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سلايدات :

ادارة سلسلة التزويد و الخدمات اللوجستية

Supply Chain Management

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اللجنة الأكاديمية لقسم الهندسة الصناعية

2023

Supply chain management

Introduction

Good or Service?

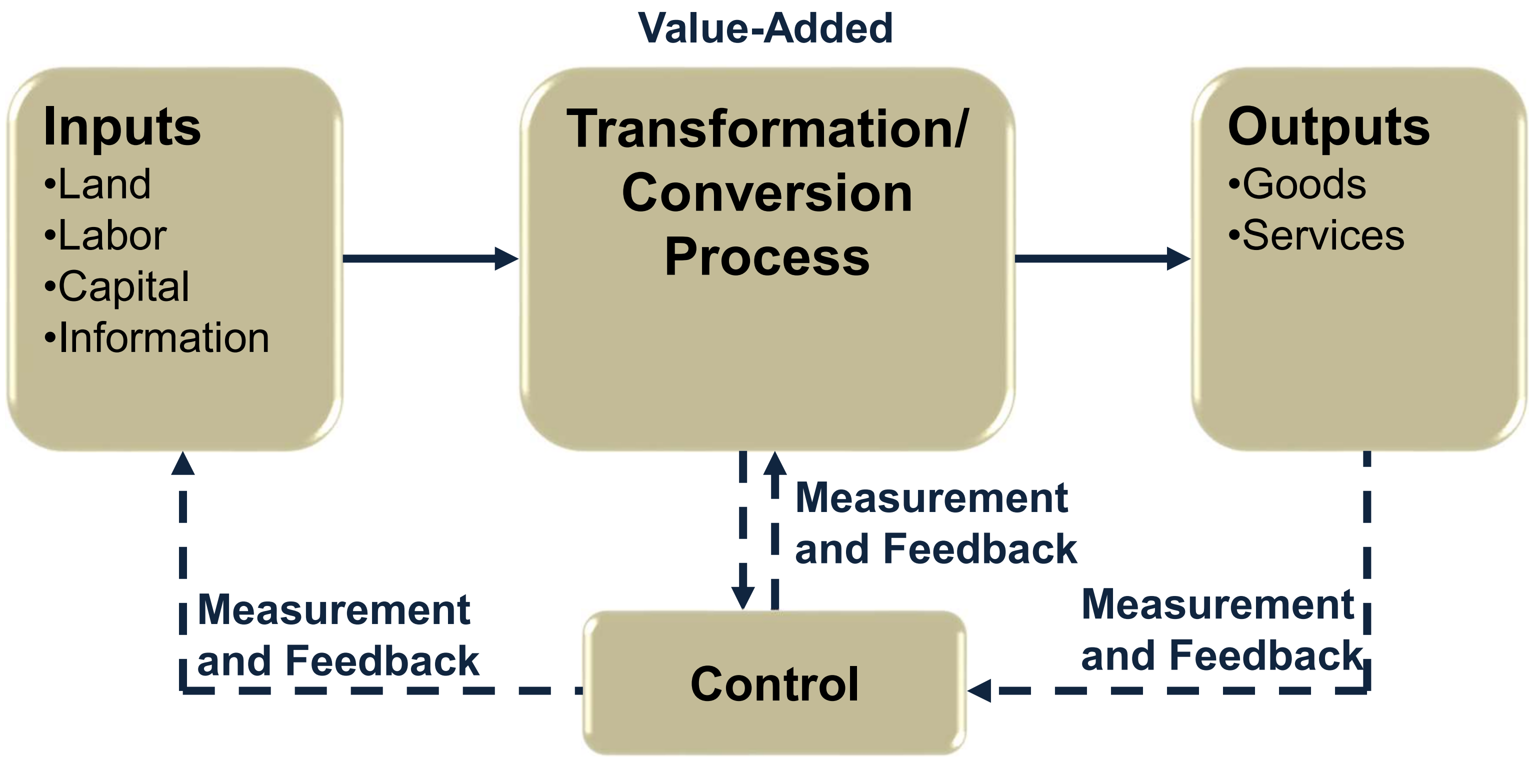
Goods are physical items that include raw materials, parts, subassemblies, and final products.

- Automobile
- Computer
- Oven
- Shampoo

Services are activities that provide some combination of time, location, form or psychological value.

- Air travel
- Education
- Haircut
- Legal counsel

The Transformation Process



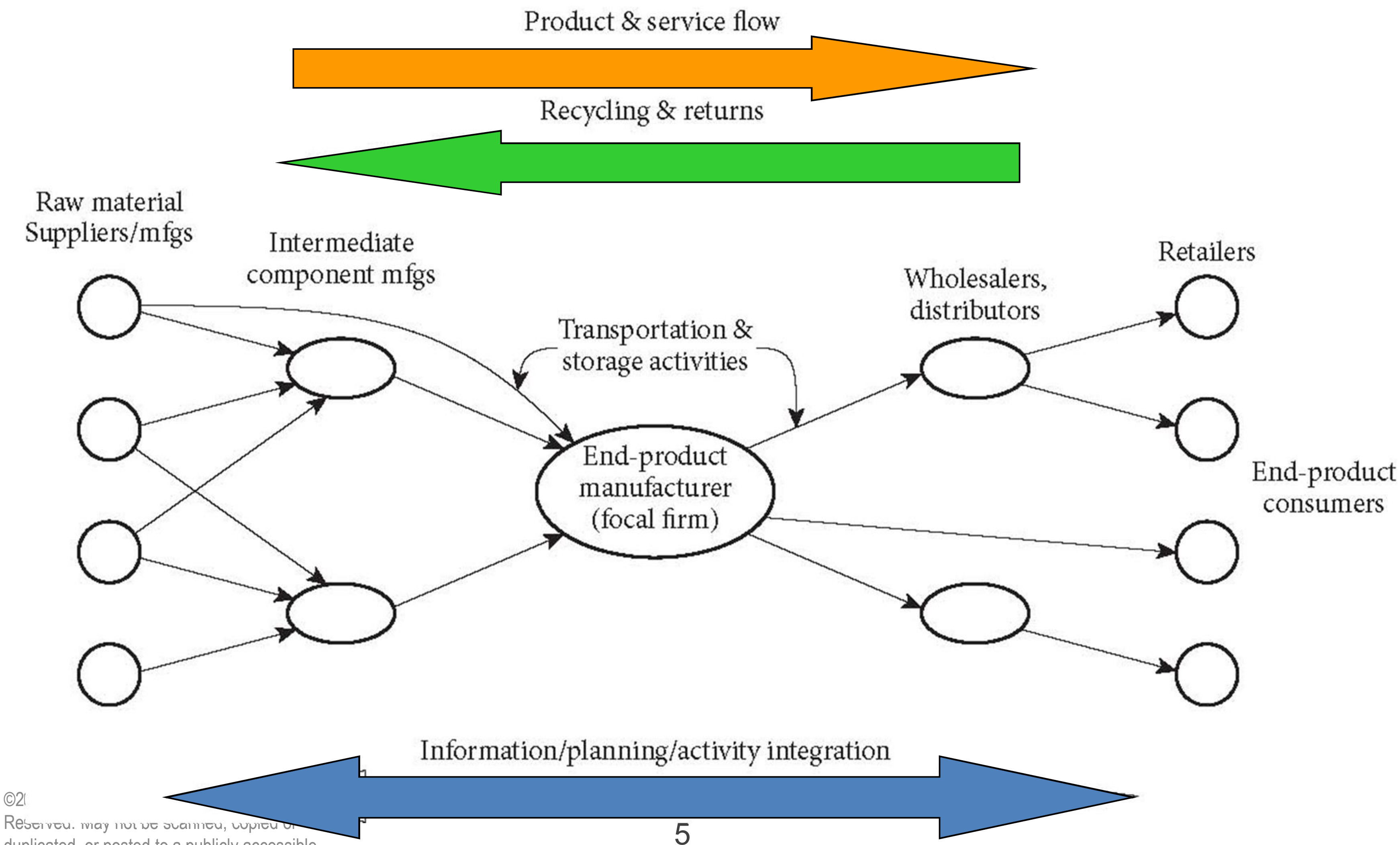
Feedback = measurements taken at various points in the transformation process

Control = The comparison of feedback against previously established standards to determine if corrective action is needed.

Supply & Demand

Operations & Supply Chains		Sales & Marketing	
Supply	>	Demand	Wasteful Costly
Supply	<	Demand	Opportunity Loss Customer Dissatisfaction
Supply	=	Demand	Ideal

What is a Supply Chain?



What is supply chain management?

- The *supply chain* is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer
- *Supply chain management* (SCM) is the management across and within a network of upstream and downstream organizations of both relationships and flows of material, information and resources
  - The purposes of SCM are to create value, enhance efficiency, and satisfy customers

What is logistics?

- Logistics involves getting
  - the right product,
  - in the right way,
  - in the right quantity and right quality,
  - in the right place at the right time,
  - for the right customer at the right cost
- Its not just ‘trucks and sheds’

Key flows in SCM

- Physical flows of materials
- Flows of information that inform the supply chain
- Resources (especially finance, but also others such as people and equipment) which help the supply chain to operate effectively
  - Furthermore, not all resources in the supply chain are tangible, for example good quality inter-company relationships are often cited as a highly important ingredient of effective supply chains

Distinguishing logistics and SCM

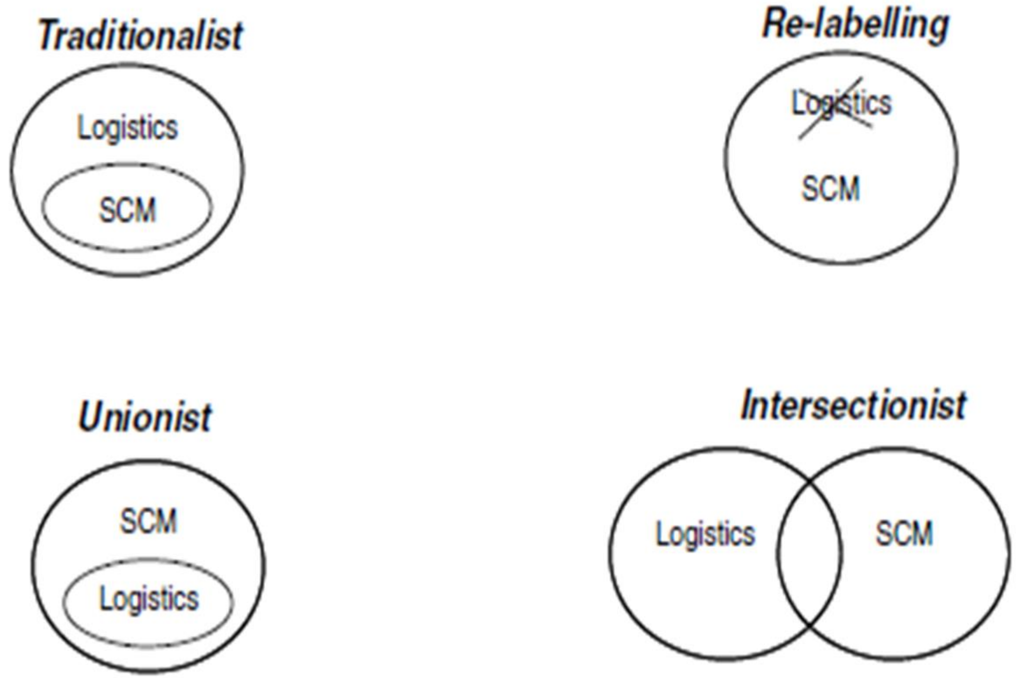


Figure 1.2 Four perspectives on logistics versus supply chain management (Source: Larson & Halldorsson, 2004)[11]

What is a Supply Chain?

