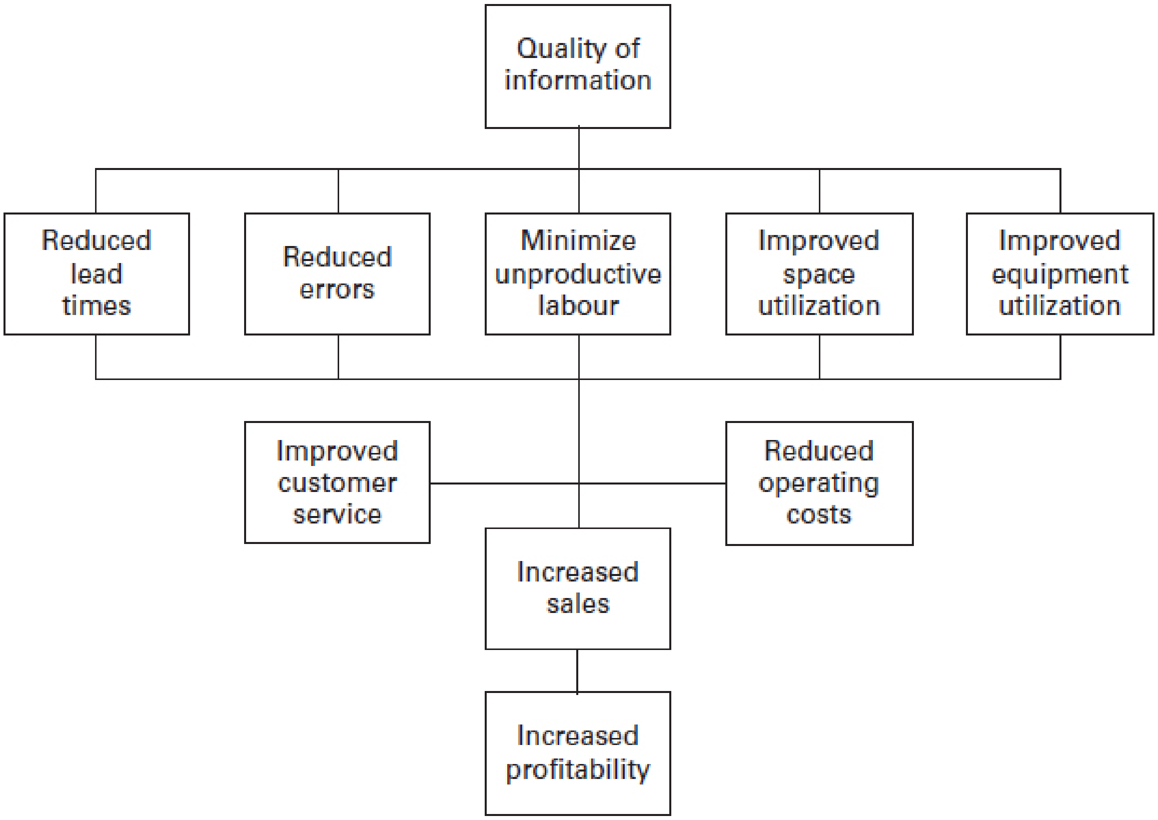
- real-time stock visibility and traceability;
- improved productivity;
- accurate stock records;
- reduction in miss-picks;
- automatic replenishment;
- reductions in returns;
- accurate reporting;
- improved responsiveness;
- remote data visibility;
- improved customer service; and
- minimized paperwork.

The diagram from Tompkins in Figure 8.1 illustrates how the quality of information can lead to increased sales and cost reduction.

There is an adage that says that any IT system costs twice as much as quoted, takes twice as long to implement and produces half the benefits.

In order to avoid this, there are a number of simple steps that need to be followed when choosing a WMS.

Figure 8.1 Advantages of quality information (used with permission of Tompkins Associates)



▶ Figure 8.1 details

Choosing a WMS

When choosing the right WMS you first need to fully understand the needs of the company and the key business requirements, not only today but some time into the future.

You need to understand your company strategy, ensure that your specific needs are met by selecting the solution that best matches your business objectives.

The solution can either be sourced internally by writing your own software or you need to ensure that you choose the right business partner to work with to develop the most effective solution.

A final step will be to calculate the return on investment (ROI) on the purchase and ongoing support of the WMS.

The process

It may be argued that not everyone needs a WMS. In fact, one of the greatest challenges to introducing a WMS is not choosing the right system but convincing the management team that one is required in the first place.

During a project to improve the space utilization and productivity within a client's warehouse we were surprised to learn that the warehouse manager had not been fully involved in discussions regarding the new ERP system that was going to be introduced.

The vendor was asked whether their system could run the warehouse operation and they replied in the affirmative. Unfortunately, the system being introduced could manage the inventory but was not a warehouse management system.

When the new system was implemented, the finance, sales and marketing teams were very happy with it but the warehouse manager was left to operate a manual system to manage the workflow through the warehouse. As a result, stock visibility improved on the system but productivity didn't change. When we suggested that the warehouse required a WMS to integrate with the ERP system, we were told that no further investment would be made in the IT system as it was able to manage inventory perfectly well.

Selecting the right WMS

To ensure that the system you choose is the right one for your operation, here are some best-practice guidelines courtesy of Business Application Software Developers Association (BASDA) (2009) and Sage Software (2005):

- Form a project team.
- Define, record, review and improve current processes. Don't automate redundant or poor processes.
- Create a list of key functions required of the new system.
- Incorporate any future growth plans in your specification.
- List the benefits to your company of a WMS.
- Research and approach a select number of vendors and select a small number with experience of providing solutions for your market sector.
- Visit reference sites to look at operational effectiveness and discuss the benefits the WMS system has brought about since implementation.
- Produce a return on investment (ROI) report.

Form a project team

Assemble a team of people capable of logical thinking who will decide what your company needs from a WMS and what functionalities it must have and those it will be nice to have. The team should include members from finance, sales, production (if applicable), IT and, of course, the warehouse.

Appoint a project leader and define each person's role, responsibilities and their level of involvement in terms of time and decision-making during this process. Ensure that all participants are able to make available the time and resources to ensure the success of the project.

Define, record, review and improve current processes

The first stage of the design process is to collect and collate as much information as possible about current processes and procedures. Once this is done you need to go through each process to decide whether it is actually required. There is no point in specifying an IT solution for a defunct process.

Do not make the error of automating poor processes. You need to get the processes within the company right before contemplating introducing a WMS. Use the project team and your warehouse staff to identify which processes they find frustrating, redundant and inefficient.

You need to understand which processes are going to be improved by the introduction of technology, by how much and whether it is cost-effective.

Understand how the warehouse communicates both internally with other departments and externally with customers, suppliers and transport companies.

Create a list of key functions

Each project team member needs to compile a list of the key functions required of a system and rank them by importance, eg 1, 2 or 3; or essential, greatly desired or nice to have.

Produce an agreed list of the essential requirements from the ideas produced by the individual team members and document them, ready to be included in a request for information (RFI).

This list should only have the essential, 'must have' functions. This will enable you to quickly discard systems that do not meet your fundamental requirements.

Incorporate any future growth plans in your specification

Although difficult to forecast, you need to take into account likely future events when specifying a WMS. For example: are you looking to increase the number of SKUs significantly over the next few years; will your future operation require a 'kitting' operation; will you need to manage a group of warehouses; are you contemplating the use of a bonded warehouse, which systems are you likely to need to interface with; what technology/automation are you planning to introduce? These are just some of the questions that need to be answered prior to specifying a new system.

List the benefits to your company of a WMS

The right WMS can maximize the productivity of your labour, increase both space and equipment utilization, improve communication and increase accuracy. All of these need to be quantified and presented alongside the ROI report.

Approach a select number of vendors; visit reference sites

There is a plethora of WMS vendors in today's marketplace offering ERP systems that incorporate WMS, best-of-breed WMSs, stock-control systems and SaaS systems. Fortunately, there is assistance out there for companies. These include consultants, comparison websites and, not to be underestimated, the experience of your own staff.

If you are in somewhat of a niche market it is always prudent to look at the systems your competitors are operating. When we took on the warehousing and distribution operation for a publishing house, we realized we needed a system that could manage royalties, licences etc.

Prior to a full invitation to tender, discuss your requirements with a couple of vendors and ask to visit some of their operational sites. Discussions with existing users will give you further insight into system capabilities and the benefits accrued and potentially revise your own thinking on systems.

Produce an ROI report

Having undertaken sufficient research, detail your requirements and approach a select number of companies to quote.

Having received the quotes and before making any decisions, involve your finance colleagues in calculating the potential return on investment. Together with an ROI calculation you need to be certain of the following, according to Stephen Cross from ATMS:

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

- improved customer and client service – through overall improved warehouse control, improved pick and despatch accuracy.

The cost of a WMS can be broken down into the following main components:

- Licence: the software licence needed to run the system. Typically, this is charged per user, ie PC user or radio data terminal user, although different models are now being offered, including paying by transaction and/or paying monthly rather than a single outright payment.
- Professional services: the costs for project management, training and go-live support.
- Development costs: software development costs for requirements not catered for in the package, including interfaces to third-party systems.
- Support cost: this is typically an annual cost based on licence costs and often development costs; look at this cost carefully: the scope of service and cost varies significantly from supplier to supplier.
- Hardware and infrastructure costs.

Ask suppliers to indicate which prices are firm 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 will find that some systems look attractive initially but when costed over a longer period they may prove a lot more expensive.

What to look for in a system

In order to be effective, a WMS needs to have the following attributes (adapted from Ruriani 2003):

Ability to interface with other systems

The ability to interface with other systems such as accounts packages, ERP and MRP systems, warehouse control systems for automation, performance and labour management systems and transport management systems, is critical. As is the requirement to update stock availability in real time on websites for e-commerce retailers. The system needs to integrate with back-office tasks such as order entry, inventory control, purchase-order modules and invoicing. The system also needs to be able to interface with automation systems, conveyors, MHE and the latest in picking technology such as voice, vision, wearable scanners, RFID and pick- and put-to-light systems. Ensure that these WMS interfaces will not incur excessive costs. In the past WMS had to interface with warehouse control systems in order to manage the hardware technology; however some of today's WMS are able to manage these directly. Conversely, warehouse control systems are now becoming fully fledged WMSs negating the requirement for two separate systems.

Modular and scalable

Where possible, look for a modular system where you only pay for the functionalities you require and therefore training and implementation can be quicker. Further modules can be added at a later date, if required.

Ensure that the WMS can be expanded to accommodate growth and/or acquisitions. A WMS needs to be able to at least meet your basic current and potential future needs. Buying a system that has functionality way beyond your requirements only leads to increased training costs, time wastage and as a consequence a poor return on your investment.

Ensure that the system can operate with the maximum number of users you are planning on having and can manage multiple sites if required.

Check with other divisions within the company to ensure that the system has the capabilities to match requirements in those areas also, should the management decide to go company-wide with the solution.

Accessible

With the mobility of staff these days it is essential that the system is accessible remotely over the web and that it is secure with access levels being password protected. The ability to retrieve data simply is a must for any system. The ability of the system to produce performance reports, cost-to-serve modelling and standard inventory interrogation are expected functionalities and should be high on the list of priorities.

Ease of operation

Select a WMS that is user-friendly. Choose a system that has a point-and-click operating environment and clear, easy-to-read screens. This can lead to enhanced staff productivity and quick system acceptance. Ensure that the system works in real time, providing instant inventory updates.

Standard system

Ensure the system supports the widely accepted standards currently in use and isn't limited to a proprietary standard that your customers may not use. Check that you receive updates regularly at no additional or at minimal cost.

Meets specific needs

If you are involved in storing Customs and Excise goods, ensure that the system is approved or can be approved by the relevant authorities. Second, ensure that the system can undertake those tasks that are crucial to your business such as tracking lot and serial numbers (if required), managing 'best before' and 'sell by' dates, the ability to quarantine items, identifying hazardous goods and being able to calculate royalties, for example.

Capable of supporting warehouse best practice

According to BASDA, to achieve best warehouse practice, systems need to be able to optimize movements within the warehouse, eg pallet put-away is coupled with pallet retrieval, known as task interleaving. Other crucial attributes include automated receipt, directed put-away, optimum pick sequences, replenishment tasks, despatch management and warehouse mapping.

Ideally, the system will be able to monitor the velocity of items within the warehouse and locate them accordingly (slotting) or alternatively provide the data in a format that can be transferred to programmes that have slotting functionality.

Reporting capabilities

Ensure the system provides comprehensive reporting suites and also reports failures.

The following video shows how Martin Brower has enhanced its operations through the use of a Manhattan WMS.

VIDEO 8i Martin Brower and Manhattan Associates WMS

Selecting a partner

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 best-in-class systems.
- Not only will the operational staff have had input into the WMS but they will also be able to understand your own

requirements better. Choose a vendor who listens effectively and understands your organization fully.

- Check how long the company has been in business and what their creditworthiness is like; be assured, they will certainly check yours.
- Choose a vendor who emphasizes the benefits of the software, not just the features. Furthermore, choose a provider that has already installed WMS systems with clients in your industry or similar.
- Ensure that the vendor can supply not only the system but also the installation, training, maintenance and help-desk service.
- Verify that your prospective WMS 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 who is culturally similar to your company, is professional and well respected in the industry. Ask for a large list of customers and visit the customer sites that you decide upon.
- 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 WMS provider can fully support you during the implementation phase.
- Select a partner that has an adequately staffed help desk that 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.

Decision table/decision matrix analysis (DMA)

In order to assist with making this decision produce a DMA as can be seen in Table 8.1 below.

- Step 1 – List all of the suppliers who are quoting for supplying the WMS.
- Step 2 – Discuss and list all of the factors you need to consider to make a decision.
- Step 3 – Give each factor a weighting in terms of importance. 1 = Does not meet minimum requirements, 5 = Exceeds requirements
- Step 4 – Give each supplier a score based on the criteria.
- Step 5 – multiply the supplier score by the factor weighting.
- Step 6 – Add up all the scores.
- Step 7 – Choose the supplier with the highest rating or possibly shortlist the top two suppliers for further discussion.

Table 8.1 DMA for a WMS

Skip table

Criteria	Weight	Vendor 1	
		Rate	Score
Software standard function	25	3	75
Software custom function	20	4	80
Ability to interface with ERP	15	4	60
Hardware supply	15	2	30
RF system	10	3	30
Development/Implementation service	5	3	15
Annual support/Maintenance cost	5	3	15
Multi-site cost	5	2	10
Total	100		315

NOTE 1 = Does not meet minimum requirements; 2 = Does not meet performance requirements by one or more factors; 3 = Expected performance; 4 = Exceeds one or more requirements; 5 = Significantly exceeds performance.

SOURCE Adapted from Tomkins Associates

Before the final decision

Ask prospective WMS providers for case studies where they have previously interfaced with your organization's specific ERP, transport management or accounting system.

Prior to making a final selection, ask the WMS provider to share a detailed implementation plan that includes an installation timeline and resource commitment.

Implementation

The following rules need to be followed prior to implementing the new system:

- Discuss with the business a suitable time to introduce a new system. The quietest sales period is normally a good time; however, this does coincide with staff taking their holidays, so ensure all the key people are available.
- Agree a realistic implementation plan with the vendor and your project team.
- Guarantee the availability of key staff during the implementation phase.
- Propose deadlines you are confident in achieving.
- Have specific milestones in place.
- Appoint super users from amongst your staff who can train new staff and identify problem areas.
- Develop a training agenda for all staff and include it in your new staff induction programme.
- Don’t look to modify the system until it is in place and working as initially specified.
- Keep reviewing the timeline and act on any slippage.

Some companies will also look to continue running their existing system in parallel until the new system is fully operational, all the functionalities have been user tested and any issues have been addressed.

Today, a number of WMS providers offer a range of solutions which encompass SaaS, cloud-based solutions and stand-alone systems. Discuss which is the most appropriate for your company.

Software as a service

Companies that have identified a need for a WMS but do not have the capital to spend on a stand-alone system are turning to alternatives.

Software as a service (SaaS) 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. Those clients in turn will choose the various modules within the software they require and pay for them as they use them.

The advantages are as follows:

- lower cost of entry;
- reduced start-up costs;
- a smaller learning curve, which means quicker adoption across your workforce;
- scalability and easy accessibility;
- instant upgrades;
- user-driven innovation; and
- ability to turn on and off as required, eg to run a temporary warehouse operation.

Such a system will be attractive to start-up companies and small and medium size enterprises (SMEs), although it could benefit larger companies who are looking for a temporary solution.

Potential disadvantages include the possibility of poor internet links between the companies and potential worries over data security. Constant upgrades can also potentially have repercussions on your own processes.

As with most things in life, rental or leasing can work out more expensive than outright purchase, therefore calculating whole-life costs and closely examining the advantages and disadvantages are paramount before making these decisions.

Cloud computing

While SaaS solutions do rely on cloud technology, not all cloud solutions are true SaaS, with all the attendant benefits.

Many legacy software vendors are offering a cloud-version of their product, but the only thing that is different is where the software is hosted.

With cloud computing, your WMS vendor hosts the software application and hardware infrastructure for you. You access the WMS via a web browser and gain the functional benefits of a new WMS without the upfront software costs (www.highjump.com).

The crucial thing is whether the vendor has just moved their ‘on premises’ software to the cloud or whether they have produced the software specifically to be cloud-based. There is a significant difference between the two.

Machine learning in the warehouse by Harry Watts SEC

One piece of technology with the potential to have an enormous impact on logistics and the warehouse is machine learning. Machine learning is a branch of AI that utilizes computer algorithms to look for patterns in big datasets and uses the insights to improve its performance or understanding of a particular problem over time. It’s a vast area of computer-science with many applications, but it’s already all around you. Virtual personal assistants (eg Siri, Alexa, etc), facial recognition and self-driving technology are just a few high-profile examples of machine learning that is becoming embedded in our day-to-day lives.

It is, however, essential to note that machine learning is an umbrella term for a variety of sub-technologies that vary considerably in complexity, sophistication and accessibility. Of course, at one end of the spectrum, technology giants such as Tesla and Google are spending billions on building supercomputer powered, deep neural networks to create next-generation technologies. But at the other end, small businesses are using simple, DIY models to improve operational decision-making and efficiency. Machine Learning, like any form of AI, does not have to come with a significant price tag and can be used to combat a myriad of challenges.

Although currently under-utilized in the warehouse, machine learning's potential impact in distribution centre design and management is virtually limitless. The language of logistics is data, and consequently, there are big datasets available in most warehouse operations. The promise of machine learning is that it can take this information and not only make connections that are virtually impossible for humans to identify but actually get better at doing so as time goes by and more data becomes available. These insights can then be fed back to either an IT system, automation system or the management team to help improve operational performance.

SEC Storage, a UK-based warehouse solution provider, has developed a machine learning platform that allows them to analyse their clients' picking data and throughput information to optimize the selection of pick-faces for new and existing SKUs. Not reliant on fixed logic-based algorithms like traditional warehouse management systems, their program instead leverages historical and current data to assess new SKUs and make accurate predictions about the most efficient type and location of pick face to utilize. In a recent application for a major high street retailer, this system helped increase pick-efficiency by 34 per cent by ensuring that SKUs were located in the most optimally positioned, and sized pick faces. Doing so resulted in both reduced travel distances and replenishment frequency, and, better still, the system is still learning and improving as more and more data becomes available to it.

In reality, given the right data, machine learning is sufficiently flexible that it can tackle most warehouse management problems in virtually any warehouse operation. Other examples of how we will use machine learning in warehouses over the coming years are as follows:

- Improving the quality of forecasting for planning and predictive purposes.
- Identifying SKUs that should be clustered together due to previously unforeseen connections in buying habits.
- More intelligent methods of classifying products – a particular example would be improving ABC banding analysis for fast, medium and slow-moving products.
- Training self-driving vehicles to safely navigate warehouse environments and work alongside human operatives.
- Image recognition software trained to recognize and identify products based upon their physical characteristics. As examples, this could help ensure order-pick accuracy or allow a robot to determine the correct item on a shelf to pick.
- Supporting augmented reality applications that provide layers of additional data and information to an operative's standard view using special wearable eyewear.

- Embedding speech recognition into processes to speed up and enhance information exchange and allow actions to be performed ‘hands-free’. Virtual personal assistants and voice-WMS applications are common examples.

Machine learning is undoubtedly a sophisticated, cutting-edge tool, and indeed, the underlying mathematics and programming can be challenging to engage with. However, the common misconception that this technology will only provide a return on investment for large companies with deep pockets is something we should lay to rest. In truth, machine learning applications can often be developed relatively cheaply since much of the underlying code required is now freely available to developers and can be highly efficient to produce. In many cases, having sufficient data is actually more problematic than the development of the code itself.

This widespread accessibility and the vast array of potential applications has led Forbes to predict that the machine learning industry will grow 1,200 per cent in seven years, as it becomes increasingly adopted by companies from all sectors, worldwide. In their logistics trend radar report, DHL predicts that machine learning will be the highest-impact technological trend over the next 10 years, ranking it above robotics, self-driving vehicles, and cloud logistics just to name a few.

XPO Logistics has introduced a flexible collaborative robot system into its warehouses in the United States and Europe. A spokesperson for XPO has recently said that ‘the technology uses machine learning to double productivity rates and to improve accuracy by as much as 40% over manual methods’.

Data security

Within logistics, companies are constantly using and transferring data; data that is likely to be either personal data or company confidential data. Whichever it is, it is important that all data is held securely and complies with all legislation.

In May 2018 the EU General Data Protection Regulation (GDPR) came into effect. In the UK this was also enshrined into future UK law under the UK Data Protection Act (DPA 2018); this means that the legislation has remained post Brexit. This law relates to all data that can personally identify an individual. Within the B2C logistics sector, personal data such as email addresses, postal addresses and telephone numbers are held throughout the supply chain.

If the data is collected by a company, for example via an e-commerce website, then the company has the responsibility to ensure that all data is held within the requirements of the law and therefore the company is defined as the ‘Controller’ of the data. If this data is passed to a third party, then the company must ensure contractually that the receiver of the data will also be complying with the law. Logistics Service Providers, for example, are likely to be considered ‘Processors’ within the legislation. Processors also have some direct legal obligations: not only does a company risk a fine of up to €20 million or 4 per cent of global turnover, whichever is the greatest, for breaching GDPR or DPA 2018 but there is also great reputational risk from any data breach. The EU, UK and US press report on data breaches regularly, particularly when affecting household brands.

Summary and conclusion

Today’s information technology systems are no longer purely involved in stock management. They also include dock, yard and labour management. They are ultra-flexible, provide remote access and visibility of stock and tasks can be operated on a pay-as-you-go basis.

A WMS is essential in today’s fast-moving environment. Information is the key and real-time data is invaluable. The introduction of a WMS can improve speed, productivity and accuracy.

The key to a successful purchase and implementation is:

- preparation and allocating sufficient time and resource to the project;
- getting your processes right before introducing the system;
- producing a base level so that the full benefits of the system can be compared;
- getting the buy-in and involvement of senior management and warehouse staff;
- choosing the most appropriate supplier; and
- ensuring that all staff are trained to an acceptable level.

However, to embark on an IT project you need to be certain that you are going to achieve significant business benefits.

Warehouse efficiency is key to effectively managing a supply chain and achieving best-in-class performance. Technology can be an enabler in this respect.

09
Warehouse layout

GWYNNE GWYNNE RICHARDS AND KEVIN MOFID

Introduction

The evolution of the modern warehouse can, in many respects, be traced back to the growth of the supermarket as this form of grocery retailing became prevalent in the late 20th century. This form of retailing demanded greater and greater efficiencies as cost savings looked to be passed on to the consumer in order to win greater market share.

Today’s highly competitive and constantly changing markets have a significant effect on the design of our warehouses and distribution centres. Continually evolving products and changing order profiles require our warehouses to be a great deal more flexible.

What we have seen over the past 13 years is an increase in the average footprint of warehouses together with an increase in the average height as can be seen in Figure 9.1 below. The increase in warehouse height has been driven by the increasing cost of land and facilitated by increases in reach heights by forklift trucks.

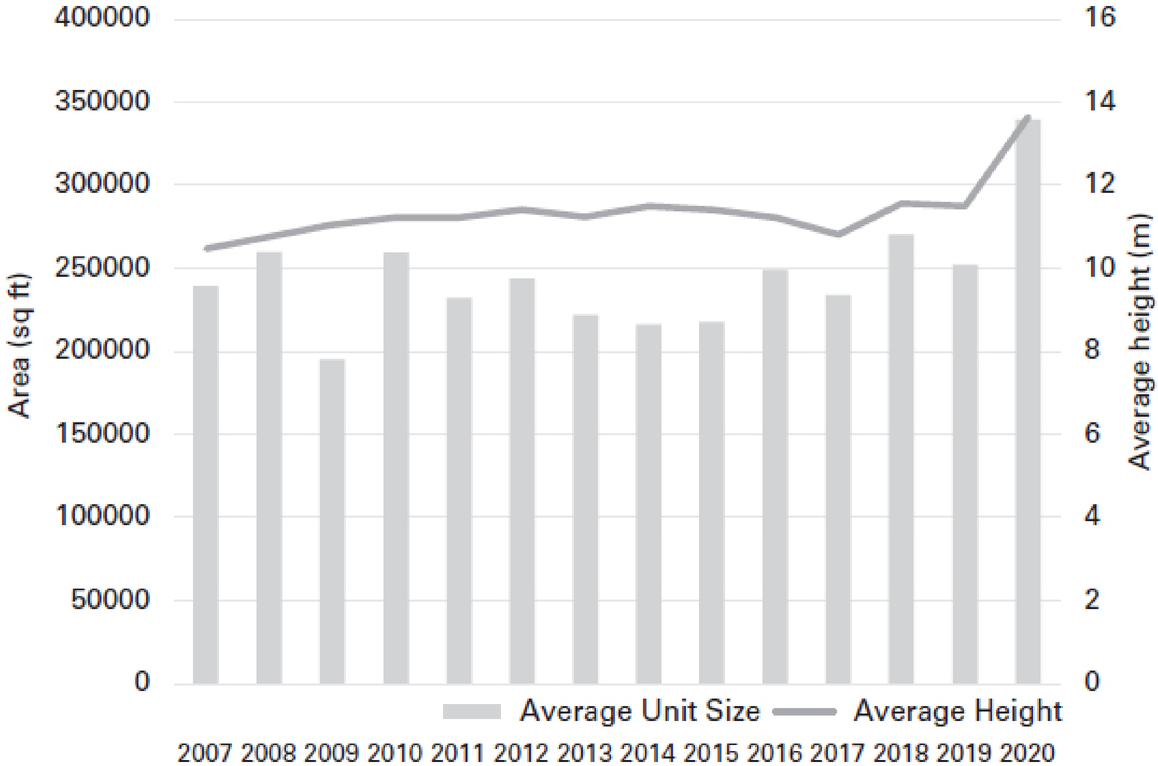
However, these averages mask the trends taking place at the leading edge of the market where developers are now routinely bringing forward speculative warehouse schemes with eaves heights of over 20 metre and a footprint of over 500,000 square feet.

The higher the warehouse, the larger the amount of racking to be installed, which in turn increases the amount of inventory being stored, which in turn has implications for the floor slab needed in the warehouse.

Manufacturers and retailers, both off and online, dominate the Avanta list of the largest warehouses in the world with Tesla and Boeing the top two and Amazon in third place with its 3.6 million square foot warehouse in Mt Juliet, Tennessee. Volkswagen and Michelin make up the top five.

The ATL Logistics Centre in Hong Kong is thought to be the largest multi-storey industrial building in the world, at 5.9 million square feet, which is divided into individual units. Conveniently located next to Kwai Chung Container Terminal 3, the facility provides warehousing space with storage racking, container storage as well as office space over multiple levels.

Figure 9.1 Average warehouse area and height 2020.



SOURCE Savills

▶ Figure 9.1 details

Table 9.1 provides indicative figures for the various elements of warehouse design based on the overall floor space of the warehouse.

Table 9.1 Indicative figures for warehouse design elements

Skip table

Design elements	Sub 10,000 sq ft	10 to 30,000 sq ft	30 to 75,000 sq ft	75 to 1 ft
Clear (eaves) height (m)	10	10	12.5	12.5
Floor loading (kN/m²)	50	50	50	50
Office content (% of total area)	10	10	7.5	5
Yard depth (minimum in m)	20	35	40	40
Level access doors	1	2	2	2
Dock doors (per 10,000 sq ft)	0	0	5	8
Roof lights (% of roof area)	15	15	15	15
Power supply (kVA per 10,000 sq ft)	300 KVA	300 KVA	300 KVA	300 K
Plot ratio (Built % of site area)	60	55	50	45

Fortna, a company involved in warehouse design, argue that there isn’t an optimal design solution for each warehouse. The most optimal design in their view is one that fully meets today’s operational requirements but has an eye to future growth by being flexible, scalable and relatively inexpensive to adapt. The idea is to design for the future whilst building for today.

A typical example is the introduction of mezzanine floors at a future date, thus fully utilizing the cubic capacity of the building.

The design of a warehouse requires attention to detail, can be very complex and relies on the collection and compilation of large quantities of relevant data.

Whether a company is building a new warehouse, moving into an existing building or looking to re-design their own facility, there are a number of fundamental areas that need to be addressed.

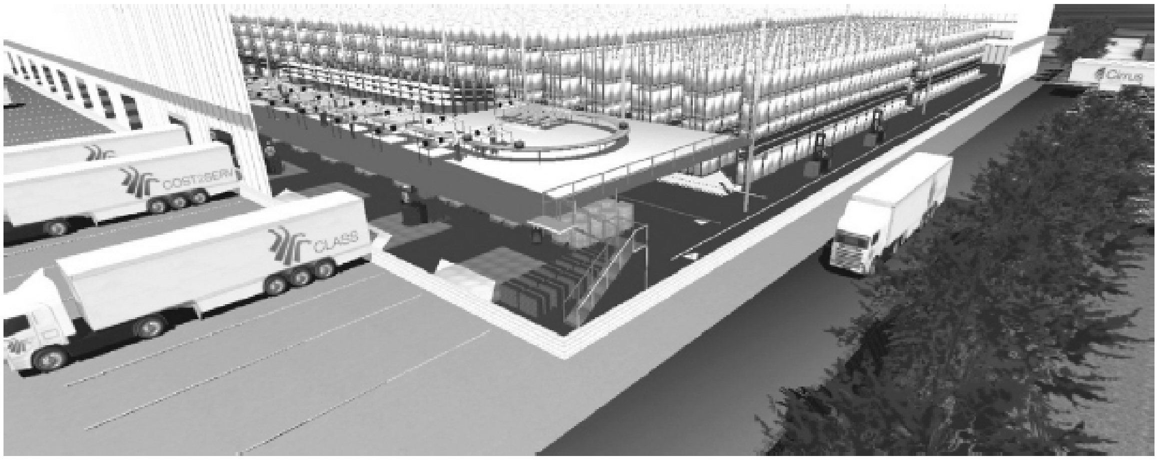
In this chapter we will look at the drivers involved in warehouse design, the alternatives available in terms of layout and suggest potential areas for cost savings through relatively simple changes to existing configurations and practices.

We do not intend to show you how to fully design a warehouse, as every company will have different requirements. However, we do want to give you an understanding of how to approach design and what we believe does and doesn’t work in terms of efficient space utilization. This chapter provides information on the type of storage equipment that can be utilized to improve space utilization.

Again, as in many other warehouse areas, design is all about trade-offs. Between speed, travel distances, space utilization, handling, access, safety, risk and cost.

There are many consultants, materials-handling, automation and racking companies who can assist you in designing the most effective warehouse layout based on the available space, your requirements and your budget. There are also simulation software packages that enable you to ‘build’ the warehouse on a computer and simulate the operation to see which layout is the most effective (see Figure 9.2).

Figure 9.2 Warehouse 3D drawing (courtesy of Körber Supply Chain)



VIDEO 9i Introduction to CLASS warehouse design software

CASE STUDY John Lewis (courtesy of Körber Supply Chain and John Lewis)

John Lewis is the UK's largest department store retailer, providing a wide range of consumer products and services from home furniture to apparel. They serve customers through 50 stores and a highly successful online business offering over 200,000 items.

John Lewis's omni-channel strategy identified the need for a new distribution centre (DC) in Milton Keynes to operate alongside two existing DCs, Magna Park 1 and 2. The new facility was required to support the retailer's commitment to continually improve customer service, productivity and product availability.

The new 600,000 square foot warehouse, with a mezzanine floor of over 250,000 square feet, mainly holds large goods requiring two-man delivery. The John Lewis need was to ensure the highest level of warehouse space efficiency, and effective communication of the design to John Lewis Partners.

Challenges summary

- verify design layout ensuring internal space sufficient for holding volumes previously held in four other warehouses;

- identify resources (labour and MHE) required to run the operation and mitigate any possible problems;
- validate that operations meet John Lewis's service level requirements;
- create a 3D visualization to ensure effective communication with John Lewis Partners; and
- evaluate impact of sending trailers with mixed large products, previously shipped.

It was vital that Cirrus were able to speedily ensure warehouse efficiency KPIs would be tested and met before building work started. John Lewis wanted to ensure that their predictions of labour requirements, equipment needed and the throughput capacity of the DC were accurate.

The Cirrus Logistics team used a combination of warehouse consultancy and its unique Warehouse Design and Simulation software application, CLASS, to meet John Lewis's requirements. Using CLASS's layout design program, existing blueprints were quickly imported to develop and refine the warehouse design.

A computer simulation modelled a live warehouse environment and ran numerous operational scenarios to identify the optimum layout. In addition, CLASS movie creator was used to make a 3D movie to aid communication with John Lewis Partners and provide visual insight into the design and operational features of the warehouse.

The simulation models showed real productivity improvements and lower congestion across parts of the warehouse.

An interesting development in this area is the utilization of virtual reality (VR) headsets where potential buyers of sophisticated automation equipment will be able to put on a VR headset and walk through the whole operation and even simulate the picking of items for example.

When (re-)designing a warehouse there are a number of factors that need to be taken into account. These include the company's likely growth over the next 5 to 10 years, the possible change in product and customer profiles, total sales during this period and the likely sales channels such as online B2B, B2C and retailer sales.

There are also a number of things that can be done to facilitate the design process. This following section will outline how to approach a warehouse (re-)design.

The areas to concentrate on are as follows:

- Gather as much data as possible and analyse it.
- Try to imagine the business in 5–10 years' time and build in flexibility.
- Concentrate on the cubic capacity of the building.
- Ensure the design is sympathetic to the existing storage equipment and MHE (if applicable).
- Put the health and safety of staff at the forefront of the design.
- In order to retain a conscientious and motivated workforce ensure that the facility has sufficient lighting and ventilation.
- Provide ergonomic equipment.
- Reduce the amount of movement required within the warehouse.
- Try to standardize the unit loads both for movement and storage.
- Understand the local building regulations and floor loading requirements.
- Don't forget the outside of the building.

Rushton, Croucher and Baker (2017) suggest the following steps in warehouse design:

- Form a project team.
- Define business requirements and design constraints.
- Agree the current and future role of the warehouse.
- Agree the processes to be carried out.
- Discuss any financial, legal and planning constraints.
- Define and obtain data.

    - Throughput levels and storage capacities.
    - Cost data.
    - Existing equipment.
- Formulate a planning base.
- Produce flow diagrams of a typical day.
- Utilize Pareto (80/20 rule).
- Define the operational principles.
    - Order lead time and cut off times.
    - Unit load types.
- Evaluate equipment types.
    - Is automation feasible and affordable?
    - Density of storage required.
- Develop environmental aspects.
    - Building certification schemes such as BREEAM, LEED and CASBEE.
    - Renewable energy.
- Prepare internal and external layouts.
- Agree flow of product and discuss various layouts.
- Take into account building constraints (columns, sprinklers etc).
- Draw up high-level procedural and information systems requirements.
- Produce flow diagrams for each process.
- Evaluate design flexibility.
- Discuss ability to flex with demand.
- Calculate equipment quantities.
- Utilize a spreadsheet or simulation software to calculate numbers of equipment and storage locations.

- Calculate staffing levels.
- Calculate capital and operating costs.
- Evaluate the design against business requirements and design constraints.
- Utilize a simulation program to identify any potential bottlenecks and try out alternatives.
- Finalize the preferred design.
- Brief the procurement team.
- Ensure the project team are experienced and available to manage the implementation.

Data collection and analysis

The item and order profiling discussed earlier in the book will provide you with an understanding of existing requirements in terms of receipt and despatch areas, storage and picking operations and, finally, areas needed for undertaking value-adding services and returns processes if applicable.

The profile needs to include the whole product range, the number of items per line, the sizes and throughput for each product code. One point to emphasize here is to ensure that you have identified non-moving and obsolete stock for disposal. There is no point in moving and making space in the new warehouse for redundant stock.

Additional data required includes the number of supplier deliveries per day and the average intake together with the number of customer deliveries and the average order size. You will also need to know the method for loading and unloading these vehicles.

A survey by Cranfield University (Baker and Perotti 2008) indicated that 52 per cent of the warehouse floor area is typically used for storage, 17 per cent for the pick/pack operation, 16 per cent for receiving and despatch, 7 per cent for value-adding services and a further 8 per cent for areas such as battery charging, empty pallet storage and other uses. This, of course, will vary depending on the type of operation envisaged.

The main floor space areas within the warehouse that need to be calculated are as follows:

- receiving area;
- quarantine and inspection area;
- reserve storage area;
- carton-picking area;
- item-pick area;
- value-adding services area;
- packing area;
- despatch area;
- cross-dock area;
- empty pallet and packaging storage area;
- MHE charging areas;
- equipment storage;
- communication cells for staff;
- training/meeting room;
- security room;
- area for security checks such as airport style screening;
- warehouse offices; and
- restrooms.

The information collected is normally current or historical and therefore future volumes and changes in product characteristics also need to be taken into account.

Furthermore, the use of averages can be misleading, and you need to decide on how you deal with peaks in the business.

An example of where the use of averages can be misleading is as follows. Within an order profile we have 100 orders with a single line item and 100 orders with three-line items. In total, we have 200 orders and 400 lines. If we calculate the average we end up with two lines per order, which doesn't feature at all in the order profile. Although simplistic in nature, we need to be aware of such possibilities on a larger scale. In these circumstances we need to determine the median and mode so that we can see the most popular line per order profile.

Very few operations have a level volume of storage and activity throughout the year. For many companies there are a number of peaks and troughs. For example, fashion companies will have two major peaks in inbound receipt prior to the launch of spring/summer and autumn/winter collections.

The question is whether we plan for and accommodate peaks in business, whether we design for the average activity or somewhere in between. According to Frazelle (2002), if the duration of the peak period is short and the ratio of peak to average is high, then it is worth considering temporary storage and labour for this overspill. If the peaks are extended and the ratio of peak to average is much smaller, the warehouse and labour requirements should be sized at or near peak requirements.

The suggestion is that you size near to average if the ratio is more than 1:5 and the peak lasts for less than half a year. You should size near the peak when the ratio is less than 1:2 and the peaks last longer.

You also need to take into account fluctuations between days of the week and not rely on weekly or monthly averages. Chapter 11 examines this in more detail.

As mentioned, there are a number of software programs on the market that can calculate the amount of space required for specific operations and storage equipment companies are more than happy to assist you in these calculations.

In the absence of sophisticated software or if you are looking for high-level calculations at an early stage, there are some rule-of-thumb calculations that can assist you in ascertaining the amount of space required for certain operations and the number of pallets that can be stored in a specific area.

Space calculations

These calculations are based on experience and are not intended to provide definitive answers to space requirements.

Receipt and despatch areas

This area is sometimes overlooked in favour of storage space; however, this is one of the most important areas in the warehouse. The warehouse operation relies on sufficient space both inside and outside the dock bays.

Getting the right balance between the number of doors, equipment and labour is difficult to achieve and as discussed in Chapter 3 requires the coordination of arrivals and departures with the availability of resources.

A congested dock area can result in arrival and departure delays, lost or misplaced product, incorrect despatches and damage to items.

The following rule-of-thumb formula can be used to calculate the likely space requirement for staging vehicles on arrival and departure:

$$\frac{\text{roundup (number of loads} \times \text{hours/load)}}{\text{time of shift}} \times \text{(size of load} \times \text{space/pallet)}$$

For example: if we receive 20 vehicles per day, 26 pallets per load with a pallet size of 1.2 metres by 1.0 metres and it takes 45 minutes per load to unload and 30 minutes per load to check and we operate an eight-hour shift:

Pallet floor space = round-up ((20 × 1.25) ÷ 8) × (26 × (1.2 × 1))

= 4 × 31.2

= 124.8 square metres

In addition to this space, we need to add working and travel space around the pallets. This space will be determined by the type of forklift or pallet truck used to unload and load the vehicles. Potentially, this can more than double the amount of space required for the pallets themselves and depends on how much access to the pallet is required. For example, a full 360-degree access to the pallet, allowing 0.5 metres of travel corridor, requires an additional 2.2 square metres of working space per pallet.

The ability to preload trailers will reduce the amount of space required at the despatch bay. The proviso here is that there are sufficient doors and/or yard space to accommodate the number of loaded trailers and the safety aspect of loading stand trailers is taken into account. The ability to double stack pallets will reduce the space required but will also limit the type of pallet truck utilized.

There may also be a requirement for a cross-dock area where goods having been received into the warehouse but not put away are to be despatched en bloc to a customer who has yet to collect the goods. This could take anywhere between a day and a month to despatch. Under these circumstances it may be prudent to use drive-in racking or push-back racking in the despatch area in order to minimize product damage and utilize cubic space.

Storage space

Calculating the amount of storage space required and the storage medium depends on a large number of factors.

Each item needs to be evaluated and a table produced to record the different item properties and as a result decide on potential storage media.

Having calculated the amount of items stored per product line and converted these into carton and pallet quantities, we are able to calculate the total number of pallets we need to store together with any shelf locations, by product line.

Once this has been calculated, produce a chart detailing the number of pallet locations required and the height requirement for each location (Table 9.2).

Table 9.2 Storage space calculation

Skip table

Dimensions				
Item code	Total number of cartons	Length cm	Width cm	Height
10779	240	25	40	20
30456	16	10	10	15
77021	800	10	15	10

Depending on the nature of the product in terms of weight, crushability, etc, it is likely that the pallet heights will vary between products and some products may only require bin or tote storage as the quantities are so low.

The next decision is the type of storage medium to use. This can include block stacking, pallet racking, automated storage, shelf and bin locations or a combination of some or all.

For example, where we have a significant number of pallets per SKU and the velocity of movement is high, we can look at high-density storage such as drive-in or drive-through racking, flow rack or shuttle systems.

Table 9.3 shows the characteristics of each individual stock item and the possible storage media envisaged.

As can be seen from Table 9.3, we have recorded as much information as possible regarding the storage and order profile of the products listed. This gives us the opportunity to decide on the most suitable storage and handling medium. A similar table can be produced to determine the size of the pick face location(s) for each product where we need to take into account the average and maximum amount of product despatched per day.

Table 9.3 Storage method options

Skip table

Item code	Characteristics	Pallets in store	Fast/medium/slow mover	Orde
010356	Standard	300	Fast	Full p
010672	Standard	18	Medium	Cartc
010779	Standard	5	Slow	Cartc
030456	High value/small part	>1	Slow	Units
077021	High value	1	Medium	Units

KEY Cbt: counterbalance forklift truck; ppt: powered pallet truck

The idea is to make sure that we do not have to replenish these locations during picking and therefore we need to size the locations appropriately based on the number of items picked per day or per shift. The number and size of the pick locations will depend on the available ground floor locations (initially) and cubic capacity of those locations.

Having produced a rule-of-thumb formula for calculating dock space, there is a formula to calculate the number of pallets that can be stored within a given cubic area when using standard adjustable pallet racking. This is as follows:

> (Number of width modules × pallets in a module width) × (number of length modules × pallets in module length) × number of height modules

where:

Module width = width of aisle + 2 pallet lengths (short side) + clearance between back-to-back pallets
Module length = width of upright + 3 × clearance + 2 pallets (long side)
Module height = height of pallet + clearance above pallet + racking beam height

For example, based on the following dimensions:

Aisle width: 3.0 metres
Pallet size: 1.20 metres × 1.00 metre
Width of upright: 0.12 metre
Clearance (sides): 0.10 metre
Clearance (height): 0.15 metre
Clearance back-to-back pallets: 0.10 metre
Racking beam height: 0.14 metre
Height of goods: 1.20 metres
Height of pallet: 0.15 metre
Warehouse height: 10 metres
Storage area length: 120 metres
Storage area width: 48 metres
Module width = 3.0 + 2 + 0.1 = 5.1 metres
Module length = 0.12 + 0.3 + 2.4 = 2.82 metres
Module height = (1.2 + 0.15) + 0.15 + 0.14 = 1.64 metres
Number of width modules = 48 ÷ 5.1 = 9
Number of length modules = 120 ÷ 2.82 = 42
Number of height modules = 10 ÷ 1.64 = 6
Total pallet capacity = (9 × 2) × (42 × 2) × 6 = 9,072 pallets

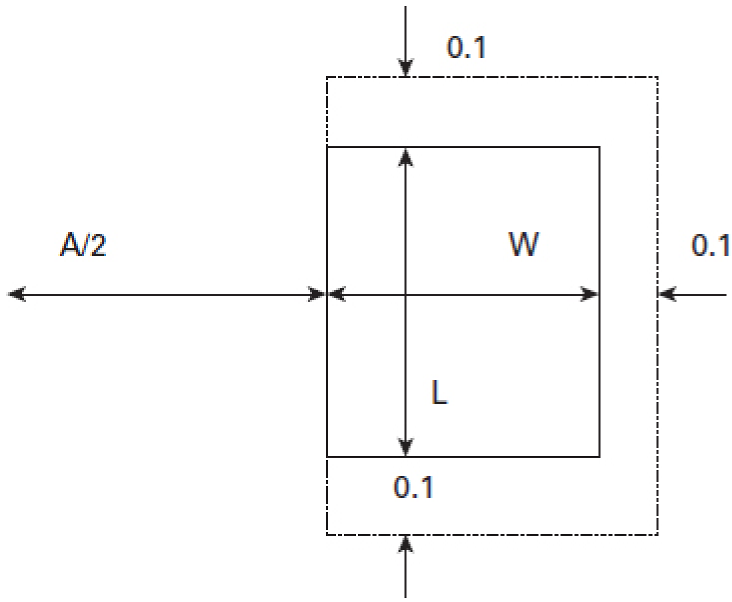
Therefore in a cubic space of 120 metres by 48 metres by 10 metres we have a capacity to store 9,072 pallets based on an overall pallet dimension of 1.2 metres by 1.0 metre by 1.35

metres and utilizing a reach truck working within an aisle width of 3 metres.