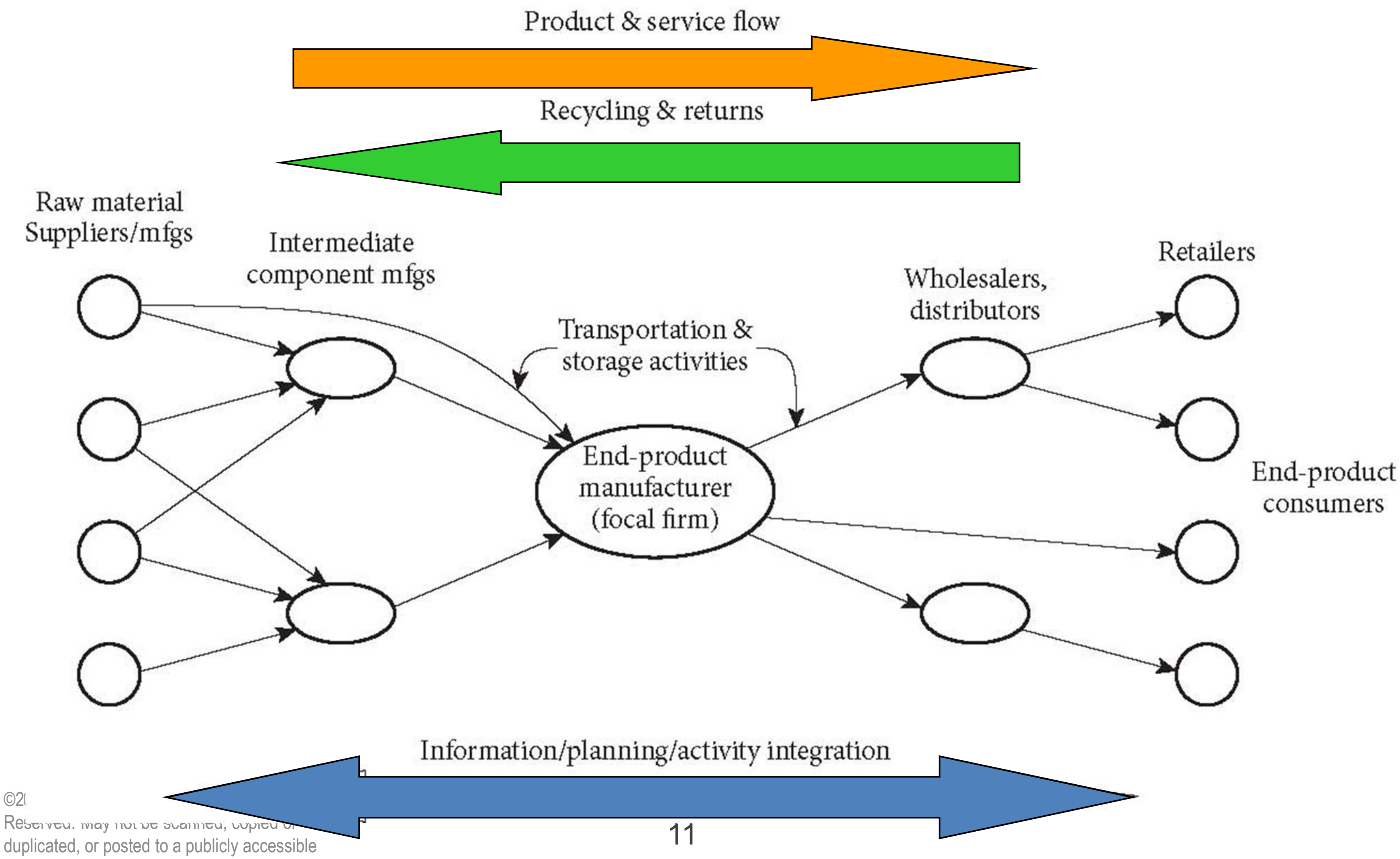
A **supply chain** consists of the flow of products and services from:

- Raw materials manufacturers
- Component and intermediate manufacturers
- Final product manufacturers
- Wholesalers and distributors and
- Retailers

Connected by transportation and storage activities, and **Integrated** through information, planning, and integration activities

Many large firms are moving away from in-house **Vertically Integrated** structures to Supply Chain Management

What is a Supply Chain? *(continued)*

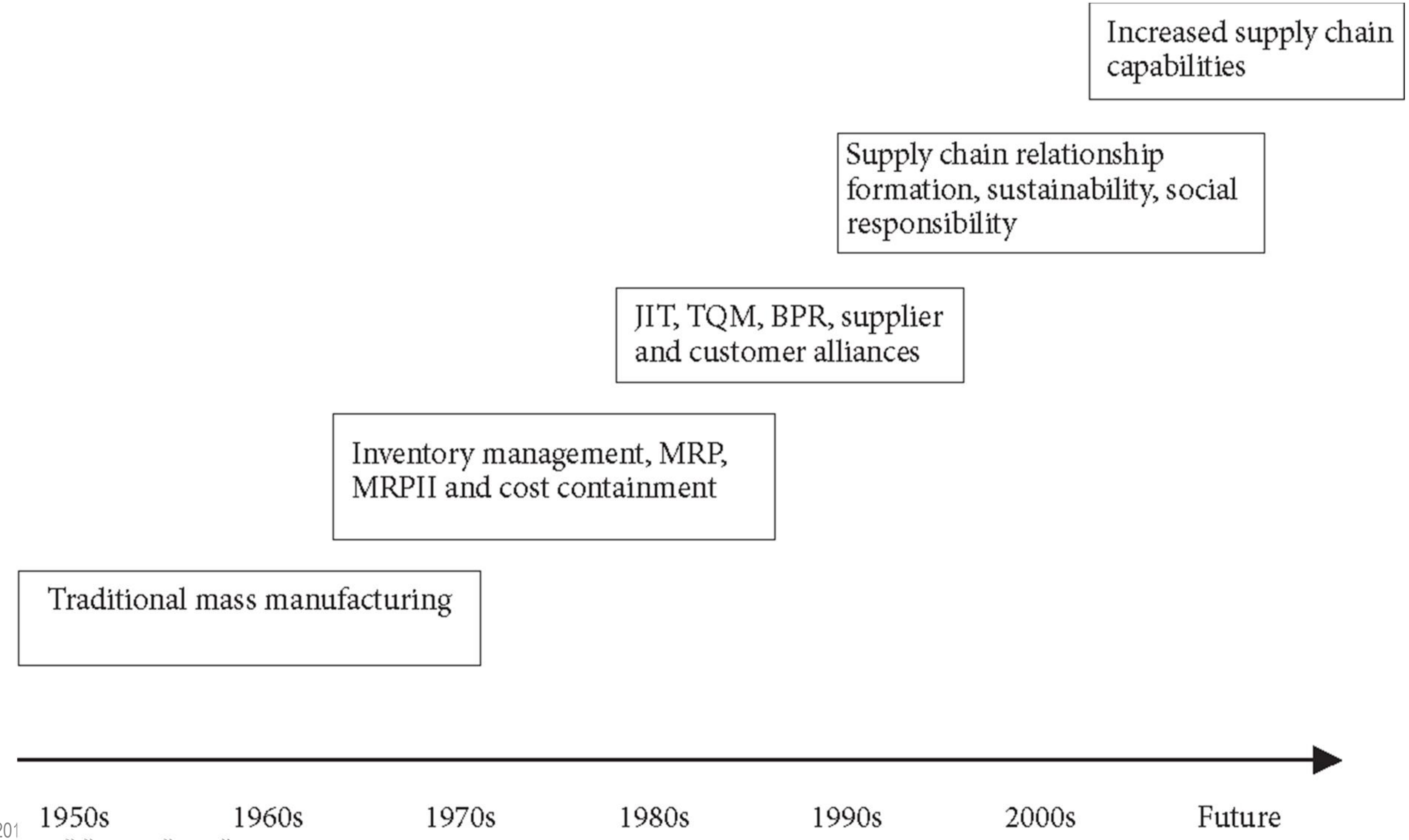


What is Supply Chain Management?

(continued)

- ***Old paradigm*** - Firm gained synergy as a vertically integrated firm encompassing the ownership and coordination of several supply chain activities. Organizational cultures emphasized short-term, company focused performance.
- ***New paradigm*** - Firm in a supply chain focuses activities in its area of specialization and enters into voluntary and trust-based relationships with supplier and customer firms.
  - All participants in the supply chain benefit.
  - Boundaries are dynamic and extend from “the firm’s suppliers’ suppliers to its customers’ customers (i.e., second tier suppliers and customers).”
  - Supply chains also include reverse logistics activities to handle returned products, warranty repairs, and recycling.

Origins of Supply Chain Management *(continued)*



The Foundations of Supply Chain Management

Supply	Supply base reduction, supplier alliances, SRM, global sourcing, ethical and sustainable sourcing
Operations	Demand management, CPFR, inventory management, MRP, ERP, lean systems, Six Sigma quality systems
Logistics	Logistics management, customer relationship management, network design, RFID, global supply chains, sustainability, service response logistics
Integration	Barriers to integration, risk and security management, performance measurement, green supply chains

Important Elements of Supply Chain Management *(continued)*

Integration Elements:

- **Supply Chain Process Integration** - when supply chain participants work for common goals. Requires intra-firm functional integration, with efforts to change attitudes & adversarial relationships
- **Supply Chain Performance Measurement** - Crucial for firms to know if procedures are working as expected
- High level supply chain performance will occur when strategies at each firm fit well with overall supply chain strategies

Growth in international trade

- There has been considerable growth in recent decades in world trade; world exports grew from $62 billion in 1950 to a peak of $16,000 billion by 2008 before subsequently declining
- Facilitated by regional trade agreements
- Hence more freight is moving all around the world
  - Logistics systems are thus having to play an increasingly important role in the global economy

The evolution of the integrated supply chain

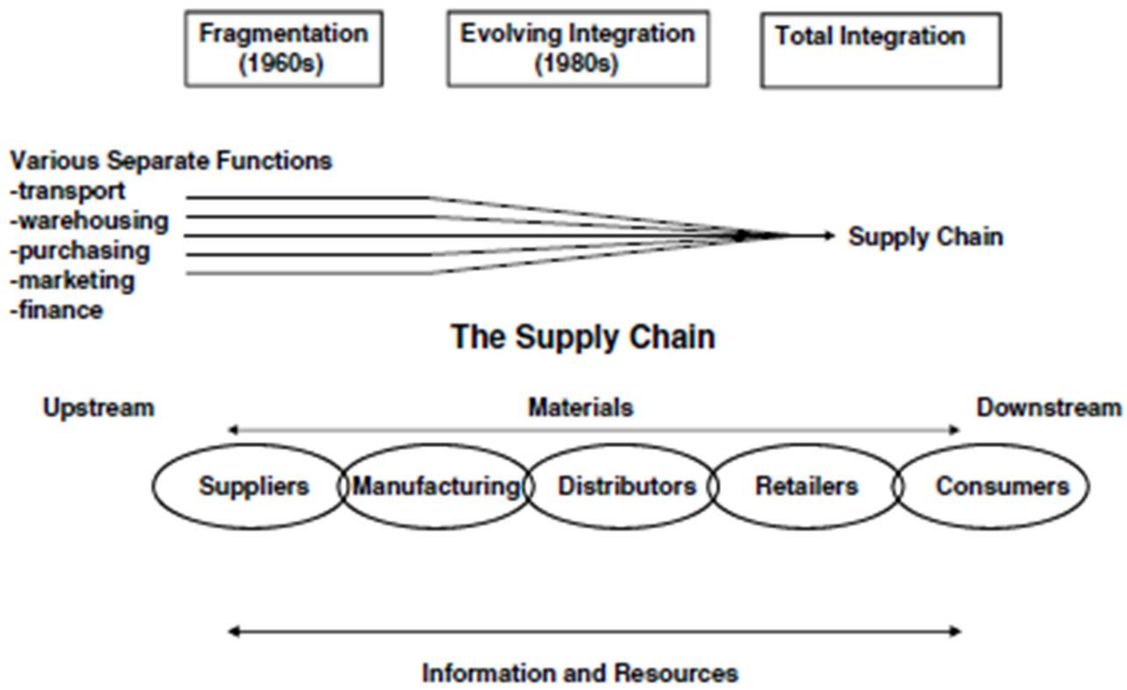


Figure 1.1 The evolution of the integrated supply chain

Measuring Logistics Performance

- The global logisitcs performance index (LPI) ranks 155 countries' logistics performance against six key dimensions:
  - Customs
  - Infrastructure
  - International shipments
  - Logistics competence
  - Tracking & tracing
  - Timeliness

Top 10 countries in the global LPI

Table 2.1 Top 10 countries in the global logistics performance index (LPI)[7]

1	Germany
2	Singapore
3	Sweden
4	Netherlands
5	Luxembourg
6	Switzerland
7	Japan
8	United Kingdom
9	Belgium
10	Norway

Outsourcing

- The transfer of to a third party of the management & delivery of a process previously performed by the company itself
- Requiring:
  - Service Level Agreements (SLAs)
  - Order winners and qualifiers
  - Supplier development
- Creating:
  - Virtual organisations

Supply chain integration

- Integration embodies various communication channels and linkages within a supply network
- Integration should not be confused with collaboration
- Integration is the alignment and interlinking of business processes
- Collaboration is a relationship between supply chain partners developed over a period of time
- Integration is possible without collaboration
- Integration is an enabler of collaboration

Supply chain integration

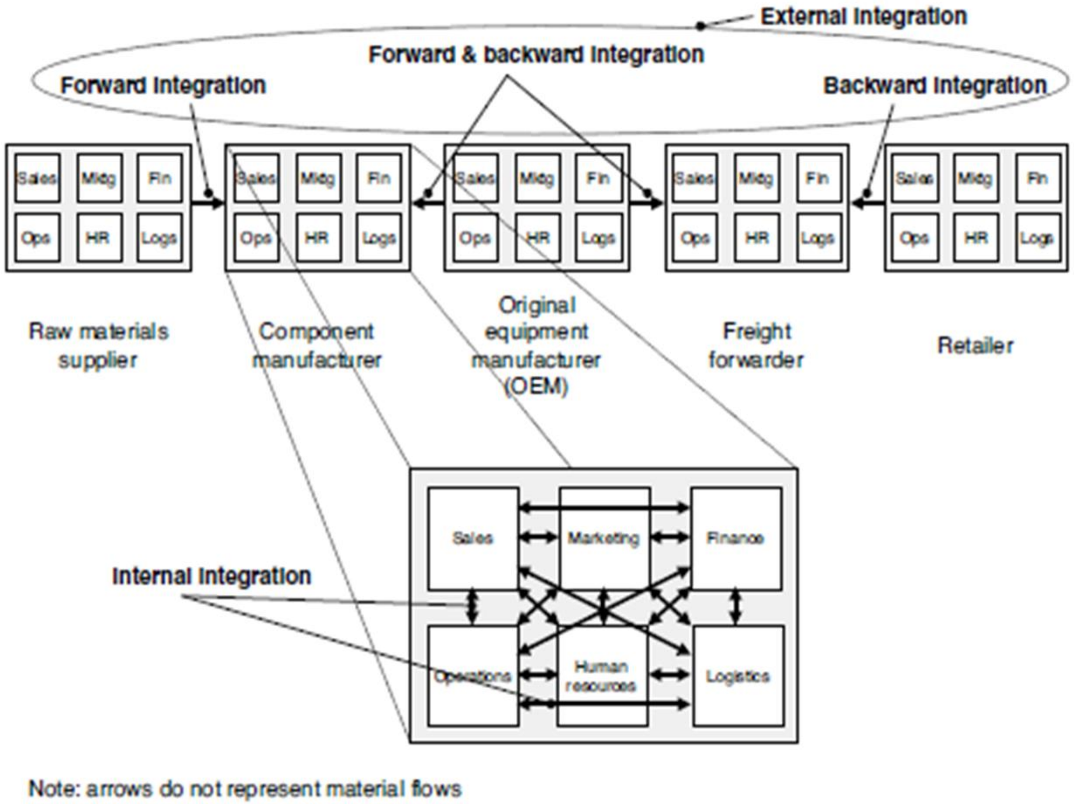


Figure 3.3 Distinctions between the primary modes of integration (Source: Fawcett & Magnan 2002)[14]

Internal integration

- To integrate communications and information systems so as to optimise their effectiveness and efficiency
- Can be achieved by structuring the organisation and the design and / or implementation of information systems for improved communication and information sharing
  - Non-value adding activity is minimised
  - Costs are reduced
  - Leadtimes are reduced
  - Service quality is improved
  - Functional silos are reduced

External integration

- EDI is a key enabler of supply chain integration
  - It streamlines information sharing and processing
- Effective and efficient organisational design is a prerequisite
- Keiretsu:
  - Original equipment manufacturers work closely with their first tier suppliers to integrate manufacturing, logistics and information processes; which is passed upstream
    - This enables just-in-time line-side delivery at their assembly plants
    - A seamless lean supply chain is created
    - The supply chain is viewed as one extended operation

The journey from open market negotiations to collaboration

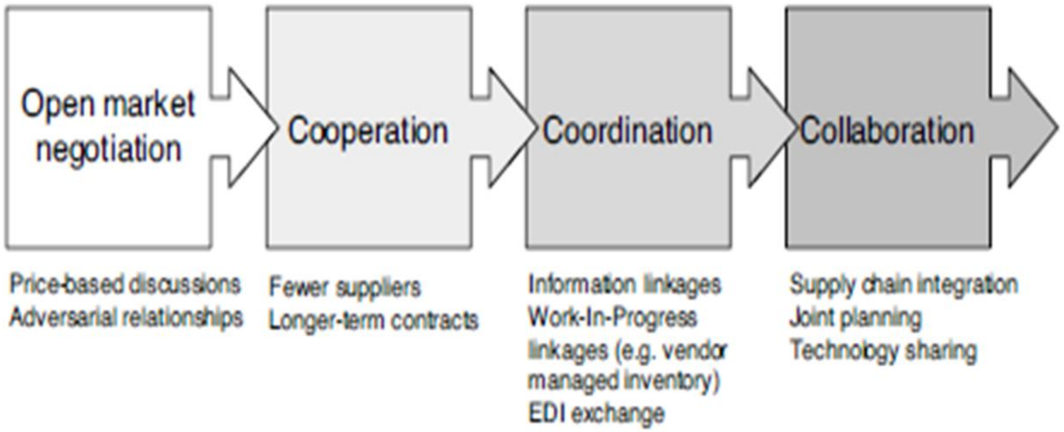
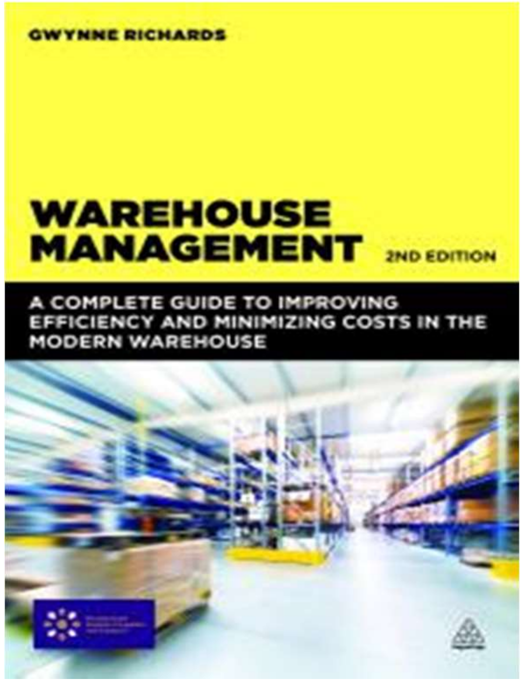


Figure 3.5 The journey from open market negotiations to collaboration (Source: Adapted from Spekman, Kamauff & Myhr 1998)[17]

Warehousing & Materials Handling

Textbook



Richards, G. (2014), Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse, Kogan Page, 2nd Edition, ISBN-13: 978-0749469344.

Warehouse definition

"Warehouses are typically viewed as a temporary place to store inventory and as a buffer in supply chains.
They serve as static units matching product availability to consumer demand and as such have a primary aim which is to facilitate the movement of goods from suppliers to customers, meeting demand in a timely and cost effective manner".
Primarily a warehouse should be a trans-shipment area where all goods received are despatched as quickly, effectively and efficiently as possible.