The number of pallets that can be stored in this particular area is determined, in the main, by the aisle width, type of racking and the size of pallet.

As mentioned earlier, this is a rule-of-thumb calculation and other factors need to be taken into account before committing to these figures. Another rule-of-thumb calculation is as follows:

Figure 9.3 Surface space requirement – rule-of-thumb calculation



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

where:

S = surface area required

A = aisle width, depends on building height

W = width of pallet = 0.8 m

L = length of pallet = 1.2 m

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

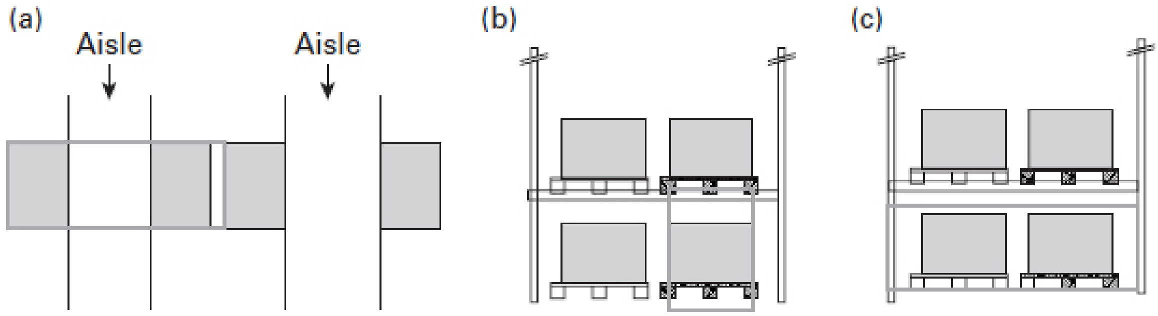
The calculations take into account the aisles between the racking but do not take into account aisles and gangways at the front of the racking. They do not take into account potential pallet overhang, rear walkways and fire exits.

Other factors that need to be taken into account are:

- Planned utilization within the warehouse. It is agreed that once storage utilization exceeds 85 per cent, productivity and safety decline. The operation will slow appreciably as put-away is delayed whilst space is being freed up.
- The presence and location of roof columns. Storage equipment manufacturers will take this into account when producing plans.
- The requirement for space between the backs of pallets (flue) and at the sides of pallets.
- The presence and location of sprinklers (ceiling or in rack). The overhead pipes and sprinklers will limit the height both within the warehouse and within the racking itself.
- The type of lighting utilized and any heating or cooling systems installed.
- Lift height of forklift truck. Different types of forklift truck will have different lift height capabilities.
- Pallet orientation (short facing or long facing). How a pallet is stored within the racking has its own trade-off within the warehouse. Storing a pallet with the long face parallel to the aisle makes it easier for operators to pick, not having to stretch too far across the pallet. However, storing the pallet with the short side parallel to the aisle means greater flexibility (UK and euro pallets can be stored in the same bay) and more pallets can be stored in a length of racking.
- Number of pallets per beam (three pallets between the uprights will increase the number of pallets stored by removing a number of uprights). This can save up to 4 per cent of space. However, the maximum weight per beam and per column needs to be adhered to.

- The requirement for cross aisles (rack tunnels) within the racking to reduce travel and the need for walkways between the end of the racking and the wall to provide escape routes for staff.
- Type of racking, for example:
    - Double-deep racking will reduce the number of aisles required.
    - Very narrow aisle storage requires less aisle width.
    - Drive-in or satellite racking doesn’t operate with aisles.
    - Flow racks only require two aisles depending on the length of the lane or potentially three if they are operated back to back.

Figure 9.4 Diagram showing the different modules – width, height and length, (a) Width module, (b) Height module, (c) Length module



▶ Figure 9.4 details

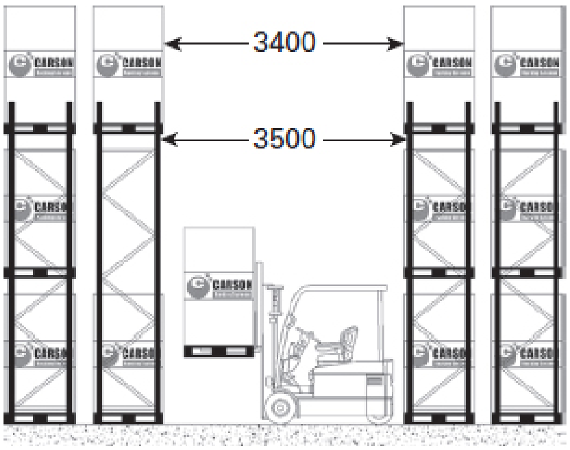
If the operation is planning to have pick faces on the floor, ie underneath the reserve storage racks, we need to take into account the total number of floor locations that will be set aside for carton-pick locations and shelf locations. We also need to be aware of part-pallet receipts and part-pallet locations if we have to pick from height.

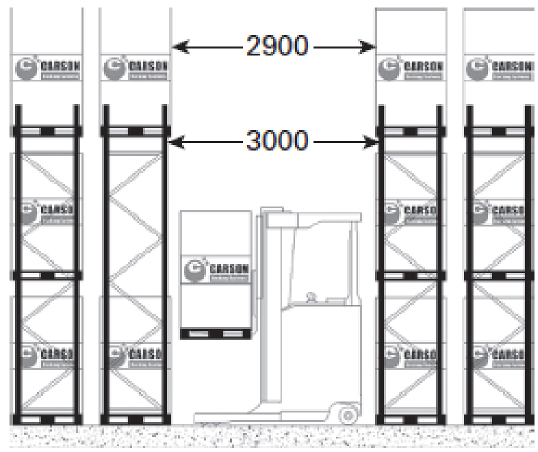
Aisle width

A crucial aspect of warehouse layout is aisle width. This is the distance between pallets in adjacent racks. To ensure safety we need to calculate the distance between the pallets once they have been put onto the racks.

The aisle width is determined by the turning circle of the forklift truck and the size of pallet being carried.

Figures 9.5 and 9.6 Aisle widths (courtesy of Carson Racking Systems Limited)





Exceptions to this are very narrow aisle and turret trucks that operate in aisles that are based on the width of the truck itself whilst articulated forklift trucks calculate aisle width based on the distance diagonally across the pallet, ie from one corner to another when a pallet is being rotated in the aisle. The safety clearance of 100 mm either side (200 mm in total) of a typical pallet will need to be added to ensure fast pallet put-away and retrieval. The second dimension is the overall width of the truck chassis when travelling along the stacking aisle.

Manufacturers of forklift trucks will provide recommendations on the minimum aisle width required for their trucks.

Deciding on the optimal aisle width is a critical part of an overall storage/materials-handling strategy. Aisle width decisions need to achieve the best combination of productivity, space utilization, flexibility, safety and equipment costs for the specific application (Piasecki 2002). Other factors include the depth of the pallet on the truck and whether there is a requirement for two trucks to pass in the aisle.

The decision will also require the user to decide whether speed or storage capacity is the main driver.

The advantages and disadvantages of each type of racking system will be discussed in greater detail in the next chapter.

Adjusting from wide aisle racking to narrow aisle can increase the storage capacity significantly; however, it is also time-consuming and can be expensive.

In order to reduce this cost Nene Warehouse Solutions provide a simple yet effective system that enables the relocation of large racking and industrial shelving units, with no need for dismantling existing frameworks as can be seen in Figure 9.7 below. Pallet racking is moved safely and economically, keeping operational downtime to a minimum.

Figure 9.7 Moving racking using a Gondola Skate (courtesy of Nene)

Other space

The amount of space set aside for packing, value-adding services and returns processing will depend on the level and type of activities envisaged within the operation, the number of staff and the type of equipment required.

An area that is regularly neglected when calculating space requirements in the warehouse is the area needed to store, recharge and change batteries or gas canisters for forklifts, a parking area for equipment when not in use, an area for storing empty pallets and packaging and an area for ancillary equipment such as stretchwrap machines, pallet inverters, etc.

Office and restroom space will be determined by the number of employees required within the warehouse.

Finally, we need to ensure that we have sufficient space outside the building for the following:

- to park vehicles that are either collecting or delivering products;
- to park own fleet vehicles (if applicable);
- electrical points for refrigerated vehicles;
- vehicle wash if applicable;
- area for water storage for sprinkler system if applicable;
- area for a generator as a back-up to the electrical supply especially for refrigerated warehouses;
- a security gate house;
- a weighbridge;
- sufficient turning circle for the largest vehicle;
- waste storage, compacting and recycling areas;
- washing area for plastic totes and pallets;
- areas for weather resistant packaging;
- parking for staff and visitor cars; and
- gas or diesel storage tanks and pumps depending on the type of road vehicles and MHE utilized.

It is likely that the whole area will be fenced off from adjoining land to ensure security.

In future, there may well be a requirement for electric charging points for vehicles.

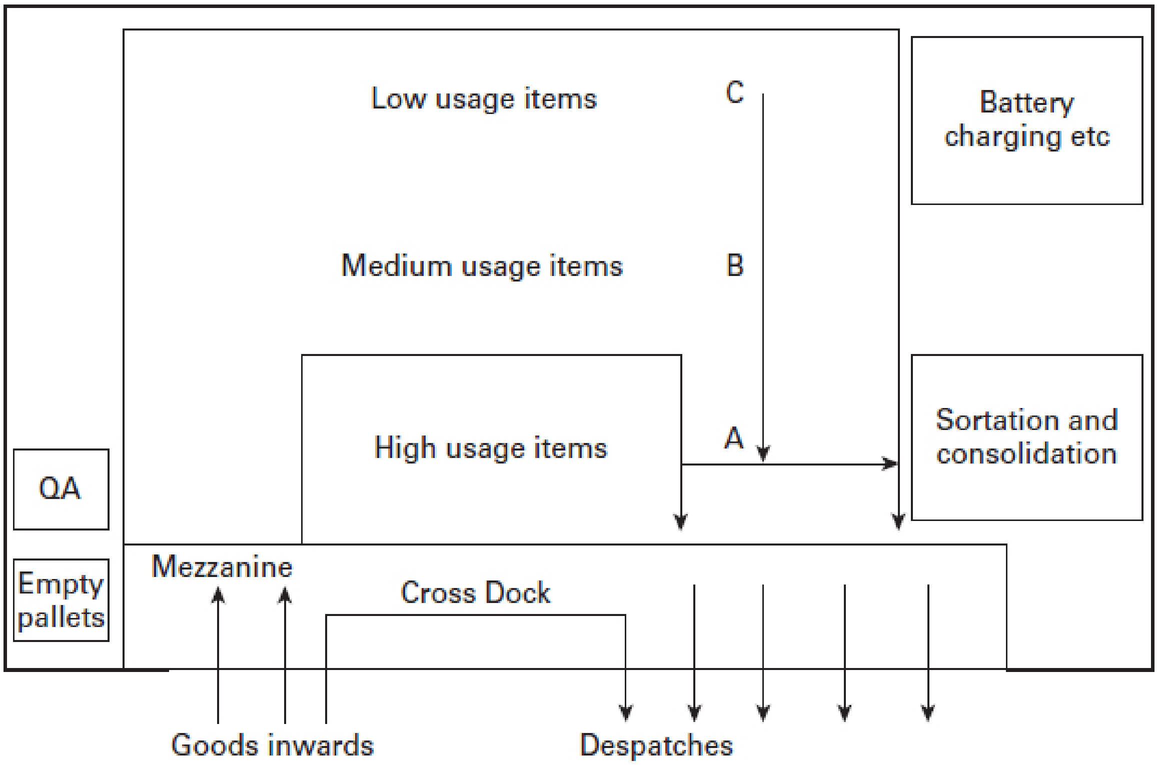
Warehouse layout examples

The warehouse layout will very much depend on the size and shape of the building, access to it, type of equipment utilized and the operation envisaged. As discussed in the section on picking, there is no 'silver bullet' warehouse layout; however, certain operations lend themselves to specific layouts. For example, parcel and pallet sortation centres tend to favour the through-flow warehouse as depicted in Figure 9.9.

The most popular warehouse layout tends to be the U-flow shape.

Figure 9.8 shows how receiving and despatch are on the same side of the building thus ensuring high dock utilization and facilitating cross docking. Doors are shared between inbound and outbound. The fastest-moving items are closest to the despatch bay, thus ensuring minimum travel and the opportunity to combine put-away and retrieval. In this example reserve storage is held above the actual carton-pick locations.

Figure 9.8 U-flow warehouse (courtesy of University of Huddersfield)



▶ Figure 9.8 details

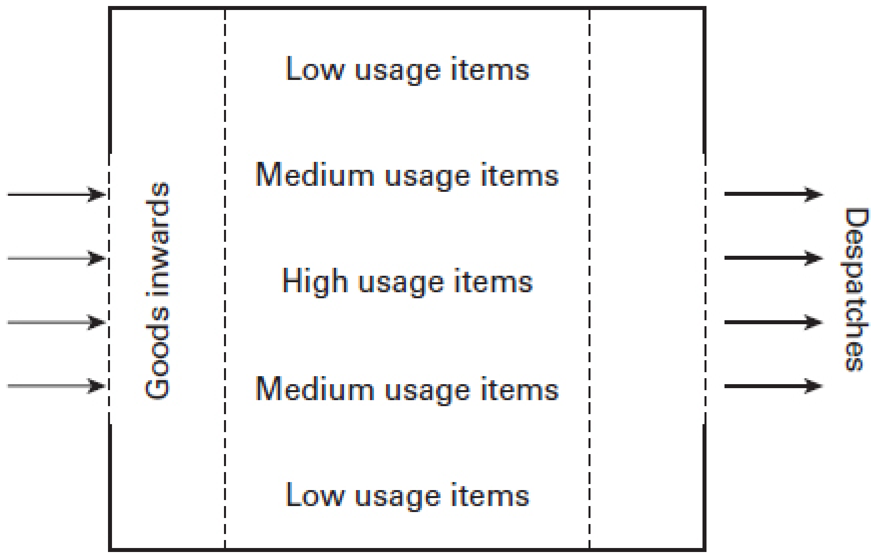
The design will be heavily influenced by the type of pick operations within the warehouse, with separate areas set aside for unit pick and value-adding services. This area could, for example, be housed on a mezzanine floor above the receiving and despatch bays.

If the warehouse operation has a high incidence of picking and value-adding activities then any low height areas within the warehouses should be set aside for these activities or, as previously mentioned, mezzanine floors constructed either on one or more levels depending on the requirement and the height and cube available.

In countries such as Singapore warehouses have multiple levels with lifts connecting the floors and in some examples roads leading to the different levels to allow vehicles to load and unload.

A through-flow warehouse as depicted in Figure 9.9 provides a layout where the movement is in straight lines and is more natural. Each layout has its advantages and disadvantages. The U-flow design enables greater utilization of the loading bays but can result in congestion and confusion if both areas are busy at the same time. It also makes security easier and access is via one side of the warehouse only. With a through-flow warehouse there are no issues with congestion but travel distances are increased. Having doors on both sides of the warehouse requires increased security and access either via two separate external gates or a perimeter road around the outside of the warehouse.

Figure 9.9 Through-flow warehouse (courtesy of University of Huddersfield)



▶ Figure 9.9 details

Having access on more than one side of the warehouse will also restrict future expansion.

The increase in multimodal use will also have an impact on future warehouse design with access required for trainload traffic within the warehouse or at least under a canopy at one end of the warehouse. Figure 9.10 depicts a rail-connected warehouse with trains entering the warehouse to be loaded and unloaded. There is also a track outside to allow for container loading and unloading and for the parking of trains whilst waiting to be loaded or unloaded.

Figure 9.10 Rail-connected warehouse (courtesy of DHL)

Finding additional space

When facing a shortage of space within the warehouse there are a number of options available, namely:

- expanding the warehouse;
- renting additional space; and
- creating more space within the existing premises.

If the company is unwilling or cannot afford to rent external space, and is unable to expand the existing warehouse or make significant structural changes, there are ways of increasing the number of storage locations without major upheavals.

A potential solution to increasing available space within a warehouse is to reduce inventory levels. Unfortunately, this tends to be beyond the remit of the warehouse manager. However, warehouse managers can identify slow and non-moving stock with a view to disposing of it in agreement with the sales and finance departments.

Although it may sound strange to suggest looking within the existing facility, there are options that might have been overlooked. Some potential options are as follows:

- Change the type of storage medium or mechanical handling equipment used. This can include changing from single-deep to double-deep racks, utilizing drive-in racking, very narrow aisle racking or introducing articulated forklift trucks, which can operate in narrower aisles.
- Consolidation of stock. Unless stock items have different best-before codes, batch numbers or expiry dates it is worth checking how many part pallets there are of certain items and spending time consolidating them. This does require the use of labour but the trade-off is between the freeing up of additional space and this cost. The alternative is renting space at a third-party warehouse. Some warehouse systems allow the storage of different products in the same location. This will require careful planning and additional training.
- Reducing beam heights within the warehouse to accommodate smaller, full or part pallets. How many times have you entered a warehouse to see half metre high pallets in 2-metre-high locations, not including pick locations, of course? Many warehouses prefer to have standard-height pallet locations as it is easier to manage

and control and is more pleasing on the eye. However, the potential for optimum space utilization is lost.

- As the majority of warehouses operate with adjustable pallet racking the most cost-effective method of storage is to have variable height locations. These will accommodate 0.5 metre, 1 metre, 1.2 metre, 1.5 metre and 2 metre pallet heights, for example.
- Moving from fixed locations to random locations. In a warehouse with fixed locations the same product is always held in the same location, irrespective of quantity and velocity. With fixed locations, if an item is out of stock you cannot use that location for anything else.
- If there is sufficient space in the yard a temporary storage structure may be the answer or the use of sea containers or trailers. Security and the potential for water or temperature related damage are areas that need to be considered before embarking on such a solution.

CASE STUDY

Temporary storage structures offer businesses across a wide range of sectors a fast solution to the demands for additional space whether that be for warehousing and storage, production facilities, distribution areas or any other number of applications.

Lauralu's client Palletower is a thriving business in the North of England. They manufacture and sell roll pallets and stillages used for product distribution. This was clearly a booming market during the pandemic where demand at online retailers and supermarkets and their subsequent distribution centres went through the roof.

Palletower had a requirement for two temporary buildings and one canopy to help them store their pallets and stillages during the assembly process. Planning permission took eight weeks to be approved, after which Lauralu supplied:

- 20 metres × 55 metres warehouse building;

- 18 metres × 25 metres warehouse building;
- 15 metres × 15 metres canopy.

All of these were constructed on a 4-metre side height.

Lauralu's temporary building solutions can last a lifetime – the aluminium frame and steel clad has no time limit on it. Once planning permission is secured they can stay in place as long as any bricks and mortar building. They are suitable for all weathers (strong winds do need to be monitored) and they can be fitted with all of the accessories required including lighting, heating, cooling, power and internet.

It is recommended that all customers seek planning permission before erecting a temporary building; however, in situations where the building is required rapidly, perhaps in response to a disaster, customers can apply for retrospective planning permission.

Figure 9.11 Temporary building courtesy of Lauralu (photograph provided by Lauralu)

Summary and conclusion

The most important factors in warehouse design are data accuracy and an understanding of both the current and future roles of the warehouse. Companies need to incorporate flexibility into the design knowing that the warehouse is likely to undertake many roles during its lifetime.

An efficient warehouse layout should reduce the amount of travel and labour touch points. It needs to avoid bottlenecks and cross traffic where feasible and ensure that movements take place in a logical sequence.

The whole cube of the building should be utilized and not just the floor space. The introduction of mezzanine floors and carousels provides excellent cube utilization where floor space is at a premium. The trade-off here is cubic utilization versus potentially slower retrieval times.

There are many opportunities to release additional space within the warehouse – we just need to look harder and ask more questions.

When designing or redesigning a warehouse we need to take the following into account.

- F – Flow (a natural flow of movement through the warehouse);
- T – Throughput (manage peaks and troughs);
- A – Accessibility (to all products);
- C – Compliance (building regulations and the environment);
- C – Compatibility (of products);
- E – Ergonomics (staff wellbeing);
- S – Safety (of staff and products); and
- S – Space (full use of cubic capacity).

10
Storage and handling equipment

Introduction

In this chapter we examine the different types of storage systems, manual handling equipment and automation used in warehousing today. Although warehouses should be about throughput, the transfer of manufacturing offshore by many countries has necessitated an increase in storage requirements. We are also seeing a revolution in materials handling equipment.

The counterbalance forklift truck has been around for over 90 years and remains the workhorse of most warehouses; however, we are now seeing significant technological advances with articulated forklift trucks, hybrid trucks, high-lift, very narrow aisle (VNA) trucks, automated guided vehicles (AGVs) and autonomous and collaborative mobile robots.

Storage equipment

There are many different forms of racking systems available on the market today. Each one performs a different role and its use will very much depend on the type of operation envisaged.

In terms of storage systems, we come across another warehouse trade-off. The trade-off here is between speed, cost and capacity.

The greater the storage need, the greater the density of pallet storage required. The potential options in these circumstances include the introduction of drive-in, double-deep, shuttle, mobile, push-back or very narrow aisle racking.

The trade-off is the fact that these systems take longer to access and deposit pallets and may require specific handling equipment or a different type of racking. Wide aisle adjustable pallet racking or selective racking on the other hand takes up more floor space but products are easier and quicker to access.

There are many different types of pallet racking configurations currently in use today. These include the following:

- wide aisle adjustable pallet racking also known as selective racking;
- double-deep pallet racking;
- narrow aisle racking;
- very narrow aisle racking;
- AS/RS racking;
- dynamic or pallet-flow racking;
- push-back racking;
- drive-in racking;
- drive-through racking;
- mobile racking;
- cantilever racking; and
- shuttle/satellite racking.

A number of companies will still operate with block or bulk storage where pallets or items are stacked one on top of the other without the use of racking. This is cheap and relatively quick to access and retrieve the pallets; however, first in first out (FIFO) is not possible and there is the potential of damage to the lower pallets. The cubic capacity of the building is also rarely fully utilized.

There is, of course, no right answer to the type of storage medium that should be used. Put five consultants in a room with stock data, ask them to come up with the optimum storage medium and you are likely to get five different answers.

The type of storage will depend on the company's requirements in terms of storage, the configuration of the building, the type of MHE currently in use and the budget available.

Each storage medium has its advantages and disadvantages.

Storage options

Block stacking

In circumstances where the warehouse height is reasonably low, where products and packaging are robust and budgets are tight, this type of storage is the most common method of storing large quantities of single SKU products. The goods are packed in unit loads and stacked on the floor to their maximum safe height, which is governed by the weight and stability of the stack. This method is also used where products do not lend themselves easily to palletization and pallet racking is out of the question.

Typical products stored in this way include white goods such as washing machines and refrigerators, kegs and barrels, cans and bottles, paper reels and rolls.

Other storage media include metal stillages used for storing automotive parts and pallet boxes, for example. I have also seen lightweight, bulky products such as golf bags stored using this method. Pallet posts and collars (wooden boards) can also be used to separate the pallets and reduce damage. There are a number of disadvantages associated with block stacking. These include:

- Access. Sufficient space needs to be allocated for forklift trucks to access each stack. Also, in order to access the bottom pallet, you need to move the pallets above. Companies tend to leave a 10-centimetre gap between the rows and a 5-centimetre gap between each pallet in the row to allow for possible overhang.
- Damage. The items at the bottom can be crushed by the weight of the items above. Care needs to be taken with the number of unit loads stacked on top of each other. Items such as white goods have a maximum stack number indicated on the packaging.
- Stock rotation. Unless product can be accessed at both ends of the row, items can only be despatched on a LIFO (last in, first out) basis.
- Space utilization. Utilization can be very poor if stock does not move quickly through the warehouse. Picking stock from either the front or the rear of the stack can lead to unusable storage areas being left; this is sometimes known as honeycombing. Calculations suggest that only 70 per cent utilization of actual floor space is achieved utilizing this method of storage. Cubic utilization also tends to be poor when block stacking items where the clear height of the warehouse is significantly higher than the stack itself as can be seen in Figure 10.1.

Figure 10.1 Example of block stacking (courtesy of Howard Tenens)

The use of pallet collars and converters can reduce the potential damage to underlying pallets and increase the stack height. The wooden, plastic or steel surrounds take the weight of the stacked pallets as opposed to the product itself. Those with drop-down front gates also enable some picking activities to take place. There is also no requirement to stretch wrap these pallets.

As can be seen from Figure 10.1, the cube of the building is not used efficiently and once a stack has been picked from, you cannot put anything in front of that stack until all the cartons have been removed.

Racked storage

The terms adjustable pallet racking (APR), selective racking and wide aisle racking (WAR) are seen as interchangeable. One point to note here is that APR is also used in narrow aisle and very narrow aisle rack construction. In this section we will discuss the advantages and disadvantages of the types of racking used in today's warehouses.

Wide aisle, APR or selective pallet racking

This racking is present in the majority of warehouses worldwide. It is the most versatile of any racking without the need for any specialized handling equipment. The beam heights can be configured to any height as required.

The racking can also be configured to take pallets in either long side or short side configuration, ie 900 millimetre or 1100 millimetre deep frames. One point to note here is that storing UK/industrial pallets (1200 × 1000 millimetre), short side facing the aisle, means that euro pallets (1200 × 800 millimetre) can also be stored in the same location without the use of decking. The issue here is the likelihood of pyramid picking as staff have to stretch deep into the racking to retrieve the items, leaving boxes at the back of the pallets. The act of leaning in can also be a hazard as staff can hit their heads on the beam.

Every pallet is accessible at any time and the racking is easy to install and, if necessary, move. Access is also quick and easy compared with most other types of racking. Steel, wooden or mesh decking can be installed across the beams to enable companies to store euro and UK pallets in the same bays with a 2.7 metre bay aperture and a 900 millimetre deep frame. The decking also allows for loose boxes to be stored at upper levels rather than putting them on pallets.

The ground floor locations can be utilized as pick faces with picking being carried out direct from pallets or from shelving designed into the bays. Reserve pallets can be stored above the pick face. See Figure 10.2. Note that if this area is used for both pallet storage, full-pallet picks and ground floor picking there is a potential issue of trucks and people operating in the same aisle at the same time. Some companies will not allow this to happen. I have also seen companies cordon off aisles if a forklift truck is putting pallets away in an adjacent aisle thus eliminating the possibility of injury due to product falling from the racking.

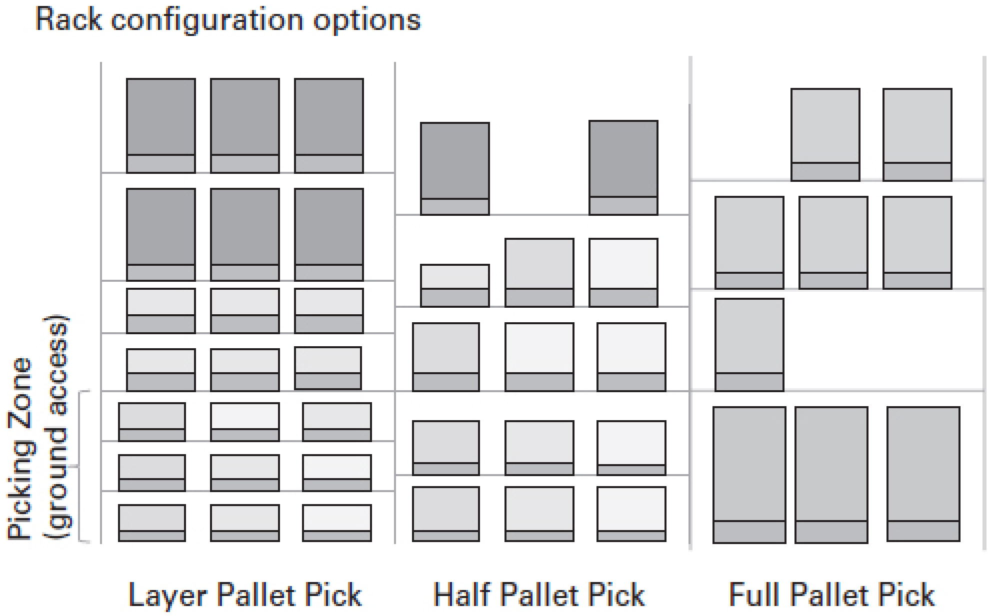
Figure 10.2 Storeganizer from Nene

VIDEO 10i Storeganizer from Nene

A further point to note is that the beams are adjustable and therefore varying pallet heights can be accommodated. There is no specific requirement to have all the beams at the same level, although it does look neater and tidier. However, if the pallet heights are variable the cubic utilisation of each location will be low. Figure 10.3 depicts a warehouse drawing with a variety of pallet heights. By adjusting the beam heights there is very little space wastage.

Having a system directed put-away system will ensure that the most suitable pallets are located in the correct locations.

Figure 10.3 Depiction of variable beam and pallet heights



As the description suggests, the disadvantage is in the fact that wider aisles are required to allow the forklift trucks a sufficient turning circle. The use of reach trucks in this area reduces the amount of aisle width required compared with counterbalance trucks. Wide aisles with counterbalance trucks tend to be between 3.5 metres (11.5 feet) and 4 metres (13.12 feet). The use of reach trucks will reduce this to 2.7 metres (8.86 feet).

The introduction of articulated forklift trucks has further reduced the requirement for wide aisles.

One point to note here is if you require the option of having two trucks operating in the aisle at the same time. If this is the case, aisles will need to be at least the width of both trucks plus clearance.

Double-deep racking

Double-deep pallet racking, as the name implies, allows pallets to be stored two deep in the racking as well as back-to-back, thus eliminating an aisle. The pallets are accessible from the same aisle. This system does require specialist equipment in the form of extendable or telescopic forks and will require slightly wider aisles. The speed of access is slower. A further point to note is that the products on the pallets need to be the same otherwise the front pallet will need to be removed to access the rear pallet. LIFO also applies here.

By reducing the number of access aisles and using the space saved to accommodate additional racking, a double-deep configuration provides a highly space-efficient storage system.

Figure 10.4 Double-deep racking (courtesy of Redirack)

Very narrow aisle racking

Very narrow aisle and narrow aisle racking, as the name implies, utilizes APR and provides storage for a greater concentration of pallets by reducing the aisle width to between 2.7 (8.86 feet) and 1.6 metres (5.25 feet). This type of racking configuration requires the use of reach trucks, articulated forklift trucks, very narrow aisle or turret trucks to deposit and access pallets.

Reach trucks require a narrower turning circle than a CBT. Very narrow aisle trucks are not required to turn in the aisles as their forks extend from the side. They are able to access pallets from both sides of the aisle by rotating the forks before entering the aisle. Pick and drop (P & D) stations are usually found at the end of the racking at each level to enable the trucks to deposit the pallets at the height at which they were retrieved. This enables counterbalance or reach trucks to collect these pallets and take them to despatch or to the pick area. The reverse also applies with trucks depositing pallets at the P & D locations prior to put-away.

Figure 10.5 Very narrow aisle racking (courtesy of Constructor Group)

Very narrow aisle trucks are manoeuvred within the aisles via wire-guided systems or guide rails. Very narrow aisle racking requires a very flat floor, especially if we are looking at heights in excess of 10 metres. During construction, companies will use lasers to ensure the flatness of the floor.

The use of guide rails prevents the use of pump trucks or powered pallet trucks in this area to pick up and deposit pallets in the pick face as they are unable to access the pallets. When using guide rails the bottom pallet has to be elevated to allow access for the forks.

The downside is that when you narrow the aisles too much this restricts the speeds at which a forklift can travel between picking locations.

The use of articulated trucks in narrower aisle racking means that reduced aisle widths can be achieved but without the need for wire-guided systems or guide rails. These trucks, however, are ‘operator-down’ trucks and therefore require greater skills to retrieve and deposit the pallets and secondly items cannot be picked direct from the pallets at height.

Drive-in/drive-through racking

Drive-in racking (see Figure 10.6) provides a safe and efficient equivalent to block stacking for loads that are too fragile or unstable to be stacked on top of each other. In place of the longitudinal beams that usually support the pallet and load on conventional racking, each upright of drive-through racking has an L-shaped load support rail for the pallets to rest on, between which there is enough space for a forklift truck to drive into the racking. The rails are carried on brackets that slot into the uprights. The pallets have to be stronger than for normal racking because they have to support the weight of the load across the gap between the rails.

Figure 10.6 Drive-in racking (courtesy of Howard Tenens)

With drive-in racking there is no requirement for aisles, therefore floor space is fully utilized. Cubic space utilization will depend on the lift height capability of the forklift truck.

Drive-in racking does not allow for FIFO; however, drive-through racking does enable you to extract pallets from the other end of the racking. This does reduce the amount of storage space available, however and also adds to the honeycomb effect as discussed previously.

Drive-in/drive-through racking is a high-density storage medium suitable for large quantities of single SKUs. Note that products cannot be mixed in each row and stock counting can be very difficult.

Its disadvantages are the increased potential for damage, not only to the product but also to the racking, and the lower speed of put-away and retrieval.

This type of storage relies on full-pallet picks as there is no scope for carton picking from the ground-floor locations.

This type of racking can be used at the despatch area to stage outgoing pallets by truck delivery, reducing the amount of floor space required in this area.

Pallet flow/live storage

Pallet-flow racking is driven by gravity. It is perfect for fast-moving product with FIFO stock rotation. Pallets are loaded at the upper end of sloping lanes, and move down by gravity, using heavy-duty skate wheels. When a pallet is removed from the pick face another pallet will take its place. One block of roller conveyor racking requires only two aisles: a loading face and a picking face, which means fast cycle times and high occupancy rates within your warehouse. Warehouse floor space utilization can be further maximized with fewer aisles by storing pallets back to back. Disadvantages are the potential reduction in cubic utilization and the fact that different products will require a different angle of incline based on the weight of the pallet. Each run level also requires the same product to be stored in it.

Figure 10.7 Pallet-flow racking (courtesy of Dexion)

Push-back racking

Push-back systems work by placing pallet loads on a series of nesting carts on rigid structural steel rails. As a pallet is loaded from the front, it pushes the pallet behind it back one position. When unloading, the front pallet is removed and the rear pallets automatically slide forward to the front picking position. This allows for easily accessible LIFO inventory management.

Operators can store product from two to five pallets deep, with front-only loading from a single aisle. Push-back offers more versatile storage than drive-in racking because each lane flows independently and vertical storage operates separately from the lanes below. This provides multiple pick facings for a variety of SKUs and pallets can be stored and retrieved without disturbing other product above or below in a single-lane or double-lane format (www.unarcorack.com).

Figure 10.8 Push-back racking (courtesy of Redirack)

The following video shows the above racking types in action.

VIDEO 10ii Rack systems from www.racksafety.org

Mobile racking

Where floor space is very expensive, a warehouse can be made very compact if the units of racking are movable by being mounted on rollers. Only enough space for one access aisle is then required, as the operator can 'move' the aisle merely by moving the units. The operator uses an onboard control panel or remote control to order a certain aisle to spread open. The process automatically provides direct access to specific goods stored in the chosen rack. Mobile bases are motorized, roll over guide rails and include a range of safety systems to guarantee secure, efficient operations. Floor space is being saved at the expense of a slowing down in the load-retrieving and put-away operation. This is mainly utilized for very slow-moving bulk items. Mobile pallet racking is an ideal system for temperature-controlled warehouses.

It has its equivalent in mobile shelving, which can be found in museums, libraries and maintenance stores where speed of retrieval is not crucial.

Figure 10.9 Mobile racking (courtesy of Dexion)

VIDEO 10iii Mobile racking from Bito

VIDEO 10iiib Mobile cantilever racking from SEC

Shuttle racking

A pallet shuttle system is similar to drive-in racking. However, it is operated by placing shuttles at the front of the racking, utilizing counterbalance, reach, articulated or very narrow aisle trucks, depending on the height of the racking. The shuttles are controlled remotely via a radio frequency (RF) battery-operated control system and special channel rails. There are no aisles and therefore the cube of the warehouse is well utilized, with the use of very long lanes. The storage system can store pallets within a system that can operate to lengths of 40 metres.

The racking features guide/support rails that run the depth of the rack structure on which an automated shuttle travels. Pallets are loaded onto a shuttle at the front of the lane, which transports the pallet down to the far end. The built-in sensors on the shuttle detect the position of existing pallets and place the new load at a predetermined distance, before returning to the start. The shuttle is easily moved between lanes by the forklift truck. Multiple shuttles can be controlled by one forklift truck driver.

Unlike drive-in racking, there is no necessity for the truck to enter the racking and therefore the potential for damage is minimized and the truck can carry on with other duties whilst the shuttle places the pallet in the correct location.

The system operates in first in, last out mode, allowing racking to be set up against a wall of a warehouse, thereby gaining space. It can also operate with FIFO, using a system that requires a separate aisle at each end. This method allows for the loading to be carried out from one side with a forklift truck and the unloading on the opposite side with another. The system automates the placement of pallets in the storage lane, reducing loading and unloading cycle times. The honeycomb effect is negated as the shuttle will bring pallets closer to the point of retrieval. The shuttles will continue to move pallets even when the operator is away from the racking.

Each level of racking is assigned to a specific product, unlike drive-in racking where every level in each row has to contain the same product code.

Shuttle racking can also utilize the space above the loading bays. As can be seen in Figure 10.10, the pallets are stored on a LIFO basis in this instance. This area can be used for marshalling loads prior to despatch.

This racking can also provide picking areas below as they do not require a forklift truck to enter the area as can be seen in Video 10iv.

Examples of shuttle racking are shown in Figures 10.10 and 10.11.

VIDEO 10iv Radio shuttle technology from BT

Figure 10.10 Shuttle racking above despatch bays (courtesy of Toyota)

Figure 10.11 Example of satellite racking (courtesy of Toyota)

CASE STUDY Shuttle system for Christie Lites

SEC Storage designed a truly unique storage solution using a multi-channel shuttle system installed at Coventry-based Christie Lites, providing a dramatic increase in volumetric capacity and five-fold rise in the amount of pickable locations, ensuring optimum operational efficiency.

SEC Storage was invited by Christie Lites, a leading US stage lighting company, to design a solution to store their stage trussing, which was being bulk-stacked at their large warehouse facility in Coventry, as this existing system was causing several key operational issues, in both capacity and selectivity.

The two design options that the client was considering prior to SEC’s involvement, were either a traditional adjustable pallet racking (APR) system or drive-in system; however, both had significant limitations.

Consequently, SEC engaged with key partners within their comprehensive supply chain and found that virtually all shuttle suppliers confirmed they would be unable to handle the load as standard.

In response to these findings, SEC Storage used their in-house logistics experts to design a completely bespoke, modified shuttle system, comprising an additional raised platform which would be inserted between the castors in order to lift the product safely.

SEC proposed technical modifications to the program algorithms and sensor technologies that would allow the products to position themselves correctly underneath the load and also designed a split-load level, allowing storage of two smaller cases within one rack, only previously possible if stored in APR.

Furthermore, SEC incorporated a rapid moving, ground floor pedestrian picking location beneath the shuttle, aided by a bespoke designed mesh system to protect users from any falling equipment, thus reducing the cost of the system and increasing pick velocity.

Key benefits of the shuttle solution

- Increased volumetric utilization of 55.3 per cent of the total cube.
- 229 per cent increase in volumetric capacity when compared with the APR option.
- 500 per cent increase in the amount of pickable locations ensuring that 100 per cent of the SKUs had their own dedicated lane, hence selectable.
- Ground floor picking level allowed for rapid picking of fast-moving products, contributing towards a significant operational cost saving.
- Design made use of readily available componentry from blue-chip suppliers, so parts could be replaced easily.
- Return-on-investment on the project is expected to be within 12–18 months.

VIDEO 10v Shuttle technology from SEC

Shuttle technology with a difference

Taking shuttle technology one step further is the iCube.

Using an iCube system means getting the absolute most out of the available storage space, without needing space for operating a forklift between rows. The movement of pallets is completely automated using 3D carriers and vertical transport lifts. Unlike the radio shuttle system, this system allows for both horizontal and vertical movement as can be seen in Video 10vi. The company suggests a potential cost of €200 per location.

VIDEO 10vi iCube in action

Very high bay warehouses

These consist essentially of massive blocks of racking, built as an integral structure to a high degree of precision, and often acting as a support for the building's roofing and wall cladding. Warehouse heights can range from 18 metres up to 60 metres. Mast cranes built into the racking structure operate in aisles little wider than the unit load handled, under computer control, with the unit loads moving automatically into or out of the racking.

The costs are high, but so is space utilization and operating efficiency and there is little doubt that more of these warehouses will be built to handle and provide quick access to goods where the range of products is wide and stock turnover is high.

A typical example is the Encirc high bay warehouse constructed by Stöcklin (see Figure 10.12), which is 35 metres high and has a footprint of 52,200 square metres. It has the capacity to store 280,000 industrial pallets.

Figure 10.12 Encirc warehouse (courtesy of Stöcklin Logistik)

Table 10.1 details each type of storage medium and compares it with its rivals, based on a number of parameters.

Table 10.1 Choosing a warehouse racking system

Skip table

	Use of floor space	Use of cubic space	Speed of throughput	Access individ
Adjustable pallet racking	**	**	***	****
Very narrow aisle	***	***	***	****
Drive-in racking	*****	***	****	**
Drive-through racking	*****	***	****	**
Double-deep racking	***	***	**	**
Push-back racking	***	***	**	**
Gravity fed racking	****	***	****	*
Mobile racking	****	***	*	****
Satellite/shuttle racking	*****	****	***	**
Satellite/shuttle racking, open both ends	*****	****	***	**

NOTE *The cost column assumes that standard adjustable pallet racking is given a base cost of 100

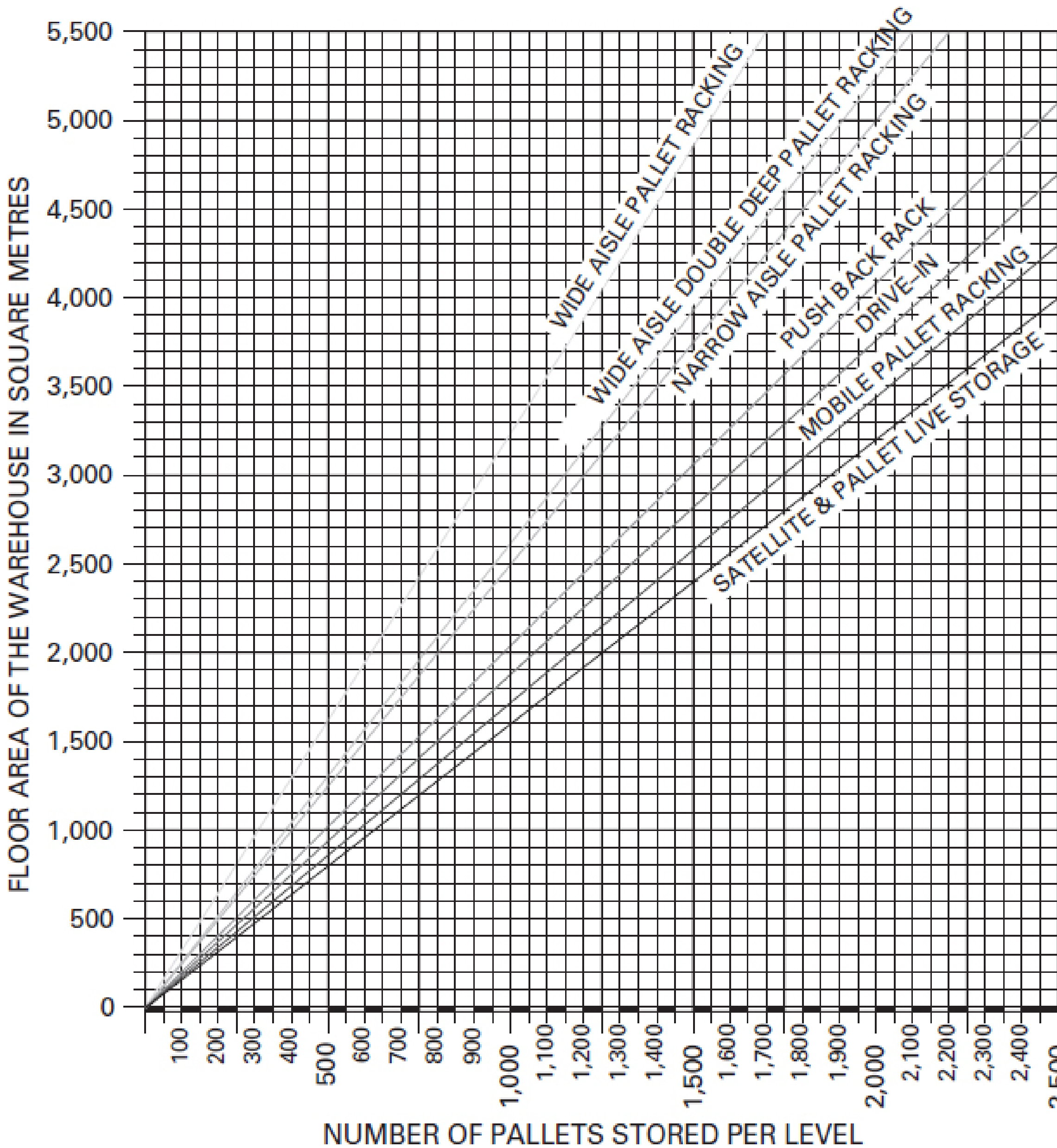
SOURCE Data provided by Nene Ltd

There are, of course, many variables that will impact on the price. The main one being pallet size and type, and, for example with drive-in racking, there are different design options and alternative support rails available. For double-deep racking it would normally be the use of APR but some trucks require a low-level beam to accommodate reach legs that would increase the price and 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. Comparison data is supplied by Nene Ltd.

Figure 10.13 shows the approximate number of euro pallets that can be stored in ground-floor locations within a given space in a warehouse based on the type of racking utilized.

Figure 10.13 Warehouse capacity graph: euro pallets (courtesy of Dexion)

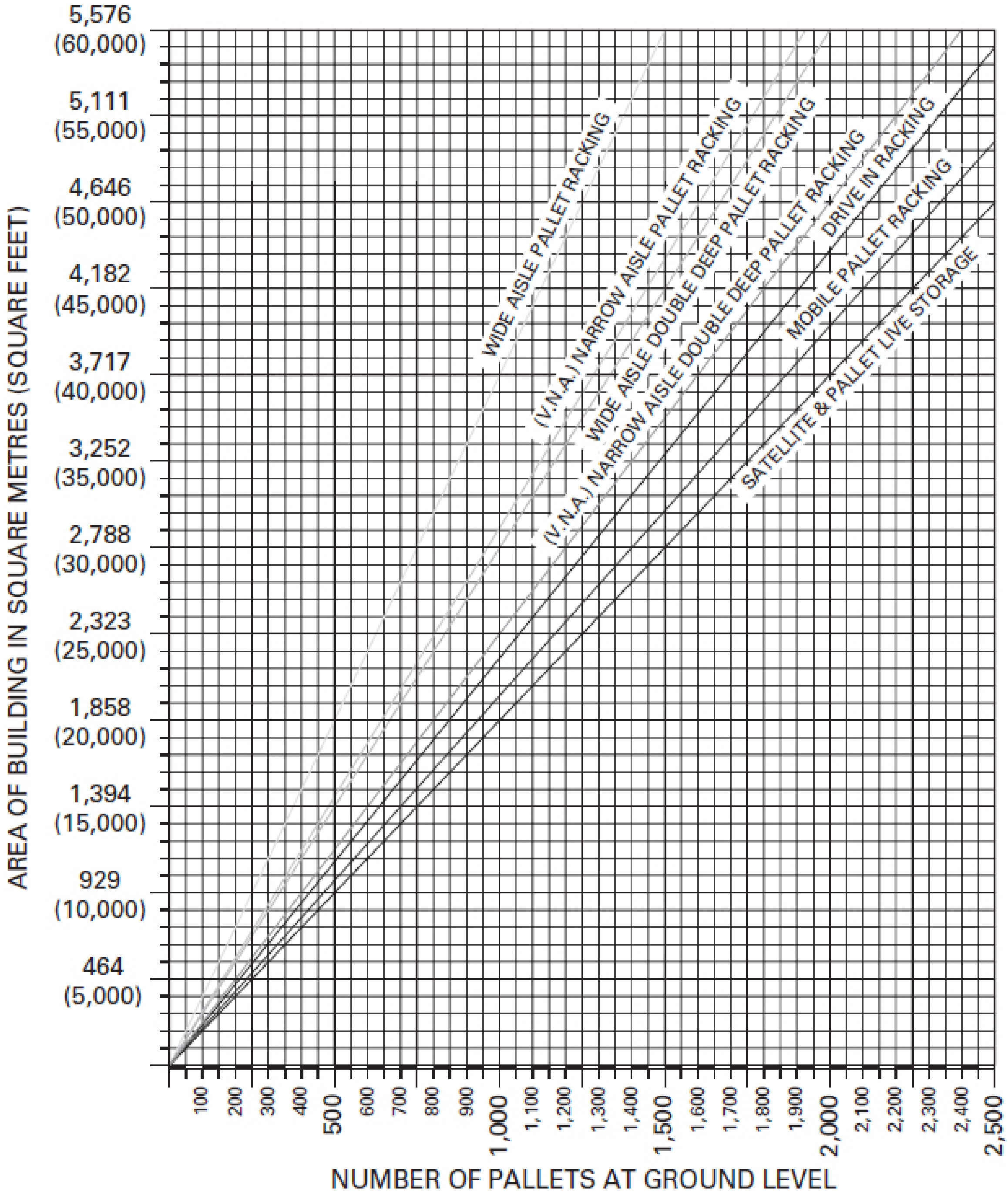


▶ Figure 10.13 details

Figure 10.14 shows the approximate number of UK pallets that can be stored in ground-floor locations within a given space in a warehouse based on the type of racking utilized.

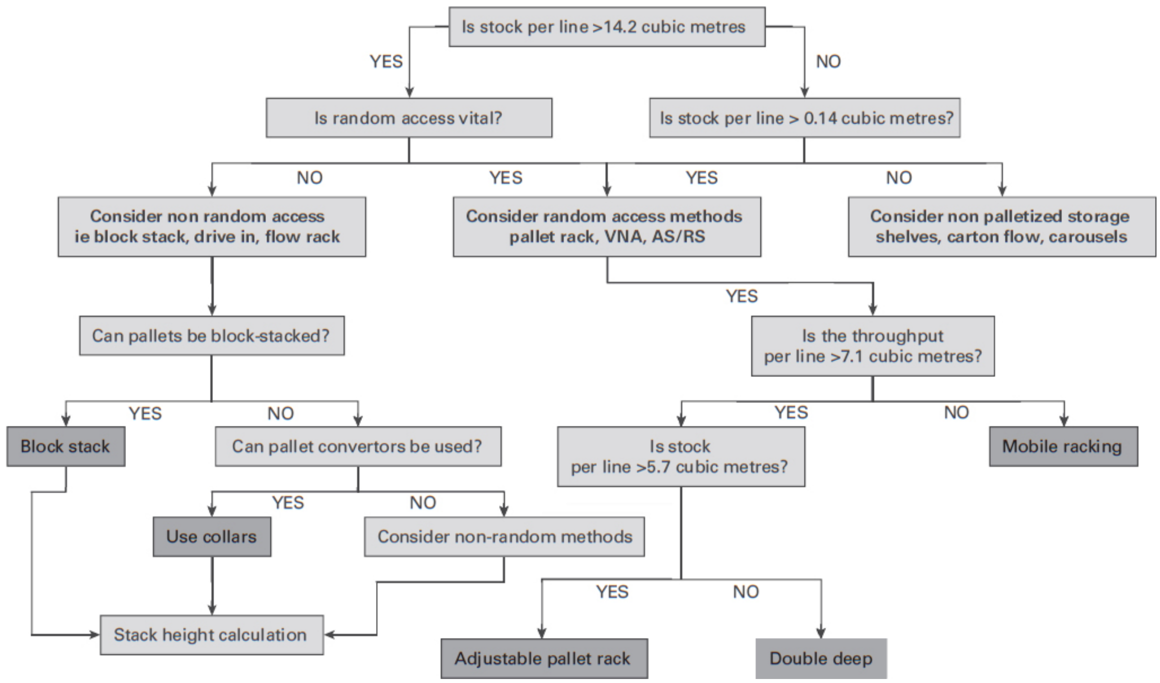
The decision tree in Figure 10.15 enables you to decide on particular types of storage systems based on the volume of the stock, sales velocity and required access.

Figure 10.14 Warehouse capacity graph: UK pallets (courtesy of Dexion)



▶ Figure 10.14 details

Figure 10.15 Two-dimensional decision tree (courtesy of Insight Holdings)



▶ Figure 10.15 details

Other storage media

Cantilever racking

Cantilever racking is an ideal solution for long or heavy items such as pipes, timber, plastic moulding, wooden boards, carpet or furniture storage. Cantilever racking can be static or mobile. It can also be single or double sided and has adjustable height shelving.

Figure 10.16 Cantilever racking (courtesy of Locators)

Mezzanine floors/raised storage areas

Where a warehouse has sufficient height it can be very cost-effective to construct a mezzanine floor. Typical areas are above the loading bays. This space can be used to construct shelving for storage, used to undertake value-adding services or for long-term storage.

If the mezzanine is to be used for product storage, you'll need to ensure it is properly structured to take the appropriate load, and that the supports are also properly specified. The floor that the vertical supports stand on will also need to be properly surveyed.

To gain access to your mezzanine you'll need to consider whether you need a lift, conveyor, steps and any gates or barriers. For example, if you need to load pallets on to the mezzanine, you'll need access for your forklifts.

Figure 10.17 shows three mezzanine floors constructed recently for a fashion retailer. The floors are used for the storage of hanging and boxed garments and to undertake value-adding services.

Figure 10.17 Mezzanine floors at Arvato (courtesy of Joe Fogg, 2016)

Carton flow rack, carton live or gravity-flow storage

Carton live storage operates by means of gravity-fed rollers on adjustable shelving. Cartons are loaded at the upper end of sloping lanes, in the rear aisle and move down under the force of gravity when a carton is removed from the pick face. The rollers can be adjusted to take different sizes of cartons and can also be fitted with a braking system to protect the more fragile items.

As can be seen in Table 10.2 and Figure 10.18, the occupancy rate is high, travel time is reduced and the system is fully FIFO compliant.

A gravity-flow system may cost more than conventional shelving, but it cuts labour costs dramatically. This is achieved by decreasing the walking distance between items being picked and the time spent looking for them. In fact, about 85 per cent of the picker's time is spent actively picking and only 15per cent walking.

Gravity-flow shelving uses floor space more efficiently. Fewer aisles are required and more product can be stored in the same amount of floor space, as shown in Table 10.2. This system can also be retro-fitted into existing racking. One factor to take into account is the length of run for gravity shelving. Too long a run can result in wasted space as each lane can only hold one product line. The option is to have one product line across a number of lanes rather than have a long run of a single SKU. Two further points to bear in mind are the need for ongoing maintenance for the rollers and, second, the fact that different products will have different weights and will require different inclines to propel them down to the front.

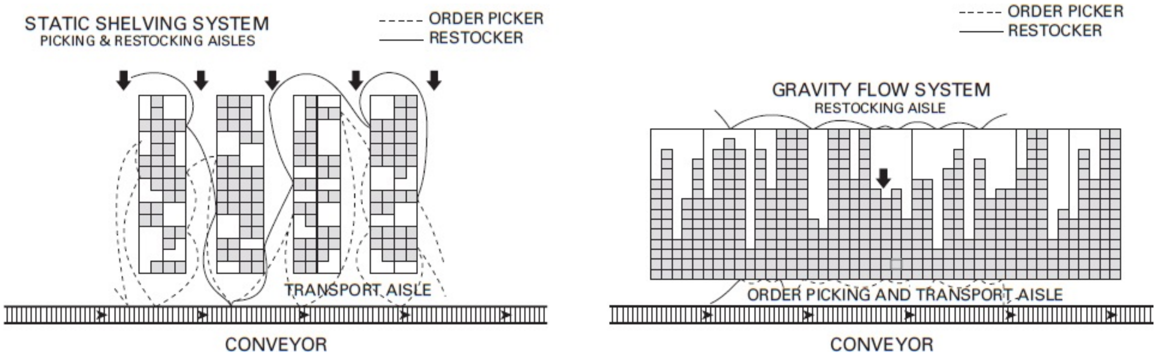
Table 10.2 Shelf storage versus carton flow storage (courtesy of Cisco Eagle)

Skip table

Factor	Gravity/carton flow	Static shelving	Gravity flow gain
If total available floor space is	Equal	Equal	–
Then items stored (0.03 cbm) =	155	120	29%
Shelves high	5	3	2
Cases per opening/face	15	12	3
	2,325 items	1,440 items	61%

VIDEO 10vii Tote and carton flow rack

Figure 10.18 Carton flow rack comparison (courtesy of Cisco Eagle)



▶ Figure 10.18 details

Figure 10.19 Carton flow rack (courtesy of KNAPP)

If space is an issue, and a second aisle cannot be accommodated, companies can use a push-back system, which loads from the front as opposed to the rear. However, this will mean a last in, first out (LIFO) as opposed to first in, first out (FIFO) system of stock control.

Full pallets of stock can be stored above the carton live storage, thus utilizing the total cube of the area.

Shelving

Shelving is used to store less than pallet quantities of product. The items can be stored in their original cartons or in totes or bins. There are many different types of shelving, most of which are adjustable with different widths and heights.

Bin or tote storage makes it possible to present a large variety of items on a very compact face. These bins or containers are of different sizes, colours and shapes, and most have semi-open fronts.

Static shelving is reasonably inexpensive. The hidden cost, as mentioned above, is the cost of labour: the amount of time operators spend travelling, picking and restocking.

Figure 10.20 Standard shelving (courtesy of Joe Fogg)

An alternative to shelving are bin drawers, which provide greater security and high-density storage (see Figures 10.21 and 10.22).

Figure 10.21 Bin drawers

Figure 10.22 Bin drawers

Mobile shelving and racking

Where space is at a premium and access to items is intermittent, as in the case of archive material and very slow-moving items such as maintenance parts, mobile shelving and racking, which runs on guides or rails and is either manually operated or powered, is a potential alternative to static shelving.

Access to each run of shelving is gained by either turning a wheel at the end of the run or by accessing it electronically at the touch of a button (see Figure 10.23). These types of storage systems are popular with maintenance stores operations.

Figure 10.23 Mobile racking

Summary

The choice of storage medium very much depends on the type of operation envisaged and whether storage or throughput is the driving factor.

The decision as to which storage medium to choose also has to take into account the height and design of the building and the type of MHE required to access the racking. The different types of equipment will be discussed next.

Warehouse handling equipment

The challenges of a 24/7 operations culture, together with an ageing workforce, demands for improved accuracy, shorter order lead times and a reduction in cost have galvanized manufacturers into producing handling systems that require minimal manual input and provide increased throughput levels.

This section reviews equipment currently in use from the humble pallet jack through to automated systems. It examines some of the enhancements that have taken place recently and provides comparisons between different types of handling equipment within the warehouse.

The key principles of materials handling are as follows:

- continuous movement is most economic;
- economy is directly proportional to size of load;
- standardization reduces costs;
- mechanization improves efficiency;
- gravity is cheap; and
- simplicity is the goal.

In choosing the correct equipment we are looking to:

- lower unit materials handling costs;
- reduce handling time;
- conserve floor space;
- prevent injuries to staff; and
- reduce energy consumption.

It is essential to consider all aspects of an operation in order to ensure that the most suitable equipment is specified and the best handling solution selected.

Important factors include:

- the load and the means of transfer, eg type of pallet;
- type of storage;
- type of operation;
- warehouse dimensions (height and travel distances);
- overhead obstructions;

- surfaces and gradients;
- working area;
- work environment (inside or outside or both); and
- environmental pressures.

To be able to decide on how to equip our warehouses with the most efficient mechanical handling equipment we need to undertake the following:

- define the functions to be performed;
- review all stock items and define their handling requirements;
- understand the travel distance and speed relationship;
- understand the limits of the building and the structures within it;
- evaluate staff capabilities;
- agree a budget; and
- evaluate vendors, equipment alternatives and relative costs.

Horizontal only movement

Examples of horizontal movement equipment include the following:

- hand pallet trucks (HPTs), pallet jacks;
- powered pallet trucks (PPTs);
- tractors/tugs;
- automated guided vehicles (AGVs); and
- conveyors.

Note also that all the vertical movement equipment discussed below can also undertake horizontal movements.

Hand pallet trucks (HPT)

A HPT has a hydraulic pump to enable the operator to lift a pallet sufficiently to be able to move it across the warehouse floor. It is a cost-effective piece of equipment to move pallets across short distances. It can also be used to manoeuvre pallets within the racking or on the back of a trailer or container. They have a lift capacity up to 2,500 kilograms approx.

Powered pallet trucks

These are battery operated and are used for loading, unloading, picking and pallet-transfer duties to and from the receiving and despatch areas. They can be supplied as pedestrian, stand-on or seated versions.

The choice of truck will depend on pallet throughput per hour and distances travelled within the warehouse.

These also have a lift capacity from 1,500 kilograms to 2,500 kilograms depending on the model.

Tow tractors/tugs

These are utilized where distances between points within the warehouse are long and there is a requirement to move a number of pallets at the same time. Pallets can be loaded onto trailers coupled to each other and towed or trammed to the required location. Typical examples are the movement from the manufacturing facility to the warehouse where they are within the same building or adjacent to each other. See Figure 10.24.

Figure 10.24 Tow truck moving multiple pallets

Automated guided vehicles

The use of automated guided vehicles is growing in popularity as companies struggle with a shortage of skilled labour, high labour costs and 24/7 operational requirements. Couple this with a reduction in cost and AGVs become a feasible alternative to man and machine for moving pallets horizontally throughout the warehouse and for loading and unloading palletized vehicles.

These AGVs can be wire guided, magnetic or gyroscopic. They can also use cameras to record their movements and then memorize them for the next trip.

A recent innovation has been the laser-guided truck. Using special reflective surfaces placed throughout the facility, the automated laser-guided vehicle continuously checks its position and path as it is controlled by the WMS.

The advantages of automated vehicles are as follows:

- computer or hand controlled;
- more durable than people;
- less strain for operators getting on and off trucks;
- long-distance and/or high-density traffic;
- fitted with security sensors and guards;
- limited potential for damage;
- reliable; and
- do not cause bottlenecks.

The disadvantages are that they are initially expensive, fully reliant on the RF system within the warehouse and may require a specially designed and obstruction-free floor area.

Figure 10.25 Open shuttle from KNAPP

Conveyors

Conveyors can also be utilized to transport pallets within a warehouse; however they can be barriers to other operations.

Vertical and horizontal movement

In order to take advantage of the cubic capacity of a building, pallets or unit loads need to be lifted into position. Forklift trucks are differentiated by their lift height capability, weight capacity and turning circle. These trucks have become a great deal more sophisticated with onboard computer screens and cameras, as can be seen in Figure 10.26.

Pallet or 'Walkie' stacker

These trucks are used for moving pallets around the warehouse and when required can lift pallets up to 5 metres. It is an electric-powered lift truck operated by a person on foot. The most common ‘walkies’ are used for lifting and moving pallets short distances. The walkie stops when the motor is not engaged. The operator holds an arm or handle called a tiller that has controls installed. They allow the operator to move back and forth or lift, respectively.

Figure 10.26 Internal view of computerized forklift truck (courtesy of Atlet)

Figure 10.27 Pallet stacker (courtesy of Locators)

CASE STUDY

Asda has recently introduced the pedestrian operated mini Bendi into their back of store operations (see Figure 10.28.)

As a business, Asda constantly looks at ways to separate pedestrians and forklift trucks in order to minimize the risk of accidental collisions. However, when segregated it can often lead to cube productivity inefficiencies. With the new truck they no longer need to compromise. Simon Grass of Asda comments:

> *The Mini Bendi allows us to significantly drive the use of the cube in our back of house areas as it can work in the narrow aisle format and maximize the usable height available but due to its way of working that allows us to have pedestrian pick within the same area permitting the stores to drop and fill effectively. This supports the reduction in the building footprint and thus improves the building's selling efficiency as we can either build a smaller store or increase the selling sq ft. It also allows us to lower the height of the building as we can now store as many pallets above 'pedestrian pick' in narrow aisles, as we could in the reach truck aisles at height, which is especially welcomed by the local planning authorities in certain areas of the country.*

Figure 10.28 Mini Bendi (courtesy of Bendi)

Counterbalance forklift trucks (CBTs)

CBTs are the most common trucks to be found in a warehouse. They are fast, flexible and versatile, but the major disadvantage is that in order to stack or retrieve a pallet they must approach the face of the pallet at 90° square. Thus, the turning circle of the truck determines the minimum aisle width.

CBTs can be three-wheel or four-wheel trucks. Three-wheel CBTs have a turning radius of between 1,335 and 1,671 millimetres. Note, however, that three-wheel trucks have a lower carrying capacity (max 2,500 kilograms) and can be unstable at the higher weights.

Four-wheel CBTs have a turning radius ranging from 1,710 to 2,705 millimetres.

These figures may differ depending on the truck manufacturer.

They are powered by diesel, battery, LPG or CNG. They can operate both inside and outside the warehouse.

Four-wheeled CBTs can carry palletized goods to and from racks up to 7.5 metres high and require aisles of approximately 3.5 metres or more in width. They have been the workhorse of the warehouse for over 60 years because of their flexibility in being able to work both inside and outside the warehouse.

To increase storage capacity by making better use of the floor space available, it is possible to reduce aisle widths by utilizing different types of trucks.

Reach or straddle trucks

These trucks are ideal for working within narrower aisles. Unlike the CBT they carry the load within the wheelbase. They are able to work in aisles of around 2.7 metres. However, most companies will increase the aisle width to 3 metres. Today's reach trucks have the ability to lift 1,000 kilograms up to 13 metres. They can operate in single and double-deep racking environments. As can be seen in Figure 10.29, the aisle is reasonably narrow, but not as narrow as those operated in by articulated and very narrow aisle trucks. These are operator-down trucks unlike the very narrow aisle trucks.

Figure 10.29 Reach truck (courtesy of Atlet)

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'.

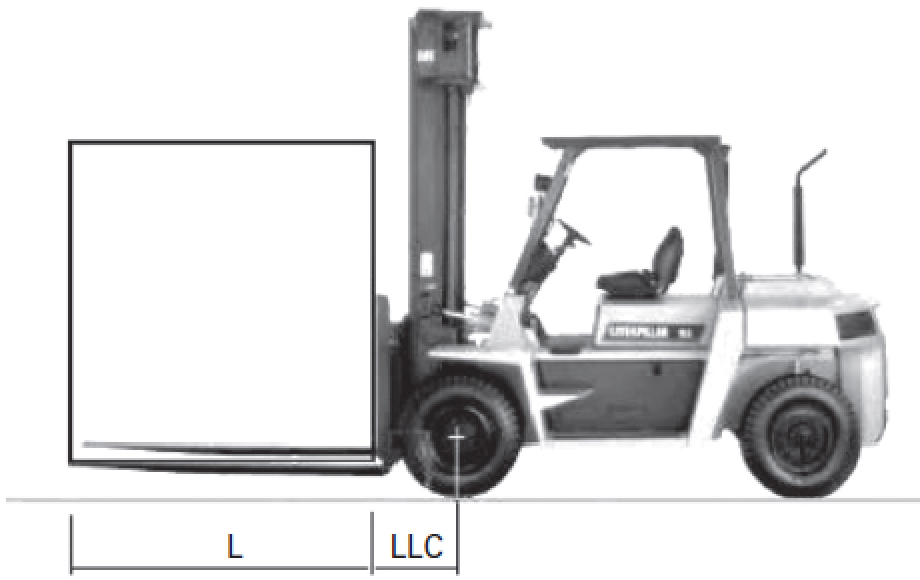
The official formula for working out the *minimum* ninety-degree stacking aisleway dimension (known as Ast4 or Ast3), is shown as:

WA + LLC + L

where:

WA = forklift truck outer turning radius
LLC = forklift truck's lost load centre
L = length of load

Figure 10.30 Aisle width calculation, CBT



Tony Sellick from Fork Lift Training suggests adding a further 300 millimetres for operator clearance (http://www.fork-lift-training.co.uk/buyersguide/forklift-aislway-turning-dimensions.html).

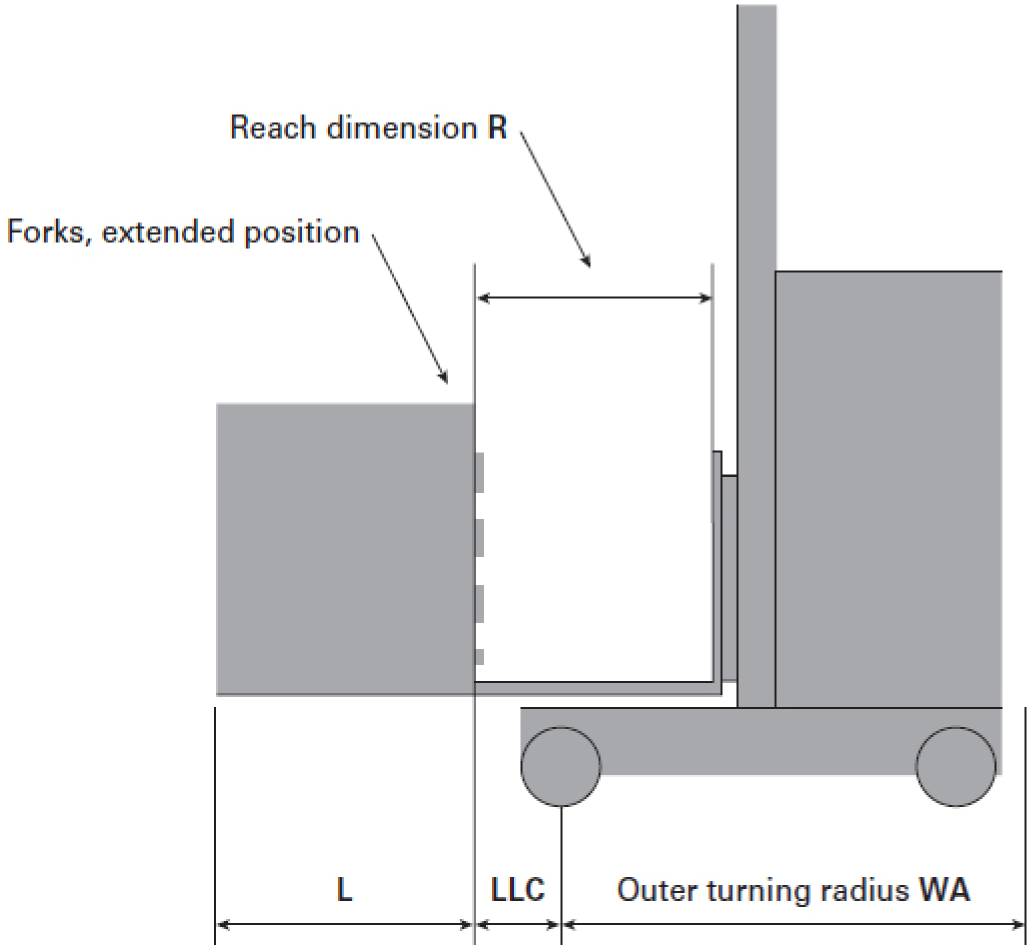
With regard to the reach truck, the following formula applies.

WA + LLC + L-R plus 230 millimetres (operator clearance)

where:

WA = forklift truck's outer turning radius
LLC = reach truck's lost load centre
R = reach distance
L = length of load

Figure 10.31 Reach truck aisle width calculation



▶ Figure 10.31 details

Very narrow aisle or turret trucks

These trucks are designed to operate with little more aisle space than their own width. The normal aisle width of a very narrow aisle truck is approximately 1.6 metres. Operating this type of truck can add approximately 33 per cent to storage capacity through the adoption of narrower aisles. The advantage over articulated and reach trucks is that the operator is eye level to the pallet at all times and heights. The maximum reach height is now up to 18 metres.

There are disadvantages, however.

- Cost is a major factor, as can be seen in Table 10.3.
- The use of operator-up VNA trucks requires large transfer gangways at both ends of each aisle to allow these trucks to switch aisles – unless, of course, you have the luxury of operating one truck per aisle.
- Furthermore, there are safety issues associated with picking because reaching out from a fixed cab to pick a carton and place it on a pallet some distance away is not ergonomic or efficient. Trucks can be fitted with harnesses for the operators.
- A VNA truck operator who is working 17 metres in the air will often struggle to notice another order picker working at ground level in the same aisle, thereby compromising order-picking efficiency and health and safety within sites where there is a high degree of low-level order picking. This can be overcome by insisting that no truck is allowed in the aisle when picking is taking place, although this isn't the most efficient use of resources.

Figure 10.32 Toyota VNA truck

A recent innovation is Jungheinrich's Warehouse Navigation System for Very Narrow Aisle Trucks.

The VNA continually feeds back its location via transponders in the floor of the warehouse. Orders received from the warehouse management system are transmitted to the truck's radio data terminal. The terminal's logistics interface translates and passes on this information directly to the truck controller (not the driver). This means the truck knows the exact destination to approach. The driver simply has to give the travel/lift command and the truck approaches the pallet location automatically in diagonal travel in the most efficient way possible.

The advantages are as follows:

- efficiency increased by up to 25 per cent;
- alleviates driver stress;
- automatic responses without scanning;
- preventing incorrect put-away and retrieval; and
- less damage on the racking.

VIDEO 10viii Linde navigation

Articulated forklift trucks (Flexi, Bendi, Aisle Master)

The introduction of articulated trucks has overcome a number of issues, including the flexibility of being able to operate the same forklift truck inside and outside the warehouse. However, these trucks are akin to a well-known yeast extract product – you either love them or you hate them; there doesn't appear to be any middle ground. Training can potentially take longer than for an equivalent truck and put-away and retrieval times will vary depending on the ability of the driver. Bendi are confident that their trucks can produce increased productivity figures in similar aisle widths to a VNA truck.

Until the articulated truck was introduced, companies had little alternative but to operate a two-truck system with a counterbalanced truck working outside and feeding a reach truck inside the warehouse. With the arrival of articulated trucks, users can eliminate this often costly and generally inefficient arrangement. Articulated forklift trucks load and unload vehicles and deliver pallets directly to the racking in a single operation. By doing so, they increase efficiency and productivity whilst abolishing double handling and the costs associated with running a larger truck fleet than is necessary.

VIDEO 10ix Articulated FLT from Narrow-aisle Flexi

The truck manufacturers argue that during a typical work cycle over a one-hour period a reach truck will move 25 pallets; over the same time and doing the same job, an articulated forklift can potentially move up to 35 pallets, according to John Maguire of Narrow Aisle Flexi Limited.

A recent addition to the AisleMaster fleet is the AME-OP, which is a stand-on electric-powered articulated forklift truck. This truck can operate both inside and outside the warehouse, lift up to 2,500 kilograms to 12.1 metres and operate as an order picker as it has a step through operator compartment allowing the operator to pick from ground level (see Figure 10.34).

Figure 10.33 Articulated forklift truck

Figure 10.34 Articulated forklift truck with low-level picking capability from AisleMaster

CASE STUDY Narrow Aisle

Rico Logistics, the diverse high quality industrial and parts fulfilment group, has maximized the storage capacity of its new warehouse facility on the outskirts of Birmingham by reconfiguring the internal layout of the site around a high-bay narrow aisle racking system served by a fleet of 14 metre lift Flexi articulated lift trucks supplied by Narrow Aisle.

Rico leased the 164,311 sq ft building at Minworth in Summer 2019 to support their rapidly expanding business and, following a consultation with Narrow Aisle's Warehouse Systems Division, the original guided narrow aisle storage scheme was stripped out of the build and the company opted for a design that allowed all of the available space to be utilized.

By introducing new pallet racking that made use of the full height of the building, Rico has been able to optimize pallet locations and pick faces and ensure that the site delivers the most cost-efficient storage cube utilization.

Figure 10.35 The Translift SpaceMate

The project was undertaken in two phases and provides some 11,000 pallet locations – an increase of 12 per cent on the facility's capacity previously. At its highest point, which is in the apex of the building's roof structure, the new racking delivers a 14 metre high top rack beam.

A fleet of five Flexi ACiON articulated VNA trucks were supplied. The company claim that a 16 per cent increase in pallet movements has been achieved on each charge cycle with this new digital motor technology.

The Flexi ACiON includes an advanced suite of 'cobotic' technology, which allows features such as the operator's vision camera height selection system and aisle sensing.

Picking pallets at height is not a problem for the Flexi ACiON thanks to the truck's integrated tilting carriage and fixed mast design, which eliminates mast sway – even at heights of 14 metres.

'By fixing the mast and allowing the operator to tilt the fork carriage, pallets can be picked and put-away on the top beam of the highest racking smoothly, safely and efficiently,' says John Maguire.

The HiMax truck can be equipped with 'reverse proximity sensors' that provide a clear audible and visual indication when approaching any object in reverse, especially useful when manoeuvring at rack aisle ends.

Safety at Rico is further enhanced by the Flexi ACiON's 'smart stop' system. The 'in-aisle sensor' disables the truck if it has come in to contact with an object, such as pallet loads, racking or rack guards within the aisle. The truck can only be restarted once the driver has reported details of the collision to the designated line manager, thus ensuring that no potential truck/rack impact incidents go unreported.

John Maguire says: Some of the most serious incidents of rack collapse within warehouses occur because truck operators fail to report collisions and the damage caused goes unnoticed until it is too late. The Flexi ACiON's "in-aisle impact sensor" system and cut-out feature mean that there is absolutely no chance of aisle impact being overlooked.'

Sideloaders

The sideloader is designed to handle long loads safely. By eliminating the need to travel with elevated long loads, the unit provides greater stability. Its integrated platform with low centre of gravity also provides a more stable base.

A recent innovation is the hydrostatic all-wheel drive truck, which differentiates itself from the traditional sit-down sideloaders by offering operators the opportunity to drive in all four directions. Lift capacity ranges from 2,500 kilograms to 8,000 kilograms.

The Combilift SL allows companies to have the benefits of narrow aisles, superior manoeuvrability and the ability to block or bulk stack by driving forwards.

Hubtex have recently introduced a fully automated electric, multi-directional sideloader. The truck is able to recognize various long loads that protrude beyond the truck and also includes dynamic mapping and precise positioning technology.

Figure 10.36 Combilift sideloader (courtesy of Locators)

AGVs

Toyota suggest that 70 per cent of the cost of operating a forklift truck is related to the driver. As a result, many companies are considering the introduction of AGVs. An AGV has the ability to transport product horizontally and more recently, vertically.

VIDEO 10x Toyota autopilot

Jungheinrich suggest that if at least three of the following relate to your own warehouse operation then you should consider the introduction of AGVs.

- Your operation is multi-shift.
- Your daily operation involves continuous transport with long/repetitive movements.
- You handle standardized unit loads such as euro pallets, industrial pallets and lattice boxes.
- Your warehouse utilizes lift heights up to 6 metres / or up to 13 metres for high-rack stackers.
- You suffer frequent damage caused by manual transport.
- You are looking to optimize your resources.
- You are looking to reduce operational costs.
- You are concerned with social distancing and the safety of your staff.
- Your intralogistics need to be more efficient, flexible and crisis-proof.

These forklift trucks are also designed to be dual mode, which can operate either with an operator or completely autonomously. This allows a phase-in of automation and/or the option to operate in a mixed environment that comes with the benefit of maximum flexibility.

Table 10.3 Comparison chart for MHE (courtesy of Locators)

Skip table

Product type	Lift height (mm)	Aisle width (mm)	Lift capacity in kg from	To
Hand pallet truck, pallet jack	N/A	1,800	1,000	3,000
Powered pallet truck	N/A	2,400	500	3,000
Powered pallet stacker	1,350–6,300	2,400–3,000	1,000	2,000
Reach truck	3,000–13000	2,650–3,150	1,000	2,500
Counterbalance truck	3,000–7,500	3,000–6,000	1,300	5,000
Low-level order picker	N/A	1,600	1,600	2,500
Medium-level order picker	2,000–4,700	1,600 – 2,300	1,000	1,200
High-level order picker	4,700– 11,000	1,600 – 2,300	1,000	1,200
Combination truck	3,000 – 18,000	1,600–2,300	1,000	1,500
Articulated forklift truck	Up to 14,000	1,600–2,200	1,000	2,000

NOTE Prices at October 2020 UK only.

SOURCE Courtesy of Locators Ltd

The aisle width quoted is the minimum requirement. Any operation that has more than one truck operating in an aisle at the same time will require wider access.

Figure 10.37 Linde AGV

Specialized equipment

Not all unit loads can be moved or picked up by standard pallet forks. There are a number of operations and products stored within a warehouse which require specialized handling equipment.

Examples of additional equipment are as follows:

- extended forks: used for retrieval from double-deep racking and for the movement of large or multiple pallets;
- crane attachment: used for picking up heavy bags, etc;
- boom attachment: used for picking up loads with a central coil, eg tyres, carpets;
- drum grip and clamps: used for moving drums and barrels;
- load clamps: used for moving or tilting items;
- carton clamps: used for lifting or moving large boxes or white goods;
- rotating paper roll clamps: used for moving and lifting paper reels;
- double pallet handlers: ability to move two pallets at the same time;
- slip sheet attachments: load push/pull mechanism for moving product from a slip sheet onto a pallet; and
- sideloading attachment for longer loads (see Figure 10.38).

Figure 10.38 Articulated forklift truck with sideloading attachment (courtesy of Bendi)

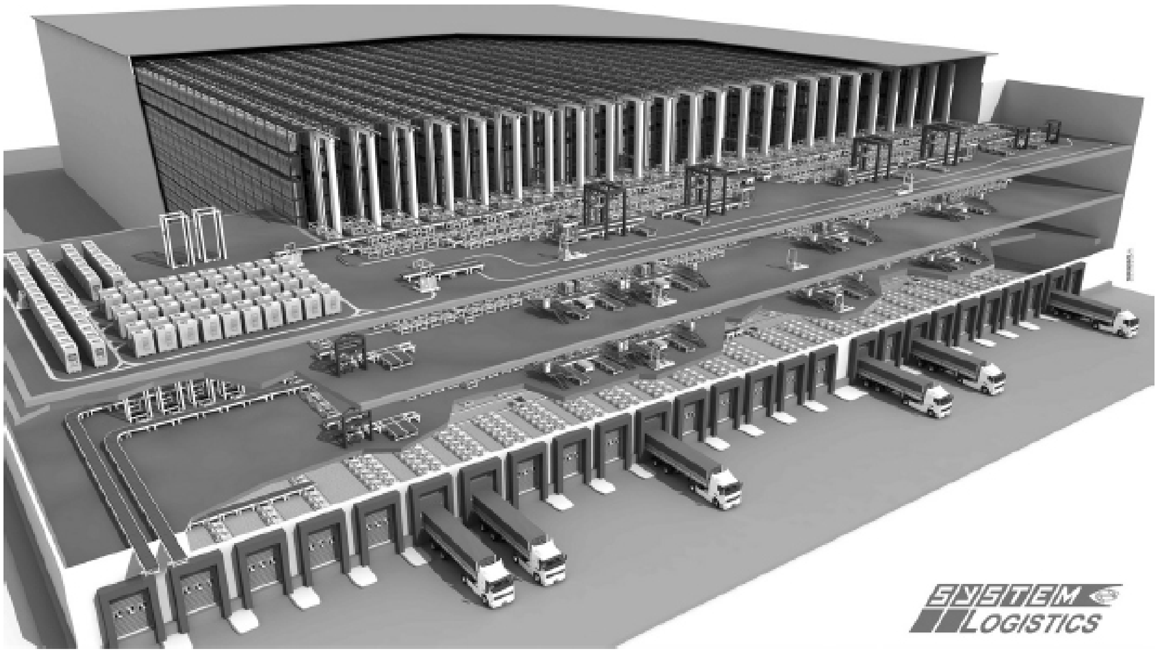
Automation – pallets

There is still a low take-up of fully automated warehouses. Automation is a big step to take and it is a decision that should not be taken lightly. However, according to Swisslog's Roland Martin 'Within e-commerce distribution, where unpredictability is a constant factor, flexibility in the supply chain becomes critical. Flexibility can be derived from implementing the right automation that can support the fluidity that e-commerce services require.'

He goes on to say: 'The right automation allows fewer manual touches, resulting in more accurate orders, improved ergonomics, lower labour costs and travel time, and fewer returns. It also saves space by operating in a smaller footprint.' Automation requires a great deal of preparation and time spent on design, evaluation and implementation. Automation can provide significant improvements in productivity and accuracy – but it can also prove to be the wrong solution. In 2004 a major supermarket chain in the United Kingdom had to write off over a quarter of a billion pounds' worth of automated equipment and IT systems due to the failure of the system to improve on-shelf availability.

Continuing to do what you've always done but more quickly and potentially with less paper is not going to improve your overall performance. As Drucker (nd) said, 'Do not believe that it is very much of an advance to do the unnecessary three times as fast.'

Figure 10.39 Highly automated solutions (courtesy of System Logistics)



Automation has its place; however, there are a number of disadvantages. These include:

- High opportunity cost: could the investment have been spent more effectively elsewhere?
- High investment costs: building, equipment, information technology.
- System failure: operations are entirely reliant on technology.
- Standardized unit loads are required.
- Anomalies are not accepted and need to be handled separately.
- More quality control is required on intake.
- High cost of disposal of equipment.
- Lack of flexibility.

Automated storage and retrieval systems (AS/RS)

This system utilizes fixed path cranes to collect pallets at the front of the racking system and transport them to empty locations within the racking. In order to improve productivity, the system collects a full pallet from the racking and deposits it at the front of the aisle prior to collecting another pallet. This dual-command system or task interleaving is very efficient. The crane can travel horizontally and vertically simultaneously, thus reducing travel time between pick up and put down.

The cranes will normally remain in one aisle. However, where storage requirements are relatively high and throughput relatively low, the cranes can be transferred from one aisle to another using transfer cars.

The racking can be one deep or potentially two deep, necessitating retractable forks. To fully automate the process, pallets are collected by AGVs and taken to the despatch area.

Figure 10.40 Crane system for AS/RS (courtesy of Stöcklin Logistik)

CASE STUDY

The automated warehouse designed by System Logistics for Tosano Group is located within the existing distribution centre and is dedicated to the handling of ‘General Groceries’. It has been built in two distinct phases. The first phase involved building a pallet storage warehouse equipped with 10 double depth stacker cranes and a fully automated picking system referred to as MOPS1.

The stacker cranes built within the distribution centre are 18 metres high. They store approximately 27,000 pallets and have a production capacity equal to 300 in/180 out per hour. An overhead handling system (hung monorail trolleys) with productivity equal to 525 pallets/h has been provided to connect the automated warehouse resulting in:

- reduction of storage space and automatic handling of over 18,000 SKUs in the picking process;
- high hourly productivity that translates into high daily volumes and consequently into prepared and shipped volumes;
- wide variety of packages handled: the MOPS system handles the individual packages without using trays or other supports.

VIDEO 10xi System Logistics pallet automation system

The following video is an automated pallet system provided to Britvic soft drinks by Logistex.

VIDEO 10xii Logistex Pallet automation system

Recent technical advances

Forklift truck manufacturers are continually looking to introduce new technology to enhance the capabilities of their forklift trucks.

Jungheinrich's automated pallet scanning and identification solution is an integral part of the forklift truck and brings considerable time and efficiency advantages to the supply chain.

The new fork-based scanning process not only results in significant time savings compared with manual scanning but reduces the forklift driver's workload and ensures low picking error rates.

They have also introduced a system that provides a position-based analysis of stacker movements that can be viewed live or retrospectively using a web-based application. Each stacker is fitted with a smartphone that communicates with Bluetooth transmitters – so-called 'beacons' – placed throughout the warehouse.

The TruckFinder function shows the current position of a vehicle inside the warehouse live, whilst ZoneGuard allows the user to define the warehouse zones in which vehicle operation is permitted.

As soon as a vehicle leaves the allowed zone, the designated recipient receives a warning via e-mail. SpeedZoning enables the customer to define special areas with warnings on speed limits, incorrect parking, etc.

The RouteOptimizer function helps optimize warehouse operations by presenting a visualized analysis of the routes travelled. This can assist in redesigning the storage locations and moving certain stock into more efficient locations.

Linde have introduced the interactive warning vest, which improves safety in situations where visibility is poor. This piece of clothing alerts the wearer as soon as an industrial truck is nearby by emitting light signals, acoustic warnings and vibrations. The safety benefit is twofold: first, the vest alerts the wearer to the potential danger, and second it increases the visibility of the individual themselves. A warning also appears on the truck.

With pressure from the environmental sector and a need to reduce energy consumption within the warehouse, manufacturers are also looking to alternative energy sources. These include the introduction of hybrid vehicles and fuel cells that are used to power lift trucks in high-throughput warehouse applications. According to Jason Reynolds from Baumann, the high cost and complexity of Stage 5 diesel engines and with red diesel use being abolished in most sectors, this will see the decline in the use of IC forklift trucks. Hydrogen fuel cells can offer higher productivity in electric lift trucks because they can be rapidly refuelled in minutes by operators, eliminating the need to change, store and maintain batteries. Plus, fuel cells produce constant voltage, which means there is no battery drop towards the end of a shift.

In a conventional electric forklift, the energy used to drive the truck is stored as electricity in a lead-acid battery. In a fuel cell-powered forklift, energy is stored as hydrogen gas and converted into electricity as needed

Using fuel cells in high-throughput warehouse applications helps improve warehouse productivity, lower operating costs, and reduce waste products.

In a three-shift operation, up to three batteries plus a charger may be needed per forklift, as well as room to store and maintain them. Battery power will not be obsolete as we will also see a growth in lithium ion batteries.

A number of trucks are also able to return charge to their batteries through regenerative lifting and braking. We will also see a growth in new charging technologies such as wireless charging.

John Buckley at Toyota recently said that in the future Toyota 'will offer digitally controlled horizontal pallet drones and high lifting four way stacker drones'. He went on to say that software will play a more significant role in the future with site telemetry to control access and remote diagnostics.

Figure 10.41 Toyota hybrid truck (courtesy of Toyota)

Summary and conclusion

The choice of equipment very much depends on the product characteristics, the warehouse dimensions and environment, the required velocity of the product through the warehouse and the available budget.

Technology within MHE is fast moving and although the counterbalance truck remains popular even after all these years it is also being adapted to keep up with these advances.

The majority of mechanical handling and storage equipment manufacturers have sophisticated systems including simulation software that is able to assist companies with their decision as to what type of racking and MHE will efficiently suit their operation. This service is normally free and although a potential sale is the goal, so is a satisfied customer.

11
Resourcing a warehouse

DAVID CAIRNS AND GWYNNE RICHARDS

> *The devil is in the detail.*
> (ANONYMOUS)

Introduction

Resource planning is all about aligning operational demand with resource allocation. Labour is traditionally the largest component of a company's distribution and fulfilment cost, typically ranging between 35 and 65 per cent. Thus the management and allocation of labour is crucial to the efficiency of the company. The higher the level of unpredictability in workload the higher the likely increase in resource cost. It is therefore important to invest time in understanding the fundamental drivers of workload and which ones, if any, you can influence. Communication both internally with other departments such as marketing and externally with key customers is one of the most important aspects of resource planning.

Having examined both people and equipment within the warehouse, we now turn our attention to how much of these resources we require to operate efficiently.

The types of resource found in a warehouse are numerous and will include operatives, equipment, consumables, general supplies, etc. In this section the focus will be on the two main types generally associated with warehouse operations – labour and equipment.

These are generally acknowledged as key, as under-resourcing will usually mean failure to meet service targets, whilst over-resourcing will mean failure to meet financial performance targets. However, whilst other resource types may appear less significant, the effects of inaccurate ordering of consumables can be equally dramatic – for example, running out of stretchwrap may contribute to damaged goods in transit, whilst no labels to print can result in a loss of ability to track product through a warehouse and potentially an inability to fulfil orders.

Resources can be categorized by the principal driver of requirements: there are two main categories: determined by level of processing activities; and determined by other factors.

In today's warehousing environment there are many examples of operations that capitalize on advancements in technology and employ automated solutions or rely heavily on high levels of system functionality. In particular, warehouses servicing e-commerce applications, can have different dependencies in terms of resources. The principles of modelling these resources can differ for some applications and these are addressed later in the chapter.

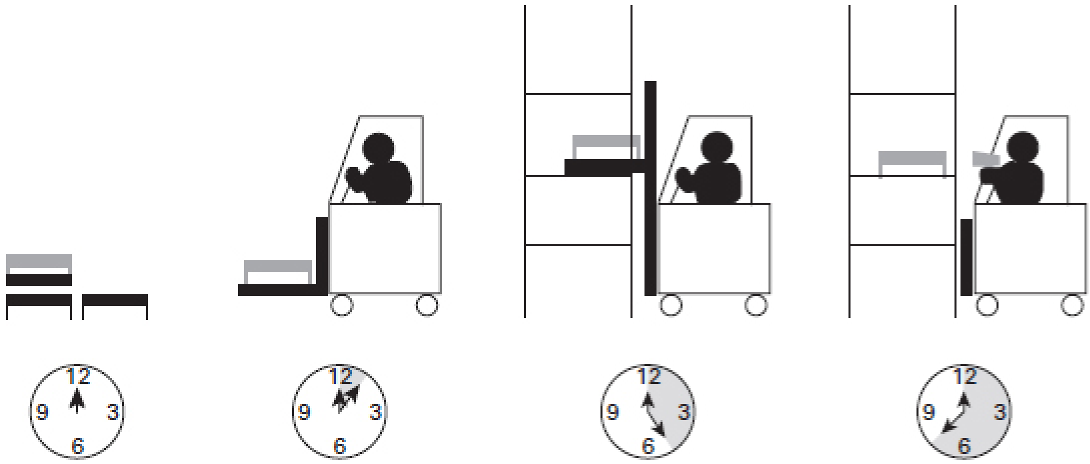
Processing activities

Processing activities will generally involve handling (touch points) product and will generate 'multiples' of resource, for example receiving product into a warehouse. By contrast, a good example of a resource whose level is determined by other factors is site security, where manning is likely to be determined by warehouse operating hours.