Van den Berg (2012)

Key Warehouse Challenges (Adapted from Dematic)

Challenge	Operational Requirements
Cost reduction	Increase productivity, improve utilisation of space, staff and equipment
Achieve the Perfect Order	Improve productivity, increase accuracy, improve handling and invest in systems
Shorter order lead times	Improve processes and increase productivity
Sales via multiple channels and increase in smaller orders	Improved picking strategies such as bulk picking and greater use of technology
Fluctuations in demand	Flexible working hours and improved forecasting
Proliferation of SKU	Improved use of equipment such as carousels, A Frames and flow racks
Labour cost and availability	Staff retention through excellent working conditions, flexible hours, training and improved productivity
Increasing cost of energy and environmental challenges	Manage energy more efficiently, better use of waste
Data accuracy and speed of transfer	Introduce Warehouse management system and real time data transfer

Type of warehouse operation

- Raw materials storage
- Intermediate, postponement, customization or sub-assembly facilities
- Finished goods storage
- Consolidation centers and transit warehouses
- Transshipment or break bulk center
- Cross-dock centers
- Sortation centers
- Fulfilment centers
- Reverse logistics centers
- Public sector warehousing

Why do we hold stock

- Uncertain demand patterns
- Trade-off between transport and shipping cost
- Discounts via bulk buying
- Distance between manufacturer and the end customer
- Cover for production shutdowns
- Ability to increase production runs
- To mange seasonal production
- High seasonality
- Spare part storage
- Work-in-progress storage

Why is Warehouse Location Important for a Business?

- **Warehouse location**
  - Location is typically prime consideration in mode of transportation selection.
  - Location decisions have strategic importance because they can help to develop sustainable competitive advantage.
  - Location decisions are risky: invest or lease?

Selecting a particular Location Type

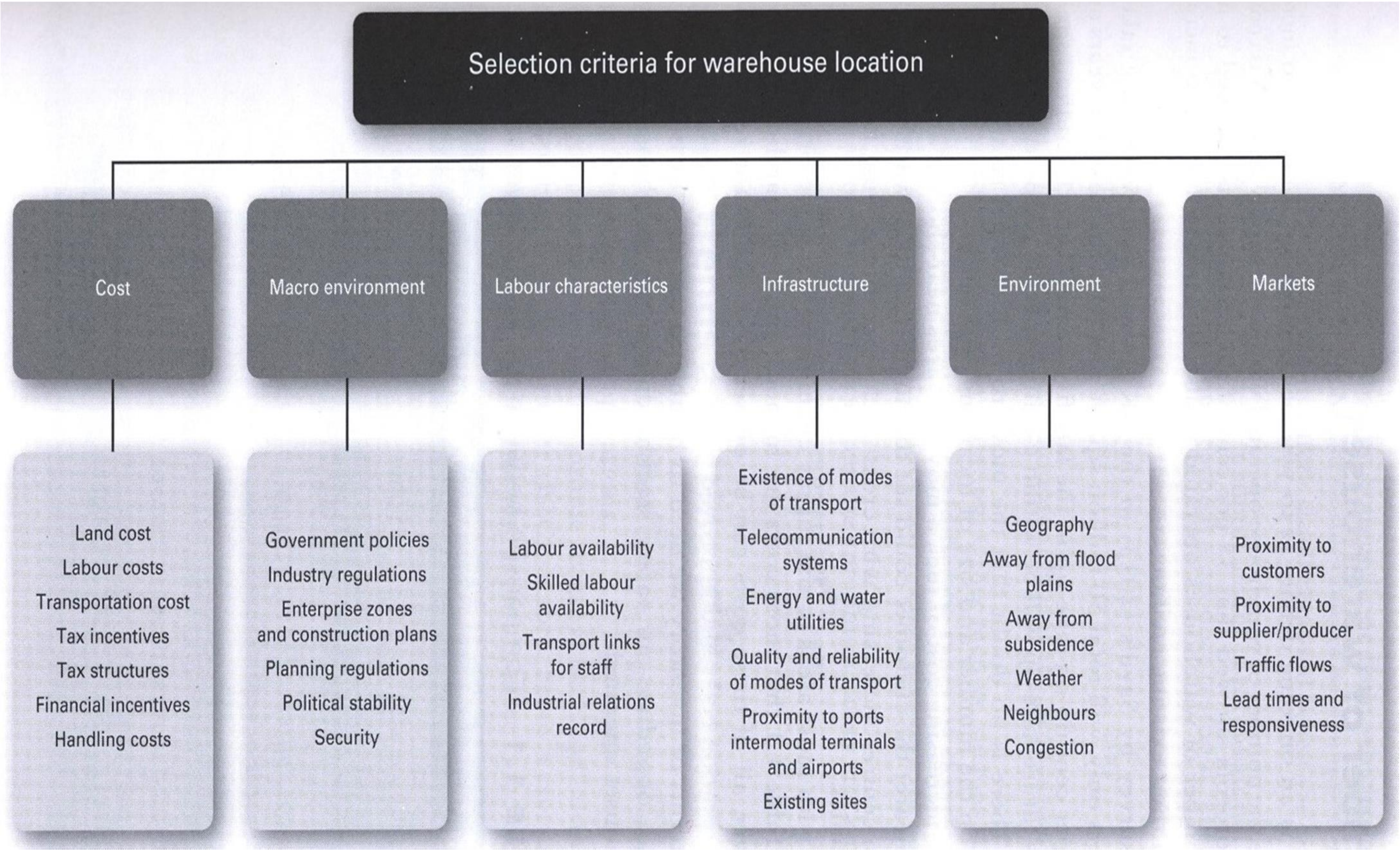
Involves evaluating a series of trade-offs between

- The size of the trade area (geographic area encompassing most of the transportation / distribution facilities)
- the occupancy cost of the location
- The vehicle traffic
- The restrictions placed on warehouses by the warehouse owners (if leased or rented)
- The convenience of the location for transporters and intermediate customers

Factors involved in Location Decision

- Cost of land, rent and rates
- Access to Transport Network
- Availability of affordable skilled labour
- Transport links for staffs
- 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 plants
- The potential neighbours (e.g. proximity to oil storage depots can be a negative factor)

Factors Determining Location of a Warehouse



Source: Page #19, Text book

Decision-Making Process

- Location decision is made through Software programs and some optimization tools
- Warehouse location decisions are of '**Multi-Criteria Decision-Making**' (MCDM) / '**Multi-Attribute Decision-Making**' (MADM) in nature
- Above decision-making tools consider all '**conflicting in-nature**' criteria having '**incommensurable units of measurements**'.
- A number of **viable alternatives** are found and the alternative decisions are ranked according to the priorities

Number of Warehouses

- Trade-off among costs, improved service, safety stock inventories
- From the angle of safety stockholding number of warehouses can be found.

- By using **Square Root Rule** introduced by **David Maister**
  - **David Maister published an** article entitled "*centralization of Inventories and The Square Root Law*" in **International Journal of Physical Distribution**

- **Square Root Law**: Average inventory increases proportionally to the square root of the number of locations in which inventory is held.

$$X2 = (X1) * \sqrt{(n2/n1)}$$

Number of Warehouses *(Continued…)*

- **Square Root Law**: Average inventory increases proportionally to the square root of the number of locations in which inventory is held.

$$X2 = (X1) * \sqrt{(n2/n1)}$$

- n1 = number of existing facilities

  n2 = number of future facilities

  X1 = existing inventory

  X2 = future inventory

- **Assumption:** The amount of the safety stock in each existing warehouse in the system is approximately the same.

Number of Warehouses *(Continued…)*

Example:

- Current inventory is 4000 units, 2 facilities grow to 8. Using the square root law the future inventory =

$$X2 = (4000) * \sqrt{(8/2)} = 8000 \text{ units.}$$

- This calculation must not be used in isolation. Other factors are to be considered:
  - Supplier and customer lead times
  - Type of the product
  - Transportation costs
  - Distribution centre costs

Number of Warehouses *(Continued…)*

❑ Comparison Between Many and Fewer Warehouses

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

Source: Page #20, Text book

Specialised Warehouses *(Continued…)*

Refrigerated warehouses

- Refrigerated warehouses provide a vital link in the cold chain from the farmer to the consumer

- Refrigerated warehouses operate at -10 to +40°F (-25 to +5°C)

- Electrical energy is used to operate refrigeration equipment

Specialised Warehouses *(Continued…)*

- Desired goals to have a **Green, Sustainable, Energy Efficient Refrigerated Storage Facility (i.e. warehouse)**

- Refrigeration equipment should operate at **high energy efficiency**
  - Designed and constructed to be robust
  - Maintainable with minimal effort
- **Environmentally friendly refrigerants should be used** that minimise:
  - Ozone depletion potential
  - Global warming potential
  - Annual energy consumption

Typical Refrigerated Warehouses

Specialised Warehouses *(Continued…)*

- **Infiltration**
  - Warm, moist ambient air entering the refrigerated facility
    - Sensible and latent heat loads **(5 seconds)**
- **Effect of Infiltration**

Ambient storage (room temp storage)

Photo – Newman Paperboard

Photo – Howard Tenens

Hazardous Goods storage

Photo - EDIE

Photo – Transmare - chemie

There are nine classes, some with divisions, as follows:

UN Class	Dangerous Goods	Division(s)	Classification
1	Explosives	1.1 - 1.6	Explosive
2	Gases	2.1	Flammable gas
		2.2	Non-flammable, non-toxic gas
		2.3	Toxic gas
3	Flammable liquid		Flammable liquid
4	Flammable solids	4.1	Flammable solid
		4.2	Spontaneously combustible substance
		4.3	Substance which in contact with water emits flammable gas
5	Oxidising substances	5.1	Oxidising substance
		5.2	Organic peroxide
6	Toxic substances	6.1	Toxic substance
		6.2	Infectious substance
7	Radioactive material		Radioactive material
8	Corrosive substances		Corrosive substance
9	Miscellaneous dangerous goods		Miscellaneous dangerous goods

Packaging and Labelling

The consignor is responsible for ensuring that the packaging conforms to the regulations for the product. The packaging can be as simple as a cardboard box or paper bag for low risk powders in small quantities to very sophisticated double skinned stainless steel packages for more complex high risk products. In general the package needs to be UN approved and compatible with the product but for every UN number there is a list of packaging options available to the packer.