There is no absolute definition as to how to categorize resources, but a good guideline for ‘processing activity’ resources is one where a small change in activity level will change the level of resources employed.

For example, Figure 11.1 illustrates the activity of put-away (of pallets to racked storage). This is a processing activity: the units measured are pallets over a set time period, the work rate (productivity) is the time taken to identify and collect a pallet, transport it and lift it into its storage slot, confirm the put-away (in this case a barcode scan is assumed) and return to the start location for the next put-away task.

Figure 11.1 Put-away time illustration



The time for this single put-away cycle can be expressed as pallets per hour (or as minutes per pallet) and the division of the productivity rate into the activity level generates a number of hours for the task in the given time period. See Table 11.1.

Table 11.1 Task breakdown

Skip table

Daily volume (average)				
Activity description	**Activity (units)**	**Unit of measure**	**Productivity standard**	**Hour**
Put-away:				
Collect pallets, put-away in wide aisle racking	198	Pallets	24	
Collect pallets, put-away in drive-in racking	300	Pallets	16	
Collect pallets, put-away in pick locations	2	Pallets	5	

This is based on a simple warehouse operation putting away 500 pallets per day. There are three put-away options for inbound product:

- into standard wide aisle reserve slots (upper levels, above picking slots);
- into high-density storage (in this example drive-in racking);
- into pick slots (ground-level wide aisle racking – for the small amount of product with no current stock).

Each has a different productivity standard to reflect the different nature of the task. To calculate the time for put-away into drive-in racking slots, the calculation of the workload for the day is:

300 pallets ÷ 16 pallets per hour = 18.75 hours

This activity utilizes an operative and a reach truck and therefore generates 18.75 operative hours AND 18.75 reach truck hours.

For this example, it is assumed that reach trucks have a truck-mounted terminal and barcode scanner. If the operative uses voice technology, 18.75 hours of voice terminal use will also be generated. It should be noted that time generated is the time that each resource is committed; this may be different to the time the resource is being used. In this example the RF scanner may be used for scanning for less than 30 seconds in each put-away cycle, and its active use may be 2 hours per day for the task identified; however, the scanner must be available to the operative when needed and it is therefore committed to 18.75 hours per day for put-away to drive-in racking. The time actually used will assist in determining how frequently the battery needs recharging and in turn will determine levels of that resource.

When constructing a resource model, there needs to be a balance between creating task lines for every element of work and recognizing where elements are interdependent and should be considered collectively. This process is different from work study as it is driven by different considerations. For example, in the illustration above there is an element of direct put-away.

This is intended for product that, when received, goes direct to the pick face to provide product for order fulfilment. In practice, this is likely to apply to a very small proportion of products where supplies have been temporarily out of stock.

In this process it is assumed that the reach truck driver will include this process element in his/her daily work. Alternatively, the driver could deliver the pallet to the front of the aisle and a second operative, using different equipment, could be employed to place product into the pick face. This is illustrated in Table 11.2.

Note that in this example a second unit of measure has been added (cartons) along with another piece of equipment – a powered pallet truck. Additionally, the RF scanner will need to be a different scanner to that associated with the reach truck.

In both approaches we can see that each additional unit to be processed generates an incremental resource requirement.

Table 11.2 Task breakdown, version 2

Skip table

	Daily volume (average)			
Activity description	**Activity (units)**	**Unit of measure**	**Productivity standard**	**Hour**
Put-away:				
Collect pallets, put-away in wide aisle racking	198	Pallets	24	
Collect pallets, put-away in drive-in racking	300	Pallets	16	
Collect pallets deliver to aisle	2	Pallets	30	
Load cartons to pick face	80	Cartons	240	

Work rates (productivity)

A key element in the resource budget is the productivity rate. There are many ways to set productivity rates. Quantitative benchmarks can provide useful comparisons; however, no two warehouses are identical.

Productivity rates are driven by multiple factors and where significant change or a new warehouse is being considered it may be difficult to establish productivity rates accurately. The following three options are regularly employed to establish budget productivity rates:

- synthesis: composite construction of productivity rates for an activity from components of each work element;

- work study: preferably using an approved work study engineer and work measurement techniques;
- historical comparison: identification of productivity levels in existing operations and factoring in change elements.

The last option is probably the most accessible. It relates to an existing work profile and has a number of the inherent characteristics that drive productivity (hit rates, order composition, etc). If a key driver for a new warehouse is productivity improvement, then understanding and building from the existing process can help identify improvements.

A warehouse simulation software package such as Class by Körber Supply Chain can be used to validate the data.

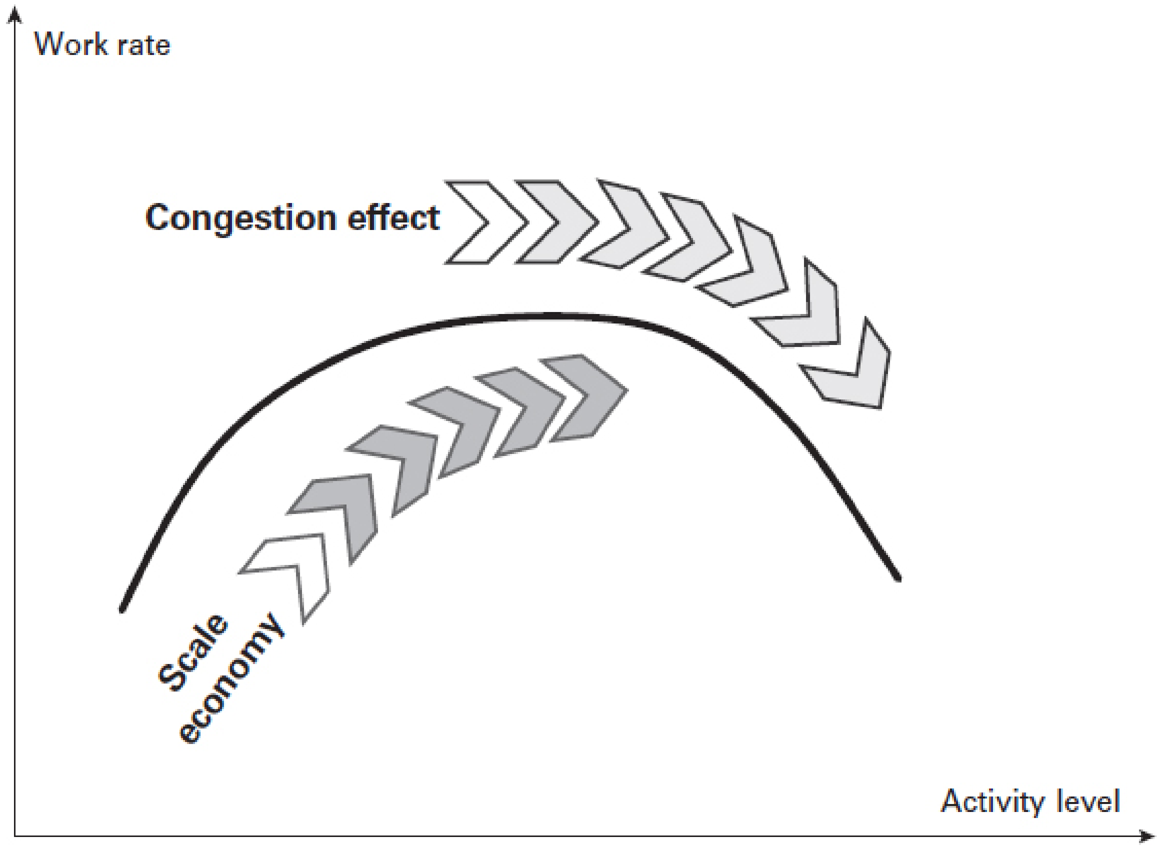
Points to bear in mind are the size of the new warehouse and the likely increase/decrease in travel time. If the new warehouse is significantly larger, performances may reduce as a result of longer travel distances within the warehouse. A change of equipment will also have an effect on productivities (for example, moving from one- to two-pallet capacity picking trucks).

Comparison with available productivity benchmarks is useful, as is supplier data for envisaged equipment. When options have been reduced to a shortlist, it is appropriate to invest time and cost by reviewing, in detail, these productivity rates to confirm assumptions and further refine and subsequently build confidence in the rates.

Techniques such as simulation may also be appropriate at this stage and may be particularly relevant where congestion is a factor in driving change. In an established situation, there are often common effects. Generally, increased activity provides opportunities to improve productivity, through increased order sizes and picking full as opposed to part cases and pallets. However, growth can also result in bottlenecks and delays occurring whilst operatives are obliged to wait to carry out specific tasks. These delays and related effects can be classed as ‘Congestion’ effects. Figure 11.2 shows the typical combined influence of scale economies and congestion on work rates.

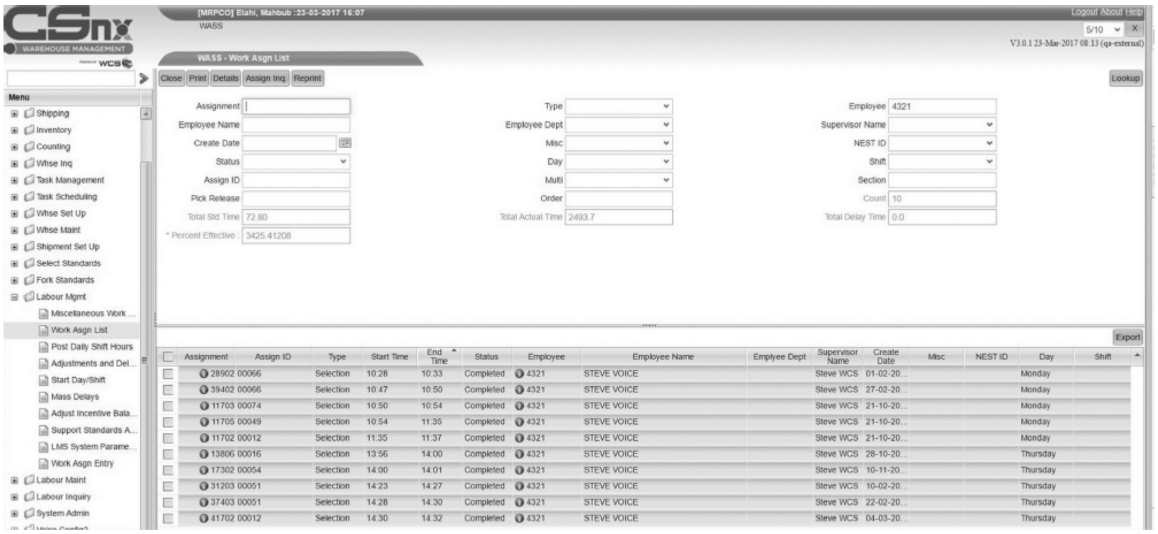
In practice, the scale economy effect is generally easier to identify than the congestion effect. As a guide, the scale economy effect will progressively flatten and an ‘optimum’ productivity rate may be achieved – the congestion effect, however, may materialize as minor or substantial deterioration of productivity. In these circumstances, you need to identify the bottleneck and consider introducing processes to improve throughput. From a picking perspective, multiple pick faces for the most popular product lines is an example.

Figure 11.2 Growth factors influencing work rates



A number of WMS (warehouse management systems) now include labour management modules that can provide information on individual assignment work content – this functionality generally uses the synthesis approach combining recognized individual activities with individual characteristics for an order/assignment (such as actual distance travelled to complete assignment). For resource budgets the outputs from such systems can be aggregated to provide budget standards. See Figure 11.3 (screenshot of a labour management system).

Figure 11.3 Screenshot of a labour management system (courtesy of WCS)



As the trend for more frequent, faster deliveries gathers pace, organizations are relying on technology to not only manage the flow of goods through their warehouses but incentivize and manage their labour operation to achieve peak performance.

Companies now expect core WMS functionality to include labour management modules (LMS) as standard. Through the use of LMS, warehouse staff can have performance goals set against accurate performance values for specific tasks, achieve bonuses based on outcomes and feel they offer a valuable contribution to the running of the operation.

An LMS can produce all the statistics and reporting requirements needed to optimize scheduling, set performance expectations and manage the workload more efficiently across the workforce. An integrated system is dynamic, so that when an order is released within the system all labour requirements are measured and calculated automatically. This allows warehouse managers to download live reports whilst monitoring activity and making appropriate adjustments to workforce allocation throughout the day.

Figure 11.4 shows an Excel program utilized by Wincanton to enable them to plan their resources efficiently within each of their warehouses.

Figure 11.4 Resource planning program (courtesy of Wincanton)

Wincanton Warehouse Benchmark Model v13

Site	Midlands No.4	Date	15/02/2017

Goods In

	Units per Annum (smallest units handled)	37,859,200
4,4,5 Monthly **Weeks in Month**	Pecentage per Month profile	
4	January	6.03%
4	February	5.70%
5	March	7.34%
4	April	10.79%
4	May	10.83%
5	June	12.80%
4	July	7.32%
4	August	6.32%
5	September	7.95%
4	October	6.93%
4	November	8.06%
5	December	9.94%
	Total	100.00%

Inbound Case Split Percentage	**Percentages**
Full Pallet	78.50%
Cage	14.90%
Handball (Containers)	6.25%
Loose Cases	0.35%
Total	100.00%

Unload Method	**Split**
Off Load Side	65.00%
Off Load Rear	35.00%
Total	100.00%

Cases Received Per UOD type	
Cases per tote	6
Cases per Full Pallet	82
Cases Per Cage	36

UODs per Vehicle	
Pallets Per Vehicle	21.5
Cages Per Vehicle	54
Cases Per Loose Delivery	24
Cases per Container	1200

Goods Out

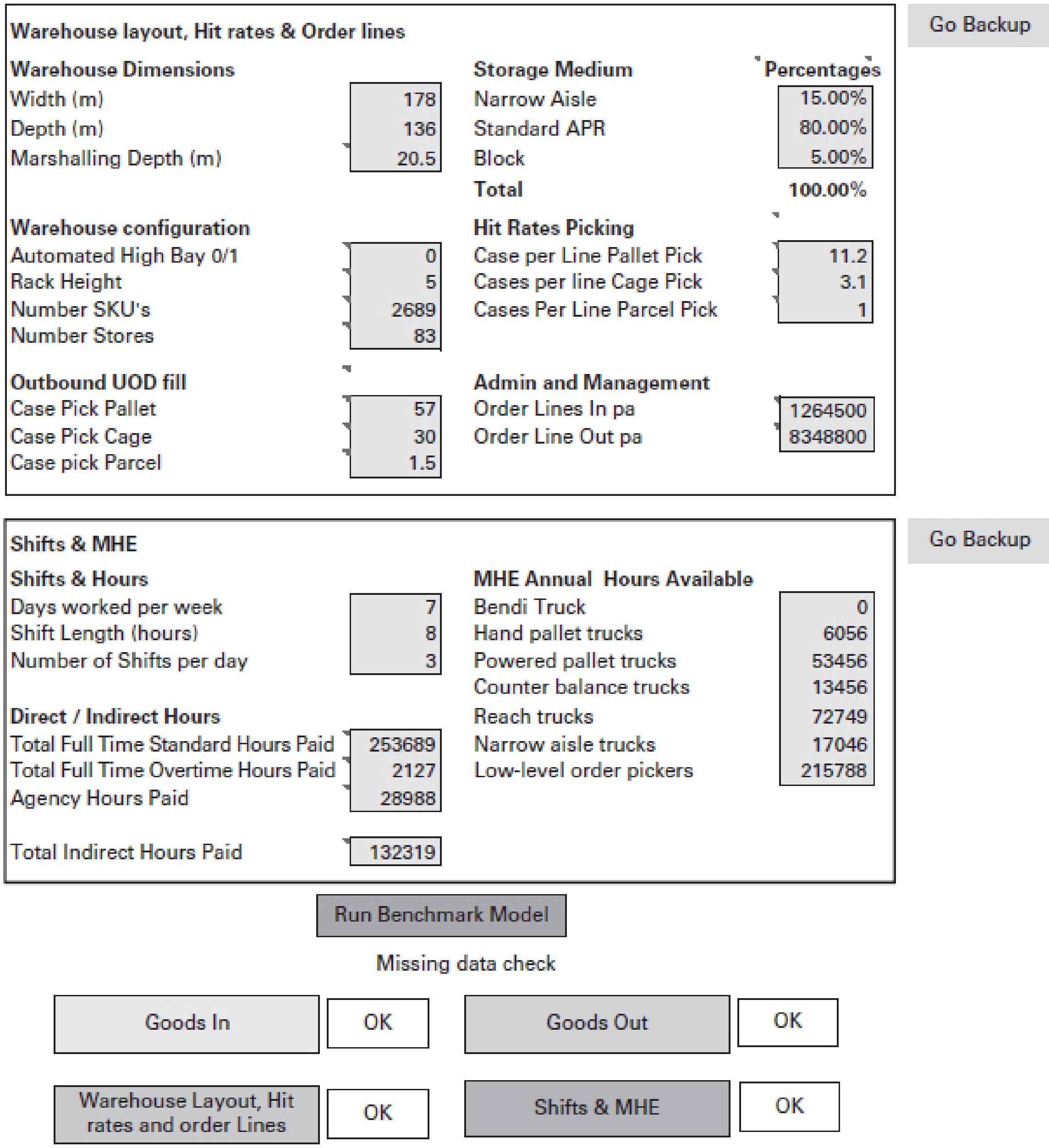
Units per Annum (smallest units handled)	37,859,200
Pecentage per Month profile	
January	6.38%
February	6.13%
March	8.54%
April	9.22%
May	8.98%
June	11.01%
July	7.45%
August	6.91%
September	8.50%
October	7.69%
November	8.05%
December	11.14%
Total	100.00%

Outbound Split Percentage	**Percentages**
Cases Cross Docked on pallets	15.99%
Cases Cross Docked in cages (calc)	14.90%
Case Picked on Full Pallet	1.03%
Case pick Pallet	54.10%
Cage Pick	13.98%
Parcel pick	0.00%
Total	100.00%

Load Out Method	**Split**
Side Load	5.00%
Rear Load	95.00%
Total	100.00%

Cases Despatched %age	**Split Calc**
Full pallet	17.02%
Case pick - Total	68.08%
Parcel Pick	0.00%

Case pick split Pallets	79.5%
Case Pick split Cages	20.5%



▶ Figure 11.4 details

Demand volatility – seasonality and in-week/in-day variation

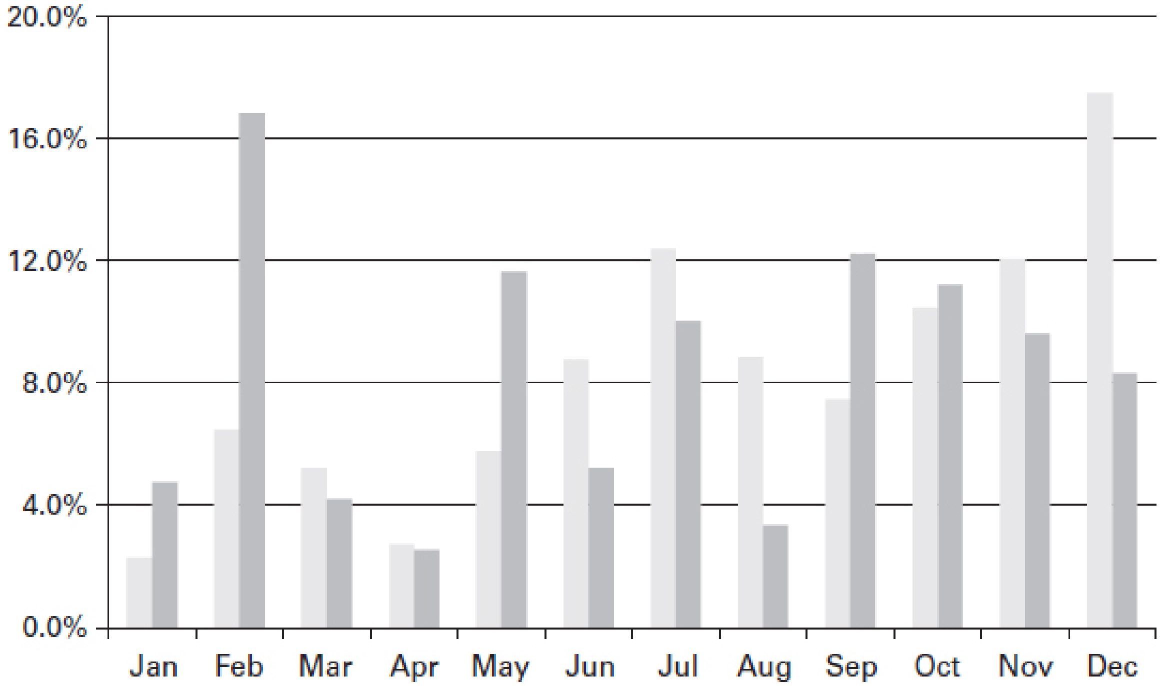
A fundamental characteristic of most businesses is that demand is variable. There is a need to model variations in demand to understand how the resource requirements will change.

The key to developing an effective resource plan and budget lies in understanding when specific warehousing activities are likely to occur. There are three main sources of variance in demands on a warehouse:

1. Seasonal variations through the course of a year. These range from clearly recognized seasonal demands, such as the sale of barbecues in summer, to variations influenced by general purchasing behaviour.
2. Variations during the course of a week. These are typically influenced by sales patterns of customers and associated buying processes; for example, there may be a surge in orders following sales at the weekend or, by contrast, a push to meet projected sales through promotions. See Figure 2.2 in Chapter 2.
3. Variations during the course of a day. This is most obvious when considering order placement on the warehouse. Many service businesses will seek to place orders up to close of normal trading for next-day delivery – in these instances the warehouse is unlikely to see complete, scheduled orders until late afternoon or early evening. The growth in B2C fulfilment has led to more variable order generation and, in many cases, substantially shorter lead times between order receipt and requirement to despatch.

Activity profiles generated during data gathering or from existing trading patterns should provide a good indication. In many operations there are predictable changes in operating profiles at peak periods – there may be larger order sizes and a tradition of a longer working day/week; in these circumstances it may be appropriate to model ‘peak’ activity alongside ‘average’. Figure 11.5 is drawn from a live warehousing situation and illustrates through the year variation.

Figure 11.5 Demand variability



▶ Figure 11.5 details

The columns in Figure 11.5 represent units and order-lines, illustrating variations in profile composition as well as activity. In this instance there was promotional activity in February, followed by selling pushes in May and July with a more sustained peak towards the end of the year. The average is 8.3 per cent per month; even with allowances for diseconomies of scale in productivity, resourcing this profile will need to address a substantially lower need for resource in the first half of the year.

Resourcing models can be quite sophisticated and require a great deal of work to construct. There are situations where, if volumes are not significantly high but seasonality plays a big part, a simple use of standard deviation will suffice. So, for example, taking a workload dataset – say picking over a period of one year – and looking at significant variance, three standard deviations from the norm gives a reasonable picture of resource requirements. Note that it's also a good idea to segment this by day of the week as we tend to see fluctuations daily.

Resource modelling

An illustrative example has been used to demonstrate typical modelling techniques. The following profile applies:

- Single stand-alone warehouse (ambient goods).
- Incoming product received on pallets (side-loaded vehicles) and containers (loose loaded).
- Storage is palletized (standard wide aisle adjustable pallet rack + drive-in pallet rack).
- Core business is carton/pallet pick, palletized despatch on tailgate loaded vehicles.
- Additional area for support activities such as relabelling, promotional packing, export preparation (Value Add 1) (product is processed and returned to warehouse stock).
- Additional area for e-commerce business providing unit pick-and-pack for internet customers (B2C). Despatch as parcels through carriers.

Four levels of activity are defined – average (24 weeks), low (18 weeks, including some with no working on public holidays); these 42 weeks traditionally operate as 5-day weeks, whilst the remaining higher activity periods – high and peak (5 weeks each) operate 6 days to meet increased demand.

In this example two profiles have been modelled – for average and peak levels of weekly activity – and low and high levels are extrapolated from these core profiles. Usually, the modelling process begins with producing either an averaged figure (say an average day or week); however, an alternative option is a typical day/week, ie the mode – where a typical day represents what happens on most days of the year, but is not necessarily the average. This is often appropriate where there is a prolonged or pronounced peak as found with seasonal products.

The main activities within the warehouse, with associated productivities and volumes for average and peak profiles, are shown in Table 11.3.

The model generates summary information for labour and each equipment type and includes data summarizing activity level. In this illustration the modelling will be taken forward using data summarized by area of activity and by equipment used; however, there is the means to include further variation using this source, for example if modelling variable mix between intake and despatch, which would reflect a stock build ahead of a peak period.

There is an important need to establish the relationship between the data used in modelling and the total volume (measure of activity) that the resource budget covers. This will typically be one year, and at various points in the modelling process it is advisable to undertake a reconciliation, by multiplying each model activity element by the number of relevant days/weeks and summing to generate an (annual) total that the modelling caters for. This can also be achieved by including a data line that generates a common figure, eg number of cases affected by the components.

The next stage of modelling addresses the second variation category – day-to-day seasonality. In many businesses, profiles will emerge that show different levels of activity on different days of the week as seen in Figure 2.2, with businesses serving fast-moving retail outlets likely to exhibit demand patterns that will reflect purchasing behaviour. The precise effect can vary if a business pulls stock (ie replenishes sales made) or pushes stock (pre-empting anticipated sales), with busiest days (for a warehouse) likely to occur after or before the busiest sales day, depending on method of supply. Note that for e-commerce the relationship is more directly linked to customer demand, with warehouse activity patterns closer to the pull model.

Table 11.3 Example of resource model

Skip table

Process	Activity description	Daily volume (Average) Activity (Units)	unit of measure	Pro st (U
Goods in	**Goods receiving**			
	Prep (veh ID, etc) / Process documentation-trailers	15.36	vehicles	
	Open vehicle (trailer-tailgate offload only)		vehicles	
	Offload pallets (side offload, place in receipt bay)	384.0	pallets	
	Inspect pallets (inc count, label scan)	384.0	pallets	
	Remedial work – repalletization (replace pallet)	2.9	pallets	
	Remedial work – repalletization (stack cases)	230.4	cases	
	Prep (veh ID, etc) / Process documentation-containers	3.8	vehicles	
	Open vehicle (container)	3.8	vehicles	
	Provide pallets for palletization of cases	96.0	pallets	
	Offload cases (from container) & palletize	7680.0	cases	

Process	Activity description	Daily volume (Average) Activity (Units)	unit of measure	Pro st (U
	Label & inspect pallets (inc count, label scan)	96.0	pallets	
	Receive goods at external storage location			
Put-away	**Put-away**			
	Collect pallets/ put-away in WA reserve slots	190.2	pallets	
	Collect pallets/ put-away in drive in slots	288.0	pallets	
	Collect pallets/ put-away in WA pick Slots	1.8	pallets	
Retrieve	**Retrieve**			
	Extract pallets from drive in for FP despatch	82.1	pallets	
	Extract pallets from WA reserve for FP despatch	4.3	pallets	
	Extract pallets from DI, replenish WA pick slot	205.9	pallets	
	Extract pallets (from WA), replenish pick slot	185.9	pallets	
	Value-add operations (1 – Case product)			

Process	Activity description	Daily volume (Average) Activity (Units)	unit of measure	Pro st (U
	Extract pallets from DI, transfer to VA area (mezz)	*12*	*pallets*	
	Receive packaging material to area (@1 lift /job)	*1*	*(pallet)*	
	Unpack singles from cases to workstations	*14400*	*units*	
	*VA process (bundling) [**aggregate for budget]*	*7200*	*units*	
	*VA process (Labelling) [**aggregate for budget]*	*7200*	*units*	
	Pack product to cases, build to pallet quantities	*14400*	*units*	
	Remove waste packaging to recycle area	*1*	*(pallet)*	
	Return pallets from VA area to storage (Drive in)	*12*	*pallets*	
	VA area indirect work	*12.5%*	*%(VA dir)*	
Case pick	**Case picking**			
	Acquire pick assignment, collect (M T) pallet	474.2	pallets	In

Process	Activity description	Daily volume (Average)		Pro st (U
		Activity (Units)	unit of measure	
	Select cases sequentially, place on order pallet	31488	cases	
	Deposit picked pallet in marshalling area	474.2	pallets	In
Marshalling	**Marshalling (Despatch)**			
	Consolidate picked pallets for despatch	394	cases	
	Detail Check (proportion of picked pallets)	13.0	pallets	
	Stretchwrap despatch pallet (picked pallets)	474.2	pallets	
Despatch	**Goods outloading (Despatch)**			
	Load Pallets (to despatch vehicles)	560.1	pallets	
	Transfer Pallets to Singles Pick'n'Pack area (mezzanine)	0.50	pallets	
	Seal Vehicle, Issue Documentation	33.0	vehicles	
	Value-add operations (2-unit pick & despatch)			

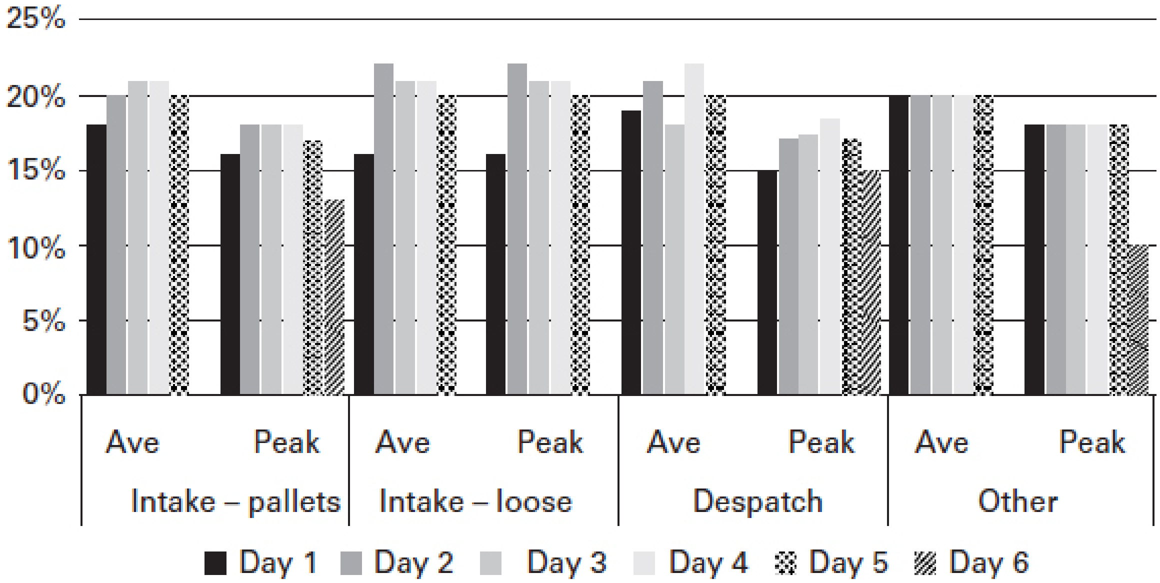
Process	Activity description	Daily volume (Average)		Pro st (U
		Activity (Units)	unit of measure	
	Receive mixed pallet of cases from main operation	*0.50*	*pallets*	
	Receive packaging materials (cartons, bags, filler)	*0.50*	*pallets*	
	Case put-away to shelf slots	*40*	*cases*	
	Unit pick (from cases), transfer to packing bench	*600*	*units*	
	Pack into shipping media, add docs & carrier label	*451*	*orders*	
	Seal packs, scan for despatch, place on ship pallet	*451*	*packs*	
	Transfer ship pallets to despatch (for collection)	*2*	*pallets*	
	Despatch via carrier (including package check)	*451*	*packs*	
	Returns – receive, examine, action	*60*	*units*	
	Indirect work hours (% of direct hours)	*10%*	*%(VA dir)*	
Other	**Other work**			
	Hygiene (planned cleaning)	2		
	Indirect work hours (% of main WH direct hours)	7.5 %		

Process	Activity description	Daily volume (Average)		Pro st (U
		Activity (Units)	unit of measure	
	- General housekeeping			In
	- Recuperation, damages, (case) returns processing			In
	- Physical stock checks, remedial activity			In
	- Handling of pallets, consumables, etc.			In
	- Other unquantified work			In
	TOTAL			
	<u>SUMMARY BY ACTIVITY</u>			
Goods in	Goods receiving			
Put-away	Put-away (to stock)			
Retrieve (FP)	Retrieve (from stock) – FP despatch			
Retrieve	Retrieve (from stock) – case picking			
Case pick	Case picking			
Marshalling	Despatch – marshalling case picked product			
despatch	Despatch – outloading pallets			
Other	Other activities (main warehouse)			

Process	Activity description	Daily volume (Average)		Pro st (U
		Activity (Units)	unit of measure	
	<u>**SUB TOTAL – Main Warehouse**</u>			
	Value-Add Ops 1 (Case product)			
	Value-Add Ops 2 (Unit Pick'n'Pack – e-shop)			
	<u>**TOTAL – All Operations**</u>			
	<u>EQUIPMENT SUMMARY</u>			
	Machine Type A: **Hand pallet truck**			
	Machine Type B: **Counterbalances**			
	Machine Type C: **Powered pallet trucks**			
	Machine Type D: **Order picker truck (LLOP)**			
	Machine Type E: **Reach truck**			
	Machine Type F: **Floor scrubber**			
	Other Equipment Type H: **Hand-held terminal**			
	Other Equipment Type V: **Voice terminal**			
	Other Equipment Type W: **Pallet wrapper**			

In practice, goods receipt is likely to follow a different profile from that of despatch in a stock-holding operation, so it is recommended to determine different daily profiles for discrete aspects of the warehouse operation. In the example, the main warehouse operations are split into palletized receipt, loose receipt, despatch and other activities, reflecting circumstances in which palletized receipt may be determined by production running times, whilst loose receipt reflects shipping and container transfer constraints. Figure 11.6 shows a graphic representation of these categories. Table 11.4 shows the daily activity levels for the two value-add operations in the warehouse. In both areas it is possible that some activities may not be extended (to a sixth day) at peak.

Figure 11.6 Daily activity profile



▶ Figure 11.6 details

The variance factors are then applied to the core resource model to generate daily resource requirements. The primary objective here is to gain an idea of overall requirements and extract a base from which to make judgements on setting resource levels. In the example, the scope of the modelling has been extended to include resource estimates for low and high periods.

It is possible to vary profiles further, and indeed vary productivity rates for different periods. For example, there may be periods of the year when case sizes vary and it is legitimate to amend the picking rate to reflect this. Similarly, productivity differences can also occur between different shifts. In practice, such additions will increase the complexity of the resource model, and care is necessary to ensure: the resulting model(s) allows for all aspects of its use to take place subsequently, eg KPI measurement and comparison; and the model does not become so complex that it loses practical application, including visibility to others.

Table 11.5 shows the application of period and daily variations to the main warehouse elements of the model at workgroup level. Similar information is available at individual activity level, and for each day of low/high period (one day shown as illustration).

Table 11.4 Value-adding service volumes by day

Skip table

		Day 1	Day 2	
Value Add 1	Ave/Peak	22%/22%	20%/20%	21
Value Add 2	Ave/Peak	24%/24%	20%/16%	16

Table 11.5 illustrates the varying requirement for resource through the course of the year. For the main warehousing operations the average daily requirement is 376.4 hours (direct labour), varying between 351.7 and 405.9 during the week; at peak the average daily figure rises to 454.7 hours, with a peak daily requirement of 507.0 hours. This implies peak days are around 20 per cent busier than average. However, the weekly requirement rises from 1,882 hours (average) to 2,728 hours at peak – almost 50 per cent; this statistic effectively affirms the logic of extending to a sixth day at peak and illustrates the nature of decision guidance that follows from careful resource planning.

Peaks and troughs of activity precipitate changes to the resources required in the warehouse. Just as there are times when additional resources are required and decisions need to be made on how to meet these needs (eg overtime, equipment hire, etc), there will also be occasions when there may be insufficient work to occupy core resources (idle time).

The approach can be applied to other elements of the operation, such as the value-add operations, and for equipment requirements.

In essence, the model progressively illustrates the key concept of variability in resource planning. The final step to introduce is the process of determining the actual levels of resource required. This invokes the third source of variability – at what times during the day is resource required.

As an example, consider despatches, which, in turn, largely determines picking. In many warehouses it is common to find that intake is biased to mornings to allow clear use of loading areas for despatch later in the day if the doors are on the same side of the warehouse. In turn, demand is placed by customers through the (office) day, with many orders being placed or finalized by a ‘cut-off’ time for next-day delivery.

In many cases such deliveries need to be loaded and en route by early morning to meet delivery schedules and, in essence, the warehouse window for picking and despatch is concentrated into the afternoon and evening.

In response to e-commerce in particular, a number of retailers have extended ordering windows to capture more customer orders. For example, UK online retailer Amazon has created service offers that essentially allow products to be delivered within hours of a customer order.

The total workload (in the example) justifies a two-shift operation and, whilst flexibility of labour allows manpower to switch tasks, some equipment is very specific in its use. In the example there are 191 hours/day of case pick on an average day (210 hours on busiest day) during an average week.

This activity – the only one to use low-level order picking trucks – takes place primarily on the late shift as there is limited work available in the morning. Despatch must be completed by the end of the day resulting in 80 per cent of activity occurring during the second shift.

In this example the requirement for low-level order picking trucks (LLOPs) is four times higher in the afternoon than in the morning; the modelling needs to reflect this, as using a daily average will lead to a serious shortfall in equipment. In the example this is achieved by allocating a proportion of each task to time windows (shift) in the working day.

Shorter time windows may be more appropriate for other operations. As the critical requirement is likely to occur on the busiest day, it is usual to use this requirement to determine equipment needs. In the example, this is Day 4, for both average and peak weeks, but it should be noted that for some equipment types the day may vary.

Table 11.6 shows the allocation of hours to shifts, and the subsequent derived numbers for equipment – this is based on the greatest required number over each of the shifts and assumes availability of 7.16 hours/shift (to match operators' availability after break allowances are taken into account).

The model in Table 11.6 has generated an estimate of the number of working pieces of equipment at average and peak periods. This is a guide for managers who are responsible for setting resource levels (equipment and labour) and require full interpretation to finalize. This process should be more of a fine-tuning effort and will take into account elements such as availability (after maintenance/repair), ability to obtain short-term hires and a practical perspective. For example, the requirement for two counterbalance trucks may be viewed as marginal so that no further provision for maintenance spares is needed (particularly if 'emergency' hire is readily available).

Table 11.5 Period and daily variations

Skip table

	Low		
	Day 3	**Day 1**	**Day 2**
Goods in	*49.4*	47.1	58.8
Put-away	*24.5*	24.3	28.2
Retrieve (FP desp.)	*4.0*	5.1	5.6
Retrieve (case pick)	*18.0*	22.9	25.3
Case pick	*143.1*	181.3	200.4
Marshalling	*14.0*	17.8	19.6
Despatch	*10.9*	13.8	15.3
other	*35.4*	39.6	39.6
	299.3	351.7	392.7
Ave/day	316.9		
Week	1584.6		

Table 11.6 Allocation of hours

Skip table

	Average / Day 4			
	Early shift	Late shift	Night shift	Ea
Goods In	46.8	11.7	0.0	
Put Away	15.9	13.0	0.0	
Retrieve (FP Desp.)	1.2	4.7	0.0	
Retrieve (Case Pick)	5.3	21.2	0.0	
Case Pick	42.0	167.9	0.0	
Marshalling	4.1	16.5	0.0	
Despatch	3.2	12.8	0.0	
Other	19.8	19.8	0.0	
	138.4	267.6	0.0	
Value Add 1	48.5	26.1	0.0	
Value Add 2	11.8	7.9	0.0	
	198.6	301.5	0.0	
Machine Type A : Hand Pallet Trucks	29.6	0.2	0.0	
Machine Type B : Counterbalances	9.2	7.6	0.0	
Machine Type C : Powered Pallet Trucks	4.9	19.5	0.0	
Machine Type D : Order Picker (LLOP)	42.0	167.9	0.0	
Machine Type E : Reach Truck	24.2	39.6	0.0	
Machine Type F : Floor Scrubber	7.2	7.2	0.0	
Other Equip Type H: Hand-Held Terminal	29.0	31.7	0.0	

Average / Day 4				
	Early shift	Late shift	Night shift	Ea
Other Equip Type V: Voice Terminal	42.0	167.9	0.0	
Other Equip Type W: Pallet Wrapper	1.9	7.7	0.0	

Skip table

Activity by shift	Intake – pallets	55%	45%
	Intake – loose	100%	0%
	Despatch	20%	80%
	Value Add 1	65%	35%
	Value Add 2	60%	40%
	Other	50%	50%

However, the requirement for 24 LLOPs may translate into 27 to cover repairs and maintenance based on experience (plus five seasonal hires). These judgements will be determined by factors such as history and availability of equipment and will generally be specific to the equipment; it should be noted that the more specialized the equipment, the more likely the requirement to carry peak and maintenance cover for the full year.

When calculating the base and supplementary levels of each type of resource there are no definitive rules. However, modelling techniques can be used to compare alternative scenarios. In our example this is achieved by manual input of different core levels of resource. Table 11.7 shows this for the calculation of labour resources, where inputs are used for the number of permanent (full-time) employees and a maximum proportion of hours worked as overtime. The model structure generates paid hours (at base rate) for the full permanent workforce, available hours (after allowances for planned and unplanned absence) and then identifies any idle hours (where less work is required than base hours available), overtime hours and temporary hours (generating overtime use first until the pre-set level is achieved, then overtime is capped and temporary labour used for remaining requirement). A contingency may also be factored in for unforeseen circumstances arising during day-to-day operations (in this model a contingency is identified for review purposes as an estimate of daily FTE (full-time equivalents) required). The complexity of the modelling process is directly proportional to the complexity being modelled, so modelling multiple shift lengths for example will increase intensity.

It may be prudent to review aspects of the resource calculations separately – for example if, historically, the warehouse management team had a view that it was difficult to obtain and/or manage more than 20 temporary employees effectively then a review of each day's work content needs to take place. In this example this occurs on three days of peak week operations (over five weeks) and an appropriate strategy can be developed. This can either be formally included in the model, informally added to the model or implemented outside the model, depending on the impact. For example, if a different spread of base hours, overtime and temporary hours through the peak week solves the problem but makes no material change to the weekly totals it may be simpler to leave the model at the weekly level.

As previously noted, it is likely that there will be some idle or unused time in the quietest periods. This is estimated in the output lines. In practice, particularly for long-established operations, such idle time may effectively appear as a reduced productivity standard, ie the productivity standard has become a measure of work per attended hour. Care should be taken in understanding what the source information consists of, and therefore how it will model reality.

Table 11.7 Labour hours calculations

Skip table

	Low		
	Day 1	**Day 2**	**Day 3**
Daily workload (hrs – main warehouse)	296	341	299
FTE required (for day work-load)	41.3	47.6	41.8
FTE required (inc contingency)	42.2	48.5	42.6
heads (main w/h)	**49.0**	**56.4**	**49.5**
VA1 workload (hrs)	*72*	*65*	*69*
FTE required (VA1)	*10.0*	*9.1*	*9.6*
VA2 workload (hrs)	*16*	*13*	*10*
FTE required (VA2)	*2.2*	*1.8*	*1.5*
Heads (VA2)	*2.5*	*2.1*	*1.7*
# permanent employees	**54**		
Max Overtime	20%		

Skip table

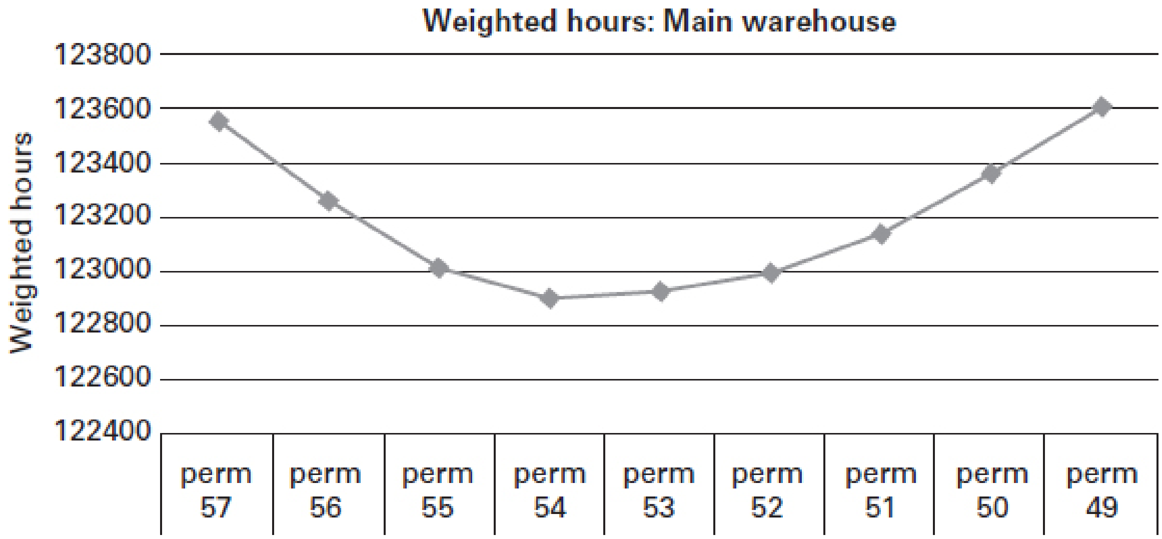
		Low		
Per Day (Main Warehouse)	Idle Time	37	0	3
	Overtime	0	8	0
	Temp Hours	0	0	0
	Base Hours	333	333	333
	Paid Base Hours	*387*	*387*	*387*

Skip table

Per week	Paid base	1935	Paid base	1935
Per period (contribution to annual budget)	# week	18	# weeks	24
	Base hours	29994	Base hours	39992
	Idle hours	1612	Idle hours	0
	Paid hours	34832	Paid hours	46442
	Overtime	142	Overtime	5176
	Temp hours	0	Temp hours	0

To assist in judging an appropriate resource level, weighted hours for the full budget are calculated. This is done by considering likely cost and estimating this by weighting overtime and temporary hours relative to the paid base hour. The calculation includes time paid for absence, as this will be a factor in the financial budget. Figure 11.7 illustrates different levels of permanent resource in the main warehouse for our example.