Having packed the product the package has to be labelled, this is not about the product labelling or CHIP labelling which has health and safety advice for the user, but a rather simple class warning symbol. On small packages a 100 mm square coloured diamond with a symbol, these can be larger on IBC's and road tankers. I have illustrated a couple of examples below:

New Haz chem codes

	Example of hazard statement	Example of precautionary statement
	Heating may cause an explosion	Keep away from heat/ sparks/open flames/ hot surfaces – no smoking
	Heating may cause a fire	Keep only in original container
	May intensify fire; oxidiser	Take any precaution to avoid mixing with combustibles
	Causes serious eye damage	Wear eye protection
	Toxic if swallowed	Do not eat, drink or smoke when using this product
	Toxic to the aquatic life, with long lasting effects	Avoid release to the environment
	New pictogram, reflects serious longer term health hazards such as carcinogenicity and respiratory sensitisation eg May cause allergy or asthma symptoms or breathing difficulties if inhaled	In case of inadequate ventilation, wear respiratory protection
	New pictogram, refers to less serious health hazards such as skin irritancy/sensitisation and replaces the CHIP symbol eg May cause an allergic skin reaction	Contaminated work clothing should not be allowed out of the workplace
	New pictogram, used when the containers hold gas under pressure eg May explode when heated	None

Temperature controlled storage

Photo by fordsproduce.com

Photo by Texas ice house

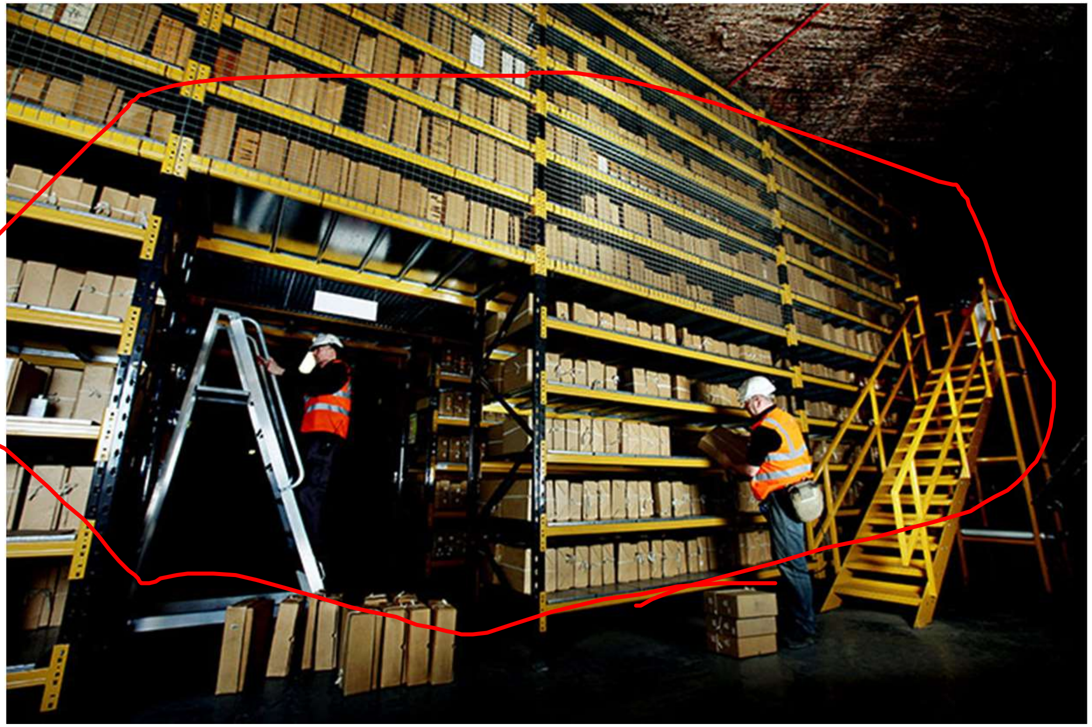
Bulk storage

Garment storage

Photo by Asda Walmart

Photo by Transformer

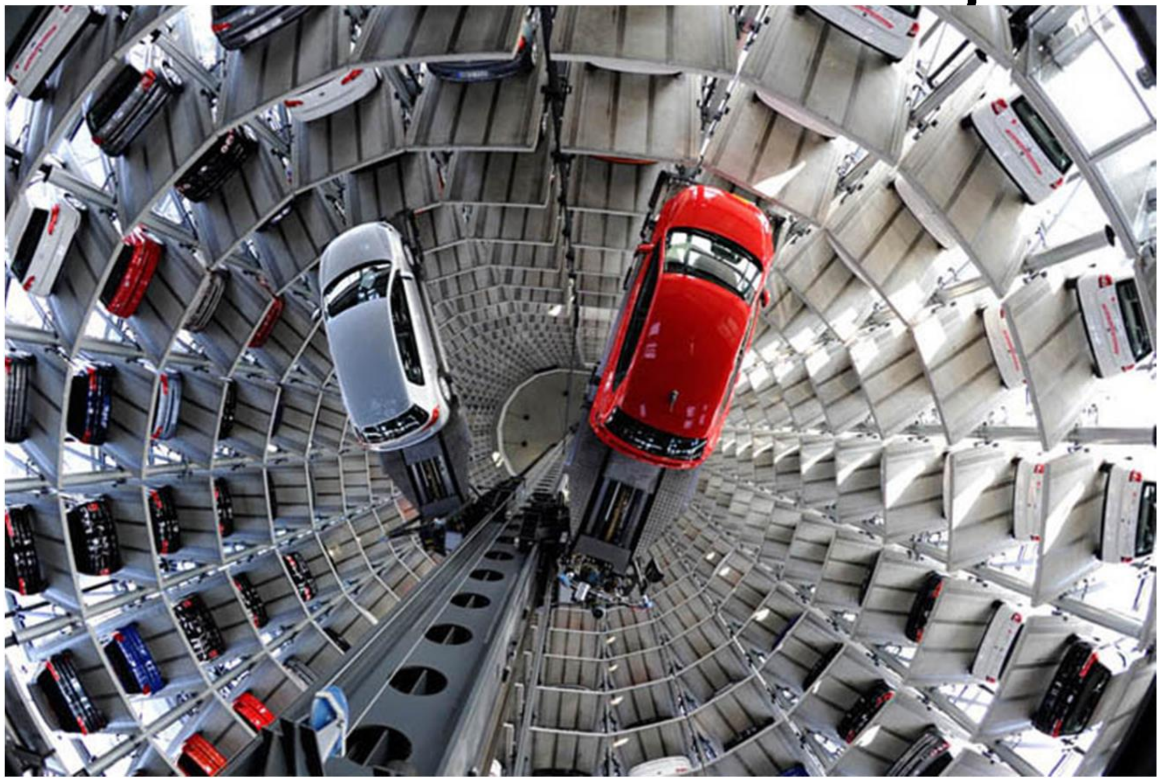
Archive Storage – Abandoned Salt mines



Fulfilment Centres

Photo by BBC News - Amazon

Other Warehouse examples



Warehouse types

Open spaces can also be classed as warehouses if products are stored for a period

Returns/Recycling warehouse

J & M Re-cycling

http://your.asda.com/sustainability-store-waste/waste-not-want-not-2

Customs warehousing - advantages

- Customs warehousing is a procedure that enables the suspension of Import Duty and/or VAT.
- Delay paying import duty and/or VAT and excise duty on your stocks of imported goods.
- If you want to re-export you don't pay import tax
- If you do not know the ultimate destination of the imported goods and want to delay having to declare imported goods to another customs procedure, for example release for free circulation
- Certain countries operate Free Trade Zones on a similar principle

Role of Warehouse Manager

❖ **Role of warehouse manager**

➢ Responsible for warehouse trade-offs in the following ways

- Increased throughput versus reduction in labour costs
- Storage density versus quicker pallet extraction
- Manual versus automated processes
- Increased pick rates versus accuracy
- Inventory holding costs versus cost of stock outs
- Speed versus safety
- Green, sustainable and energy efficient facility versus low total costs

Warehouse Management Systems

- Manages **warehouse inventory, space, equipment, and labour resources** to direct the **flow of materials and information from receiving and put-away to light assembly, order picking, value-added processing and shipment**

Warehouse Processes

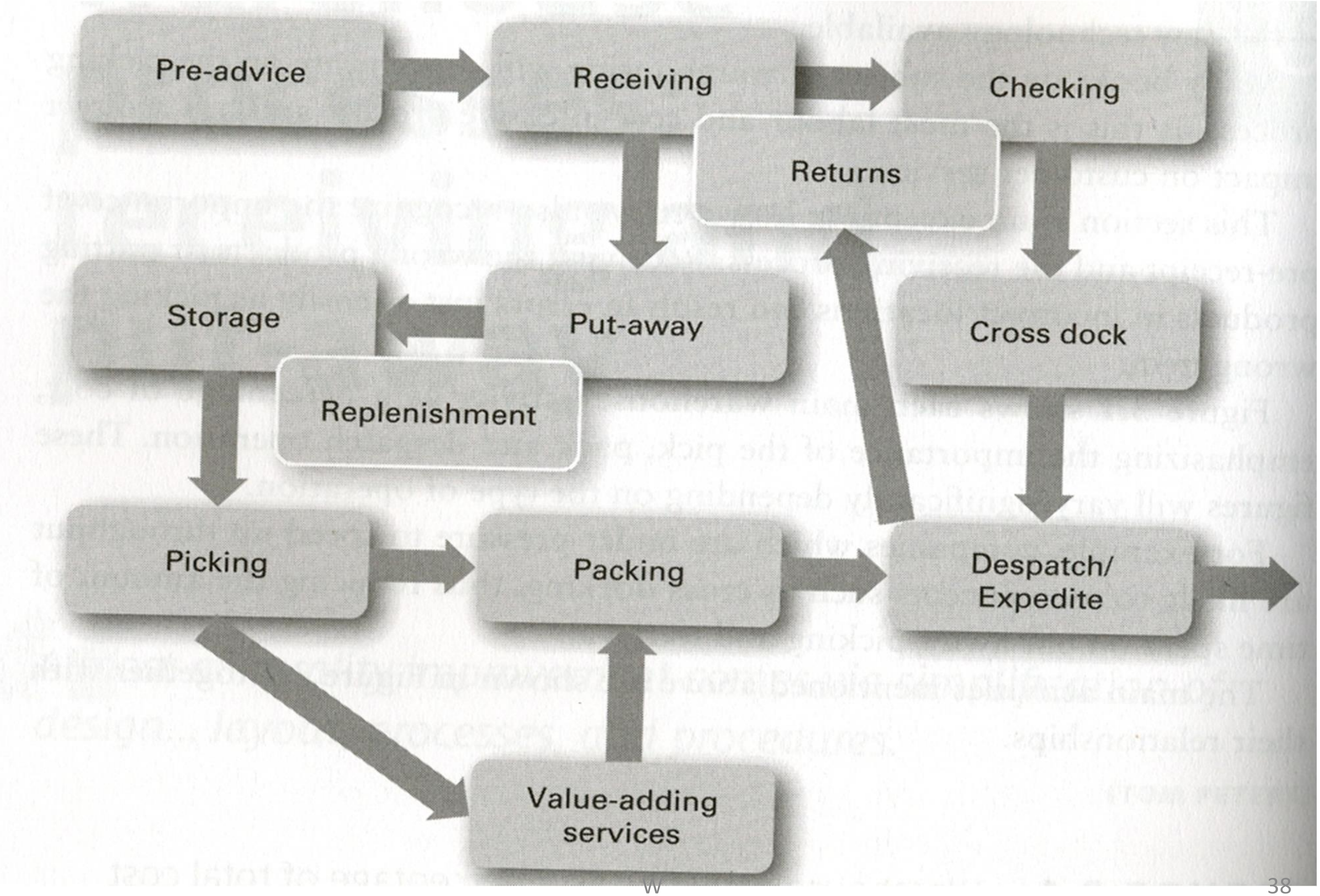
WMS Functions

- **Pre-receipt** https://www.youtube.com/watch?v=ZMVTDjsPzxE
- **Receiving** https://www.youtube.com/watch?v=7Lajnise5q8
- **in-handling** https://www.youtube.com/watch?v=EufyxVoovYg
- **Preparation**
- **Offloading** https://www.youtube.com/watch?v=oo6TLtX1w68
- **Checking** https://www.youtube.com/watch?v=qhmzCLR7bV8