Figure 11.7 Weighted hours



▶ Figure 11.7 details

The graph in Figure 11.7, although specific to the example, illustrates some common features in resource modelling. The shape is typical with a 'flat' U-shape near the optimum number – in this case the difference is negligible between 52 and 55 permanent employees. (Given these exclude contingency, which was estimated as one to two operatives, the model would indicate 54–55 staff as the optimum level in this case.) The increases in hours committed on either side of the optimum reflect common phenomena:

- a higher number of permanent staff will carry a penalty of higher idle hours;
- a lower number of permanent staff generates higher costs for overtime payments and temporary staff.

There is also a potential for lower productivity if excessive overtime is worked or large numbers of temporary staff are employed.

Model outputs can be tailored to financial budget inputs but most of the core information is contained in this model – permanent staff, hours worked, overtime hours, temporary staff hours, equipment levels, equipment hire, etc.

It may not be necessary or appropriate to use such techniques for all resource types, illustrated by the two value-add examples.

Here Value Add 1 covers bundling and relabelling work and is expected to be a series of individual jobs. The resource model provides a broad estimate, but in practice each job will be an individual cost (or price) and there is likely to be more inherent variability.

For such circumstances it may be more appropriate to have a small core staff, supplemented by temporary labour as required for individual jobs. For Value Add 2 there is more consistency in work content, but as this is a more volatile business stream then it may be appropriate to consider part-time employees whose hours can be increased at peak periods then supplemented by temporary resource. Again, it is possible that an unfamiliar workforce may deliver lower productivity and/or higher error rates than an experienced workforce and this should be factored into the decision making. A key element is understanding how well systems support the untrained operative in achieving higher productivity – for example, systems that provide operator assistance in deciding which product to pick are likely to see higher initial productivity and lower error rates.

Other factors

Other resource requirements are not driven by processing activity. These include resources that are determined by time cycles. Examples are clerical, administrative and managerial staff, the equipment they use (system terminals, etc) and indirect activities for the operation as a whole, such as canteen staff and security. For these resources there may be choices between direct provision and bought-in services. The touch-labour modelling will give a forecast of activity in terms of volume and numbers employed along with timings, from which judgements of levels of such resources can be made.

For example, an operations office will require manning whilst the operation is active, but numbers of personnel may vary according to type of activity. Factors such as the number of orders, type of paperwork (eg import/export documentation) will influence choice, and a key element will be the nature of the IT systems employed and the levels of manual intervention envisaged.

A voice picking operation should require less intervention than a paper-based operation. It is also necessary to consider which functions are the responsibility of the warehouse. Security could be within the warehouse remit on a stand-alone site, but excluded if the warehouse is co-located with production or other company functions.

The scale of an operation will drive the management structure along with functional responsibility. Reference to historical arrangements can provide a good starting point as approaches vary significantly between organizations. This is particularly the case for first line management, where responsibilities can be incorporated as working supervisors or shared with team leaders.

In these cases some adjustments to the hours required for processing activity may therefore be required – in the example it is quite likely that this will apply in both value-add operations.

Resource modelling will also generate projected usage data that can be used to assist in the procurement process for new MHE, where lease/rental costs vary with use. Daily hours of use for equipment will help determine whether spare batteries are required.

Suppliers can also help advise on availability and cost of equipment hire during peak periods – in some instances this element can be incorporated into lease/long-term rental arrangements for the main fleet.

Some activities are periodic rather than a direct daily function. These include training, which can be determined by changes in the operation or general training, which may be scheduled to capitalize on lower activity periods and therefore utilize idle time. Such activities need to be noted and accounted for when setting resource levels – as is the particular activity related to periodic inventory counting; this is a good example of a predictable activity that follows a different set of rules.

In the case of some businesses there is a requirement to count product at intervals (wall to wall count) that may necessitate a cessation of standard operations – inventory being ‘fixed’ when the comparative count is undertaken.

Such activity is not suited to an averaged week – it will be undertaken as a stand-alone exercise and requires modelling as such. In practice, it may involve one-off additional hours and can be added to financial budgets as a separate line.

The use of cycle counting will potentially negate this requirement but will also need to be included in the labour hours, either under direct hours if using a ‘left on location’ check or indirect if utilizing a separate stock counting team.

Fulfilment centre resource planning

Resource planning for fulfilment centres can follow the same principles. In the fulfilment centre the warehousing activities are geared more to direct supply to end customer, and typically involve picking and packing at individual item level. Whilst the requirements of this type of activity can differ, the receiving and picking elements can follow the same principles. The differences can occur in put-away, in that product may be pre-packed on intake as seen in the iHerb.com video. In the example above there was provision for a small pick-and-pack operation treated as a value-add function – in the more recent fulfilment centre operations the core of the operation is around pick-and-pack and this accounts for the bulk of labour (in manual operations) or can be automated. In manual operations there are grounds to consider two changes to the resource modelling – both are driven by the nature of demand. With greater potential for shorter processing time from (warehouse) order to receipt to despatch and the need to pack product as well as pick, there is potential for greater use of part-time labour to cope with heightened peaks in demand through the day. The modelling process can be similar but may need to be framed in shorter work periods – say 4-hour, or even 2-hour segments instead of traditional shifts. The outputs can then be tailored to design a mix of overlapping shifts and part-time working to provide a good match of labour to demand. Video 11i is a good example of this.

In turn, this requires a different view of other resources – the demand for some resources will be determined by the number required over a shorter time span.

VIDEO 11i E-commerce packing operation courtesy of Paulas's Choice

For equipment this can mean there is more time available during normal operating hours for planned maintenance and it may be possible to adjust the allowances.

It is also worth considering other resource in the same way as labour and equipment as it becomes more activity driven – in particular, highly peaked pick activity effectively makes packing stations a flexible resource and the number required can be determined by this approach. If approaching this type of operational planning from scratch it is also worth taking into account potential constraints of other elements of the service, for example many online grocery retailers have home delivery capacity determined by availability of delivery resource, particularly if that resource is bespoke. In practice many effectively limit the demand on their fulfilment operation by having a limit on vehicle space for delivery.

Modelling automation

Modelling automation and the resources associated with the use of automation is becoming increasingly relevant to modern day warehousing, for both traditional applications and e-commerce. Automated solutions have elements that require resources either in direct proportion to activity or in stepped levels. A good example of this is robotics such as automated layer picking, which will have a mixture of elements that are both fixed and (semi-)variable. The software for controlling the robotics is an example of a fixed element, whilst the robotic arms and heads are variable and likely to be evaluated on an activity basis – for example, if a robotic arm can handle 40 layers per hour and 600 picks are required in an eight-hour period, the minimum will be two layer pick robots plus any spare coverage. However, if the requirement varies between 400 picks and 1,000 picks over the course of a year, then the requirement may increase to four robots to cover the peak need as it is unlikely that 'hired' equipment will provide a feasible option for peaks.

An alternative is to supplement with a manual operation, which can be turned on and off as required.

Additionally, if the layer picking requires source pallets to be brought to the picker then this element of work, which is likely to be additional to a standard operation, needs to be factored in to the resource model.

In essence, automation operates under different guidelines when considering modelling resources. First, it is likely that resource levels will need to be set to cover peak need, even though use will be at low levels for much of the time, and second, it is necessary to fully evaluate and model any additional work that is required to prepare products for automated handling.

The resource budget, and the resulting inputs to any financial model, needs to reflect the resources that will be required to deliver the operation in totality.

The automation equipment suppliers will be able to assist in terms of modelling these requirements.

Summary and conclusion

In summary, direct resource is resource that directly handles product (unload, load, pick, pack), and can be measured against predefined productivity rates.

Indirect resource is resource that completes tasks that support and enable the direct resource to execute their roles. They are less likely to handle product or directly impact productivity

Indirect resource is difficult to manage against predefined productivity rates as they are less tangible roles. They are often seen as non-value-adding tasks albeit still important.

Where companies are unable to measure actual hours per task, indirect resource can be planned as an overall percentage of total direct resource hours, eg:

> Total direct hrs = 200, indirect ratio is 12.5 per cent of direct, so indirect hours = 25 hrs

This additional cost can be seen as a 'quick win' cost area to focus on in order to drive savings in an inefficient warehouse.

Sigma Efficiency, in a recent client project, found that pre-shift briefing lengths varied across different supervisors and team leaders. Having recognised this, utilizing their DC Performance Management software, the company was able to standardize the length of the briefing and increase overall productivity.

Having built up the resource model, you are able to transfer this data into a financial budget and will be able to monitor the actual resource requirements and costs against those budgeted.

Productivity standards can also be compared with actual achievement and the resource model adjusted accordingly.

Finally, the model can assist you in estimating prices for goods and services as the model can be adapted to calculate not only the resource for the whole warehouse but specific operations or clients within it.

The data can also be introduced into a LMS, which has further benefits.

According to WCS, labour productivity improvements in the range of 15 per cent to 30 per cent are possible and are commonly achieved. A 10–40 per cent operational cost reduction is not only attainable but is common with the proper implementation of a labour management solution.

12
Warehouse costs

> *Every dollar of cost (or expense) that is cut falls directly to the bottom line. This makes sense because it is true.*
> (ANONYMOUS)

Introduction

The cost of operating a warehouse can average between 1 and 5 per cent of cost of goods sold, depending on the type of company and the value of its goods. In the 2021 WERC survey typical percentages were between 6.4 and 10 per cent with a median figure of 8.35 per cent and a best-in-class figure of < 3.7 per cent. These figures need to be taken in context. For example, a pallet of laptops will take up the same amount of space and the same amount of handling as a pallet of baked beans, yet the value of goods will be significantly different, hence the variation in the percentage cost of sales. Warehousing also makes up around 20 to 30 per cent of a company's total logistics costs with inventory carrying costs at a further 20 to 25 per cent.

The warehouse costs tend to be made up as follows:

- labour: 45–50 per cent;
- building: 25 per cent;
- building services including utilities: 15 per cent;
- equipment: 10–15 per cent;

- IT: 5–10 per cent.

These figures will vary based on the amount of automation and technology utilized within the warehouse.

As a result, warehouse managers require a comprehensive knowledge of all costs and cost drivers within the warehouse as they are under significant pressure to reduce costs yet continue to produce optimum customer service with the added pressure of reduced inventory but increased numbers of SKU.

Managers are also expected to contribute data to the company budget and continually reassess the resource and cost budget in line with the actual operation.

This chapter looks at the typical costs within a warehouse and aims to assist managers in understanding these costs, enabling them to produce budgets, calculate return on investment for particular projects and use the information for decision-making, evaluating performance, activity costing and, in the case of third-party logistics service providers, charging.

The chapter also compares traditional costing models with activity-based costing and goes on to discuss the advantages and disadvantages of costing models such as open-book, closed-book and cost-plus.

Types of costs

The costs typically associated with a warehouse operation are shown below:

Space costs:

- rent/leasing costs on building/land and building depreciation (depending on how the building and land has been acquired);

- insurance;
- rates or local government taxes;
- utility and telecoms costs;
- fixtures and fittings depreciation;
- racking depreciation;
- refrigeration plant depreciation (if applicable);
- repairs and maintenance;
- cleaning, security, other building equipment depreciation;
- waste disposal.

Direct labour costs (fixed); warehouse operators:

- wages including on-costs;
- personnel insurance;
- safety wear (PPE);
- welfare;
- training.

Indirect labour costs (fixed): warehouse management including supervisors and administrators:

- wages including on-costs;
- insurance;
- safety wear (PPE);
- welfare;
- training.

Labour costs (variable):

- overtime, bonuses, agency labour.

Equipment costs (fixed):

- depreciation/lease costs/rental costs.

Equipment costs (variable):

- running costs, eg fuel, tyres, lubricants, batteries;
- packaging, pallets, stretchwrap, labels.

Overhead costs (management, finance, human resources, IT and administration):

- salaries and on-costs plus benefits in kind such as mobile phones, accommodation, etc;
- company cars and running costs;
- office equipment and furniture depreciation/lease/rental costs;
- information technology costs (hardware and software).

Overhead costs (sales and marketing in 3PLs):

- salaries and on-costs plus benefits in kind such as mobile phones, accommodation, etc;
- company cars and running costs;
- marketing spend, eg advertising, exhibitions, brochures, etc.

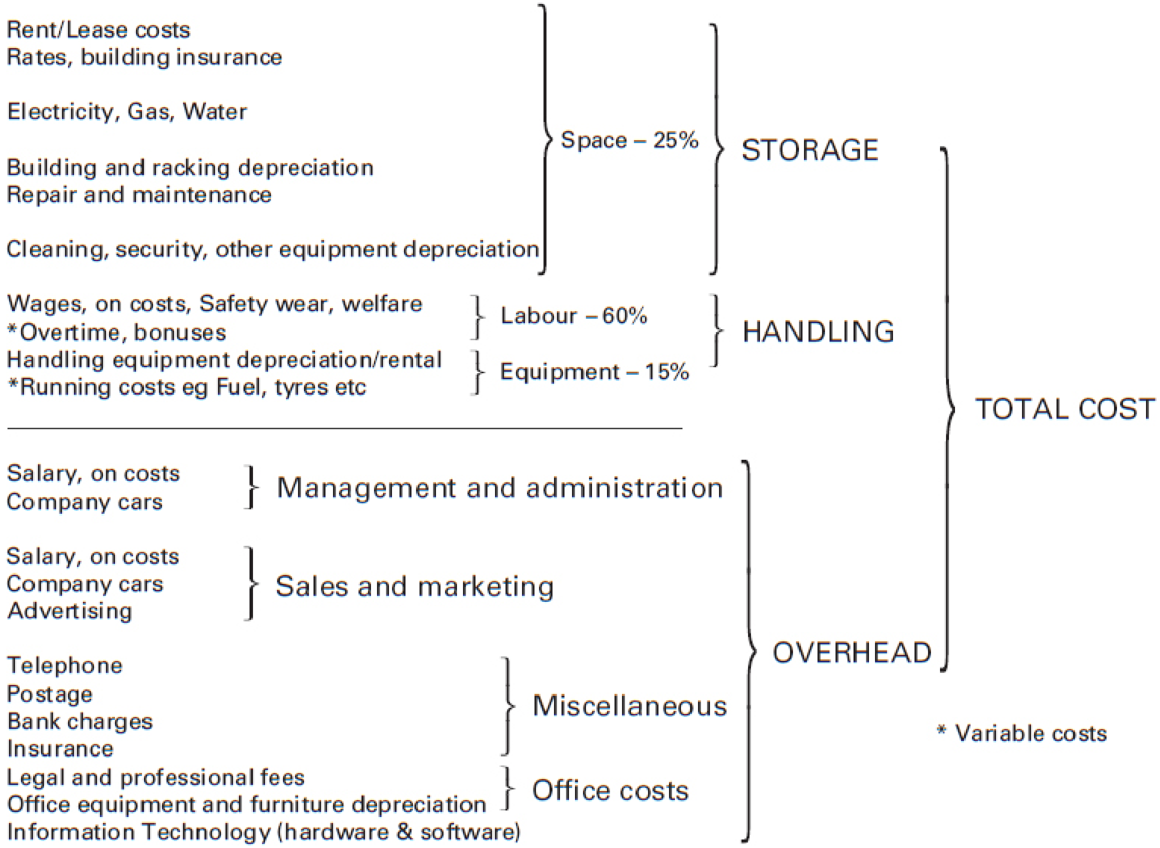
Miscellaneous costs:

- communication costs;
- postage;
- bank charges and interest payments;
- funding costs/cost of finance;
- insurance;
- legal and professional fees;
- audit fees.

As well as wages and salaries, total labour costs include employer’s social contributions (including national insurance contributions (UK) and pensions, paid on behalf of the employee) and other non-wage costs including sickness, maternity and paternity costs, vocational training costs and recruitment costs plus any benefits in kind which might apply.

As can be seen in Figure 12.1, the costs can be built up to produce a total warehouse cost. Third-party logistics companies can add an element of profit in order to produce a costing model to charge clients. This model can be used in conjunction with the resource model in Chapter 11 to calculate activity rates such as handling costs per pallet and/or per case picked and cost per pallet stored.

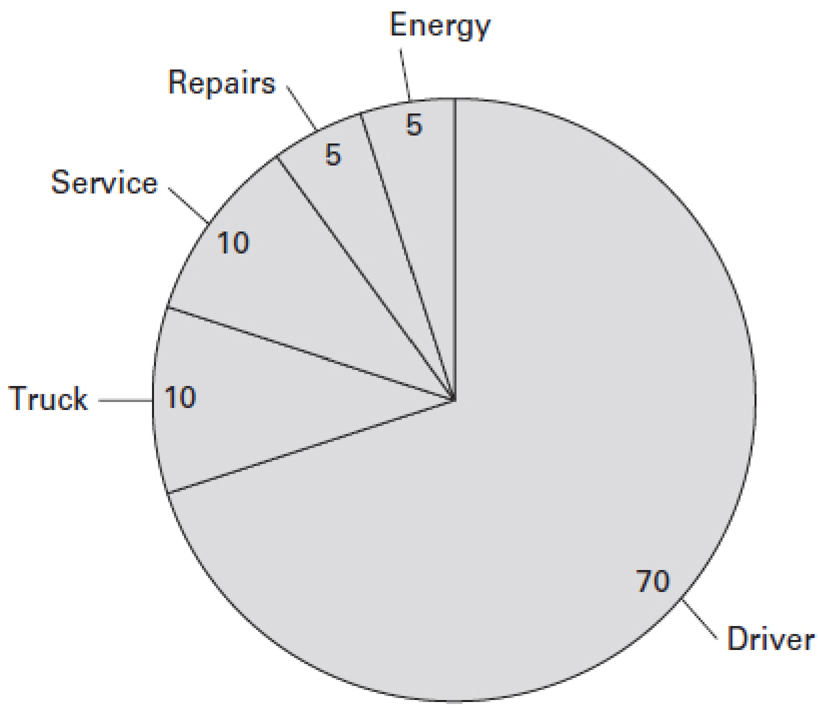
Figure 12.1 Simple warehouse cost tree



▶ Figure 12.1 details

Figure 12.2 provides a breakdown of the cost of ownership related to forklift truck operations.

Figure 12.2 Breakdown of the cost of ownership – FLT (courtesy of Toyota)



Return on investment (ROI)

This is a measure used to evaluate the efficiency of an investment or to compare a number of different investments. ROI is important to calculate because if an investment doesn't have a positive ROI or if there are other opportunities with a higher ROI, then the investment should not be made.

The calculation of ROI percentage is as follows:

(Gain from investment (or savings) – cost of investment) ÷ cost of investment × 100

A similar calculation is the payback period. 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 cost and opportunity cost, the latter being what must be given up (the next best alternative) as a result of the decision.

In this voice picking trial a client calculated that their 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 figures were as follows:

- pick productivity savings: £52,800;
- increased accuracy: £33,600;
- total savings: £86,400;
- investment in voice: £68,900;
- therefore (£86,400 – £68,900) ÷ £68,900 × 100 = 25.4 per cent;
- payback period = £68,900 ÷ £86,400 × 12 months = 9.6 months.

This isn't a totally accurate picture as, in this example, no account is taken of extra training costs, effect on the business during the early stages of implementation, etc.

However, this does give the company a reasonably accurate picture of the potential ROI for other similar investments.

Traditional versus activity-based costing systems

According to Themido *et al* (2000), companies in the past could keep unprofitable products and customers in the hope that one day they would become profitable, because the winners would more than compensate for the losers. In today's economy the margin for error is much smaller and pressures are increasing on companies to improve their bottom-line performance. Standard accounting methods are able to tell us whether we are making an overall profit or not; however, it is more difficult to determine which customers, products, processes, services or warehouses contribute most or least to that profit.

The knowledge of the real cost of a product or service and the cost to serve specific channels and customers is very important to a company in today's competitive market.

Christopher (1998) states that logistics costing systems 'should be capable of not only identifying the costs that result from providing customer services in the marketplace but also enabling separate cost and revenue analyses to be made by customer type and by market segment or distribution channel'.

Managers therefore need to be able to calculate the cost to serve for each customer and where possible the warehousing cost for each product.

From experience, smaller customers tend to be high maintenance. The 80/20 rule can apply in these situations. The 80 per cent of customers generating 20 per cent of the revenue tend to be the more demanding.

When I joined a third-party logistics shared-user operation I found that we had 29 clients in total. The total revenue generated from 20 of the customers came to less than 10 per cent of total sales. At the time we didn't have the systems in place to calculate the profitability of each customer, but having evaluated each one in terms of future potential, we decided to terminate the agreements of 19 of the customers and as a result we ended up with an increased profit margin.

In this section we will look at two types of costing system that are relevant to warehouse operations. These are the traditional costing method and activity-based costing.

Traditional costing methods

Traditional costing models tend to allocate overhead costs arbitrarily. Table 12.1 shows a typical manual warehouse cost structure.

Table 12.1 Warehouse cost structure

Skip table

Space cost	£1,677,000
Space as percentage of total warehouse cost	54%
Labour cost	£1,200,000
Labour as percentage of total warehouse cost	39%
Equipment cost	£215,000
Equipment as percentage of total warehouse cost	7%
Total direct cost	£3,092,000
Overhead cost	£742,000
Total cost	£3,834,000
Overhead as percentage of total direct cost	24%

Example

In terms of storage, let us assume that our warehouse has 10,000 × 1.5 metre high pallet locations. From a cost point of view each location costs £167.70 per annum. In order to allocate the overhead cost we need to add a further 24 per cent to this figure, which comes to a total cost of £207.95.

In terms of labour, if we assume total labour hours within the warehouse each year of 120,000 hours, our labour cost is £10.00 per hour. By adding the overhead our cost comes to £12.40.

Taking this one step further, if we look at Customer A, who uses a large number of warehouse labour hours and space yet his pull on management time, for example, is low, he is penalized for the way the overhead costs have been allocated. See Table 12.2.

Table 12.2 Overhead contribution

Skip table

	Number of pallet locations	Number of labour hours	Total overhead contribution %	Pull on manag time %
Customer A	2,000	20,000	17.3%	5%
Customer B	200	200	1.15%	10%

We will look at how shared-user warehouses can calculate storage and labour charges later in this chapter.

With the proliferation of products and service complexity, a single overhead rate is no longer sufficient.

In most cases, overhead does not reduce as labour or equipment reduces. Therefore as volumes reduce, overhead as a percentage of direct costs actually increases.

Overhead rates are also based on predicted volumes or utilization and therefore as utilization reduces the percentage allocation of overhead needs to increase.

For example, go back to our shared-user warehouse and Customer A. If he decides to reduce his stockholding and it is not replaced by another client, the charge per location needs to be increased. Based on a reduction of 500 pallets, his overhead contribution reduces by 2.7 per cent (£20,125), yet the overhead cost to the company is unlikely to reduce in the short term.

As can be seen, traditional costing methods have a number of weaknesses – which is why many companies are turning to other methods of costing. Activity-based costing is one of these methods.

Activity-based costing

According to Griful-Miquela (2001):

> Activity-based costing systems are designed so that any costs that cannot be attributed directly to a product (or service) flow into the activities that make them necessary. The cost of each activity then flows to the product(s) (or service) that makes the activity necessary based on their respective consumption of that activity.

Activity-based costing looks to allocate indirect costs to processes in a way that accurately reflects how the costs are actually incurred. This is in contrast to traditional costing methods.

When looking to introduce an ABC model, you need to have a comprehensive knowledge of the company, its operations and the roles of each of the staff members. This is normally carried out by observing the operation for a period of time and recording how long it takes for each activity.

A good guideline for selecting the cost drivers that most accurately reflect the cost of performing an activity is to ask the people who do that work which elements will increase or decrease the time and effort required to do their job. Table 12.3 provides an example.

Table 12.3 Main warehouse activities and cost drivers (adapted from Griful-Miquela 2001)

Skip table

Activities	Cost drivers
Order receipt	Order volume and order source (EDI, fax, phone or post)
Unload incoming goods	Quantity and unit load (pallets or cartons)
Palletize	Quantity of cartons
Check incoming goods	Quantity (including returns)
Put away incoming goods	Quantity, pallets or cartons
Picking	Number of visits to pick location, number of lines, number of units
Packaging and labelling	Number of orders picked/packed/labelled
Replenishment	Unit load quantity
Load outgoing goods	Unit load quantity

Once all the operational and overhead costs have been calculated and each customer's pull on the services has been documented, companies can calculate the profitability of each client and see how this affects the cost structure of the business.

The overheads should be allocated based on the actual management time dedicated to each activity and customer. Cost of telephone calls, printing, etc should also be allocated on a usage basis for example.

This analysis of overheads is likely to be the most complicated to perform. This is the main difference between ABC and traditional methods, where in the latter, overheads are allocated across all activities as a percentage of cost. With ABC it is necessary to carry out in-depth studies over a period of time in order to find the relationship between overheads, services and customers.

Once all of the activities have been evaluated and costs allocated to customers, there is likely to be some unused capacity.

For example, a warehouse with a total capacity for storage of 10,000 pallets is not going to be 100 per cent occupied. Similarly, not all of the MHE and labour hours will be allocated to individual customers in totality.

It is therefore very useful to produce a table indicating the degree of utilization for all those areas.

These costs either need to be managed out of the operation through a reduction in labour and equipment, or taken into account when initially quoting the customer or allocating to a particular product, or accepted in the short term as an inevitable cost and work towards increasing utilization or throughput to allocate these costs to a new product or client. It is pertinent to point out here that 100 per cent utilization in terms of both storage capacity and equipment utilization is not a positive thing.

If all the costs incurred are allocated against individual customers this will increase the charges to those customers, which could result in lower sales and a further reduction in capacity utilization.

According to Griful-Miquela (2001), whenever unused capacity appears, it is necessary to analyse the reasons leading to this situation. Depending on the reasons, the actions to be undertaken may differ. For example, the degree of unused capacity can be an indicator of how the employees are allocated among the different activities. It is possible to reallocate some of them with this information. For example, the in-handling team may have additional capacity and could therefore be allocated to replenishment or picking tasks. It is very important to analyse when a constraint appears. This might indicate the need for a new investment in the short term or risk being unable to cope with future requirements if no action is taken.

As previously discussed, a warehouse cannot operate efficiently if it is 100 per cent occupied, therefore there have to be some empty pallet locations. Similarly with labour, we have to take into account breaks during the working day, varying capabilities and times of inactivity.

Table 12.4 shows an example of an ABC model. We have calculated the number of pallet spaces occupied and number of labour and MHE hours allocated to each customer. We have also allocated the management time in hours per customer and allocated other overhead costs such as postage, legal expenses, insurance, etc on a percentage basis, based on the administrative hours.

Table 12.4 Example ABC model

Skip table

	Space (No of pallets)	Labour (No of hours)	MHE (No of hours)	Adr hou
Total capacity	10,000 pallets	120,000 hours	30,000 hours	10,0
Customer A	2,000	20,000	5,000	500
Customer B	200	200	100	1,00
Customer C	1,400	25,000	8,000	2,00
Customer D	900	18,000	4,500	2,50
Customer E	2,300	21,800	3,000	1,50
Customer F	1,000	12,000	1,900	1,00
Operational leeway/unproductive hours	1,500	18,000	5,000	1,00
Unused capacity	700	5,000	2,500	500

The above hours can be further broken down into the individual activities within the warehouse and the costs allocated by customer. These costs can then be compared to the actual charges levied to the customer and any shortfall examined.

We can also calculate the total handling and storage cost per product line and then compare this to the amount of revenue and profit gained from these lines. Shortfalls can result in a delisting of these lines and removal from the warehouse.

Having calculated all of the above, we are also able to see the amount of unused capacity within the warehouse.

The disadvantages of using ABC include the amount of work involved and difficulty in collecting accurate data. Implementation can take time and there needs to be a cost–benefit analysis in terms of the time taken and the benefits accrued. There may be an argument to allocate some costs less accurately if they are a small percentage of the total cost.

Charging for shared-user warehouse services

A shared-user warehouse is one in which a third-party logistics provider stores on behalf of a number of different customers. They may be related in some way as suppliers to a particular retailer, for example, or competitors who have decided to come together to share resource and save on outbound distribution costs.

Examples of the latter include bicycle manufacturers in the Netherlands who saw the storage and handling of their products being specialized and potentially costly. Other warehouses can have very diverse clients. When operating a third-party warehouse in the 1990s we had three toy companies, a book publisher, a drinks manufacturer, two white goods manufacturers, a software company, a kitchen utensils manufacturer, a pet food manufacturer and a photographic film manufacturer.

Products ranged from bulk block-stacked cans and bottles of beer, bulk block-stacked washing machines, pallets of cartons containing toys, kitchen utensils, cans of pet food and books and shelves of software titles.

So how do you charge these clients for the storage, handling and despatch of their products?

Shared-user warehouse customers are normally charged on an activity basis. Typical methods of charging are as follows.

Storage charges

Storage charge examples:

- rate per pallet stored per week;
- rate per item stored per week;
- rate per square foot/square metre occupied per week;
- rate per cubic foot/cubic metre occupied per week;
- rate per tonne stored per week;
- rate per shelf location utilized per week; and
- fixed rental cost per week/month.

In the first six examples the rate is based on the unit of measure (UoM). This can cover clients who are storing pallets or items such as white goods which can be bulk block-stacked, clients who require racked pallet storage or those who require smaller locations such as shelving or a combination of all three.

Note that within the rates charged there needs to be an element for access and working space.

Calculating the total number of pallets to be charged per week can be done in a number of ways:

- the highest number of pallets in store during the week;
- the average number of pallets in stock per week;
- opening stock plus intake; and
- opening stock plus intake minus despatches.

In scenario 1 (Table 12.5) the charge will be for 200 pallets, this being the highest number in stock that week.

In scenario 2 the charge will be for 125 pallets, this being the average over the week.

In scenario 3 the charge will be for 400 pallets (day 1 stock plus intake total).

In scenario 4 the charge will be for 70 pallets.

Most companies will look for a minimum charge. In this example, the minimum charge is likely to be for 100 pallets.

Note that 3PLs tend to charge storage on the basis of rate per week or part thereof.

Table 12.5 Pallet storage charge calculations

Skip table

Number of pallets/days	Sun	Mon	Tues
Number of pallets	100	100	175
Intake	0	100	100
Despatches	0	25	75

In the case of a fixed rental cost per week or month, the client pays a fixed rate each week or month based on a previously agreed area or number of UoMs. For example, a client may require an area of 1,000 square feet in which to store product and carry out some value-adding services.

If the client does not use the whole space, they will still be charged the full rate. From the client's point of view, they are able to budget accurately each month. If the client exceeds the amount of space agreed they will pay an additional charge.

Handling charges

These are commonly known as RH&D charges, or receipt, handling and despatch. These are normally charged on a rate per pallet in-handled. Companies have to be careful here as this only covers full pallets handled in and handled out. If items are despatched as cartons an in-handling charge per pallet is normally used together with a rate per case despatched. Also, if cartons arrive loose-loaded in a container you will need to calculate the length of time it takes to unload by hand, palletize and put away the items. A charge per carton is normally levied.

The costs are based on the amount of time calculated to undertake each movement plus the cost of the mechanical handling equipment utilized.

A typical example is shown in Table 12.6.

Table 12.6 In-handling cost per pallet

Skip table

Activity	Labour time	Labour charge per hour	Total labour cost	Equip per ho
Unload 13.6 metre trailer (26 pallets)	0.5 hours	£17.00	£8.50	£10.0
Take to racking	0.5 hours	£17.00	£8.50	£10.0
Put away in racking	1 hour	£17.00	£17.00	£18.0
Total cost				
Cost per pallet in-handled excluding administration and supervisory costs, overhead and profit				

In terms of outhandling costs, if it is the same full pallet we can use the same costs as above but in reverse providing the times are the same to undertake each activity. Thus the RH&D cost will be £4.78 per pallet in-handled. If the despatch is in cartons or individual items, we need to calculate the amount of time it takes to pick, pack and load an order.

For this rate we need to understand the customer's outbound operation in terms of number of orders, lines and units per order, packing and labelling requirements.

The cost build-up will be as follows:

- Labour – time
    - collection of order;
    - travel time to each location;

- pick time at each location;
- travel time to despatch area;
- labelling and packing time;
- checking time (if necessary);
- loading time.

- Equipment – time
  - use of powered pallet truck;
  - contribution to voice technology for example.
- Other
  - packing and labelling materials;
  - replenishment;
  - supervisory and administration costs;
  - overhead;
  - profit.

Once calculated and divided by the number of cases/units per order we should end up with a cost per case/unit outhandled.

Value-added services

These would normally be charged on an hourly basis until a cost per unit can be calculated taking into account the productivity, eg number of units labelled per hour. In this case you will also need to take into account the cost of the labels and allocate space and equipment costs to the charge. You need to factor in the cost of picking the products from their locations together with any ancillary items and the transfer to and from the value-added services area. Supervisory costs should also be taken into account. Note these costs apply to 3PL warehouses but also to companies who are asked to provide this service to their retailer customers.

Other costs that can be incurred in a 3PL warehouse include the following:

- supply of pallets;
- administration of pallet rental scheme;
- stock counts.

Logistics charging methods

In both internally and externally operated warehouses, costs need to be presented to customers – whether these are external customers or internal customers who have a cost attributed to their products.

As noted earlier, many businesses look at warehousing costs as a percentage of sales or production cost. In some instances costs are applied on this basis. This can be dangerous unless there is a safety net for the supplier. As throughput and storage decline, it is unlikely that the number of people required will be reduced at the same percentage rate. Also, it is unlikely that the vacated space will be filled immediately. More often, though, costs are presented to the customer as an internal or external charge supported, to different degrees, by invoices and cost justifications.

The principles discussed earlier in this chapter identify the basis of justifying costs and charges for services supplied. In the case of third-party supply this will be in the form of invoices. The following sections describe how to construct those invoices or cost allocations.

Open-book contracts

An open-book contract is based on total transparency between supplier and customer. The client is able to see exactly what costs the third party is incurring and is able to discuss these costs and potential cost-reduction strategies.

It is common in these types of contract to agree a management fee that is determined by performance. A base fee will be agreed together with set targets. If the targets are achieved, the management fee will be paid in full. If exceeded the management fee can be increased; if the third party falls short due to poor performance, they could forfeit *some* of their management fee.

This type of charging allows the client to become involved in the process and identify areas where its own performance can have an effect on the overall cost. Within an internal process the product owner can identify which factors have an impact on the total product cost.

Table 12.7 is an example of an open-book proposal.

Table 12.7 Open-book warehouse charges — example

Skip table

Estimated annual budget	
Warehouse operative costs	£237,816
MHE, maintenance and consumables	£ 50,320
Rent and rates	£313,159
Shared indirect structure plus two dedicated admin	£102,465
Depreciation and insurance	£31,268
Utilities and other site costs	£59,979
IT	£35,056
Management fee and central overhead costs	£106,272
Total annual cost to company xyz	**£936,335**

Cost-plus contracts

These contracts are similar to open-book; however, in most cases the 'plus' element is based on a percentage of cost. This can lead to the perverse situation where the higher the costs incurred on the contract, the higher the profit earned by the third party.

Cost-plus arrangements historically evolved to counter fears that fixed and variable rates masked true costs and allowed third-party providers to extract high profits. Cost-plus took the first step towards identifying cost and setting (at the time) a 'reasonable' profit.

In these types of contract there needs to be stringent targets and a commitment to reduce overall costs. A gain–share agreement where both parties 'win' when costs are reduced is a potential method of ensuring focus on cost reduction.

Closed-book contracts

In these types of contract, charges are based on the activities carried out by the third party as discussed above. The charges will include an element for overhead contribution and profit margin.

As volumes increase, so will the total revenue earned by the third party. Conversely, as volumes reduce so will the third-party provider's revenue unless a minimum level of activity is agreed.

With open-book contracts customers get fixed, index-linked prices for given volumes and are unable to see the actual third-party costs. Third parties will look to cushion some of the fluctuations in volume by imposing minimum storage and throughput levels.

This type of charging has its advantages and disadvantages. The main advantage is that costs are closely related to sales in terms of order throughput. Storage costs are based on the number of items stored and therefore can highlight when stock levels are higher than expected.

The main disadvantage is that it is more difficult to budget as costs will vary month by month depending on activities within the warehouse.

Second, rate reviews tend to occur annually and therefore do not reflect performance improvement as it occurs.

See Table 12.8 for an example of closed-book charging.

Table 12.8 Activity-based charging or closed-book charging

Skip table

Warehouse rates	Volume	Charge
Pallet storage 1.0 × 1.2 × 1.4 m high UK pallet per week	3,600	£1.35
In-handling per pallet single SKU	10,400	£1.80
In-handling per case	374,880	£0.11
20' container in-handled	50	Included within in-handling per case
40' container in-handled	100	Included within in-handling per case
Pallet wrap inbound	7,810	£1.10
Pallet put away	7,810	£1.80
Order processing inbound		Included within inbound RH&D
Picking (pence per case)	514,427	£0.15
Replenishment	514,427	£0.19
Full pallet single SKU despatch	11,642	£1.80
Loading of pallets	23,674	Included within outbound RH&D
VAS hour	1,666	£15.50
Order processing out	12,360	Included within outbound RH&D
Labelling (per label)	23,674	£0.13
Stocktake – once per annum		Included
Returns per carton	3,014	£0.90
Pallet wrapping out	10,717	£1.10
Pallet supply UK 1200 × 1000mm		£5.50

Hybrid

There are a number of different charging systems that can take elements of the above and combine them – for example, charges for fixed items such as property rental and IT assets may be paid for on an open-book basis whilst item throughput can be charged for on an activity basis.

Summary and conclusion

Warehouse managers require a comprehensive understanding of the costs that relate to their warehouse operation. This is not only to contribute to the company budget but also to enable the company to allocate costs to products or, in a third-party relationship, to charge for the services provided. It can also identify loss-making customers or products if we delve deeply enough into the figures.

13

Performance measurement and management

Introduction

In today's economy it has been said that the customer is no longer king but dictator. With the proliferation of websites reviewing products and services, it has become even more important to match or even exceed customer expectations in terms of quality and the service provided. Customer loyalty is on the wane with companies having to compete much harder to retain customers.

One example of poor service can far outweigh all of the times where deliveries were made on time and complete.

A Honeywell survey reported that the average global cost of one picking error is $59, resulting in distribution centres losing, on average, more than $400,000 annually on miss-picks.

Respondents said the cost of a miss-pick in the United States ranks highest ($67), followed by France ($60), Germany ($52) and the United Kingdom ($50). Not only are companies likely to lose customers but it also directly affects the bottom line.

No longer can companies take an order and quote a 28-day delivery service; in most cases delivery is expected next day and in some cases even on the same day.

The next point to note is that it is far cheaper to keep an existing customer than find a new one. Therefore, satisfying your current customer base is paramount.

Well-established research by Reichheld and Teal (2001) found that, for many companies, an increase of 5 per cent in customer retention can increase profits by 25 to 95 per cent. The same study found that it costs six to seven times more to gain a new customer than to keep an existing one.

From a warehouse perspective, this means that you have to ensure accuracy, quality, timeliness and cost-effectiveness within the processes you control. By doing this, you are contributing to a high-performance operation and as a result, contributing to customer satisfaction and retention.

As discussed previously, the warehouse operation is crucial in ensuring that the customer gets the right product at the right time and in the right condition.

This chapter looks at why we need to measure performance, what we need to measure and how we can use this information to improve our overall service to our customers.

Why do we need to measure?

There are a number of reasons why we need to measure performance and productivity within the warehouse. We measure because we need to:

- ensure customer satisfaction through service improvement;
- ensure that there is a culture of continuous improvement within the operation;

- discover potential issues before they become major problems;
- train staff in the right areas; and
- reward staff where appropriate.

Unless we measure our performance against our customers' expectations and continually improve on that performance, we are not only in danger of losing our customers but we will also incur additional costs.

For example, incorrect item or quantity of items sent will incur the following:

- finance department is affected by delayed payments and possible penalties;
- inventory department has to provide extra stock cover;
- sales department has to handle complaints and authorize returns;
- transport department has to effect extra deliveries and collections;
- warehouse has to re-pick and re-pack thus duplicating activities;
- a full returns procedure has to take place;
- possible product disposal/write-off;
- review of processes needs to take place;
- potential additional training required;
- potential loss of sale if incorrect item sent was required by another customer;
- potential loss of sale if customer decides not to accept item as too late;
- loss of product if client keeps the over-delivered product;
- possible need to provide incentives to get customer to remain; and

- potential loss of customer.

What should we be measuring?

According to Ackerman (2003), we should be measuring four areas within the warehouse:

- reliability;
- flexibility;
- cost; and
- asset utilization.

Reliability includes on-time delivery, order fill rates and accuracy. Order cycle time is probably the best measure of flexibility as it covers all aspects of the customer order process: how we handle the order initially, whether we have the stock available, how quickly we can process the order through the warehouse and, finally, how quickly we can deliver to the customer.

Cost measurements include cost as a percentage of sales and productivity against labour hours. Asset utilization will include efficient use of warehouse space, MHE, staff and storage equipment.

Warehouse utilization is normally measured in the amount of floor space utilized. However, it is more realistic to measure the cubic utilization of the building. Other companies will look at the number of pallet locations utilized against the total number of locations available.

Frazelle (2002) suggests that as occupancy rates exceed 86 per cent utilization, productivity and safety decline exponentially with each percentage point increase in occupancy. He goes on to say that warehouses managed in real time might be able to operate at 90 per cent occupancy, although this is wholly dependent on the accuracy of the system and the experience of the warehouse team.

The introduction of a new client into a shared user warehouse together with an increase in stock holding of a current customer resulted in a utilization figure of 98 per cent. This was not sustainable and slowed the operation down appreciably.

Third-party logistics companies will look to increase space utilization to the maximum as this is a revenue stream for them. However, productivity reduces significantly when space is at a premium. The coordination of pallets out and pallets in (in that order) is paramount, otherwise major bottlenecks appear.

In order to ensure that you provide your customers with the service they require, you need to understand your customers' requirements both as a whole and individually and, secondly, the limitations you have within your company and operation.

Performance is a broad term that covers both overall economic and operational aspects. Slack *et al* (2001) offer the following description of high-performance operations that most companies strive to accomplish:

- High-quality operations don't waste time or effort having to re-do things, nor are their internal customers inconvenienced by flawed service.
- Fast operations ensure a quick turnaround of orders.
- Dependable operations can be relied on to deliver exactly as planned. This eliminates wasteful disruption and allows the other micro-operations to operate efficiently.

- Flexible operations adapt to changing circumstances quickly and without disrupting the rest of the operation.
- Low-cost operations lead to higher profits as well as allowing the company to sell their products at a competitive price.

One of the main things to understand is that in terms of performance measures, you need to:

- monitor performance against the criteria that are important to your customers (delivery of the perfect order);
- monitor performance against the criteria that are important to you (costs).

As can be seen in Figure 13.1, different players have different ideas as to what is important in terms of performance measurement. The figure depicts which key performance indicators (KPIs) are important to a retailer and which are important to their third-party logistics service provider.

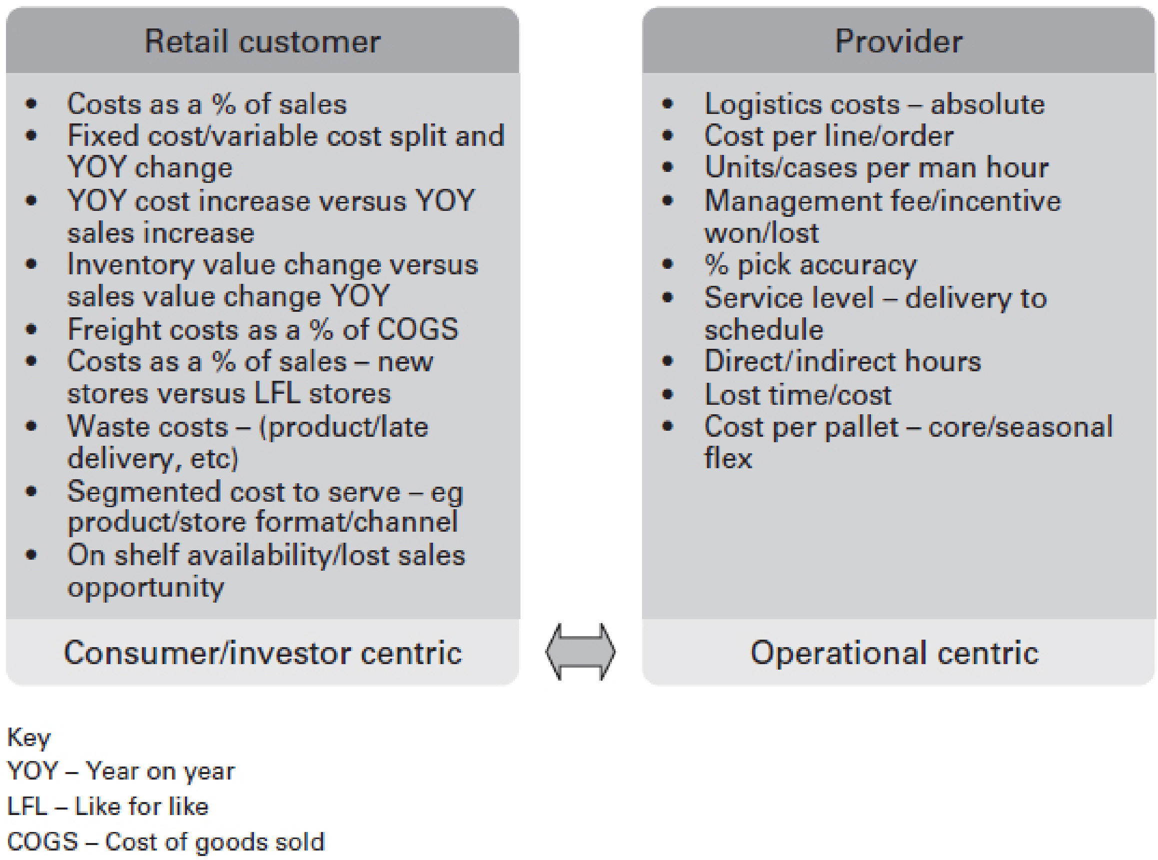
The best measures therefore are those that are aligned to and governed by customer expectations. However, they also need to be aligned to your company's resources.

According to Rushton, Croucher and Baker (2010), there is a need to balance the level of customer service with the cost of providing that service. They go on to say that the cost of providing a given service is markedly higher the nearer it reaches the 'perfect service', that is, 100 per cent on time in full.

For example, 100 per cent next day, on time, in full may only be achieved by having sufficient inventory to satisfy every customer's needs, and every order that leaves the building needs to be double or triple checked for accuracy.

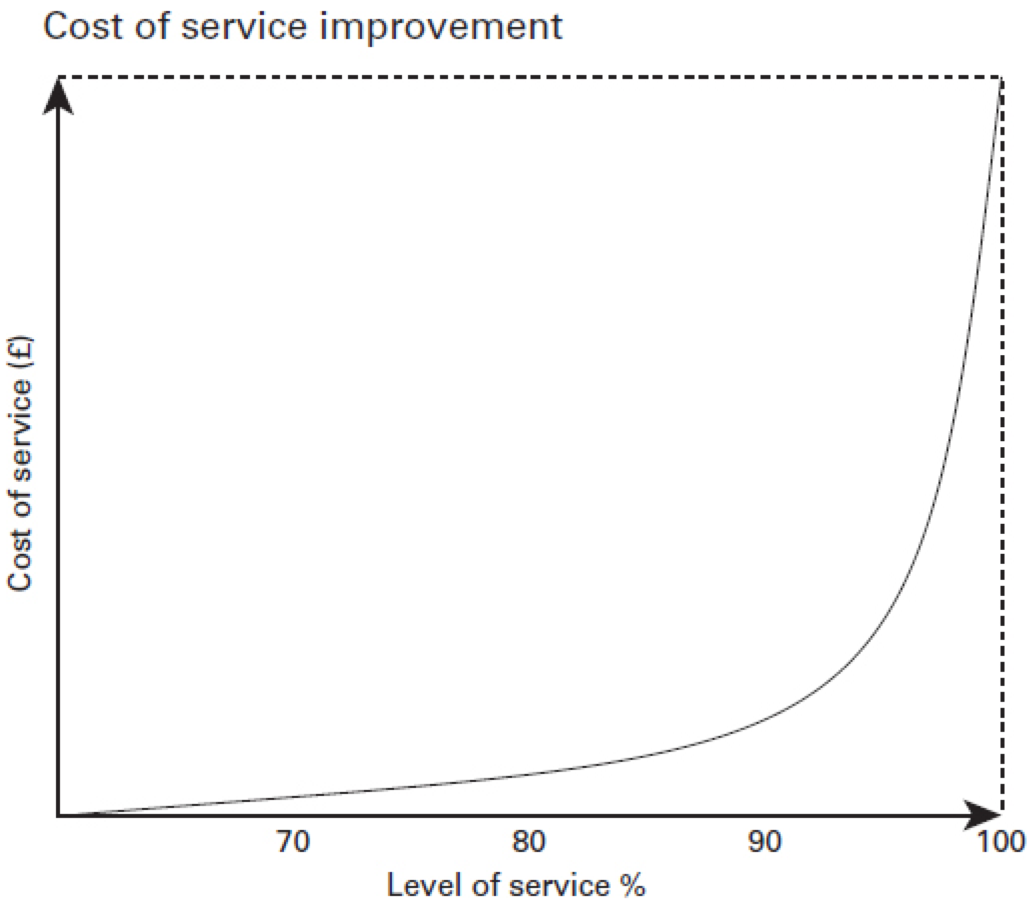
They say that the cost of an increase in service from 95 to 100 per cent will be far greater than an increase from 70 to 90 per cent, as can be seen in Figure 13.2. This may be anathema to certain companies and cultures where service is overriding and paramount; however, you have to be realistic and accept that 100 pe cent on time in full every time is desirable but not always achievable.

Figure 13.1 Retailer and third-party KPIs (courtesy of Steve Whyman)



▶ Figure 13.1 details

Figure 13.2 Cost of service improvement (courtesy of Rushton, Croucher and Baker 2010)



▶ Figure 13.2 details

Productivity is part of the overall performance umbrella: productivity output such as goods and services produced in relation to inputs that include labour, finance, material and other resources.

Warehouse managers have a number of inputs and resources under their control including labour and MHE. The key to running an efficient warehouse is to make best use of these inputs.

The essence of productivity measurement is the recording and analysis of the time it takes to perform each handling movement within the warehouse. This seems a daunting task. However, if you are to continually improve the operation you need to be able to measure it accurately. Not only do you need to measure each activity but also measure it at different times of the day and undertaken by different people.

The task, of course, is much easier if you are using technology such as voice or radio data terminals, where the system can log start and finish times. As previously discussed, this technology can record all the movements and tasks performed by operators in the warehouse, providing reports that the warehouse manager can use to assess and improve performance.

The example in Table 13.1 shows a typical manual record of work.

Table 13.1 Manual record of work

Skip table

Name: D Morgan Shift No 1 Area: zone 1 Day: Monday				
Task description	**Start time**	**Finish time**	**Volume**	**Lines p**
Pick order 123456	08.45	09.03	50 cases	5
Pick order 123498	09.05	09.30	80 cases	6
Stretch wrap pallets	09.31	10.07	24 pallets	
Load trailer ab072	10.08	10.38	24 pallets	

When measuring these activities you also need to take into account the following:

- preparation time (collecting equipment, pallet, paperwork);
- human factors (skills, motivation, fatigue, breaks);
- mechanical factors (battery changing, attachment changes, refuelling); and
- operational factors (location system, product placement, congestion).

These can be a significant percentage of the time taken to undertake the task.

If you are a third-party operator you need to know how long it takes you to undertake the different tasks associated with the warehouse in order to quote and charge your customers accordingly. Chapter 12 looks at third-party warehousing and how to cost each activity.

The crucial factor in any form of productivity or performance measurement is to ensure the cooperation of staff.

The staff need to know how the measures are derived and why they are important. They must be made aware of the reasons behind the measurements, what the information will be used for and that they will also become beneficiaries of an improved operation.

Finally, you need to decide whether the measures are individual or taken on a group basis.

According to Tom Peters, you can’t manage what you don’t measure.

There are many areas within the warehouse where performance is key to the company’s wellbeing.

As mentioned previously, getting the right product to the right customer in the correct quantity and condition, on time and at a competitive price are key to retaining that customer. Today some will also add the need to be environmentally friendly as well.

How to choose the right performance measures

Each company will have different priorities, a different customer base and a different method of operation. In order to choose the most appropriate measure you need to undertake the following:

- Understand your business and its strategy.
- Decide on the objectives.

- Understand which KPIs are likely to assist in meeting the objectives.
- Ensure the KPIs are aligned with other KPIs within the company.
- Nominate KPI owners.
- Ensure that everyone ‘buys into’ (ie, is on board with) achieving the targets. If the KPI isn’t relevant, replace it.
- If the KPI isn’t achieved analyse why and if necessary revise it.

Vitasek (2004) developed a process that helps to establish department metrics that support the overall corporate objectives and links accountability to achieve goals where the work gets done. It also creates an environment where employees use their metrics to drive positive change in the business.

For example, if the company goal is to reduce order lead time and improve accuracy the targets shown in Table 13.2 can be set for specific departments.

Table 13.2 Department metrics (courtesy of Vitasek 2004)

Skip table

Department	Target
Receiving	Reduce dock-to-stock time
Customer service	Reduce order process time
Picking	Improve pick accuracy Increase pick productivity

The first task in any performance measurement system is to understand the vision of the company and how your department can assist in achieving the company's goals.

Too often department heads will produce key performance measures which they are comfortable with and which are easily achievable but are not aligned to the company's vision and are rarely of interest to senior managers. Departments end up with too many measures, which detract from the day-to-day running of the operation.

The measures you choose need to be SMART. That is, they need to be:

- **S**pecific. Objectives should specify what they want to achieve. Are they clear and unambiguous?
- **M**easurable. Can we put a value on the kpi? Eg How much, how long, how many?
- **A**chievable. Are the targets you set achievable and attainable?
- **R**elevant. Are the measures relevant to the overall goal and strategy of the company?
- **T**imely. Are the timescales realistic and how often do you measure?

Include Evaluate and Review to make the KPIs 'smarter'.

You need to ensure that the data collected is accurate.

Moseley (2004) and Vitasek (2004) suggest that when introducing KPIs you should:

- use terminology that your staff understand and is meaningful to them;
- understand what your staff need to do to improve service or reduce costs as identified by the KPIs;
- try to use common industry KPIs so that you can benchmark your own operation against your peers;
- review the data regularly and look for specific trends;
- not overreact to a particular data point;
- only introduce measures you know you can implement, measure and improve;
- only introduce cost-effective metrics, ie ensure that it doesn't cost you more to manage than the likely savings you make;
- be seen to be using the data; there is nothing more frustrating than collecting data which isn't used.

Traditional productivity measures

There are many traditional productivity measures in use in today's warehouses.

The first of these group measures are based on labour, space and equipment utilization.

Labour hours' utilization

This measurement looks at the utilization of labour hours within the warehouse based on the total number of labour hours available to work over a particular shift, day or even week. The available hours should not include breaks.

The calculation is:

(Labour hours used × 100) ÷ labour hours available

Warehouse area utilization

This can be measured in a number of different ways. We can look at floor space utilization but more realistically we should measure the cubic capacity of the warehouse.

Alternatively, we can measure the number of pallet locations utilized against the total possible locations.

The calculation is:

(Space used × 100) ÷ space available

For example, space utilization = 8,600 pallet spaces occupied ÷ 10,000 pallet spaces available = 86 per cent utilization.

If your warehouse has a number of different sections with racking in some areas and floor storage in others then a number of calculations will be required.

Note that you need to measure the space that can be specifically used for storage. Areas used for goods in, despatch, value-adding services, etc should not be included in your calculations.

Although improving space utilization is an important goal for any warehouse, the key to improving overall warehouse productivity, that is space and labour, is to find the best compromise between storage utilization and handling efficiency.

As a guideline, the best-in-class WERC benchmark measure (2021) for this KPI is >92 per cent with a median figure of 85 per cent.

Note that most writers suggest that 86 per cent is the optimum utilization percentage as any figure above this can reduce productivity and increase the potential for health and safety issues.

MHE utilization

The utilization figure is based on available hours having taken into account down time for repairs and servicing.

The calculation is:

(MHE hours used × 100) ÷ MHE hours available

The next group of measures looks at cost performance.

In financial terms, measures include cost as a percentage of sales and cost per order despatched.

These are calculated as follows.

Cost as a percentage of cost of goods sold

As a guideline the best-in-class WERC benchmark measure (2021) for this KPI is < 3.7 per cent with a median figure of 8.35 per cent.

The calculation is:

(Total warehousing cost × 100) ÷ total cost of goods sold

Cost per unit despatched

As a guideline the best-in-class WERC benchmark measure (2021) for this KPI is \$0.42 with a median figure of \$1.55.

The calculation is:

> Total warehouse cost ÷ total number of units shipped

The above performance cost measures need to be handled with care. Cheaper products despatched from the warehouse can result in a higher cost per order, which is not a reflection of increased costs in the warehouse but the nature of the products themselves.

This third group is based on productivity measures.

Lines picked per hour

As a guideline the best-in-class WERC benchmark measure (2021) for lines picked per hour is ≥ 49.04 lines per hour with a median figure of 21.

The calculation is:

> Lines picked ÷ total hours available

Orders picked per hour

As a guideline the best-in-class WERC benchmark measure (2021) for orders picked per hour was >35 with a median figure of 12.

The calculation is:

> Orders picked ÷ total hours available

Dock-to-stock time

This is the time taken from arrival of vehicle on the receiving bay to visibility of stock on the system.

As a guideline the best-in-class WERC benchmark measure (2021) for this KPI is < 2.144 hours with a median figure of 8 hours.

This is important as the product isn't available for sale unless it is shown as available on the system.

The final group is based on customer service measures.

Percentage of orders shipped complete

The calculation is:

> (Order lines and units shipped complete × 100) ÷ total orders received

As a guideline the best-in-class WERC benchmark measure (2021) for this KPI is ≥ 99.56 per cent with a median figure of 98.0 per cent.

On-time shipments

As a guideline the best-in-class WERC benchmark measure (2021) for this KPI is ≥ 99.26 per cent with a median figure of 97.3 per cent.

The calculation is:

> Orders delivered as per customers' requests × 100 ÷ total orders received

In terms of performance measures, the 12 metrics most commonly used in distribution centres, according to a recent survey in the United States by WERC (2021), are shown below. The 2020 positions are in brackets.

- average warehouse capacity used (1);
- order-picking accuracy (% per order) (3);
- peak warehouse capacity used (5);
- on-time shipments (7);
- percentage of orders with on-time delivery* (4);
- shipped complete per customer order* (2);
- shipped damage free* (6);
- correct documentation* (8);
- dock-to-stock cycle time in hours (10);
- on-time ready to ship (–);
- percentage of supplier orders received damage free (13);
- inventory count accuracy (% by location) (9).

* Perfect order metric

The following are other measures that have appeared in the top 12 in the past:

- overtime hours to total hours;
- contract employees to total workforce;
- cross-trained employee percentage;
- percentage of supplier orders received damage free.

A full list of warehouse performance measures will be included later together with actual metrics from the study.

New performance metrics

One of the most common measures today is OTIF (on time and in full).

This metric has been joined by the perfect order metric as the most popular customer service metric (see above list). This not only requires on time in full delivery but also the item has to be damage free, have the correct documentation and label and finally an accurate invoice.

In the following example all four metrics are measured individually and then multiplied together to produce the perfect order percentage:

On-time delivery = 97 per cent
In full delivery = 98.5 per cent
Damage free = 99.5 per cent
Accurate documentation, labelling and invoicing = 98 per cent
Therefore the perfect order metric is 97 per cent × 98.5 per cent × 99.5 per cent × 98 per cent = 93.2 per cent.
In terms of OTIF, we get a result of 95.5 per cent (97 per cent × 98.5 per cent).

Inventory measures

A warehouse manager is tasked with accounting for and measuring inventory but has limited influence on the level of inventory held in the warehouse. However, you may be asked to produce the following metrics.

Stock cover in days

As a guideline the best-in-class WERC benchmark measure for this KPI is <30 days with a median figure of 60 days.

This can be calculated by dividing the current level of stock by the total annual sales and multiplying by 365. This can be done using the actual number of units in stock or the value of the stock. This tells us how many days' cover we have of stock.

For example, in Table 13.3 we can see that product code 99172100 has two and a half years' worth of stock in the warehouse. On the other hand, product code 90152100 only has five days' stock in the warehouse.

Stock turn

This can be calculated by dividing the total number of units sold by the average number of units in stock.

For example, in Table 13.3 product 90132100 has a stock turn of eight, which is reasonable, whereas product code 99172100 has a stock turn of 0.4, which means that the stock turns over less than once per annum – in fact once every 2.5 years.

Table 13.3 Stock cover calculations

Skip table

Product code	Number of units in stock	Anr
90132100	500	
90133100	1,400	
90133200	1,000	
90152100	30	
90153100	40	
90153200	80	
99172100	1,000	
99173100	16	

These calculations can be used to determine stock ordering policy and also whether some stock should be returned to the manufacturer, a sales campaign organized or the stock disposed of. Other possibilities are to put the stock onto an auction site such as eBay, sell to market traders at a heavy discount, send to charity or sell to the staff at a discount.

The days' stock figure should be aligned with the supplier lead time, the criticality of the item and the availability of the item from other sources.

As with many aspects of logistics, a balance needs to be reached between ensuring the maximum possible service with a minimum stockholding.

Stock/inventory accuracy

Another example of inventory measures includes stock accuracy. Whether stock is counted once, twice a year or daily by cycle or perpetual inventory counting, stock accuracy is an important measure. The more accurate the stock the more likely you are to fulfil orders correctly and increase efficiency.

Measures include the following:

> Location stock accuracy percentage = (number of correct locations ÷ number of locations counted) × 100
>
> Stock line accuracy = (number of correct lines counted ÷ total no of lines counted) × 100
>
> Stock unit accuracy = (actual quantity by SKU ÷ expected quantity by SKU) × 100

As a guideline the WERC best-in-class benchmark measure (2021) for this KPI is ≥ 99.9 per cent with a median figure of 99.0 per cent.

Many companies compare the value of goods in the warehouse to book stock as a measure of stock accuracy.

Reporting a 100 per cent accurate stock count because the stock value is as expected and therefore 'correct' can hide a number of sins.

Surplus obsolete stock in the warehouse amounting to £10,000 with a corresponding shortfall of £10,000 worth of popular items, although potentially acceptable from a finance department viewpoint, can significantly affect the warehouse operation.

Accuracy by line and by location is paramount for an efficient warehouse. Inventory count accuracy by dollars per unit is a finance measure not a warehouse measure.

Damaged inventory

This measures the amount of damage caused within the warehouse. It can be measured by dividing the total number of damaged items by the total number of items processed through the warehouse. It can also be measured in monetary terms:

Damaged items percentage = items found damaged ÷ items despatched per month × 100

Some companies will include damaged items within shrinkage. Best-in-class from the 2020 WERC survey is < 0.3 per cent with the median figure at 1 per cent.

Hard and soft measures

The above forms of measurement are referred to as hard measures. By this we mean they are relatively easy to measure, being quantifiable and less ambiguous.

Having been appointed customer services manager for a third-party warehouse operator, I was constantly being told by our customers how poor our service was. I decided to introduce performance measures into the operation to enable us to either refute the customer claims or improve the service in the areas where we were failing.

We looked at which measures were important to our customers.

Once the measures were in place we were able to prove to our customers that our service was in line with the Service Level Agreements and reasonably in line with their expectations. The problem in the past was that customers only remembered the times when service was below standard. Once the measures were in place this changed the customers' perceptions immediately.

Staff were tasked with producing KPIs for the areas that were important to our customers. These were discussed at monthly review meetings and any shortfall in service was examined in detail. This took the adversarial approach away from the meetings and both the good and bad performances were discussed and evaluated.

In contrast, soft measurements are those that deal with intangible attributes.

A typical example is customer satisfaction with accuracy of delivery when we ask the question – how are we doing? Soft measures are good at measuring perceived changes and will often provide a more complete picture of success compared with narrowly focused hard measures.

Soft measures are difficult, but not impossible, to define and measure. For example, a survey via a questionnaire can be used to assess several aspects of user satisfaction, for example on a scale of 1 to 10. The survey can be repeated at appropriate intervals to examine changes in perceived service.

Surveys can be used to improve service quality by asking customers to score the provider against a company thought to be excellent in its market.

Research by Landrum *et al* (2009) has shown reliability and responsiveness to be the most important contributing factors to service quality. Reliability factors include the following:

- providing services as promised;
- dependability in handling customers' service problems;
- performing services right the first time;
- providing services at the promised time;
- maintaining error-free records.

As can be seen, these measures relate very closely to the perfect order metric.

Integrated performance models

Integrated performance models are a mix of actual performance data and customer perception. The data is compiled from actual performance reports and from questionnaires sent to customers on a regular basis.

As can be seen from Table 13.4, each category is given a target rating and a weight of importance. This produces a target score by multiplying the two together.

Table 13.4 Integrated performance model (adapted from and printed with permission of Tompkins Associates 1998)

Skip table

Category	Target rating	Weight	Target score
Perfect order completion	5	50	250
Inventory accuracy	5	40	200
Housekeeping/safety	5	40	200
Labour productivity	5	30	150
Space utilization	4	30	120
Labour utilization	4	30	120
Damaged items	5	30	150
Warehouse layout	4	20	80
Equipment utilization	4	10	40
Staff training	5	10	50
Environmental	4	10	40
TOTAL		300	**1,400**
Performance index			

NOTE (R) = Red (poor); (A) = Amber (caution); (G) = Green (good).

An actual rating is also given based on the results of the survey and the actual performance, which in turn produces an actual score.

Areas that are underperforming against target are highlighted using the red, amber and green (RAG) model. The red areas are the ones that will require immediate attention whilst the amber areas will need to be tackled once the red areas have been improved.

As can be seen from Table 13.4, perfect order completion is given a target rating of 5 out of 5, with the highest weighting of

50, giving a target score of 250.

The categories are chosen to reflect the vision of the company and need to be SMART.

In any form of performance measurement you need to ensure that your measures are aligned with your customers' requirements and expectations. For example, 100 per cent despatch of what's available from the warehouse is not always the same as the quantities ordered by the customer. The order may have been adjusted by the sales staff before it reached the warehouse.

Second, 24-hour despatch from order receipt at the warehouse may not be 24 hours from the placement of the order. The order could have been delayed in customer services.

Benchmarking

This section looks at benchmarking and how it can assist you in your operation.

Benchmarking has been around since the early 19th century; however, it came to the fore in the 1980s when it was championed by the Xerox Corporation.

It is a process of comparing performance with operations of other companies, or operations within the same company, identifying high-performance or best-in-class operations and learning what it is they do that allows them to achieve that high level of performance.

Why should we benchmark?

Benchmarking enables us to:

- understand our own performance;

- identify any shortcomings;
- introduce training programmes;
- discover what others are doing better;
- identify performance targets that can be demonstrated to be achievable;
- accelerate and manage change;
- improve processes;
- understand what is best practice.

A word of caution. Benchmarking may point to best current practice but not to best possible practice. ‘As good as’ is not ‘better than’. It is not a substitute for creativity and innovation.

Benchmarking can be undertaken both internally and externally. There are a number of supply chain and logistics related benchmarking clubs. These include the Chartered Institute of Logistics and Transport’s Logmark, Benchmarking Success and the United States’ WERC and APQC.

In terms of external benchmarking, you need to choose your partners carefully. To this end there are also industry-specific benchmarking surveys such as those produced by the Institute of Grocery Distribution for retailers.

As in performance measurement, there are pitfalls to avoid. Benchmarking should not be considered until you have an intimate knowledge of your own processes and results. Second, do not select processes to benchmark that don’t have sufficient potential for improvement.

The principles of benchmarking are as follows:

- collaboration;
- confidentiality;
- value;
- flexibility;

- honesty;
- openness; and
- reputation.

There is always likely to be a reluctance to share information with competitors. However, in order to produce meaningful results, honesty and openness are paramount.

One potential method of ensuring confidentiality and anonymity is to utilize a third party such as a benchmarking group, a consultancy or a university.

The example in Table 13.5 is from Mondelēz, who benchmark each of their distribution centres Europe-wide. All the centres work towards the same targets to enable a comparison across sites and ensure best practice is achieved.

Table 13.5 Mondelēz benchmarking model

Skip table

Country and site			
UK: 3PL A			
Category			**Units**
Warehouse	**Operational metrics**	Cases despatched (total)	Number
		Pallets despatched (total)	Number
		Case pick pallets despatched	%
		Total warehouse cost including overheads	£
	KPIs	Full pallet pick	%
		Cost per case despatched	£
		Cost per pallet despatched	£
Service	**KPIs**	Case fill (Log Ops responsible)	%
		On time in full (Log Ops responsible)	%
Transport IB	**Operational metrics**	Number of cases received	Number
		Number of pallets received	Number
		Number of loads received	Number
	KPIs	Vehicle utilization	%
Transport OB	**Operational metrics**	Number of cases despatched	Number
		Number of pallets despatched	Number
		Number of loads despatched	Number
	KPIs	Vehicle utilization	%
Inventory	**Operational metrics**	Total inventory value	Euro

Country and site			
UK: 3PL A			
Category			**Units**
		Total warehouse pallet capacity	Number
		Number of pallets in stock (month end)	Number
		Value of inventory written off (Log Ops responsibility)	Euro
	KPIs	Warehouse utilization	%
Safety	**KPIs**	LTIFR (global definition)	Number
		Total number accidents	Number
		Number of lost time accidents	Number
Quality	**Operational metrics**	Number of pallets on hold or in quarantine	Number
	KPIs	Cases damaged in transit	Number
		Cases damaged in warehouse	Number
		Transport security incidents reported	Number
Environment	**Operational metrics**	Electricity consumption	KWh
		Gas consumption	Cubic metre
		Transport CO2 emissions	Tonnes
	KPIs	Outbound CO2 per pallet shipped	Tonnes
	KPIs	Electricity consumption per pallet shipped	KWh

IB = Inbound

OB = Outbound

Log Ops = Logistics Operations

LTIFR = Lost Time Injury Frequency Rates

There are eight major areas made up from 34 individual measures. Utilizing this benchmarking tool, the Mondelēz team is able to compare its own in-house operations with that of their third-party logistics providers.

Table 13.6 shows an internal benchmarking model from Wincanton, a UK third-party logistics provider. Targets were set and then compared against actual results.

Table 13.6 Internal benchmarking (courtesy of Wincanton)

Skip table

Wincanton

Wincanton Benchmark Model: Output

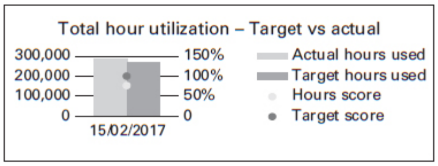
Back to Data Input

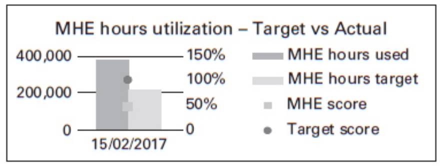
Site: Midlands No.4

Date: 15/02/2017

Save result - to show improvements over time on graph (max 6 times)

View SMVs (Standard Minute Values) - to support planning





Total hours used	Actual used	Target hours	Current score	Ahead/(Behind) standard	100% optimum hours
Total full-time standard hours paid	253689	234000	73.79%	–6%	187200
Total full-time overtime hours paid	2127	287	10.81%	–69%	230
Agency hours paid	28988	39047	107.76%	28%	31238
Total hours used	**284804**	**273334**	**76.78%**	**–3%**	**218667**

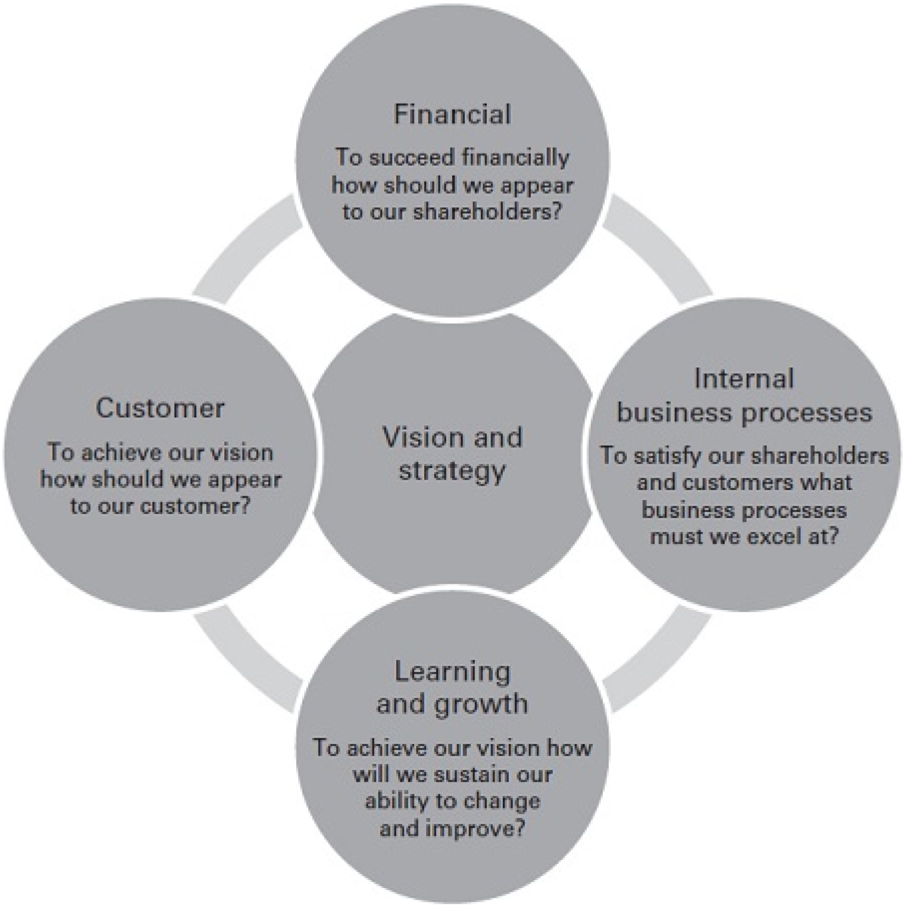
Total hours used	Actual used	Target hours	Current score	Ahead/(Behind) standard	100% optimum hours
Bendi truck	0	0	0.00%	0%	0
Hand pallet trucks	6056	681	8.99%	–71%	545
Powered pallet trucks	53456	40526	60.65%	–19%	32420
Counterbalance trucks	13456	11922	70.88%	–9%	9537
Reach trucks	72749	36177	39.78%	–40%	28941
Narrow aisle trucks	17046	1677	7.87%	–72%	1342
Low-level order pickers	215788	124452	46.14%	–34%	99562
MHE hours used	**378551**	**215434**	**45.53%**	**–34%**	**172347**

▶ Table 13.6 details

Balanced scorecard

The balanced scorecard, developed by Kaplan and Norton (1996), is another method of recording performance (see Figure 13.3).

Figure 13.3 The balanced scorecard (Kaplan and Norton 1996)



▶ Figure 13.3 details

The scorecard looks at a number of dimensions, which include finance, customer satisfaction, internal processes and staff development and innovation.

Each measure will have objectives and targets, which are measured against actual performance.

Introducing a balanced scorecard approach should result in better processes, a motivated team of people, increased customer satisfaction and improved communication.

As can be seen from the Mondelēz example, the warehouse operation will contribute to the overall company scorecard. The Mondelēz scorecard has specific sections on warehouse operations, inventory, quality, safety and the environment – all of which can be integrated with other departments operating within the company.

The performance and productivity metrics shown in Table 13.7 were elicited from WERC members in 2021. We have chosen our top 14 metrics together with the four metrics which make up the perfect order metric, with a cross-section across customer satisfaction, supplier performance, accuracy, utilization, productivity and inventory measures.

Table 13.7 WERC performance metrics (2021) (courtesy of WERC)

Skip table

	Lowest 20% of respondents	Typical	Best-i
Perfect order index	< 73.64%	≥ 89.3 and < 95.7%	≥ 98.4
% orders delivered on time	< 90.24%	≥ 95.1 and <98.4%	≥ 99.2
% orders shipped complete	< 92%	≥ 97.1 and <99%	≥ 99.5
% orders shipped damaged free	< 95.58%	≥ 98.6 and < 99.2%	≥ 99.7
% orders sent with correct documentation	< 92.8%	≥ 98.08 and 99.2%	≥ 99.8
Internal order cycle time	> 36 hours	≥ 6 and < 18 hours	< 2 ho
Cost as a % of COGS	> 30%	≥ 6.4 and <10%	<3.7%
Order-picking accuracy	< 97.96%	≥99.06 and < 99.7%	≥ 99.9
On-time ready to ship	< 92.88%	≥ 97.26 and < 99%	≥ 99.8
Average warehouse capacity used	< 75%	≥ 80 and <86.18%	≥ 92%
Annual workforce turnover	> 39.4	≥ 10.02 and < 20	< 4.82
Unplanned absence %	> 11%	≥ 5 and < 8%	≥ 2.1 a
Dock-to-stock cycle time in hours	> 24	≥ 4.086 and <14.68	< 2.14
Lines received and put-away per hour	< 7	≥ 15 and < 25	≥ 56
Inventory count accuracy by location per unit	< 93%	≥ 98 and < 9.342%	≥ 99.9

	Lowest 20% of respondents	Typical	Best-i
Days on hand, finished goods inventory	> 94.4	≥ 45 and < 64.8	< 30
Supplier on-time delivery	< 80%	≥ 90 and < 95%	≥ 98.3

KEY < Less than; > Greater than; ≥ Greater than or equal to; ≤ Less than or equal to

The best-in-class figures are definitely targets to benchmark against. However, this will very much depend on the types of companies who replied to the survey. Warehouse space utilization of ≥ 90 per cent suggests a very slick operation with real-time technology at the forefront of operations. Note that this figure may not fully reflect best practice. Many studies have shown that an average warehouse capacity of between 80 and 86 per cent allows the warehouse to respond efficiently to shifts in demand.

Companies are able to benchmark their own activities against those in the survey including by sector by visiting www.werc.org.

Health and safety metrics will be covered in Chapter 14.

Summary and conclusion

Measuring performance is key to running an efficient operation. However, the measures need to be SMART and aligned to the company's strategic vision.

One important point to note is that traditional KPIs report on the status of an operation or step in a process at a particular point in time. They are useful in comparing performance over time, but situations change rapidly and targets and measures need to change in unison with the changing environment.

There are a large number of performance measures related to warehouse operations. However, you should only measure those areas that are important to your customers and to your company, ie those measures that will drive the business forward. Don’t measure just for the sake of it.

Being able to collect data is fine, but it’s what happens as a result of collecting and analysing the data that is important. These measures have to take you somewhere.

14
Health and safety

GWYNNE RICHARDS, JERRY RUDD AND AARON & PARTNERS LLP

> *Health and safety is a fundamental part of business. Boards need someone with passion and energy to ensure it stays at the core of the organization.*
> (HEALTH AND SAFETY EXECUTIVE)

Introduction

During a discussion on LinkedIn, managers were asked which areas in the warehouse were high on their priority list. Safety was the most popular answer. This chapter looks to inform managers of the potential hazards found within the warehouse and how they can make the area as safe as possible for their staff. Accidents will happen; however, there are processes that can reduce the dangers significantly.

Ensuring the health and safety of the workforce should not be thought of only in terms of its direct costs but also in terms of the financial benefits it can bring. Accidents and poor health do cost money, both directly, eg in terms of absence, lost productivity and damage to goods and equipment; and indirectly, eg through poor morale and damage to the company's reputation. Substantial fines and damages can be imposed by the courts and in extreme cases individual managers can face lengthy prison sentences. In this chapter we will examine not only the physical wellbeing of staff but also their mental health.

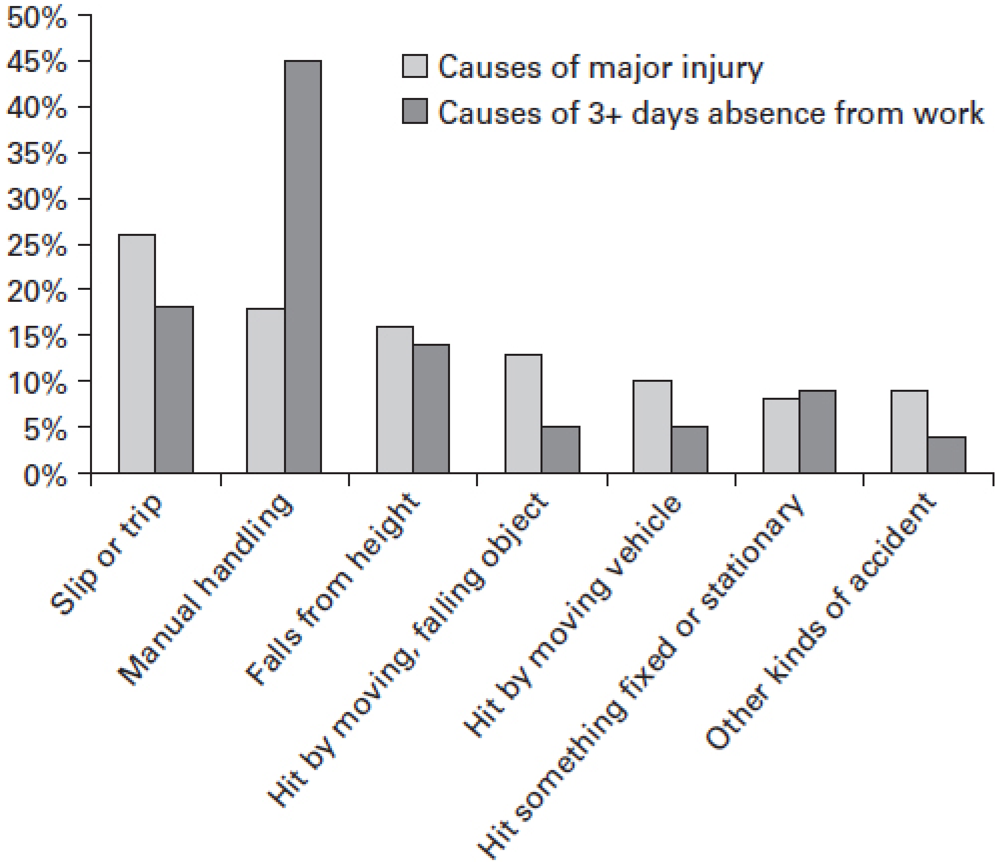
According to an article in *Management Today*, company boards are becoming aware of the potential boost that good health and safety practice can give to employee wellbeing and productivity. Furniss (2017) says that when workers know that a company cares they become more comfortable flagging up issues as they know the company will do something about them.

The increasing fines on both companies and their management is also concentrating the minds of company boards. UK courts are also being directed to punish near misses or accidents waiting to happen.

Warehousing and storage cover a whole range of activities, all of which have their own hazards and risks. Employers need to ensure effective health and safety management, looking at the risks involved in the workplace and then putting in place effective control measures to properly manage health and safety.

The main causes of major injuries in the warehouse, according to the HSE (Health and Safety Executive), are shown in Figure 14.1.

Figure 14.1 Main causes of injuries in the warehouse (www.HSE.gov.uk)



▶ Figure 14.1 details

OSHA (Occupational Safety and Health Administration) also cite the following:

- unsafe use of forklifts;
- improper stacking of products;
- failure to use proper personal protective equipment (PPE);
- failure to follow proper lockout/tagout procedures, ie prevent equipment from being accidentally energized;
- inadequate fire safety provisions; and
- repetitive motion injuries.

According to the HSE, there are around 1,300 serious forklift accidents each year.

In terms of recording injuries received within the warehouse, OSHA require companies to record the total recordable incidence rate.

OSHA injuries and illnesses include all work-related deaths, illnesses, and injuries that result in a loss of consciousness, restriction of work or motion, permanent transfer to another job within the company, or that require some type of medical treatment other than first-aid treatment (as defined by OSHA).

The formula is as follows:

The incidence rates represent the number of injuries and illnesses per 100 full-time workers and were calculated as (N/EH) x 200,000 where:

N = number of injuries and illnesses
EH = total hours worked by all employees during the calendar year
200,000 = base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year)
= OSHA incidence rate

This can be included in your list of warehouse performance measures.

Another measure can be the number of days since a reportable accident occurred.

Depending on the workplace and specific work types, there may be other risks on site that need to be considered as well as those set out above. Warehousing is a very complex industry that exposes workers to a whole variety of risks, and therefore employers must ensure that health and safety is treated with the utmost importance at management level.

A health and safety policy is a stepping stone to ensuring health and safety in the workplace, and in the United Kingdom if a business has more than five employees (this includes directors) there must be a written policy in place. This policy should be brought to the attention of all employees.

For companies who employ fewer than five staff, it is not a strict legal requirement to maintain certain written records, including a written health and safety policy. However, there are clear benefits in doing so, and it is difficult to see how a company that hasn't kept records could prove that it had taken necessary steps if required to do so. Keeping written records is therefore strongly recommended for all organizations no matter how small. Each country will have its own health and safety legislation and therefore we will concentrate on the aspects we believe to be important and relevant.

The Health and Safety at Work Act (1974) in the United Kingdom requires an employer to ensure the health, safety and welfare of employees, as far as is reasonably practical. It places responsibility for health and safety into three categories:

- employer responsibilities:
    - provision of a health and safety statement policy;
    - provision of safety equipment;
    - commitment to train staff.

Added to this, employers need to ensure the continued safety of the equipment it provides and also the provision of up to date information and clear supervision.

- employee responsibilities:
    - obligation to cooperate with their employer;

    - obligation to undertake training, report issues and not to misuse equipment.
- manufacturers' responsibilities:
    - ensure product is safe to use and fit for purpose.

Risk assessments

In today's atmosphere of increased litigation, there is added pressure on managers to ensure the safety of their employees. Managers have to take appropriate steps to identify potential areas where accidents can occur and take steps to avoid them.

Note that a hazard is anything that may cause harm, such as chemicals, working from height, broken pallets, etc. The risk is the chance, high or low, that somebody could be harmed by these and other hazards, together with an indication of how serious the harm could be.

A risk assessment is an important step in protecting your workforce and your business as well as complying with the law. It helps you to focus on the risks that really matter in your workplace, ie the ones with the potential to cause harm. For most, that means simple, cheap and effective measures to ensure that the workforce is fully protected.

The law does not expect you to eliminate all risk but you are required to protect staff and visitors as far as is reasonably practicable. According to the HSE, this means that you 'have to take action on the health and safety risks in the warehouse except where the cost (in terms of time and effort as well as money) of doing so is "grossly disproportionate" to the reduction in the risk'.

A risk assessment is simply a careful examination of what can cause harm to people so that you can weigh up whether you have taken enough precautions or should do more to prevent harm. Staff and others have a right to be protected from harm caused by a failure to take reasonable control measures. You are legally required to assess the risks in your workplace, so you must put plans in place to control risks. However, don't overcomplicate the process. Most risks are easily identifiable and the necessary control measures are easy to implement.

You also need to decide whether you have the necessary experience in-house to undertake the risk assessment or whether you need to employ an external health and safety expert.

A risk assessment can be broken down into five stages:

Step 1: Identify the hazards.
Step 2: Decide who might be harmed and how.
Step 3: Evaluate the risks and decide on precautions.
Step 4: Record and communicate your findings and implement them.
Step 5: Review your risk assessment regularly and update if necessary.

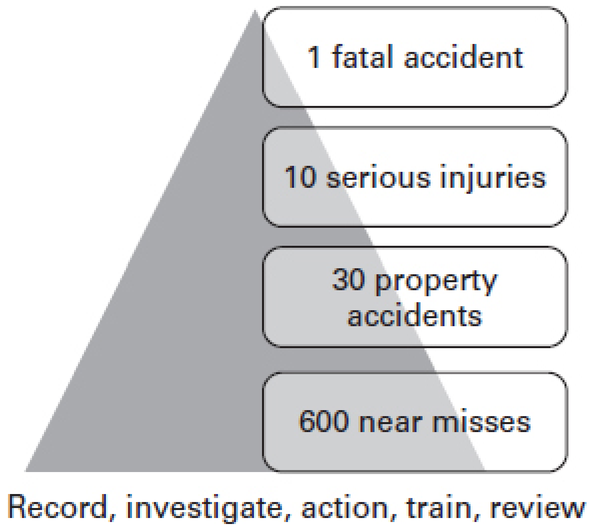
Identify the hazards

Walk around the warehouse, internally and externally, and look at what could reasonably be expected to cause harm.

Ask your colleagues and staff if they are aware of any potential hazards.

Check the manufacturers' instructions or data sheets for chemicals and equipment as they can be very helpful in spelling out the hazards and putting them in their true perspective. Check back on your accident records (ensure that near misses are also recorded). See Figure 14.2.

Figure 14.2 The accident pyramid (adapted from Bird and Germain 1996)



Assess potential long-term effects to health, eg high levels of noise or exposure to harmful substances.

The accident pyramid shows that for every 600 near misses there are 10 serious injuries and for every 10 serious injuries there can be one fatality. Thus, every near miss needs to be recorded, investigated, actioned, staff trained and the situation reviewed regularly.

Wincanton, a UK 3PL, have a KPI that requires the recording of over 300 near misses during a specific period. Staff are encouraged to look out for any possible threat to their wellbeing.

Decide who might be harmed and how; then evaluate the risks and decide on precautions

For each hazard you need to be clear about who might be at risk and potentially harmed; it will help you to identify the best way of managing the risk. That doesn't mean listing everyone by name, but rather identifying groups of people (eg in-handling team, visitors).

Remember:

- Some workers have particular requirements, eg new staff and people with disabilities may be at particular risk.
- Include cleaners, visitors, contractors, maintenance workers, etc who may not be in the workplace all the time.
- In each case, identify how they might be harmed, ie what type of injury or ill health might occur. For example, 'Staff stacking shelves may suffer back injury from repeated lifting of boxes.'
- Evaluate the risks and decide on precautions.
- Discuss your findings with the company's safety representative.

Having identified the hazards, you then have to decide what to do about them. The law requires you to do everything 'reasonably practicable' to protect people from harm. You can work this out for yourself, but the easiest way is to compare what you are doing with good practice.

First, look at what you're already doing. Think about what controls you have in place and how the work is organized. Compare this with good practice and see if there's more you should be doing to bring yourself up to standard. In asking yourself this, consider:

- Can I get rid of the hazard altogether?

For example, if there is a risk of traffic office personnel getting struck by a vehicle when walking across the yard to the admin office to collect dispatch paperwork, can it be sent electronically to the traffic office and printed there, eliminating the need to walk across the yard?

- If not, how can I control the risks so that harm is unlikely?
- When controlling risks, apply the following principles, if possible, in this order:
    - Try a less risky option (eg switch to using a less hazardous chemical).
    - Prevent access to the hazard (eg by using guardrails).
    - Organize work to reduce exposure to the hazard (eg put barriers between pedestrians and traffic).
    - Issue PPE (eg clothing, footwear, goggles).
    - Provide welfare facilities (eg first aid and washing facilities for removal of contamination).

Improving health and safety need not cost a great deal. For instance, placing a mirror on a dangerous blind corner to help prevent vehicle accidents is a low-cost precaution, considering the risks. Failure to take simple precautions can cost you a lot more if an accident does happen.

Involve staff, so that you can be sure that what you propose to do will work in practice and won't introduce any new hazards.

If a new hazard is introduced, a separate risk assessment must be carried out. For example, if a new piece of lifting equipment is introduced, only trained staff should be allowed to use it. Note that if staff are consulted they are more likely to comply with new procedures.

Record and communicate your findings and implement them

Putting the results of your risk assessment into practice will make a difference when looking after people and your business.

Recording the results of your risk assessment and sharing them with your staff encourage you to do this. When recording your results, keep it simple: for example ‘Tripping over rubbish: bins provided, staff instructed, daily housekeeping checks’, or ‘Broken pallets in racking: products repalletized, daily housekeeping check.’

Staff communication is key in this respect.

The HSE does not expect a risk assessment to be perfect, but it must be suitable and sufficient. You need to be able to show that:

- a proper check was made;
- you asked who might be affected;
- you dealt with all the obvious significant hazards, taking into account the number of people who could be involved;
- the precautions are reasonable, and the remaining risk is low; and
- you involved your staff or their representatives in the process.

If, like many businesses, you find that there are quite a lot of improvements that you could make, big and small, don’t try to do everything at once. Make a plan of action to deal with the most important things first. Health and safety inspectors acknowledge the efforts of businesses that are clearly trying to make improvements.

A good plan of action often includes a mixture of different things such as:

- a few cheap or easy improvements that can be done quickly, perhaps as a temporary solution until more reliable controls are in place;
- long-term solutions to those risks most likely to cause accidents or ill health;
- long-term solutions to those risks with the worst potential consequences;
- arrangements for training employees on the main risks that remain and how they are to be controlled;
- regular checks to make sure that the control measures stay in place; and
- clear responsibilities – who will lead on what action and by when.