https://www.youtube.com/watch?v=aP6k5VYvGHc

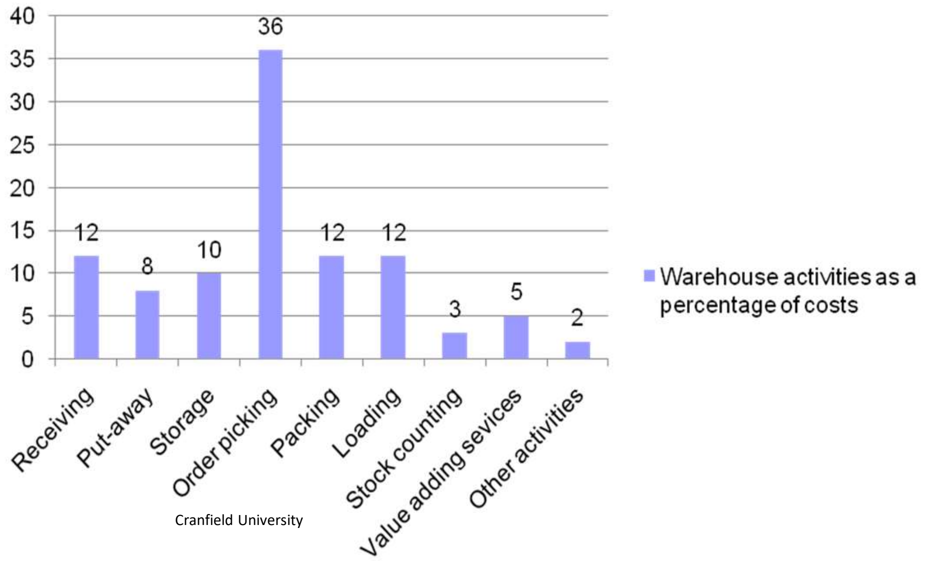
- **Cross docking**
- **Recording**
- **Quality control**
- **Put-away**

Warehouse Processes and Relationships



Warehouse functions

- Goods inward/receipt
- Inward sortation and Cross-docking
- Storage
- Replenishment
- Order picking
- Secondary sortation
- Collation
- Postponement
- Value adding services
- Despatch
- Housekeeping
- Stock counting
- Returns processing



Cranfield University

Pre-receipt

- Agree specifications with supplier
- Inform supplier of requirem
  - Size and type of delivery vehicle
  - Size and type of pallets
  - Size of cartons
  - Labelling requirements
  - Delivery documentation
  - Pre-notification
  - Delivery procedures
    - Unloading requirements
    - Role of the driver

Pre-Receipt *(Continued…)*

Metal stillage

Roll cage

Pallets

Pallet Dimension

Dimensions in mm (W × L)	Dimensions in inches (W × L)	Country of use
1219 × 1016	48.00 × 40.00	North America
1000 × 1200	39.37 × 47.24	UK and Asia; pallet commonly referred to as a UK or industrial pallet
1165 × 1165	44.88 × 44.88	Australia
1067 × 1067	42.00 × 42.00	Most countries
1100 × 1100	43.30 × 43.30	Asia
800 × 1200	31.50 × 47.24	Europe; pallet commonly known as a euro pallet

Pallet Dimension *(Continued…)*

The following website provides a tool for calculating the pallet dimension and weight as well

http://onpallet.com

- Open this website and play with the web page using different dimensions and weights.

Checking in Loads

- TiHi describes the arrangement of cases on a pallet.
- It stands for Timarandum Height or ‘layers of’ × height.
- ‘Ti’ means the number of boxes or cases in a pallet layer.
- ‘Hi’ means the number of layers high on a pallet.

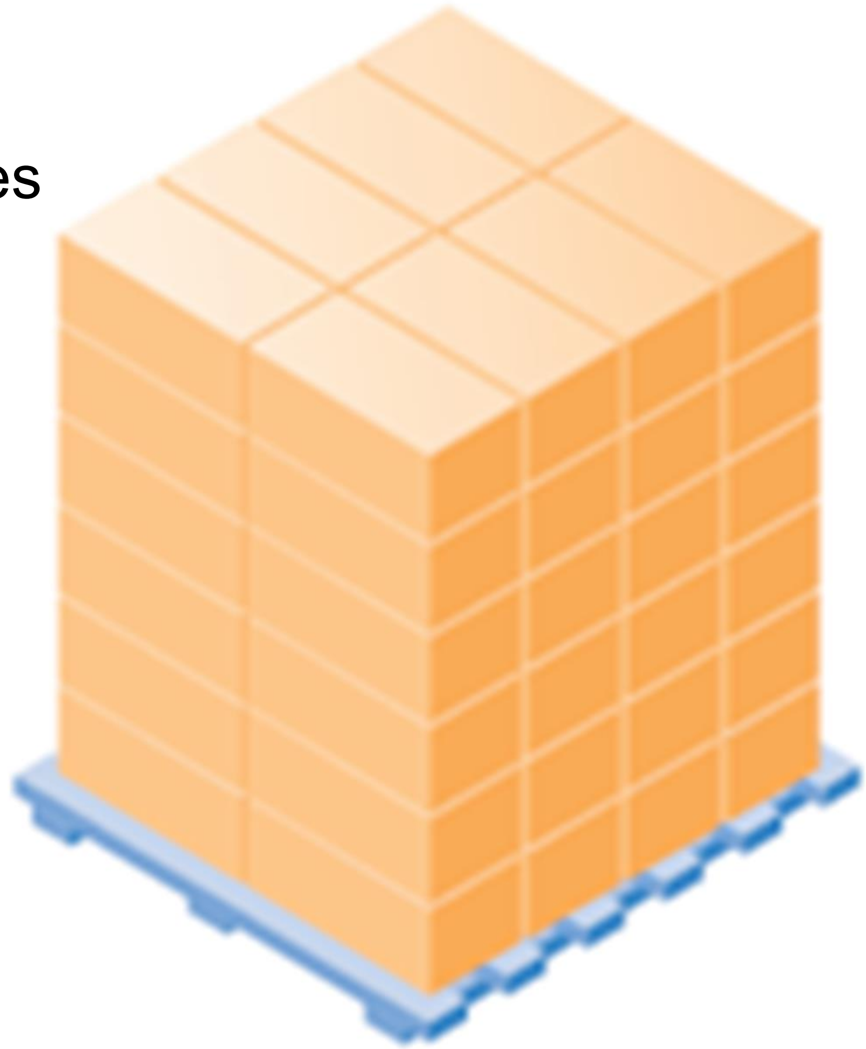
❖ **TiHi** refers to the number of boxes/cartons stored on a layer, or **tier**, (the Ti) and the number of **layers high** that these will be stacked on the pallet (the Hi)

Checking in Loads *(Continued…)*

Example:

➢A TiHi of 8 × 6 means 8 cases

per layer; 6 layers high.



Ti and Hi →

Ti × Hi = Pallet quantity

TiHi = 8 × 6

Pallet quantity = 48

Checking in Loads *(Continued…)*

When pallets arrive, the **TiHi** must be the same as on the delivery note.

Imagine this:

Pallet A = 120 cases with a TiHi of 20 × 6

Pallet B = 120 cases identical to those on pallet A, but with a TiHi of 6 × 20

- Which TiHi gives the taller pallet?
- Which TiHi gives the larger ‘footprint’?
- How many cases make this larger ‘footprint’?

Checking in Loads *(Continued…)*

Distribution centre D5 Warehouse 15

P.O. 384493202 DELIVERY NO. 77033

QUANTITIES OUTSTANDING: Nothing to report

CODE	PROD	QTY	TIHI
029550003040	NC Marinades - BBQ	120	Ti x hi = 20 x 6
029550003884	NC Marinades - Frch	120	Ti x hi = 20 x 6
029550003728	NC Marinades - Ital	120	Ti x hi = 20 x 6

What problems might occur if a tihi of 6 × 20 is accepted when a tihi of 20 × 6 is on the delivery sheet?

Pallets

- Pallet rental companies
  - Charged on a pence per day basis
  - E.g. Chep, IPP, LPR
  - Pallets are normally in very good condition
  - Does require both suppliers and buyers to be part of the rental scheme
  - Removes requirement to collect pallets from customers

V

Packaging

- Be involved when initially discussing new products
  - It's not all about the product!! – think about the packaging!
- Nature of the product – size, selling quantities, hazard, cost
- Arrival packaging, returnable plastic pallets, stillages etc
- Labelling
- Nature of storage medium
- Despatch quantities
- Recycled packaging

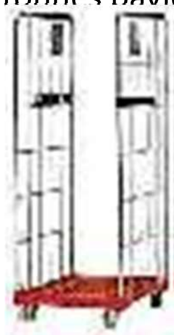
The protective packaging company

Unitisation

- An approach aimed at creating an appropriate standard module for handling, storage, movement, loading and unloading during the transport and distribution process.
  - Small containers used in small parts storage and handling.
  - Wooden pallets which have become a key unit load within the EU market.
  - Totes and Dollies
  - Cage and box pallets
  - Roll cage pallets used in wholesale operations, e.g. grocery distribution
  - Stillages – used in automotive
  - Intermediate bulk containers in ranges of one to two tonnes payloads







The importance of Unit Loads

Used by manufacturers, retailers and service providers, unit loads are key cost drivers. They impact on transport, storage, handling and packaging, which together represent 12-15% of the retail sales price.

Developing more Efficient Unit Loads is critical to the success of Efficient Consumer Response and is estimated to save 1.2% of the retail sales price.

E.g. Prescribed length and width is seen as a must by manufacturers and retailers, with the 600x400 master module accepted as the basis in Europe for 1200 x 800mm pallets.

Receiving

- 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, fragility etc)
- Unload and check quantities and quality of delivery
- Record variances – possible quarantine
- Check status of goods
- Label or ID tag
- Record quantities
- Clear dock area and ensure goods are on system and available to pick – dock to stock time is crucial!
- Locate - Quarantine, cross dock, pick face, reserve storage

Reverse Logistics

Definition:

“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)

- Packaging can also be included in this process

Reverse Logistics

Motivations:

•Government policy (e.g. Waste Electrical and Electronic Equipment Directive, (WEEE) 2007).