An example of a warehouse risk assessment can be found in Table 14.1. Remember, prioritize and tackle the most important things first. As you complete each action, tick it off your plan. Note that the entries in Table 14.1 are examples only. Each company will have its own unique hazards. For example, falls from height can include falling from a dock leveller.

Table 14.1 Example risk assessment partly completed for the warehouse

Skip table

Location:		Date:		Assess
What are the hazards?	Who might be harmed and how?	What are you already doing?	What further action is necessary?	Action
Falls from height	Staff can suffer severe or even fatal injuries if they fall whilst climbing racking	All staff are given instructions never to climb racking – monitored by supervisors	Signage put in place to reiterate the point. Equipment made available to enable staff to access racking safely	Wareh Manag
	Staff or contractor could suffer severe or fatal injuries falling through fragile roof lights when effecting repairs	No controls in place	Put up 'fragile roof' signs on each side of the building and at access points	Facilit Manag
			Only trained contractors to access the roof	Facilit Manag
			Full risk assessment to be undertaken by contractor	FM/C
Slips, trips and falls	All staff may suffer sprains or fractures if they trip over debris or slip on spillages	Flooring kept dry and quality maintained	Suitable absorber to be made available for liquid spills	FM
		All staff trained to maintain good housekeeping standards	Extra bins provided for waste	FM
Manual handling				
Falling objects				
Operation of MHE				
Machinery				
Traffic movements				

Location:		Date:		Assess
What are the hazards?	Who might be harmed and how?	What are you already doing?	What further action is necessary?	Action
Portable electrical equipment				
Lighting				
Hazardous substances				
Fire				
Hygiene and Comfort				

Review your assessment regularly and update if necessary

Few workplaces stay the same. Sooner or later, you will bring in new equipment, substances and procedures that could lead to new hazards. It makes sense, therefore, to review what you are doing on an ongoing basis. Every three months or after a significant incident, formally review where you are, to make sure you are still improving or at least not sliding back.

Look at your risk assessment again. Have there been any changes? Are there improvements you still need to make? Have your workers spotted a problem? Have you learnt anything from accidents or near misses? Make sure your risk assessment stays up to date.

When you are running a business it's all too easy to forget about reviewing your risk assessment – until something has gone wrong and it's too late. Set a review date for the risk assessment. Write it down and note it in your diary as a regular event.

During the year, if there is a significant change, don't wait: check your risk assessment and, where necessary, amend it. If possible, it is best to think about the risk assessment when you're planning your change – that way you leave yourself more flexibility.

A Word version of a risk assessment document (Table 14.1) can be downloaded from http://howtologistics.com/product-category/audit-tools/ for a small fee.

Layout and design

As part of a health and safety regime, steps must be taken to protect the welfare of employees and visitors, and therefore a safe and healthy environment must be ensured with proper welfare facilities being made available.

In terms of ensuring a safe environment, a warehouse should be designed and laid out to allow people to move around it safely. A well-thought-out design and layout of a warehouse will help to reduce accidents, particularly those involving vehicles and slips/trips. Points to consider when thinking about design and layout include:

- storage areas, aisles and gangways;
- pedestrian traffic routes;
- ensure that all personnel have a reason to be there;
- stairs and ramps; and
- emergency escape routes.

Included in this should be the regular inspection and maintenance of equipment within the warehouse.

Racking tends to be the largest structure within the warehouse and at times the most neglected in terms of inspection. The following racking checklist can be drawn up as an inspection sheet, and should be introduced and checked regularly:

- Is the equipment on sound, level flooring?
- Is it still installed correctly?
- Are double-sided runs connected properly?
- Are the aisles wide enough?
- Are the beam connector locks securely fastened?
- Is there damage to the rack deflector guards and barriers?
- Are the racks aligned properly?
- Are the correct pallets being used?
- Are the pallets in good condition?
- Is there any visible damage to the beams and columns?
- When was it last inspected?
- Are there signs on the end detailing weight capacities?
- Are staff trained properly?
- Are there any receptacles for rubbish, eg shrink wrap, packaging, broken bits of pallet?

A significant hazard within any warehouse is where improperly stored goods can fall and injure staff. Carrying out these checks regularly should minimize these occurrences.

Figure 14.3 shows the importance of ensuring that beam connector locks are installed for each and every beam to avoid catastrophic damage. The picture shows how damage has been minimized by correct procedures.

Figure 14.3 Partial rack collapse (courtesy of Nene)

VIDEO 14i Example of rack collapse

This video shows a forklift truck travelling slowly between racking and floor storage. Note how the merest of contact brings the racking down. Rack protectors could have stopped this from happening. Fortunately the driver escaped unscathed.

Fire safety

Employers need to have an emergency plan that describes what is expected of employees in the event of an emergency, including:

- provisions for emergency exit locations and evacuation procedures;
- procedures for accounting for all employees and visitors; and
- location and use of fire extinguishers and other emergency equipment.

A fire risk assessment must be undertaken to ensure that fire safety procedures, fire prevention measures and fire precautions are all in place and correct. The five stages of fire risk assessment are:

Step 1: Identify fire hazards.
Step 2: Identify people at risk.
Step 3: Evaluate, remove, reduce and protect from risk.
Step 4: Record, plan, inform, instruct and train.
Step 5: Review and revise risk assessments as necessary.

It is important to ensure that there is an escape route from all parts of the building, eg dead ends of racking aisles must not be neglected and sufficient space allowed for escape. The introduction of sprinkler systems throughout the warehouse should isolate a fire and minimize the damage to the stock. However, there have been occasions when the pipes have been damaged by forklift trucks and caused unnecessary damage. Careful placement of sprinklers is therefore essential, and the use of protective guards should also be considered.

An Ocado warehouse in Andover UK was completely destroyed in 2020. Investigators found an electrical fault at a battery charging unit, which caused the plastic lid on the top of a grocery-carrying robot to catch fire. The fire detection system ‘did not detect the fire as designed’, and although the sprinkler system started operating 11 minutes later it was apparently turned off by staff who thought they could deal with the fire locally. This, unfortunately, led to a ‘significant’ growth in the fire.

Although sprinklers can cause significant water damage, they are very effective in extinguishing fires.

Figure 14.4 shows a sprinkler system on a mezzanine floor.

Figure 14.4 Sprinkler system (courtesy of Joe Fogg)

Slips and trips

Within the storage and warehousing industry, slips and trips are a very serious problem. They are responsible for one-third of major injuries and a fifth of over-three-days absence injuries in the United Kingdom. According to the US Department of Labor, slips, trips and falls make up the majority of general industry accidents, which account for 15 per cent of all accidental deaths, 25 per cent of all injury claims, and 95 million lost work days – annually. That's 65 per cent of the total of lost workdays. Therefore a working environment must be created where they are much less likely to happen.

According to Scott Stone from Cisco Eagle companies need to:

- Enforce good housekeeping. Don’t allow spills to stay on the floor. Soak up oil or greasy waste and instantly mop up liquid spills. Be sure you have absorbent powders and other cleaning agents on hand. Also, consider purchasing spill containment systems and liquid storage cabinets.
- Don’t let your aisles become cluttered. Clutter can hide spills and cause fall hazards.
- Remove or strictly control the use of cell phones. People walking in a warehouse or on a plant floor while texting or otherwise paying attention to their phone screen are asking for an accident (a slip, or worse, collision with an industrial vehicle).
- Provide anti-slip mats wherever possible, but in particular in areas known for wet or oily conditions. Install carpet mats at entrances to reduce wet shoes entering an area where polished concrete can make them into ice skates.
- Make sure workers wear appropriate footwear on your plant floor. Slippery, inadequate shoes are a major contributor to slip and fall accidents.
- Be sure handrails are installed wherever possible. Use gates and other obstructions to slow the pace of walking in critical areas.
- Be certain that lighting is adequate.
- Train for success. Make sure people understand that running isn’t allowed on your floor, nor are other dangerous behaviours.
- Keep floors and traffic routes free from obstructions that may present a hazard, particularly near stairs, on emergency routes or in/near doorways.

The workplace must be regularly inspected to ensure that flooring remains adequate and repairs are undertaken wherever necessary. Any spillages must be cleaned up immediately.

Manual handling

In warehousing, manual handling can often cause work-related problems, including back pain and neck pain. If manual tasks are carried out, a risk assessment must be undertaken and the potential risk should be avoided if possible. If this risk cannot be avoided, the risk of injury occurring must be minimized as far as possible. When considering a manual handling operation, the following must be taken into account:

- the task;
- the load;
- the frequency of the task;
- the working environment; and
- individual capacity.

Wherever possible, you should try to use mechanical handling devices such as lift trucks, pallet trucks, trolleys or scissors lifts. Mechanical handling devices should help to avoid or reduce manual handling operations (see Video 14ii).

VIDEO 14ii The use of an exoskeleton with the warehouse

All employees should be trained in safe manual handling techniques, training should be specific to the tasks that they undertake and all such training should be recorded. Operators should also be encouraged to get a co-worker to assist if a product is too heavy.

Shelves and bins should also be repositioned to reduce lifts from shoulder and floor height. Popular items should be kept on the middle shelves to avoid continuous bending and stretching.

Finally, ensure that overhead lighting is adequate for the task in hand.

Working at height

1. Working at height can be a particular risk in the warehousing and storage industry and any working at height must be properly planned, supervised and carried out in as safe a manner as possible. Generally, it is advisable that all work at height should be avoided; however, if this is impossible, equipment must be provided to allow such work to be carried out in as safe a way as possible. Any equipment that is provided to allow working at height must be inspected regularly to ensure that it remains safe and is being used in the correct manner.
2. The use of cages on forks is now banned in some countries. In any event, they should not be used for regular tasks such as routine maintenance. Boom lifts or platforms (cherry pickers) are a safer alternative.

Vehicles

A common cause of accidents in the loading bay is from vehicle creep, where a lorry either drifts slightly away from the loading dock or, in the worst-case scenario, the driver moves off before warehouse operatives have actually finished loading or unloading the vehicle. This is known as a 'drive-away' and can have serious, indeed fatal, consequences.

From a safety aspect, there needs to be assurance that the vehicle cannot be driven away whilst it is in the process of being unloaded. This can be done in a number of ways:

- The vehicle keys can be held on the loading bay and handed back to the driver when the unloading operation has been completed.
- The vehicle/trailer can be immobilized in some way either by using wheel locks, clamps, chocks or trailer safety interlocks which fit to the air hose coupling and interlock with the warehouse bay door.
- A system of lights can be introduced on the loading bay indicating when it is safe for a driver to pull away from the bay.

A combination of the above is likely to be the most effective safety system. Ruth Waring of Acumen adds a note of warning: 'Foreign drivers with left-hand-drive vehicles operating in the UK can easily get confused by traffic light systems on bay doors, as they may be looking at the wrong set of lights and still pull away whilst loading is ongoing.'

Another thing to watch out for is drivers who deliberately carry a spare set of keys so they can listen to the radio or have the heater on while they are waiting. Placing a high 'Stop' sign right in front of the cab (this can be moved by a forklift truck if pallet mounted) makes it much harder for the driver to misinterpret any signals from the loaders and simply drive off.

Drive-away can also happen when the trailer is being loaded/unloaded from the side by forklift truck, where the driver thinks the loading has finished and drives off. If the forks are in a pallet at the time, the forklift truck can tip over 90 degrees, which has also led to fatalities.

Vehicle creep isn't the only hazard in the loading bay, according to John Meale (2010) from Thorworld:

> Most trailers are not equipped with internal lighting, so it's a good idea to fit dock lights to improve visibility. Otherwise, operatives entering the vehicle from a brightly lit warehouse can struggle to adjust to the change in conditions and may not see potential hazards, causing injury to themselves or potentially damaging goods.

Loading bays should also be fitted with safety guards to ensure that staff and trucks cannot fall from the dock when not in use.

With regard to the driver, there are a number of issues. First, there is the decision whether the driver should assist in the offloading of the vehicle or at least supervise the offloading to ensure damage isn't caused to the product during this process. The driver will have to comply with the health and safety policy of the warehouse.

With the increase in imported goods and cross-border movements, the production of driver guidelines in different languages will assist in the communication process between drivers and the receiving team. Issuing picture guidance is also a good idea.

It is important to ensure that moving vehicles (whether forklifts or road vehicles) are segregated from pedestrians as much as possible. This applies equally to yard space and other outdoor areas, as to loading bays and other areas within the warehouse. Steps that you can take include:

- Only essential personnel should be permitted to enter working areas.
- All staff and visitors must wear hi-viz tops.

- Within those areas, there should be clearly designated walkways. These should follow the shortest safe route to discourage people from taking short cuts.
- Walkways should be protected by barriers wherever possible. Barriers should be placed outside doorways to prevent people walking straight out into a dangerous area.
- Delivery vehicles should receive instructions on arrival, from a security guard or via an intercom.
- If this is not possible, there should be clear signage and road markings. This should include signage that shows a driver where they must report.
- There should be a speed limit on site, and a one-way system is desirable.
- Trailer coupling and uncoupling must be carried out in a safe manner.

Forklift trucks

In accidents involving forklift trucks, 87 per cent were attributed to counter-balance trucks. The highest number of accidents (48 per cent) occur when stacking/retrieving goods, and the greatest cause of accidents is being struck by a moving vehicle.

As many accidents occur when operating or when in the vicinity of forklift trucks, we have listed the following guidelines from the US National Institute for Occupational Safety and Health (NIOSH).

NIOSH recommends that employers and workers comply with OSHA regulations and consensus standards, maintain equipment and take the following measures to prevent injury when operating or working near forklifts.

The key areas are as follows:

- Make sure that workers do not operate a forklift unless they have been trained and licensed.
- Develop, implement and enforce a comprehensive written safety programme that includes worker training, operator licensing and a timetable for reviewing and revising the programme.
- Establish a vehicle inspection and maintenance programme.
- Retro fit forklifts with an operator restraint system if possible.
- Ensure that operators use only an approved lifting cage and adhere to general safety practices for elevating personnel with a forklift. Also, secure the platform to the lifting carriage or forks. NB As discussed previously, some countries do not allow this practice anymore. Check the legislation in your own country.
- Do not move the forklift whilst the cage is in the air.
- Provide means for personnel on the platform to shut off power to the truck whenever the truck is equipped with vertical only or vertical and horizontal controls for lifting personnel.
- Separate forklift traffic and other workers where possible.
- Limit some aisles to workers on foot only or forklifts only.
- Restrict the use of forklifts near time clocks, break rooms, cafeterias and main exits, particularly when the flow of workers on foot is at a peak (such as at the end of a shift or during breaks).
- Install physical barriers where practical to ensure that workstations are isolated from aisles travelled by forklifts.

- Evaluate intersections and other blind corners to determine whether overhead dome mirrors could improve the visibility of forklift operators or workers on foot.
- Make every effort to alert workers when a forklift is nearby. Use horns, audible reversing alarms and flashing lights to warn workers and other forklift operators in the area. Flashing lights are especially important in areas where the ambient noise level is high.
- Ensure that workplace safety inspections are routinely conducted by a person who can identify hazards and conditions that are dangerous to workers. Hazards include obstructions in the aisle, blind corners and intersections and forklifts that come too close to workers on foot. The person who conducts the inspections should have the authority to implement prompt corrective measures.
- Do not store bins, racks or other materials at corners, intersections or other locations that obstruct the view of operators or workers at workstations.
- Enforce safe driving practices such as obeying speed limits, stopping at stop signs and slowing down and blowing the horn at intersections.
- Repair and maintain cracks, crumbling edges and other defects on loading docks, aisles and other operating surfaces.

Warehouse equipment legislation

There are two major parts of legislation within the UK that relate directly to the operation of warehouse equipment: Provision and Use of Work Equipment Regulations, 1998

(PUWER 1998), and the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER).

All mechanical handling and lifting equipment is classed as ‘work equipment’ and subject to PUWER. These regulations require:

- the inspection and maintenance of equipment;
- the provision of information, instruction and training;
- the marking of controls;
- that mobile work equipment for carrying persons is suitable;
- protection from rolling over;
- facilities to prevent unauthorized operation;
- the provision of lighting equipment where necessary;
- the provision, where necessary, of devices to improve vision.

All equipment must be suitable for its intended use, and that it is only used for those purposes.

Finally, with regard to lifting equipment used within the warehouse, LOLER states that lifting equipment needs to be inspected and thoroughly examined:

- after installation and before first use;
- if lifting people or is a lifting attachment – every six months;
- at least every 12 months for all other equipment; and
- each time the equipment has been involved in an accident.

Under LOLER, the safe working load of equipment must be clearly shown. Lifts must be properly planned, including the identification and assessment of associated risks – a generic plan will be suitable for lifting standard pallets in a warehouse. Use of the equipment must also be properly supervised.

Note that hand pallet trucks should only be operated by trained personnel – there have been a lot of broken ankles caused by improper use.

Note that inspection has to be made by someone who is competent, sufficiently independent and impartial to make objective decisions. Serious defects should be reported to the HSE and the item taken out of service.

First aid

You should consider and plan for any accidents or emergency that could occur in which an employee or a member of the public is exposed to danger. It is recommended that procedures are in place to deal with emergencies such as serious injuries, spills or fire.

There must be some provision for first aid and the Health and Safety (First Aid) Regulations 1981 set out first aid requirements for the workplace. Assessments of first aid needs should be carried out to ensure that there are adequate and appropriate equipment and facilities in giving first aid to employees (including a first aid box and first aid room, depending on the size of the warehouse).

Businesses should have an ‘appointed person’ where necessary to take charge in the event of an emergency. This person does not need to be a qualified first aider, but should take charge of the first aid arrangements, whether this means just looking after a first aid box and calling the emergency services, or something more. However, qualified first aiders should be considered. Whether these are needed and the number required depends on the nature of the warehouse, number of employees and the location of the site.

First aid training must be available to any first aiders and they must be retrained before the expiration of each three-year certificate in first aid at work. In terms of how many qualified first aiders are required, an example would be that a medium-risk warehouse with fewer than 20 employees only requires at least one appointed person. However, as a general rule there must be at least one qualified first aider for every 50 people employed. Ensuring cover at different times of the day is a sensible procedure.

Insuring against liability

Most warehouse operators in the UK will have cover to insure themselves against liabilities to third parties including members of the public. But they are also required under the Employers' Liability (Compulsory Insurance) Act to take out a policy with an authorized insurer against liability for bodily injury or disease affecting employees.

However, it is worth remembering that just having a policy in place is not enough: warehouse businesses will need to comply with health and safety law and take all reasonably practicable measures to protect employees – as described above.

If such systems for risk assessment and protection of employees are not in place leading to a claim against an operator by an employee, this may affect insurance cover; in some circumstances the insurer could sue the operator for the cost of the compensation.

Above all, it is important to note that companies and even individual managers can be prosecuted under health and safety legislation – whether or not there is a policy in place.

Health

Not all health issues are visible. For example, employees feel stress when they can’t cope with pressures and other issues. Employers should match demands to employees’ skills and knowledge. Employees can get stressed if they feel they don’t have the skills or time to meet tight deadlines as in shorter order lead times. Providing planning, training and support can reduce pressure and bring stress levels down. Stress affects people differently – what stresses one person may not affect another. Factors like skills and experience, age or disability may all affect whether an employee can cope. Stress is not considered to be an illness but it can make you ill. Recognizing the signs of stress will help employers to take steps to stop, lower and manage stress in their workplace.

According to the HSE, there are six main areas of work design that can affect stress levels. Companies need to manage these properly. They are:

- demands;
- control;
- support;
- relationships;
- role;
- change.

Employers should assess the risks in these areas to manage stress in the workplace.

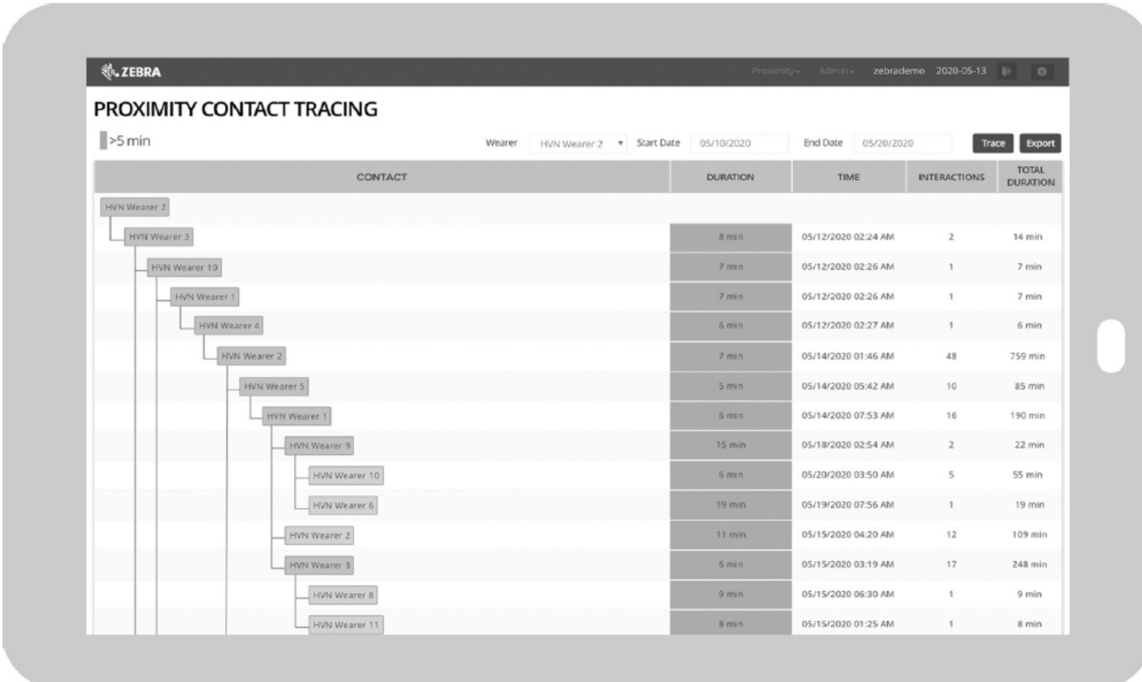
Alongside areas such as stress, COVID-19 has had a significant effect on warehouse operations.

The need to socially distance within the warehouse and the requirement to wear additional PPE is a significant challenge for warehouse and logistics managers.

In this respect we are seeing technology companies introduce new functionality such as distance warnings when staff are too close to each other and producing records of which staff have been in close contact with others who have subsequently tested positive for the virus.

Zebra's 'MotionWorks Proximity' is a system that not only alerts the person but also provides contact tracing audits as to who that person has been in close proximity to.

Figure 14.5 Contact tracing software from Zebra



▶ Figure 14.5 details

The introduction of goods-to-person picking has alleviated many of the issues related to COVID-19 with ‘robots’ and automated storage and retrieval systems (ASRS) of different types bringing items to the operatives who can be stationed at a reasonable distance away from their colleagues. These systems also reduce the number of staff touching the products. However. this can bring additional H&S concerns with staff having to handle up to four times the volume than previously, potentially leading to increased stress and musculoskeletal injuries.

Along with wearing the appropriate face coverings, training workers on how to prevent the spread of COVID-19, and other control measures, OSHA recommends that all warehouses take these steps:

- Establish a written, worksite-specific COVID-19 prevention plan at every facility, perform a comprehensive risk assessment of all work areas and work tasks, and designate a person at each facility to implement the plan.
- Identify contact information for the local health department where the facility is located for communicating information about COVID-19 outbreaks among workers.
- Train and communicate with workers and worker representatives on the plan and make the plan available to workers and their representatives.
- Regularly evaluate the workplace for compliance with the plan and document and correct deficiencies identified.
- Investigate any COVID-19 illness and determine if any work-related factors could have contributed to risk of infection. Update the plan as needed to prevent further cases.
- Implement the necessary processes and protocols when a workplace has an outbreak.
- Identify close contacts (within six feet for 15 minutes or more) of an infected worker and take steps to isolate COVID-19 positive worker(s) and close contacts.

Summary and conclusion

Health and safety at work has become a major concern of warehouse managers. The casualty rates remain high and the increase in litigation as a result of injuries sustained in the warehouse has put added pressure on warehouse managers.

Managers need to be vigilant and undertake regular risk assessments. They need to ensure that their staff are working to the correct procedures and that equipment is maintained to the highest standards.

According to the HSE, addressing health and safety should not be seen as a regulatory burden. It offers significant opportunities. Benefits can include:

- reduced costs and reduced risks: employee absence and turnover rates are lower, accidents are fewer, the threat of legal action is lessened;
- improved standing among suppliers and partners;
- a better reputation for corporate responsibility among investors, customers and communities; and
- increased productivity: employees are healthier, happier and better motivated.

There are many excellent publications by the HSE in the UK and OSHA in the United States, which provide guidance on health and safety within the warehouse. Details are given at the end of this chapter.

Jerry Rudd, one of my co-writers for this chapter has written a comprehensive book on Health and Safety in Logistics also published by Kogan Page. Additional information and assistance can be found at the following websites:

www.hse.gov.uk
www.osha.gov

15 The warehouse and the environment

GWYNNE RICHARDS AND KEVIN MOFID, SAVILLS

Introduction

In recent years, environmental and waste issues have affected us all, both at home and at work.

Recycling has become an everyday occurrence and carbon footprints are being left but not without trace. These issues have also become ingrained into corporate social responsibility, but what does this mean for the warehousing sector?

Environmental legislation has made carbon the ‘new currency’ in a ‘carbon economy’. This new economy means organizations need to be aware of their ‘carbon footprints’, where their emissions come from and how they can reduce them. Business outcomes are therefore entwined with environmental aims. The Carbon Trust emphasizes that ‘by stimulating resource efficient and low carbon action we contribute to green goals, including the lowering of carbon emissions, the development of low carbon businesses, increased energy security and job creation’ (Carbon Trust 2016).

In 2019, the UK government and the devolved administrations committed to the net zero target as recommended by the Committee on Climate Change. Reaching net zero greenhouse gas (GHG) emissions requires extensive changes across the economy and real estate has a key role to play. Buildings currently contribute some 19 per cent of global greenhouse gas emissions but this could double – or even treble – by 2050 if action is not taken now, according to Intergovernmental Panel on Climate Change research.

Whilst the UK led the way for advanced economies to legislate to deliver net zero targets by 2050 just under half of the world's annual GDP is now covered by nations, regions and cities that are legislating for a net zero emissions target.

In the UK, new warehouse development will be forced to take on more of a share of already ambitious targets and the UK planning system will be key to enforcing such targets. In the June 2020 progress report to Parliament the Committee on Climate Change noted that buildings have slightly decreased their share of emissions but more work was needed, particularly in the commercial sector.

Some local authorities have been trialling use of the DEFRA Biodiversity Impact Calculator and Air Quality Damage Cost Calculator to arrive at a monetary valuation of air quality impacts and habitat loss associated with proposed development. These calculators will become standard across the country and developers will be faced with additional costs, meaning that either additional financial contributions to local authorities will be required, or on-site mitigation is identified to offset the costs in order for planning permission to be granted and development to proceed.

A recent survey by Savills, Property Week and warehouse developer Tritax Symmetry found that environmental and social value features were becoming more important to warehouse occupiers with 67 per cent of survey respondents saying green and sustainability features were important in a new warehouse building. This is a rise from 54.5 per cent from the previous survey and has meant that green issues now rank 6th in the list of most important features compared with the year before. See Table 15.1.

Table 15.1 Important features for warehouse occupiers

Skip table

	2017	2018	2019	2020
Building affordability, rent, service charge, etc	84.7	82.9	87.3	81.3
Good power supply	75.5	77	73.6	78.6
Staff wellbeing	81.1	77.9	76.4	78.4
Flexible lease length	72.1	72.3	70.9	77.4
Car parking	80.4	75.2	71.8	70.3
Green sustainability features	51.4	54	54.5	67
Sufficient height	65.8	75.2	67.9	67
Enough loading doors	76.6	70.8	69.1	65.2
Long lease length	54.5	68.8	67	58
Deep enough yard	60.9	54	56	54.5
Minimal columns	55	55.8	59.1	54.1
Ability to retrofit mezzanine	40.9	43.2	45.5	40

As regulation and sustainability targets evolve the impact on warehouse design is expected to continue as developers strive to reach net zero goals. Occupiers of warehouse space can expect to see more sustainability features offered by landlords and developers and may have to factor in changes to operations which meet sustainability goals.

Over time, the sustainability agenda has broadened to embrace not just environmental issues but other social and governance factors (ESG factors). In this context, there is an emerging interest among some developers and investors in developing warehouses or logistics parks that provide enhanced building characteristics and amenities that address worker wellbeing (number 3 in the table above). This interest largely reflects the increasing challenges that companies are facing in attracting and retaining labour for warehouses.

One manifestation of this approach, according to JLL, is the interest among some warehouse developers, investors and occupiers in securing the WELL Building Standard. The foundation WELL version 2 is based around 10 broad concepts according to the International Well Building Institute, as follows:

- water;
- nourishment;
- light;
- fitness;
- movement;
- thermal comfort;
- mind;
- sound;
- materials;
- community.

Although WELL certification is very new in warehousing, with only one scheme certified in Europe and a further two globally, JLL envisage growing interest in wellbeing considerations in warehouse design among both occupiers, developers and investors.

Changes may also evolve outside of the warehouse environment, which will in turn impact the location of any future warehouse development. One such example is the implementation of clean air zones in urban environments. Whilst approaches vary, and some areas will be more stringent than others, potential exists to ban petrol and diesel vehicles from certain parts of the urban road network.

In real estate terms this creates issues that need to be managed with operators potentially needing to locate warehouse facilities much closer to Central Business Districts than before to accommodate delivery on electric vehicles or cargo bikes. Any such real estate relocation would come at a cost as rental levels and land values tend to rise the closer you are to the city centres.

Examples of such practice are only just emerging but in the smaller urban logistics space, parcel operator DPD has been at the forefront of such a movement and has recently acquired space in central London that meets this criteria. The unit is underground and was formerly used as a car park. Using a combination of ramps and lifts, along with electric vehicle infrastructure, DPD are able to deliver parcels to the local area and significantly reduce emissions in the process.

At the larger end of warehouse size, Dutch logistics company Rhenus Logistics was recently awarded the highest BREEAM rating ever achieved for an industrial building. BREEAM being the world's longest established method of assessing, rating, and certifying the sustainability of buildings. The building in Tilburg, Holland, is 650,000 square feet (60,385 square metres) and the roof is covered with over 13,000 solar panels, meaning the site produces not only enough energy to power its own operation, but also feeds back into the country’s electrical grid powering approximately 750 households on an annual basis.

The building is completely airtight, meaning no hot air escapes in the winter. The roof also houses two large pumps that draw heat from the air outside and use it to keep the inside of the building warm. There are electric boilers for exceptionally cold days, which the company estimates are used only 10 days each year.

Along the side, and at either end, are huge glass windows, allowing light into the building. Not only is it thought to improve the wellbeing and productivity of workers, by making it a nicer environment, but it means they use 70 per cent less electricity in lighting the premises.

Rhenus logistics expect buildings such as this to become common place in years to come due to increased legislation but also the fact that by investing in sustainability features means the building costs less to run in the long term.

Keith Horgan of the Carbon Trust Partnership (CTP) commented that ‘there are substantial opportunities within the warehousing industry to save energy, costs and reduce carbon by the simple implementation of existing, low-energy technology.’ He said: ‘We are not talking about high-tech solutions but pragmatic and cost-effective actions. For example, lighting and heating are the core areas for energy- and carbon-saving focus. The UK warehousing industry could save in excess of £150 million in energy costs and 1.5 million tonnes of carbon by making simple changes’ (United Kingdom Warehousing Association, 2010).

BNP Paribas Real Estate’s Warehouse of the Future report highlights sustainability as being at the forefront of occupier’s requirements, with 86 per cent of respondents agreeing that sustainability initiatives are important to the future of warehousing. The findings also showed that over two-thirds of the occupiers surveyed would pay a rental premium for a green unit if it saved on operational costs. In addition to this 76 per cent of respondents stated that they would look favourably on warehousing that was powered by some form of sustainable energy such as wind, solar, biomass or energy from waste.

In this chapter we look at how operations within the warehouse affect the environment and how the warehouse can play its part in reducing carbon emissions.

Legislation and other pressures

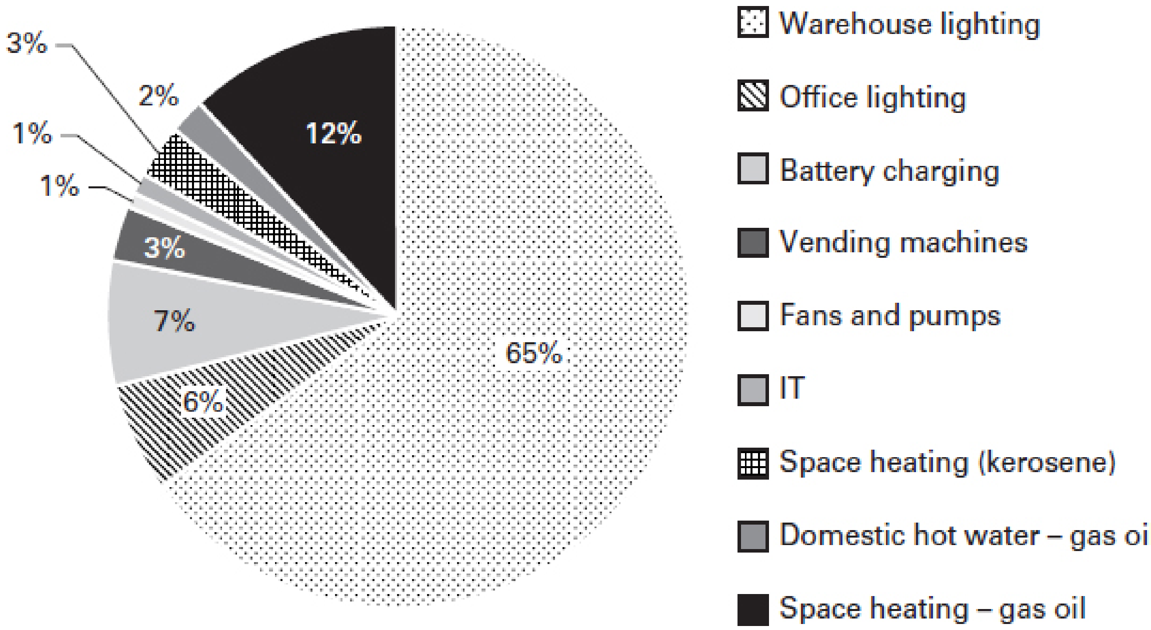
Environmental legislation has an impact on many organizations and will increasingly require new approaches to the management and reduction of energy and carbon emissions.

Each country or group of countries will have its own legislation in relation to the environment.

Warehouse energy usage

Figure 15.1 shows the energy usage within an average-sized warehouse of circa 15,000 square metres.

Figure 15.1 Warehouse energy usage (courtesy of UKWA 2010 and the CTP)



▶ Figure 15.1 details

As can be seen, the main areas of energy use in UK warehouses are heating and lighting, with research showing that the sector could potentially achieve a 16 per cent reduction in emissions in these areas. In warmer climates cooling systems will be a significant factor.

Table 15.2 outlines the key areas and low-capital-cost actions to reduce energy consumption and carbon dioxide emissions within warehouses. These opportunities were observed during a series of energy audits of UKWA members' sites under an initiative between the Carbon Trust and UKWA.

Table 15.2 Potential warehouse energy savings

Skip table

Key carbon reduction areas	Typical savings based on 10 fittings unless stated otherwise		
	£	**CO_2 tonnes**	**Based upon**
Turn lights off in warehouse when an area is unoccupied	£700	4.26	50% reduction in lighting
Turn lights off in warehouse when daylight is sufficient	£300	4.92	18% reduction in lighting
Replace 250 W and 400 W sodium or 400 W metal halide lights	£550	3	
Install lighting controls	£70	0.4	T8 having controls added
Clean or replace roof lights	£300	4.92	18% reduction in lighting
Turn off external lights used for loading/unloading when daylight is sufficient	£420	2.5	50% reduction in lighting over 12 months
Control space heating systems efficiently	10–15% saving	10–15% saving	
Ensure efficient control of air conditioning	£120 based on one unit	0.72	
Ensure hot water supply is sized in relation to site occupancy	10% of site fossil fuel	10% of site fossil fuel	

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.

- 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.
- Introduce solar panels where feasible.
- Use of alternative energy production methods:
    - Wind turbines.
    - Biomass boilers.
- Heating 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 the 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:
    - using ventilation stacks;
    - atria and automatic window openings combined with automatic control systems;
    - passive cooling such as breathable walls;
    - using the effective thermal mass of buildings to reduce cooling and ventilation energy.

- Cooling the warehouse can also increase energy costs.
    - Introduce sunlight reflectors.
    - Use of mobile air handling units.
    - By coating your warehouse's roof in bright, reflective paint, you allow it to reflect the sun's light rather than absorbing it.

- Switching off equipment when not in use, minimise vehicle idling.
- Ensure all doors have sufficient seals to prevent air and water entry.
- Rainwater collection for reuse in vehicle washing, toilets, etc.
- Low water use in sanitary appliances.
- Check insulation levels and increase where practical.
- 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, fuel cell or hybrid forklift trucks.
- In rack charging for narrow aisle trucks and shuttles.
- Movement reduction within the warehouse to reduce energy consumption.
    - Use of ABC analysis to ensure popular items are placed close to the despatch area.
- Kinetic energy plates provision 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 MHE 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.

Introducing automation systems and building upwards will also reduce energy costs overall and reduce land use. The introduction of IoT and machine-to-machine technology will also improve efficiency and cut costs.

The use of smart meters, which record the amount of electricity consumed and when it was consumed, will also assist companies in identifying where consumption is greater than expected.

Finally, ensure that your warehouse is also operating effectively – no unnecessary movements, accurate picking and despatch and effective utilization of space.

XPO and Nestlé have collaborated on a 638,000 square foot warehouse, which they are calling their ‘digital distribution warehouse of the future’. The facility is designed as a multi-user space to accommodate solutions tailored to the needs of different logistics operations, the companies said, adding that sustainability was a core consideration in the design and location of the building. The site is on a railhead, and Nestlé will be despatching exports and deliveries into the London area via rail. A liquified gas refuelling station is currently being developed at the site to enable Nestlé to operate energy-efficient gas trucks instead of diesel.

Energy production

The self-production of energy is a potential option for warehouse operators to consider when looking to offset their CO2 usage as mentioned in the Rhenus example above.

Amazon is to install solar panels on the rooftops of its fulfilment centres across the world.

‘As our fulfilment network continues to expand, we want to help generate more renewable energy at both existing and new facilities around the world in partnership with community and business leaders,’ said Dave Clark, senior vice president of worldwide operations. He went on to say: ‘By diversifying our energy portfolio, we can keep business costs low and pass along further savings to customers. It’s a win-win.’

Marks & Spencer in the United Kingdom has installed the largest single roof mounted solar panel array of 24,272 panels to date. These generate nearly 25 per cent of the energy required for the site.

Wind turbines and the production of energy from biomass can also be a viable way to generate low lifecycle emissions at an acceptable cost, according to DHL's sustainability study.

Regulation plays an important role here.

With regard to warehouses we shouldn't forget the actual building materials with Marks & Spencer using stone and concrete from the dismantled power station it replaced to build the new warehouse. In fact, according to JLL, warehouses should be designed for deconstruction / disassembly thus reducing emissions at end-of-life demolition.

The environment and waste

The overarching legislation governing waste includes the Waste (England and Wales) Regulations 2011 (implementing the European Waste Framework), the Environmental Permitting Regulations 2010 and the Environmental Protection Act 1990.

Waste is defined as something which the holder or producer discards. If something is discarded then it will remain waste until it has gone through what is known as a 'recovery operation'.

In the UK if you store, treat or dispose of waste you need to hold an environmental permit, be technically competent and be regulated by the Environment Agency, Natural Resources Wales or the Scottish Environmental Protection Agency.

It is an offence to store, treat or dispose of waste without either an environmental permit or an exemption. There is also personal responsibility on directors and managers to ensure there is no breach of the legislation, and they can be prosecuted personally.

A holder of waste has a duty of care to ensure it is deposited or transferred to an authorized person.

Overall, to comply with the duty you must take reasonable steps to:

- prevent the escape of waste whilst you hold it;
- transfer it to an authorized (suitably licensed) person; and
- provide written information which identifies and describes the waste being transferred.

To avoid a breach of Section 33 of the Environmental Protection Act 1990, for instance, you need to prevent waste causing pollution or harm to the environment either when it is under your control or when the waste is transferred.

Other regimes for specific waste types include the Waste Electrical and Electronic Equipment (WEEE) directive. This affects, but is not limited to, importers, manufacturers, retailers and business users.

If you export WEEE you have to be approved by the Environment Agency and issue evidence notes when you receive whole WEEE appliances. You must also have systems and procedures in place to ensure you provide accurate reports to the Environment Agency. If you produce WEEE you are obliged to join a compliance scheme.

Packaging

Product packaging has a significant impact on the sustainability of the supply chain as a whole.

There are three main types of packaging, according to Envirowise, a UK government agency:

- Primary (sales) packaging. This is the packaging around a product at the point of purchase by the user/consumer. Examples include bottles, tins, plastic covers or wrapping.
- Secondary (grouped) packaging. This packaging groups a number of items together until the point of sale. Examples include an inner or outer box/carton and strapping that binds a number of items together.
- Tertiary (transport) packaging. This packaging allows handling and transportation of a number of grouped items as a single unit load. Over recent years the mainstays of returnable transit packaging (RTP), the wooden pallet and the metal stillage, have been joined by many other forms of RTP. These include plastic pallets, tote boxes and metal cages.

By carefully segregating its waste into cardboard, plastics and general waste, one food contract packaging company reduced its waste removal costs by 45 per cent and is now recovering approximately 30 per cent of its packaging.

It is possible to significantly reduce packaging costs and cut waste levels by implementing relatively simple measures, many with low or no associated costs; or, if there is a cost, payback is relatively quick.

Taking action on waste packaging will:

- increase overall profitability;
- increase staff awareness of environmental and cost-saving issues;

- develop closer relationships with suppliers and customers through shared benefits and cost savings;
- reduce the use of finite resources;
- reduce the volume of waste going to landfill;
- reduce product damage;
- enhance environmental performance;
- promote a better company image;
- meet current and future obligations under packaging waste regulations at least possible cost.

Packaging design

Although the majority of waste initiatives begin at the design stage and are mainly the concern of the production department, the warehouse can have a significant influence on the amount of packaging used.

When designing product packaging there needs to be an input from the warehouse operation. For example, secondary packaging needs to fit the actual pallet dimensions. Any overhang on the pallet can lead to packaging damage, an increase in the amount of stretchwrap required and potential issues when the product is put away in the racking.

Pallets

Although the mainstay of transit packaging over many years, the pallet can be replaced or at least augmented by other forms of tertiary packaging.

For example, an alternative to the use of pallets where the products are lightweight in design include slip sheets and corrugated trays. Not only do they reduce the use of wooden pallets, but they are lighter, take up less space in a container, and are significantly cheaper, especially in circumstances where pallets are not returned.

However, if your operation necessitates the use of pallets there needs to be a process in place to track and recover pallets. A previous client spent in excess of €800,000 on wooden stillages that are left at customer premises. In such cases, alternative methods of encasing and transporting the product need to be evaluated. These can include collapsible metal stillages, which, although more expensive to produce initially, can be returned for reuse without significantly reducing the back-loading abilities of the delivery vehicles.

Utilizing recycled pallets can have a number of advantages over new pallets. They are likely to be cheaper and potentially stronger as a result of seasoning, which increases the strength of the wood. They are also exempt from packaging waste regulations.

Plastic pallets that are recyclable are also a potential alternative albeit they take more energy to produce, are more expensive at the outset and will require a robust system to track their whereabouts. The use of RFID tags is an option here.

Stretchwrap

Suppliers can end up using excessive stretchwrap to stabilize product on a pallet. Alternatives include banding such as the pallet tidy straps manufactured by Velcro.

Although a capital purchase, stretchwrap machines can reduce the usage of wrap and make the unit load more stable.

Cartons

As with many of the topics we have discussed in relation to the warehouse operation, packaging again results in trade-offs.

A significant trade-off is the strength of the packaging and potentially less damage versus the additional cost of the packaging. A current client is having to replace packaging received from the Far East on a regular basis as a result of substandard cardboard.

When picking individual items from secondary packaging, there is going to be a surplus of cartons. Where possible, cartons should be reused.

The replacement of cardboard packaging with plastic totes is possible. However, a robust system of tracking and tracing the equipment needs to be in place. This may well change as we see the introduction of more automated systems. Some companies are now embedding RFID chips into their reusable packaging.

Labelling

When labelling product in the warehouse it is advisable not to use paper labels that cannot be easily removed. Some plastic re-processors will not accept plastics contaminated with paper.

Product waste

Poor stock rotation can lead to waste with out-of-date items. FIFO and expiry date systems must be applied to minimize out-of-life stock.

Waste disposal

If packaging cannot be reused, look to reduce disposal costs by segregating the waste correctly and, where feasible, selling it to waste recyclers or re-processors. You can also set it against the purchase of packaging recovery notes.

Hazardous waste

Something is hazardous if it is dangerous to people, animals or the environment. You should first check the goods are as stated in the consignment/transfer note and follow your own acceptance criteria. If the goods are later found to be hazardous you may become the producer of the hazardous waste and will need to comply with the legislation governing this specific waste type.

Forklift trucks

Electric lift trucks are superior to internal combustion engine models when it comes to the environment. Indoor air quality is improved by eliminating internal combustion exhaust within a facility.

If utilizing electric lift trucks, it is not necessary to vent outside air into a facility to offset internal combustion exhaust or to exchange air as frequently through heating, ventilation and air-conditioning systems, which is good for the environment and has the added benefit of reducing heating and air-conditioning costs.

If electricity is generated by renewable sources such as wind and solar power, then electric lift trucks are truly emission-free. However, the environmental impact of an electric truck is more than just being emission-free. Electric trucks use no engine oil, transmission fluid, radiator fluid or filters that have to be changed on a regular basis. These waste items can be very harmful to the environment if they are not handled and disposed of properly (Hyster 2010).

There is another school of thought according to Johnson (2008), however, that ‘fuel carbon footprints of electric and LPG (Liquefied Petroleum Gas) forklifts are, in principle, about equal, whilst in actual practice, LPG’s footprint is smaller than that of electricity.’

Toyota has recently introduced a new Geneo-Hybrid forklift truck, which is expected to cut CO2 emissions and fuel consumption by 50 per cent whilst delivering the operational performance of an equivalent conventional diesel-powered forklift. Other manufacturers are introducing hydrogen fuel cell powered forklifts as discussed in Chapter 10.