• Economic Considerations

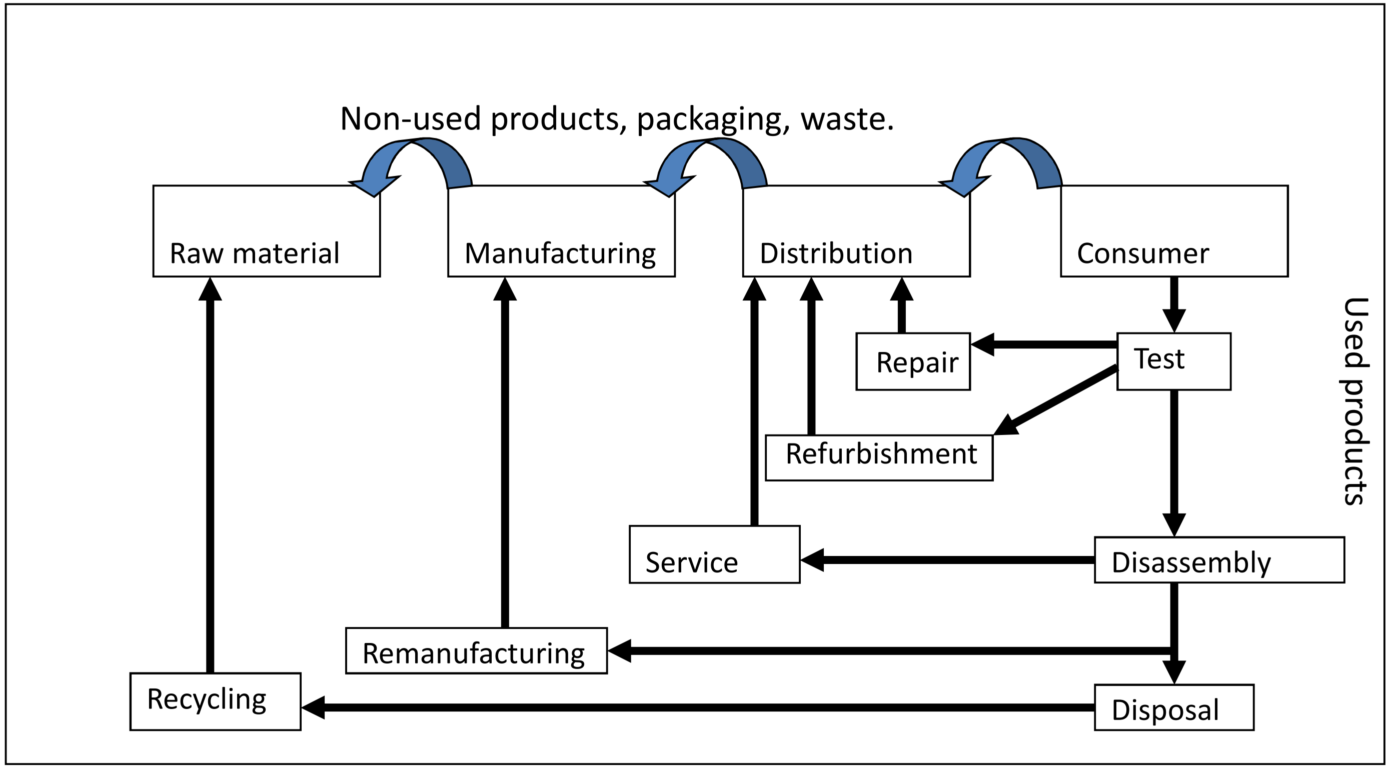
• Environmental Considerations

Challenges:

- Variability of process: Volume of returns and quality of what is returned makes process more difficult to manage.
- Ensuring the correct recovery option is chosen.
- Cost

Rahman (2012) in Mangan *etal* (2012)

Returns



Non-used products, packaging, waste.
Raw material
Manufacturing
Distribution
Consumer
Used products
Test
Repair
Refurbishment
Service
Disassembly
Remanufacturing
Recycling
Disposal

Recovery Options

Degree of change in the original product ↑

Recycle – Extract material from used produces or by-products from manufacturing and use them to produce new products.

Remanufacture - Restoration of used products to "new" condition, to be used in their original function, by replacing worn or damaged parts.

Reuse – Use product or material again for the same function, in its original form or with little enhancement or change.

Refurbish – Make changes to the appearance of a product by cleaning, painting, etc. Structural parts remain intact.

Recondition – Change and restore to a previous normal condition, make new or as if new again.

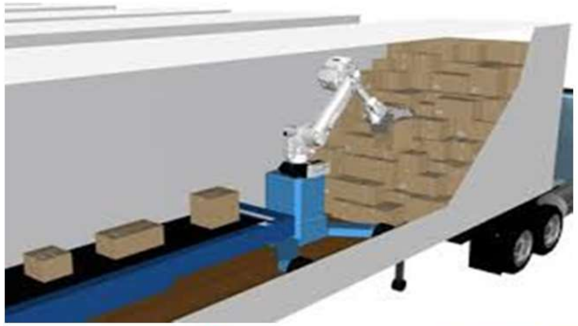
Repair – Fix the fault and use.

Reprocess – Use again after process.

Emmett and Sood, (2010)

- The final option is 'disposal'

In-handling equipment



Dock Equipment

Dock Levelers
  - Hydraulic
  - Air Bag
  - Mechanical
  - Power Assisted

- Bumper Pads
- Dock Shelters
- Dock Lights
- Safety lights/warnings
- Operating procedures
- Signage in different languages

Labelling and Put-away

- Ensure supplier has labelled products correctly
- Produce own labels although not as efficient
- Scan labels
- System determined put-away
- Location allocation by system or manual
- Take into account size, weight, velocity, compatibility
- Quarantine areas
- Fixed or random locations?
- Check stock rotation policy
- Consolidate stock if FIFO rules allow
- Record stock against the location
- Task interleaving or dual cycling – put-away and retrieve in same movement

Inbound and put away processes

Inbound check

Location verification and put-away

WMS

Location I.D.

- 4 E 14 C 1 or
- 04.05.14.03.01

Where 4 (04) = zone

E (05) = Aisle

14 = Bay

B (03) = Level

1(01) = Pallet, Shelf or bin position

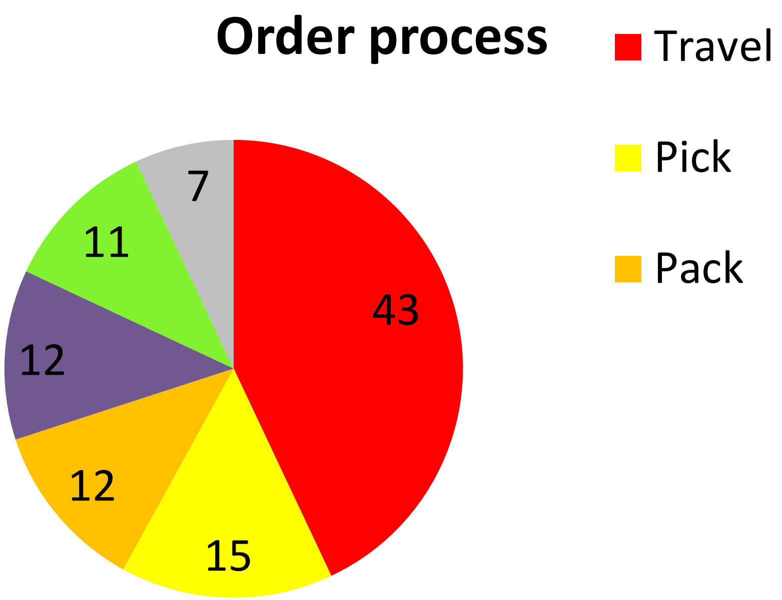
Picking systems

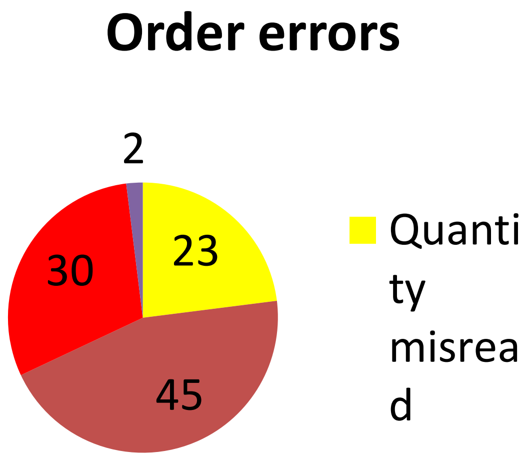
- Picking is paramount to any warehouse operation
  - It is the most labour intensive
  - It is fundamental to customer service
  - There are often extensive floor space requirements
  - There may be limited scope for automation

On average up to 65% of the warehouse operating expenses can be attributed to the Picking function.

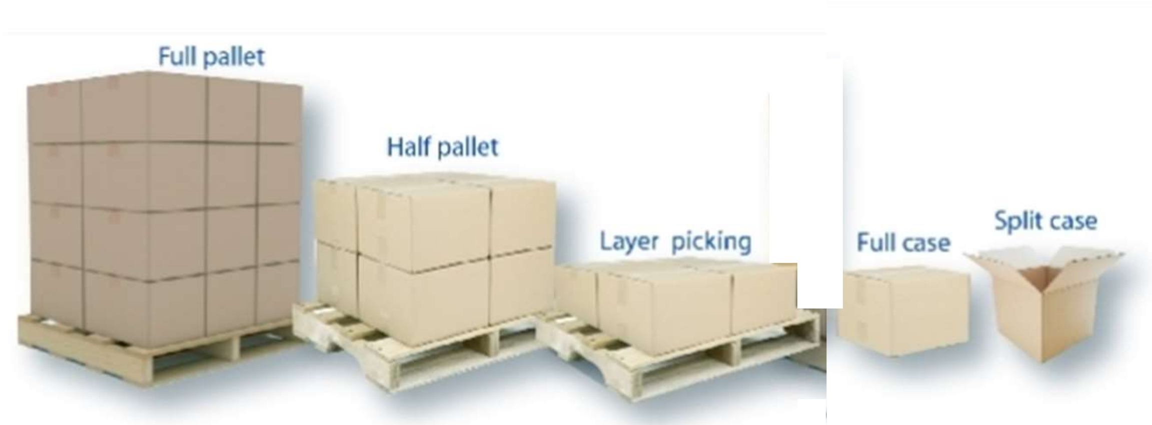
On average travel time accounts for 50% of the total picking time (Petersen C.G. 2002).

The pick process and likely errors





Pick volumes



Product location tool - Slotting

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

- Are fast-moving items in the most accessible locations?
- Are slots allocated in the most efficient manner according to product size and weight?
- Are pallets allocated to the correct height slot
- Is your storage capacity optimized for your current stock?
- Are items that sell together close to each other

As input data changes, such as seasonal ordering trends or new or discontinued products, Slotting Optimization can revise its recommendations incrementally, to keep your warehouse at maximum efficiency without costly overhauls.