Equipment disposal

Finally, we need to ensure that we have an end-of-life policy for our warehouse equipment and ensure these items are recycled in an efficient manner.

Summary and conclusion

A major challenge across all industry sectors today is ensuring a sustainable supply chain.

Clearly, there are solutions on the market that can help warehouses operate in a more sustainable way. By combining available technologies and solutions in terms of energy savings, such as heating and cooling systems, and alternative energy sources, a warehouse can be designed that emits 70 per cent less CO2 than a typical 15-year-old warehouse.

McGraw Hill Construction (2013) in their research found that companies who either built ‘green’ warehouses or retrofitted ‘green’ ideas decreased operating costs by 15 per cent and 13 per cent respectively and attained payback within a maximum of eight years.

We must also encourage staff to be responsible in terms of energy efficiency within the warehouse. Turning off lights and electronic equipment when not in use and switching off forklift trucks when idling are only a few ways of increasing energy efficiency.

16

The warehouse of the future

Introduction

Niels Bohr said ‘Prediction is very difficult, especially if it’s about the future’. We are now at a stage where the challenges within the supply chain are necessitating a change of mindset amongst warehouse operators, with automation and robotics being considered a viable and at times necessary alternative to large amounts of labour. This is now being seen globally.

We are also seeing companies such as Amazon, JD.com (see video below) and AliBaba in China together with many UK retailers introducing robotics on a large scale. Amazon recently received a patent for its idea of a warehouse in the sky with orders being fulfilled in an airship and the items being delivered by drones. They’ve also filed a patent for underwater warehouses utilizing acoustic vibrations to make packages rise to the surface. Farfetched it may seem at the moment, but these companies are pushing the envelope in order to meet ever increasing and complicated challenges. The development of artificial intelligence (AI) and virtual reality (VR) will also have a significant effect on warehousing in the future.

VIDEO 16i JD.com Shanghai

The continuing challenges faced by companies are many and varied.

The following list is not exhaustive butd etails the number of challenges being faced by companies today and those likely to be faced in the future.

- One of the biggest challenges is the growth in e-commerce. This is already resulting in the following:
    - smaller, more frequent orders;
    - shorter order lead times;
    - next-day delivery will be the norm;
    - same-day delivery in certain circumstances;
    - increase in home delivery;
    - increase in personalization of items.
- Other challenges are as follows:
    - a greater proliferation of product lines or SKU;
    - a requirement for accurate information in real time;
    - the need to achieve the perfect order to ensure competitiveness;
    - a requirement for lower overall inventory and overall cost reduction;
    - an increase in the cost of land;
    - increasing labour costs;
    - ageing populations in many countries;
    - a shortage of skilled labour;
    - a shortage of management knowledge and expertise;
    - the moral question as to what to do with displaced staff on a large scale;
    - security of products;
    - traceability of items;
    - cold chain storage and distribution;

- a greater need for systems integration – ERP systems with WMS and TMS, for example;
- the growth in cloud-based systems and the reluctance in some quarters to accept them – especially in terms of data security;
- overall data security;
- local and global regulations and protectionism;
- sustainability demands – pressure for more environmentally friendly warehouses;
- more buzz words such as Industry 4.0, M to M (machine-to-machine) and the Internet of Things;
- dealing with extraneous events such as the COVID-19 pandemic.

Suppliers, users and academics are having to look at ways of overcoming these challenges. New technology is continually being introduced and, as Mark Strand says, ‘the future is now’ in many respects. Concepts such as fully automated warehouses, carbon-neutral buildings, hybrid trucks, robotics, drones, voice, vision and optically guided warehouse operations are all in their various stages of development.

So, what of the warehouse of the future? One revolutionary product or process is 3D printing or additive manufacturing – what effect will this have on the warehouse of the future? Will we actually need warehouses in their current form for example? Could this lead to the demise of maintenance stores?

This section will look at the likely role of the warehouse in tomorrow’s supply chain, what it might look like and the new technology which will be adopted.

Context

First, we need to put things into context and be aware that warehousing in the future will be affected by many factors, such as:

- Globally, we have a growing but ageing population. This means that land will be at a premium with some research suggesting that 70 per cent of the world's population will be living in cities by 2030. There are likely to be labour shortages in key areas, which suggests a significant growth in automation, but in those areas where automation is not an option there will be a need for elder friendly workplaces and in some countries people will be required to prolong their working lives.
- The growing economies of not only the BRICS countries (Brazil, Russia, India, China and South Africa) but also those of the developing world, especially in the Far East in countries such as Malaysia, Indonesia and Vietnam where consumerism and the growth of the internet will put even greater pressure on consumer product manufacturers and their warehouses. Consumer awareness and demand for new products and services will continue to increase.
- As economies grow and the population gets older, there will be greater competition for staff. Warehousing has not been a career of choice for many people because of its image and companies are going to have to market themselves better to become more attractive to today's youth. The introduction of more technology into these warehouses will be significant in this respect. Conversely, the introduction of greater automation could see a reduction in the requirement for staff at an operational level but an increase in more technologically astute staff.

More than 10 million jobs in the UK – a third of the total – are thought to be at risk from automation within the next two decades according to a UK think tank – IPPR. Gale (2017) suggests that the 2020s will be the decade of redeployment rather than unemployment with staff having to re-train and upskill. The closure of many high street retailers as a result of the move away from purchases from bricks and mortar stores to online will see the possibility of staff redeployment into the retail fulfilment centres.

- Sustainability will play a significant role in supply chain operations in the future. The green lobby will look to the supply chain for initiatives in terms of alternative energy use, reduction in CO2 emissions, reduction in waste and water usage and the use of alternative forms of transport. This will include intermodal transport initiatives as well as fuel-efficient MHE. Consumers and retailers will also be encouraged to source locally leading to an increase in demand for neighbourhood warehouses.
- As fossil fuels decline there will be a move towards more sustainable energy. Companies will look to warehouse automation and the use of greener vehicles whilst developers and warehouse operators will be encouraged to consider solar panels, wind turbines and the use of waste product for energy production. New and existing warehouses will be equipped with electric charging points for delivery vehicles and also hydrogen filling stations.
- The potential introduction of government taxation initiatives to encourage companies to reduce their impact on the environment.

- An increasing pressure on companies to collaborate and share resources. Many warehouses and, for that matter, transport modes are under-utilized, so pressure from the green lobby and also continued pressure to further reduce costs will encourage more companies to collaborate.
- Technology will continue to improve, evolve and become more affordable. As has been proven time and again, the next big idea is likely to be just around the corner.
- The shortage of and subsequent increasing cost of land will see the development of more underground warehouses. This isn't a new phenomenon with abandoned salt mines in the UK being utilized for archive storage as is also the case with limestone mining caves in Kansas City – the largest underground complex in the world. Recently, plans have been approved to create a 175,000-square metre underground logistics space by Heathrow Airport, one of the most expensive locations in the world to have a warehouse. In Tel Aviv, a microfulfilment centre has been built in an old underground parking lot, and has been designed with three temperature zones. This underground dark store will store fresh, ambient, chilled and frozen food items and provide a one-hour grocery delivery service within Tel Aviv.

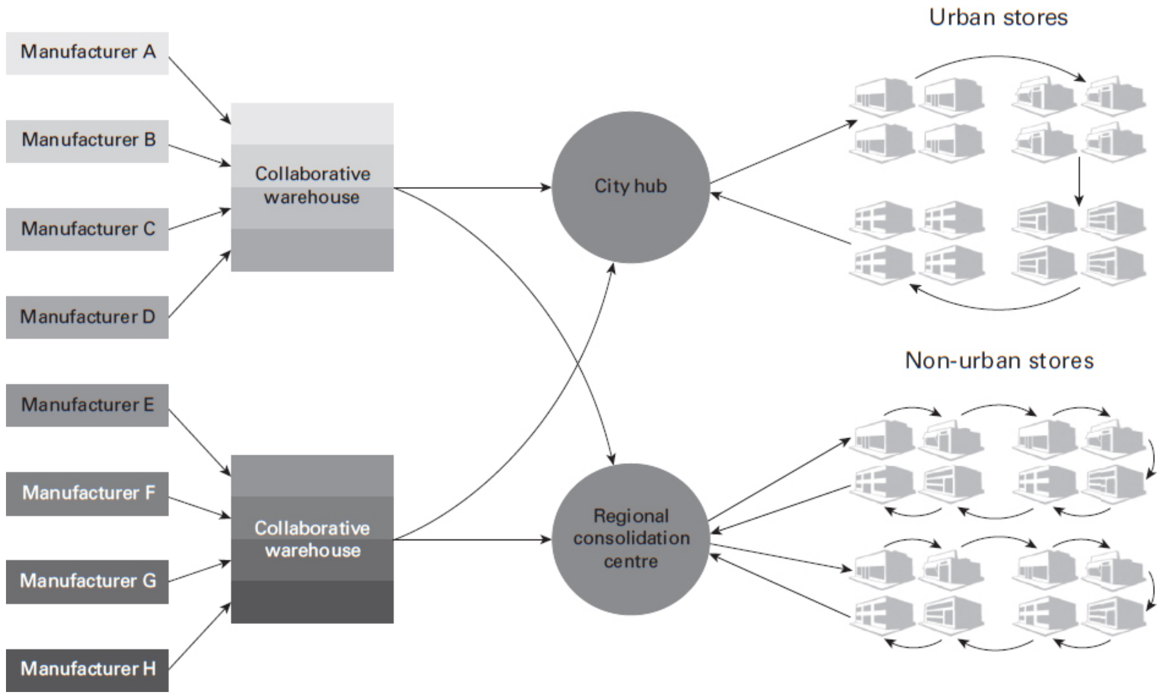
VIDEO 16ii Underground warehouse in Tel Aviv

In relation to the shortage of warehouse space, JLL suggests a growth in technology platforms that connect businesses that need warehouse space with owners or occupiers that have surplus space, which could stimulate on-demand warehousing and new models of occupation. In addition to platform providers such as Timocom, which describes itself as 'Europe's largest warehousing exchange' offering access to over 7,000 warehouse spaces in 44 countries, a number of third-party logistics service providers are also offering a similar service through their own portfolios. The type of service on offer in on-demand warehouses varies from basic storage to more valued added services, including the use of automated solutions. JLL go on to say that this on-demand space is typically acquired on a pay per use basis, but other models could be applicable – such as where a company pays a subscription fee to a single landlord to access facilities (subject to space availability) wherever and whenever it needs them. These models challenge the traditional leasing model with potential implications for risk and value for property owners.

A further example is Wincanton's 'Virtual Access to Storage and Transport' (VAST) to make finding and selling warehouse space quick and easy, via www.oneVASTwarehouse.com. This collaborative platform matches buyers and sellers of warehouse space, allowing companies that need on-demand access to storage to find it quickly and warehouse owners the opportunity to advertise underutilized space to generate a new income stream.

As we can see from Figure 16.1, warehouses will remain a vital cog in the supply chain. I believe we will see both retailers and manufacturers working closely together and collaborating on storage and distribution, with warehouses becoming consolidation centres, regional hubs and shared-use facilities. The expectation will be that 3PLs will facilitate at least some of this in future.

Figure 16.1 Collaborative warehousing (© The Consumer Goods Forum, Capgemini; reprinted with permission)



▶ Figure 16.1 details

A recent collaboration is between XPO Logistics and Nestlé. They have designed a warehouse using Swisslog automation technology, which includes robotics and automated sorting systems. The site also includes an innovation hub that will function as an incubator to test new ways of addressing logistics needs. XPO will conduct real-life operating trials of promising technologies and will showcase innovations to customers. The facility is designed as a multi-user space to accommodate solutions tailored to the needs of different logistics operations.

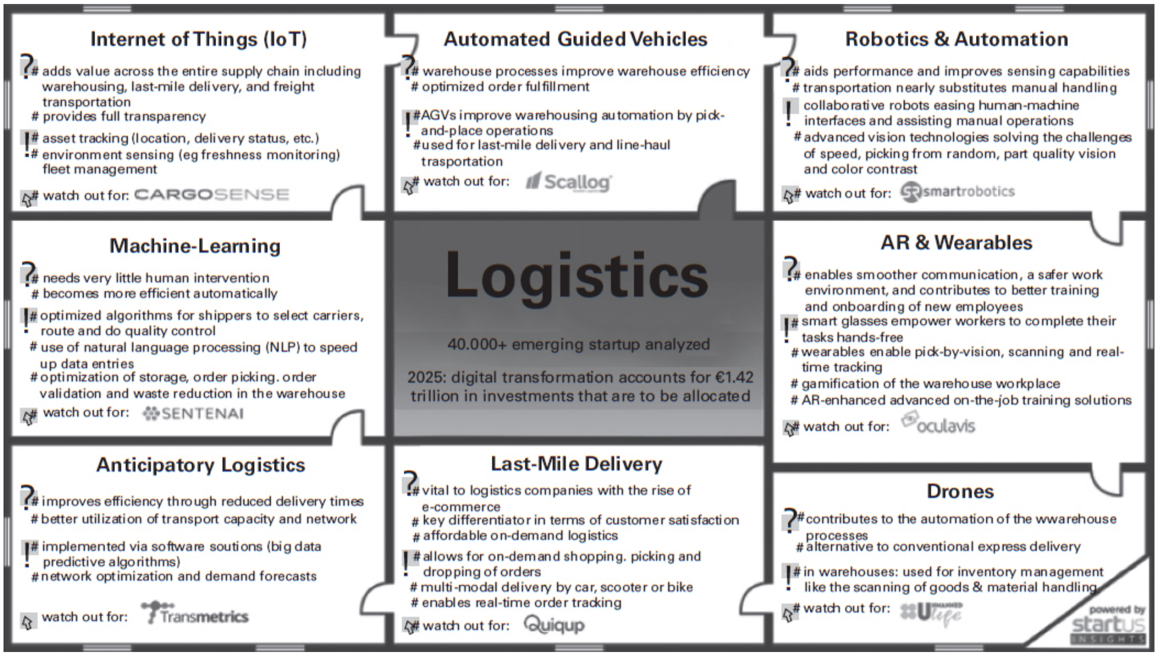
Generation Z – the post-90s generation – has entered the market, as both consumers and employees. Having grown up using e-mail, social networking and communications technology such as mobile/smart phones, MP3 players, laptops/tablets and games consoles including virtual reality, they have never known a world without them. Adept at switching between multiple platforms, formats and devices, they expect to utilize the technology they are familiar with in the work environment, accelerating the prevalence of Bring Your Own Device (BYOD) in industries heavily reliant on the timely transfer of data, such as logistics.

According to Pierfrancesco Manenti, vice president analyst with the Gartner Supply Chain practice, ‘This generation has grown up with digital technologies, so today’s supply chain leaders expect them to be innovators that accelerate supply chain digitalization and pave the way towards hyperautomation.’ Hyperautomation involves a combination of technologies that include robotic process automation (RPA), machine learning (ML), artificial intelligence (AI) and many others.

Predictions for the future

Startus Insights have produced the following chart outlining their thoughts on the future of logistics. As can be seen from the chart, many of the ideas are already in operation, albeit on a small scale at present; however, this is likely to change significantly over the next few years. Big Data and the Internet of Things, together with ML, will play a significant role in the future of warehousing.

Figure 16.2 Startus Insights



▶ Figure 16.2 details

Views of the future: the warehouse

What of the warehouse itself?

I’m certain that those of us who grew up in the sixties and seventies would not have predicted the miniaturization of communication handsets and the increasing computer power we have today in such small units. The other phenomenon has been the internet and the effect it has on the way we do business today. This leads me on to the role of the warehouse in the future.

Some would argue that there won’t be a requirement for stocked warehouses as companies will manage their supply chains so well that cross docking or trans-shipment will be the norm and therefore warehouses will become transit sheds, sortation centres, parcel and pallet hubs. However, COVID-19 has shown that this is unlikely to be the case any time soon.

Second, with the growth in e-retailing there will be more fulfilment and returns centres as opposed to warehouses. In addition, with the increase in fuel costs there may be an argument for production becoming more localized and therefore warehouses will become an extension of the production plant once again. This should lead to a more just-in-time method of order fulfilment. We are already seeing the phenomenon of direct-to-customer deliveries from the manufacturers, thus bypassing retailers.

Recent events in both Europe and the United States also point towards the protection of local manufacturing and a move to in-shoring. The situation with Brexit has also seen companies from the UK setting up warehouses or outsourcing to 3PLs in continental Europe to overcome issues resulting from the UK leaving the Single Market and the Customs Union.

For those of us who subscribe to the view that warehouses will still exist some time into the future, what function will they perform and what will they look like?

The current trend seems to be towards greater centralization of warehousing, with retailers building bigger sheds with more automation, replacing smaller regional centres.

Others argue that the rising cost of fuel and customer demand for shorter order lead times will result in a greater number of local warehouses.

The following video shows a microfulfilment centre at a service station.

VIDEO 16iii KNAPP

Reduced footfall in the stores is also seeing many retailers operating some of their e-commerce operations in local stores. This includes order picking and returns processing with retailers incentivizing consumers to return product in store.

Local centres will act as replenishment centres for stores, and continued growth in e-retailing will increase home delivery significantly. Kellogg's in the United States recently announced a move away from direct-to-store delivery as volumes are reducing with the advent of online grocery shopping.

Amazon's strategy is to be as close to its customers as possible so that they can react quickly to any order placed. Hence the idea of having significant numbers of fulfilment centres – these are separated into different categories such as sortable centres (approx. 800,000 square feet) for smaller products, non-sortable centres 600,000 to 1,000,000 square feet) for larger products, sortation centres and delivery stations for last mile delivery, receiving centres for large deliveries from suppliers and finally, specialist facilities for specific products such as Amazon Fresh. Amazon are also contemplating mobile warehouses such as airships and vehicles with 3D printers on board.

Orders to the warehouse will continue to grow appreciably with e-commerce but the number of lines and items per order will be small. Thus, where individual items are ordered by consumers over the internet, there will be a greater need for technological solutions and quicker, more accurate methods of order picking and despatch.

Automation will play a big part in the warehouse of the future and it is likely that we will have many types of robots criss-crossing the floor, collecting and depositing pallets, cartons and totes to wherever they are needed, with very few humans in sight.

Robots will move both horizontally and vertically, making full use of the cube of the warehouse. Radio frequency sensors will be placed strategically throughout the warehouse to ensure that there aren't any breaks in transmission and to guide the various automated equipment.

An example of this is the partnership between Prime Vision and Delft Robotics. By combining the high flexibility of robotic arms with the versatile sensing capabilities of 3D vision technology, it will be possible to provide solutions to automation problems that have – until now – been impossible or too expensive to develop. Intelligent robotic systems will use a combination of technologies that allow the system to 'look' at its work environment. In this way, robotic systems are able to cope with product differences, which is particularly important in the courier and e-commerce sectors, where the processing of parcel variety remains a major barrier to wide scale robotic adoption. Their automated parcel sortation system, instead of using fixed chutes, use intelligent robots to autonomously make sorting decisions for parcels. This operation can be up and running very quickly and is ideal for local parcel sortation centres.

The partnership between Prime Vision and Delft Robotics will also lend itself to integration with the Internet of Things (IoT).

We humans will no doubt still be involved in some capacity but mainly as managers, IT specialists and equipment service engineers. Skilled pickers will potentially still have a place on the warehouse floor where goods-to-picker systems will continue to be used. However, vision-checking systems will take the place of the human eye and scanners. Staff will also be required for various value-added tasks such as repacking, relabelling, stencilling, kimballing and kitting.

Amazon argues that even though it is introducing automation into its warehouses, it is still increasing its staffing levels as consumer demand increases.

Voice-activated technologies such as Amazon's Alexa or Google Assistant are currently being adapted so that a warehouse operative can find information just by asking a question. For example, imagine asking questions about staging area availability or stock locations while driving a forklift, or picking orders to a conveyor line. A voice assistant similar to these consumer technologies will answer these questions. Voice picking systems are already able to put the operator in touch with their supervisor whilst out on the shop floor.

In order for automation to work efficiently, everything will need to be fairly uniform. Pallets will need to be the same size – no combinations of UK, US, euro or print pallets, for example. Cartons will also need to be standardized. Alternatively, goods will be moved in plastic, returnable and recyclable totes.

As for the building itself, it is likely to be built with sustainability in mind as discussed in Chapter 15.

The warehouses will operate 24 hours per day, seven days a week.

The majority of warehouses are likely to be high bay (at least 14-metre eaves) with some lower height warehouses or sections of warehouses to act as cross-docking operations and areas for value-adding services. The continued growth in third-party logistics and shared-user warehousing is also likely to see larger warehouses with the potential for sub-division.

The increase in product lines could also see greater use of multiple mezzanine floors.

According to JLL, in certain European cities, where the availability of industrial land is particularly constrained and land values are high, they are beginning to see some ‘industrial intensification’ by the development of multi-level warehouses, where the upper levels are serviced by cargo lifts and multi-storey ramps, which provide direct vehicle access to the upper floors.

These types of warehouses are commonly seen in cities such as Singapore.

As for location, port-centric logistics is increasing in popularity together with the increased use of rail transportation, which suggests coastal locations or those linked by inland waterways and rail. A typical example is the General Mills operation with Culina based at Peel Ports’s Port Salford facility near Manchester. In total, 80 per cent of the Great Mills volume is now transported via the Manchester Ship Canal and General Mills expects to save 600,000 road haulage miles each year whilst providing a ‘future proof’ solution to market trends.

However, the predicted acceleration in e-commerce will also drive demand in cities and major urban areas to support last mile fulfilment. According to JLL, this demand will encourage wider urban infill by developers and investors, which in some locations will include the re-purposing of retail stores. Tomorrow’s logistics buildings in cities will be designed for rapid throughput with requirements for more doors, more yard space and more energy supply points.

Finally, there will be a requirement for greater flexibility with shorter lease terms.

The following scenario for the future of warehousing looks at the use of technology to its utmost.

Potential future scenario

As a driverless vehicle arrives on site its RFID tag will be read and the vehicle guided to the relevant loading bay. On reaching the bay, its roller shutter door will open, as will the loading bay door, and the rails within the trailer will connect to rails within the warehouse. The conveyor will be activated and the pallets will be unloaded. Each pallet will move through a portal where each pallet and item tag will be read and the data sent direct to the WMS. An AGV will take the pallet to its relevant location, be it the despatch bay for cross docking or into deep storage. If the products are destined for the picking area they will be de-layered robotically and each layer of product placed into a tote for onward delivery to the mini-load AS/RS storage area. Suppliers will be informed of any discrepancies and their payments adjusted accordingly.

Loose loaded trailers will be unloaded with a robotic arm and palletized robotically.

The system will control all of the movements within the warehouse with no requirement to print pick lists, communicate with PDAs or send voice instructions to us humans. The paperless warehouse should become a reality (unlike the paperless office, which has been much heralded but never achieved).

All items are RFID tagged and are tracked throughout the warehouse.

Once an order is received, the mini-load or AMR system will send the tote or shelving containing the product(s) to a pick station and a robot with suction pads and a camera will read the RFID chip or compare its image with that of the order, pick up the item and place it into another tote or carton for despatch. This task may be done by a human if the robot's dexterity is called into question.

The tote will be lidded, labelled automatically and placed on a conveyor or CMR and loaded onto a waiting vehicle.

Where delivery is required in a cardboard container the box will be cut to size and a lid fitted. Marketing material can also be added at this stage. To reduce paper, this could be in the form of QR codes printed on the packaging.

Video 16iv is a view of the immediate future from Chinese e-commerce retailer JD.com.

VIDEO 16iv The future of warehousing JD.com

The problem will be how to manage complexity. The requirement for individual items to be picked from cartons will continue to pose problems for a fully automated warehouse. The growth of internet shopping and orders for individual items will continue to pose challenges to warehouse operators, so human intervention will still be a fundamental requirement.

Robot dexterity may be improved but this could be at the risk of slowing down the operation as a whole.

Videos 16v and 16vi from Boston Dynamics show how robotics is advancing and how robots could well take the place of humans in the warehouse of the future, but a few years down the line.

VIDEO 16v Future robotics from Boston Dynamics

VIDEO 16vi Future robotics from Boston Dynamics

It may be that robots, conveyors, AGVs and AMRs will bring the products to the operator but the actual act of picking and packing could well remain with a human.

Other advances

Other advances include the Internet of Things, Industry 4.0 and Machine-to-Machine (M to M) communication where everything from camera systems to automation equipment is totally integrated into a WMS or WCS. Conveyors, carousels and even storage racks could eventually link to each other, your computer systems, and various personal devices in an advanced warehouse. No need to re-enter data or introduce middleware – the machines will communicate directly with each other. ‘These buzzwords should not be intimidating – Industry 4.0 is more of an evolution rather than a revolution,’ says Swisslog’s Dr Kerstin Höfle.

VIDEO 16vii Industry 4.0 – Linde’s vision of logistics of the future

One other piece of technology is 3D printing or additive manufacturing. 3D printing was originally developed as an automated method of producing prototypes. Although there are several competing technologies, most work on the basis of building up layers of material (sometimes plastic, ceramics or even metal powders) using a computer-aided design. Hence, it is referred to as an ‘additive’ process; each layer is ‘printed’ until a three-dimensional product is created.

A report by Transport Intelligence suggests that 3D printing ‘is already very good at producing products (even with moving parts), which previously would have required the assembly of multiple components’, and that by ‘eliminating the assembly phase there will be huge savings for the manufacturer in terms of labor costs'. 3D printing-based production can also reduce or eliminate storage, handling and distribution costs.

People will be able to print a required item at home providing they have the scanned image or the blueprints of the product itself.

The report goes on to say that: 'A major new sector of the logistics industry will emerge dealing with the storage and movement of the raw materials which "feed" the 3D printers. As 3D printers become more affordable to the general public, the home delivery market of these materials will increase.'

Global and national parts warehouses as well as forward stock locations will potentially become unnecessary. At present billions of dollars are spent on holding stock to supply parts for products as diverse as cars and x-ray machines. In some cases, a huge amount of redundancy is built into supply chains to enable parts to be despatched in a very short timescale to get machines up and running again as fast as possible. Currently, parts are held 'just in case' rather than just in time.

A typical example is Arconic, a global technology, engineering and advanced manufacturing leader, which has entered into two agreements to supply Airbus with 3D printed metal parts for its commercial aircraft.

Arconic will supply 3D printed components made from high temperature nickel superalloys, and 3D printed titanium airframe parts.

The service parts logistics industry will be either transformed or decimated by 3D manufacturing – or perhaps both! With small 3D printing machines available, operations in remote locations or even in an engineer's van will only need electronic libraries of designs available to them on a local computer. They can then call up the design of the spare part required and immediately print it. Defective parts could simply be scanned in 3D, fixed in the computer's memory and the new part printed. The implications for maintenance stores inventory are clear. At the time of writing, companies such as British Telecom are already trialling these machines for use by their engineers.

A recent report by DHL suggests that while the 3D printing market is estimated to grow between US $180 billion and US $490 billion by 2025, it will not become a substitute for mass-production but a complementary process.

DHL sees the following advantages:

- lower number of production steps to design, prototype and manufacture highly complex and/or customized products;
- faster delivery time through on-demand and decentralized production strategies;
- lower logistics and production costs (eg reduced shipping and storage costs, potential elimination of import/export costs through localized production, elimination of new production tools and moulds and costly modifications to factories);
- higher sustainability and efficiency in production through using the least amount of material and energy in production.

VIDEO 16viii Faster, cheaper 3D printing for manufacturing parts

Summary and conclusion

Warehouses in highly developed countries will no doubt adopt the latest technology and companies whose products can absorb the high initial capital investment will be at the forefront of warehouse automation.

However, as discussed previously, automation is not for everyone and warehouses will continue to hold stock and employ staff to receive, put away, pick and despatch products.

It is hoped that this book has given you, the reader, an insight into warehouse operations in the 21st century. Although investment in technology will improve and speed up operations, changes in processes, attitudes and improved communication both internally and externally are the stepping stones. These need to be firmly in place and cannot be by-passed under any circumstances prior to any thoughts of automation.

The growth in e-commerce will continue to challenge warehouse managers globally and the change in profile from full-carton and full-pallet picks to individual-item picks will have equipment manufacturers seeking the Holy Grail of pick systems. Whatever that may be.

One thing is certain: we cannot afford to stand still. US Rear Admiral Grace Hopper (1906–92) once said, ‘The most damaging phrase in the language is: “It’s always been done that way”.’

This is a statement I have heard many times in my career and therefore I hope this book has given you some new ideas to think about. Hopefully, you will be able to implement them and they will help you improve efficiency and minimize costs in your own operation.

APPENDIX 1

GLOBAL WAREHOUSE COSTS

Skip table

City	Prime rent (annual $ per sq ft)	Tax and service charges (annual $ per sq ft)
London GB	$20	$11
Tokyo JP	$25	$5
Stockholm SE	$11	$1
Rotterdam NL	$8	$1
Gothenburg SE	$9	$1
Amsterdam NL	$7	$1
Hamburg DE	$9	$1
Dusseldorf DE	$8	$1
Frankfurt DE	$9	$1
Sydney AU	$14	$4
Berlin DE	$9	$1
Midlands GB	$10	$5
North West GB	$10	$5
Melbourne AU	$10	$3
Yorkshire GB	$8	$5
Perth AU	$8	$3
Milan IT	$6	$1
Rome IT	$6	$1
Hong Kong CN	$21	$4
Dublin IE	$13	$2
NYC Boroughs US	$15	$4
Brussels BE	$7	$1
Paris FR	$6	$5
Marseille FR	$5	$4
Antwerp NL	$6	$1
Lyon FR	$6	$3
Los Angeles US	$14	$2
Baltimore US	$8	$4
Singapore SG	$21	$3
Inland Empire US	$9	$2
Northern New Jersey US	$10	$3
Philadelphia US	$8	$4
Dallas US	$7	$1
Barcelona ES	$9	$1
Chicago US	$7	$2

City	Prime rent (annual $ per sq ft)	Tax and service charges (annual $ per sq ft)
Seoul KR	$14	$1
Madrid ES	$7	$1
Prague CZ	$6	$1
Wroclaw PL	$5	$2
Tri City PL	$5	$2
Katowice PL	$5	$2
Warsaw PL	$6	$2
Shanghai CN	$11	$3
Poznan PL	$5	$2
Beijing CN	$13	$4
Shenzhen CN	$11	$3
Dubai AE	$14	$4
Abu Dhabi AE	$11	$1
Chengdu CN	$6	$2
Mumbai IN	$4	$0
Delhi IN	$3	$0
Bangalore IN	$3	$0
Ho Chi Minh City VN	$8	$2
Hanoi VN	$5	$1

APPENDIX 2

WAREHOUSE AUDIT CHECKLISTS

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
External				
Comprehensive signage for delivery drivers in multiple languages				
Comprehensive signage for visitors				
Separate routes for trucks and pedestrians				
Staff cars parked away from warehouse exits				
Is there disabled access into the building?				
Perimeter fencing in good order				
Security gates/barriers in good working order				
External ground in good condition				
Exterior lighting is sufficient and in good order				
LPG and diesel for MHE kept in suitably safe and secure area				
Separate area for storage of waste				

packaging, away from the main building

Are broken pallets and defective equipment stored safely and away from the main building?

Vehicle speeds are controlled

Is there sufficient space for goods vehicle parking?

Sufficient turning space for all types of vehicles

Skip table

Warehouse audit

Carried out by: Loca

Date:

Item	No	Poor	Good	Exc
Internal page 1				
Personnel security checks on entry and exit				
All exits are secure				
Visitors and attendance books available for inspection and accurate				
Visitors are given safety briefing/instructions				
Visitors are escorted at all times				
Is there disabled access into the warehouse?				
Intruder alarm systems installed and inspected regularly				
Stock adequately protected from theft and pilferage				
Is the building, including the roof, wind- and watertight?				
Is the floor surface in good condition (clean and dry)?				
Is the floor capable of taking the weight of the storage				

medium and load in terms of point loading?

Sufficient doors for volume of traffic entering and leaving the warehouse

Warehouse is clean and tidy

Documented cleaning schedule in place

Adequate pest control in place

Teams given responsibility for cleanliness of own areas

Internal page 2

Exits clearly lit, marked and obstruction free

Adequate number of personnel exit doors

Fire escapes, fire doors clearly marked

Are there sufficient fire doors?

Are fire doors obstruction free?

Fire protection system in place, eg sprinklers

Fire alarms are tested weekly

Fire alarm drills are carried out periodically

Fire extinguishers and water hoses clearly marked
Escape routes clearly marked and obstruction free
Doors and windows are fitted with safety glass

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
Internal page 3				
Sufficient space between rack ends and external walls				
No smoking signs clearly visible				
Safety equipment regularly inspected, checked and maintained				
First aid boxes provided and fully stocked				
Eye wash facilities available				
Named and suitably trained first aiders				
At least one first aider per 50 staff				
Lighting is sufficient in each section				
Sufficient natural light available				
Eco lighting used				
Lights are switched off when area not in use				
Clerestory windows and roof lights cleaned regularly				

Is there sufficient emergency lighting provided in areas where staff are at risk?

Is the air quality acceptable?

Is there an audible alarm to detect unsafe areas with poor ventilation?

Is the noise at an acceptable level?

Is the temperature conducive to working?

Internal page 4

Are there sufficient, visible thermometers?

Are battery-charging areas marked adequately and clear of obstruction?

Trucks recharged in a well-ventilated and risk-free area

Is there suitable safety information signage at the battery-charge area?

Are tools and packing materials

stored in their designated areas?
Racking condition is checked regularly and reported
Racking is independently inspected regularly
Are there any broken or collapsing pallets in the racking?
Are there any overhanging pallets in the racks?
Weight capacity visible on the end of the racks
Waste receptacles at the end of each aisle
Are racking legs protected?

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
Systems and equipment				
Warehouse IT systems				
Is there a Warehouse Management System in place?				
Is the system adequate for the current operation?				
Are data backups taken daily and stored off-site?				
Are Display Equipment Regulations adhered to?				
Mechanical handling equipment				
Staff have correct licence for type of truck operated				
Responsible staff trained to operate MHE				
Record of safety training kept up to date				
MHE is appropriate for the tasks				
MHE is serviced				

regularly

A service chart is visible for all MHE

Service and repair records are kept up to date

Pre-operational daily, weekly and monthly checks are carried out on the equipment and recorded

Inspections carried out on lifting equipment every six months

All defects reported to the employer immediately

Safe working load limits clearly marked

Audible signals used when trucks reversing and turning corners

Do forklifts travel at safe speeds?

Is equipment parked in designated areas when not in use, keys removed and forks lowered?

Contingency planning

Documented contingency plan

in place for:
Equipment downtime
System downtime
Labour issues
Supplier issues
Other emergencies
List of emergency contact numbers held and updated

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
Inbound operation				
Inbound processes manual available				
Vehicle booking-in system utilized				
Scheduling of vehicle arrivals				
Pre-notification of goods to be received				
Vehicle immobilized during unloading				
Delivery drivers given instructions on what to do whilst on site				
Drivers' instructions in multiple languages				
Instructions for inbound goods handling provided				
Is the dock area clear of stored materials and obstructions?				
Sufficient stock of empty pallets available				
Sufficient space for empty pallet				

storage
Sufficient space to lay out goods for checking
Recording of number of pallets received
Pallet exchange system in place
Product quantity and condition check
Log of supplier non-conformance kept, eg incorrect paperwork, quantities, products, condition of goods, condition of packaging, TiHi met, pallet overhang.
Sufficient handling equipment provided
Recording of unloading times (dock-to-stock time)
Quarantine area for non-compliance
Quality control area provided
All non-conforming stock dealt with quickly
Are returned

items dealt with
immediately?

Skip table

Warehouse audit

Carried out by:				Loc
Date:				
Item	No	Poor	Good	Exc
Put-away and storage				
System/management directed put-away				
FIFO stock rotation is followed correctly				
Best-before-date stock is managed				
ABC analysis (see page 000) used for product location				
Location IDs are marked clearly				
Accurate recording of stock location				
Task interleaving/dual-cycling undertaken – one pallet in, one pallet out				
Is slotting used effectively (see page 000)?				
Random location system used				
Stock transferred between locations based on ABC analysis				
Is the cube utilization of locations efficient?				
Is location utilization between 80% and 90%?				

Is space usage monitored and action taken to minimize wasted or excess space?

Are part pallets consolidated where feasible?

Product tracking in place

Are damaged items promptly identified and dealt with appropriately?

Items do not overhang pallets

Stock control

FIFO rotation is adhered to

Are items stored in the correct location?

Are high-value goods stored securely?

Are hazardous items stored under the correct conditions?

Are non-moving items regularly reviewed, eg FISH (first in, still here)?

Perpetual inventory counting takes place

Stock counting accuracy is measured

Stock counts use the 'blind' count method (quantity not revealed to counter)

Errors are investigated thoroughly

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
Picking				
Forward pick areas are close to despatch				
Pick locations are replenished efficiently				
Replenishment does not take place during picking				
Sufficient stock held in each location for each shift				
Items that sell together are located next to each other				
Very similar items are separated				
Fast-moving items are in the most accessible locations				
Stock is arranged with consideration to product size and weight				
Fast-moving items are on middle shelves				
The pick list provides an				

efficient pick path
Heavier items are picked first
Pick instructions are clear and concise
Sufficient scanners/voice units available for the team
Pyramid picking is evident
Pick accuracy is measured and monitored

Despatch

Departure times are planned
Sufficient space to lay out despatches
Products are packed securely and safely
Load optimization is apparent
Products are packed to minimize transport costs
Outbound pallets are recorded

Skip table

Warehouse audit				
Carried out by:				Locati
Date:				
Item	No	Poor	Good	Excell
Other areas				
Staff and housekeeping				
Does daily and weekly resource planning take place?				
Are daily work tasks balanced and prioritized?				
Are tasks checked from an ergonomic point of view?				
Are resources maximized to avoid idle time?				
Are activities timed and compared against target?				
Are activities reviewed regularly?				
Are staff trained regularly?				
Are staff encouraged to suggest improvements?				
Are staff uniformed and smart?				
Are staff issued with PPE?				

Is PPE adequate for the tasks required?

Warehouse – performance management

Is performance measured?

Is there a suite of relevant performance measures?

Are performance measures shared with staff and visible in the warehouse?

Is staff productivity measured?

Is productivity data shared with staff?

Skip table

Warehouse audit				
Carried out by:				Loc
Date:				
Item	No	Poor	Good	Exc
Legislative & Health and Safety requirements				
Warehouse Safety Policy Document available for inspection/displayed				
Risk assessments carried out				
Risk assessments available for inspection				
Near miss record book kept				
Accident book kept				
Accident book kept up to date				
Manual handling assessment available for inspection				
COSHH assessment carried out				
Equipment statutory Inspection Certificates available for inspection				
Waste disposal arrangements in place				
***Following notices displayed:**				
Employer's Liability and Public Liability				

Certificate
Health and Safety Information for Employee Regulations 1999
Health and Safety Policy
COSHH information signage
Electric shock signage
*__Staff awareness of following regulations:__
Aware of HSE requirements (UK)
Aware of OSHA requirements (USA)
Health and Safety (Signs & Signals) Regs 1996
Health & Safety (First Aid) Regulations 1981
Provision and Use at Work Equipment Regulations (1998)
Lifting Operations and Lifting Equipment Regulations 1998
Display Screen Equipment Regulations (1992)
Regulatory Reform (Fire Safety) Order 2005
The Pollution Prevention and

Control Act 1999
The Environmental Protection Act 1990
The Hazardous Waste Regulations
Producer Responsibility Obligations (Packaging Waste) Regulations
Waste Electrical & Electronic Equipment Regulations 2007
* Note that different countries will have different requirements and legislation

Further information

This audit can be downloaded in Excel format (for a small fee) from www.howtologistics.com.

Suggested reading to ensure safe and legal practices

UK HSE: **www.hse.gov.uk**
UK COMAH: **www.hse.gov.uk/comah/index.htm**
UK SEMA: **www.sema.org.uk/**
USA OSHA: **www.osha.gov/**
Europe EPA: **www.epa.gov/lawsregs/regulations/**
Risk: **www.ioshroutefinder.co.uk**

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GLOSSARY

5S: Japanese methodology for organizing the workplace

80/20 rule: See Pareto analysis

ABC (costing): Activity-based costing: relating costs to activities performed

ABC analysis: See Pareto analysis

ADC: Automatic data capture

AGV: Automated guided vehicle: robot for moving material around (driverless vehicle)

AIDC: Automatic identification and data collection

AMR: Autonomous mobile robot

Annualized hours: Flexible hours system

APR: Adjustable pallet racking

ASN: Advanced shipping notice

AS/RS: Automated storage and retrieval system

B2B: Business to business

B2C: Business to consumer

Back order: Order for items that are not currently in stock

Brownfield site: Site on which there has been previous development, eg factory or other building

CBT: Counterbalanced forklift truck

Centre of gravity method:

Method for finding the best location, taking into account volumes supplied, travel distances and transport costs

CHIP: Chemical hazards, information and packaging regulations: UK legislation

CILT: Chartered Institute of Logistics and Transport

CMR: Collaborative mobile robot

CNG: Compressed Natural Gas

COI: Cube per order index

Collation: Collecting together items for the same delivery vehicle; see also marshalling area

Consolidation: Bringing together items from different sources to go to the same destination

COSHH: Control of substances hazardous to health regulations: UK legislation

CPFR: Collaborative planning, forecasting and replenishment: www.cpfr.org

Cross dock: Mainly used for pallets, where arriving items are immediately sorted for despatch without being put into stock

Cycle counting: Counting inventory of an item once during each replenishment order cycle

DC: Distribution centre

Dynamic allocation: Mainly used in pallet warehouses; each time a pallet arrives, a location is assigned to it; in general, this location does not depend on the item type or location of pallets of similar items

EAN: European article number: www.ean.org

EAN 128: High-density barcode coding system

EAN-13 (gtin-13): 13-digit barcode

ECR: Efficient consumer response: a supply chain practice for meeting consumer demand whilst reducing cost and inventory with manufacturers and retailers working closely together

EDI: Electronic data interchange

EPC: Electronic product code: code issued by agreed authority for an individual product (enabling slap'n'ship) such that other organizations can recognize the product

EPC Global: Not-for-profit organization set up by UCC and EAN International, responsible for implementing and maintaining globally agreed RFID standard codes

EPOS: Electronic point of sale

ERP: Enterprise resource planning; claims to take MRP2 (manufacturing resource planning) further by linking planning between businesses, and enabling better integration between the production and business management systems used in a firm

Euro pallet: Pallets of size 1200 mm × 800 mm made to euro pallet-agreed specifications

FAO: The United Nations Food and Agriculture Organization

FIFO: First in, first out method of stock rotation

FILO: First in, last out

FISH: First in, still here – refers to very slow-moving stock

FLT: Forklift truck

FTL: Full truck load

FTP: File transfer protocol

GFR: Good-faith receiving: no/limited checks on inbound goods

Greenfield site: Site that has not been developed before and is still countryside

GTIN: Global trade item number

HACCP: Hazard analysis and critical control point

HASWA: Health and Safety at Work etc Act: UK legislation

HMI: Human–machine interaction

HU/HD: Hoist up/hoist down

ID: Identity or identification

ISPM 15: International Standards for Phytosanitary Measures Publication No 15 (2009): Regulation of Wood Packaging Material in International Trade

IT: Information technology

JIT: Ordering stock frequently in small quantities; for finished stock this means only ordering what will almost certainly be sold in the very near future

Kaizen: Japanese methodology for quality improvement

Kanban: Japanese card system for controlling just-in-time material flow

KPI: Key performance indicator

LIFO: Last in, first out method of stock rotation

LOLER: Lifting operations and lifting equipment regulations: UK legislation

LPG: Liquefied Petroleum Gas

LTL: Less than truck load, ie partly full vehicle

LU: Logistical unit, eg pallet, case

Marshalling area: Where packages or items are grouped together for a purpose, eg grouped by delivery route; see also collation

MHE: Materials handling equipment, eg forklift truck, or mechanical handling equipment

NDC: National distribution centre

OCR: Optical character recognition; usually characters are in a format readable by humans and machines

OMS: Order management system

OTIF: On time and in full: the order must be delivered with exactly the items and quantities as ordered and on the day requested

Pareto analysis: To identify the most important activities or items which account for 80 per cent of the value, turnover, etc; also known as the 80/20 rule and ABC analysis

PDA: Personal digital assistant: a mobile device that functions as a personal information manager

Perpetual inventory counting: Counting a proportion of the inventory each week, in order to spread the cost of counting stock through the year

Picking: The act of selecting items from stock for an order

Postponement: Deferring creating variants of a product or customization of a product until the latest possible stage of production or distribution

PPE: Personal protective equipment

PPT: Powered pallet truck

QC: Quality control

QR: Quick response: products are produced and delivered in the variety and volume that match demand; the manufacturer bases production on data from retailers – little and often

RDC: Regional distribution centre

RDT: Radio data terminal

RF: Radio frequency

RFDC: Radio frequency data capture

RFID: Radio frequency identification

RIDDOR: Reporting of injuries, diseases and dangerous occurrences regulations: UK legislation

RSI: Repetitive strain injury

RTP: Returnable transit packaging

SAP: A widely used ERP system; see ERP

SCM: Supply chain management

SKU: Stock-keeping unit; each different item to be stored is a different SKU; note that two different-sized packages of the same substance or item are considered to be different SKUs; also referred to as product lines

Slap‘n’ship:

Using EPC-compliant RFID tags such that other organizations can recognize those products, enabling tracking and tracing through the supply chain worldwide

Slotting strategy: Deciding where each item should be located in the warehouse

SMI: Supplier-managed inventory or VMI (vendor-managed inventory)

Sortation: Sorting a group of items into different orders or destinations

SSCC: Serial shipping container code: unique worldwide 18-digit number applied to logistical unit, incorporating the AN.UCC company prefix

Static or fixed allocation: Each item in the warehouse is given a particular location where that item type will always be found

Stock cover: Period of time that current level of stock is capable of supporting sales, using average usage values

Stock turns annual: Number of times on average that the stock is used and replenished during the year

SVL: System vehicle loop

TEU: Twenty foot equivalent unit – a 20 foot shipping container

TMS: Transport management system: software to plan vehicle loads and routing

TQM: Total quality management

Trans-shipment: Movement of goods from one set of vehicles to another for onward delivery

ULD: Unit load device container utilized for airfreight

UoM: Unit of measurement

VDU: Visual display unit

VMI: Vendor-managed inventory

VNA: Very narrow aisle

WEEE directive: European directive for safe disposal of waste electrical and electronic equipment

WERC: An association for logistics and warehousing professionals

WIP: Work in progress

WMS: Warehouse management system

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