Replenishment

When using pick or forward locations

- Replenishment is the replacement of goods picked from the forward locations
- Goods are transferred from bulk or reserve locations
- This can be done overnight, at the beginning or end of a shift or during the picking process depending on the urgency – however try not to replenish at the same time as you are picking
- Ensure sufficient items in pick location for duration of shift if possible

- **Biggest error is to have an empty pick location**

Value Adding Services

- Labelling
- Kitting
- Sub-assembly
- Testing
- Packing
- Shrinkwrapping
- Tagging
- Kimballing
- Promotional work (e.g. BOGOF)
- Gift wrapping
- Call centre support

Despatch

- Random quality checks on exit depending on product value
- Pack products securely and safely
- Weigh product as an alternative to physical count
- Recording of batch numbers, serial numbers etc.
- Load manifest compilation
- Loading in sequence
- Load optimisation (e.g. Cubiscan)
- Smooth the flow of despatches
- Vehicle sealed and recorded

Load optimisation

Pallet configuration – no overhang
- Optimum number of cartons

Vehicle load configuration – Optimum number of pallets/cartons

http://onpallet.com/

Packing on despatch

Stretch-wrap machine

Stretch-wrap by hand

Pallet straps (courtesy of Velcro)

Shrink-wrap tunnel
(Courtesy logismarket)

Packing station, (courtesy Cisco Eagle)

Automatic carton erector and sealer

Housekeeping/Supervision

If you have a large warehouse you may have separate teams for the following:

- Provision, allocation and maintenance of equipment
- Replenishment of fast moving items
- Dealing promptly with non-conforming, lost or found stock
- Security of high value or hazardous stock
- Identification of non-moving stock
- Ensuring efficient space utilisation
- Work flow and congestion
- Cleanliness of warehouse
- Review of procedures

Minimising Theft

- Staff training and awareness
- Use of CCTV
- Use of lockable cages or Carousels for high value goods
- Parking of cars away from the warehouse
- Random searches
- Regular cycle counts
- Staff vigilance
  - Especially in dark, less accessible areas of the warehouse. These are prime areas from which product will disappear. Same goes for inventory near exit doors. Staging areas for both incoming and outgoing shipments may be too close to the dock doors. If no one is around to keep an eye out, it would be easy to take something and put it in a truck.
- Conduct security surveys/audits (Independent)
- Use security tags for vehicles leaving the warehouse

Stock counting

- Perpetual inventory or cycle counting
  - Use ABC analysis to determine how many and how often you count which items of stock e.g. 8% of A, 4% of B and 2% of C items
- Monthly, quarterly, annual stock checks
  - Depends on what you agree ' your auditors

N.B. You need to be organised:
Who's counting, are they trained and motivated, what are you counting, when do you count, what tools do you need.

Stock turn

- How often stock turns over in a warehouse
- How to calculate:
  - Divide the total throughput of items by the average number of items in stock

  Or

  - Divide the total cost of sales by the total average cost of goods stored at a particular time

Examples of stock turn
100+: Japanese manufacturing company
30-100: Good European manufacturing or distribution
10-30: Typical European manufacturing
10 – 35: Retailer
<10: Poor European manufacturing
<2: Maintenance stores

Stock turn

- The following table provides data regarding sales and average stock holding per month for ACME products.
- Calculate the stock turn.

Month	Sales per month	Average no. of units in stock
January	40,000	150,000
February	32,000	165,000
March	35,000	170,000
April	90,000	175,000
May	100,000	165,000
June	75,000	153,000
July	45,000	126,000
August	32,500	122,000
September	40,000	165,000
October	58,000	185,000
November	74,000	195,000
December	84,000	110,000

Stock turn

Month	Sales per month (units)	Average no. of units in stock (units)
January	40,000	150,000
February	32,000	165,000
March	35,000	170,000
April	90,000	175,000
May	100,000	165,000
June	75,000	153,000
July	45,000	126,000
August	32,500	122,000
September	40,000	165,000
October	58,000	185,000
November	74,000	195,000
December	84,000	110,000
	705,500	156,750
Stock turn = 4.5		

Days stock in hand

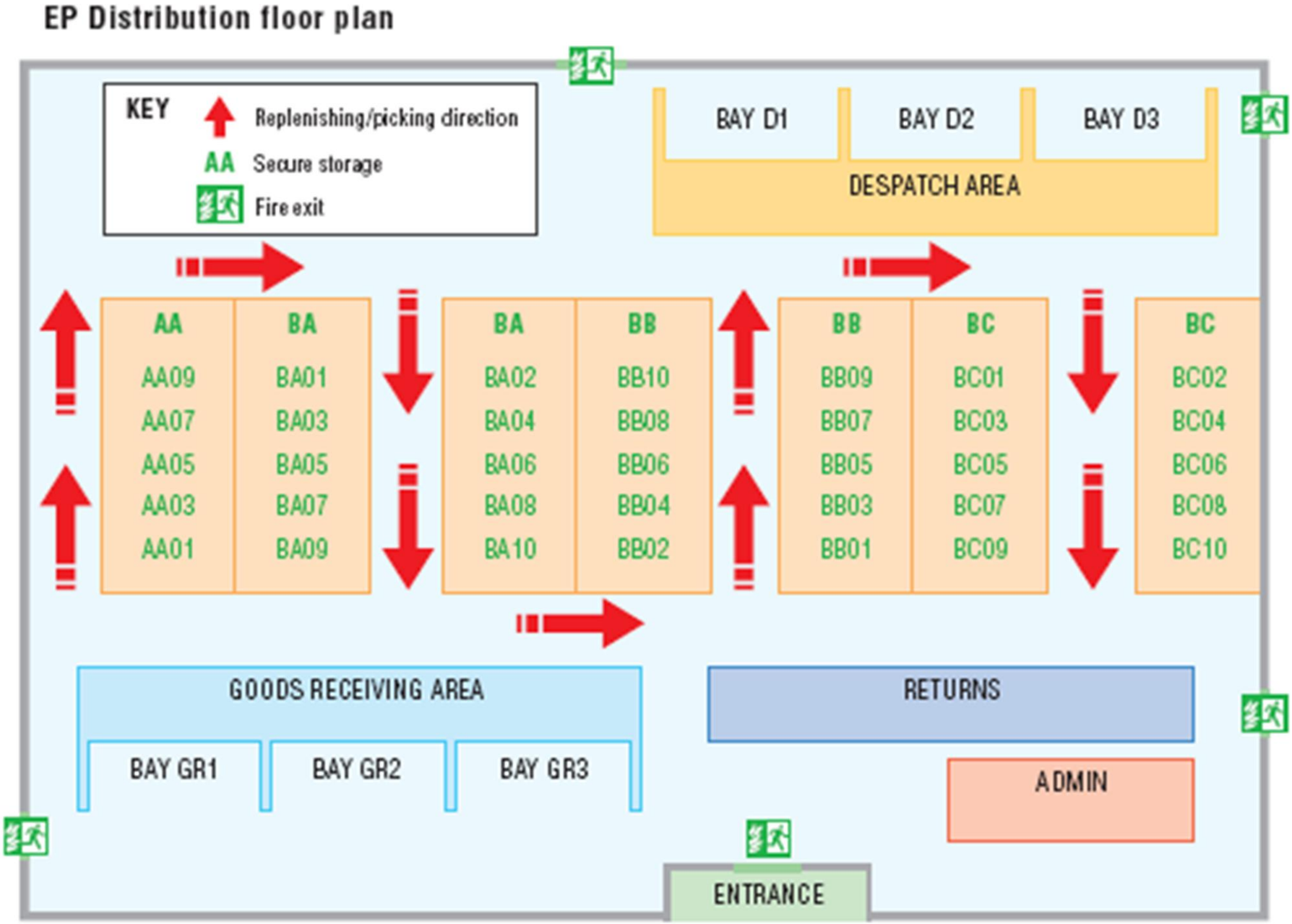
Item ID	Description	Tot QOH	M1-12 Usage	Days stock	Year's stock
SE041-002-02R	BOTTLE REPLACEMENT SALINE STA	39	1	14235.0	39.0
HN031-020-01	CAP .375 IN NPT SST	77	3	9368.3	25.7
ZN80	CASSETTE 9X12	24	1	8760.0	24.0
EC211-001-01	CONNECTOR F TYPE CRIMP-ON	96	4	8760.0	24.0
0285263	BOOTLACE FERRULE 1.5 SQ MM WIRE INSULATED BLACK PK 100	92	4	8395.0	23.0
MF551-S11-13	ALL THREAD .25-20UNC-2A X 1 316SS	64	3	7786.7	21.3
MB041-011-01	SEAL SHAFT RING CURVETECH	20	1	7300.0	20.0
0218293	FERRULE 90 SERIES -4 SST	19	1	6935.0	19.0
EC121-033-01	CONNECTOR CIRCULAR STRAIGHT PLUG 6 PIN MALE	16	1	5840.0	16.0
0378818	CAPACITOR ALUM ELECTROLYTIC 100UF 35VDC RADIAL 8MM DIA	47	3	5718.3	15.7
0415982	HOSE SUCTION 1-1/4 IN W/ FEMALE JIC STR ENDS SPEL-6000 TMS	15	1	5475.0	15.0
AC99-R	CLEANER (AEROSOL)ARDROX 9PR5	30	2	5475.0	15.0
AD99-R	DEVELOPER (AEROSOL)ARDROX 9D1B	28	2	5110.0	14.0
HN071-078-01	ELBOW .75 NPTF 90 DEG SST	25	2	4562.5	12.5
0009398	HEAT SHRINK SLEEVING BLK 3IN DIA ADHESIVE WALL	12	1	4380.0	12.0
0314786	KIT FIRST AID 50 PERSON	12	1	4380.0	12.0
BPGA	GRIGRI	12	1	4380.0	12.0
0206719	LIFT TUBE MOUNT AFT	35	3	4258.3	11.7
0318915	COUNTERSINK SLTD FLT LG 90 DEG M2.5 - 0.45 X 10MM	23	2	4197.5	11.5
0270423	TUBE STABBING GUIDE CAGE EXTENSION DETAIL	11	1	4015.0	11.0
CA121-002-02	TAPE DUCT OLIVE DRAB 2.83 IN WIDE X 60 YD LONG	21	2	3832.5	10.5
IX01-0005AB	AGFA RCF SCREENS 70mm x 5mtr	21	2	3832.5	10.5
MM021-523-01	O-RING,8.10 ID X .070 BUNA 70 004-0792	21	2	3832.5	10.5
AD02-R	DEVELOPER MANUAL G128 2QBUS	10	1	3650.0	10.0
0006659	CONNECTOR BNC PLUG RG179 75 OHM MINIMUM	20	2	3650.0	10.0
MB011-N22-79	O-RING 2-279 BUNA N70	20	2	3650.0	10.0

Putting Goods into Warehouse

- Finding the correct place to store goods in a warehouse can be tricky.

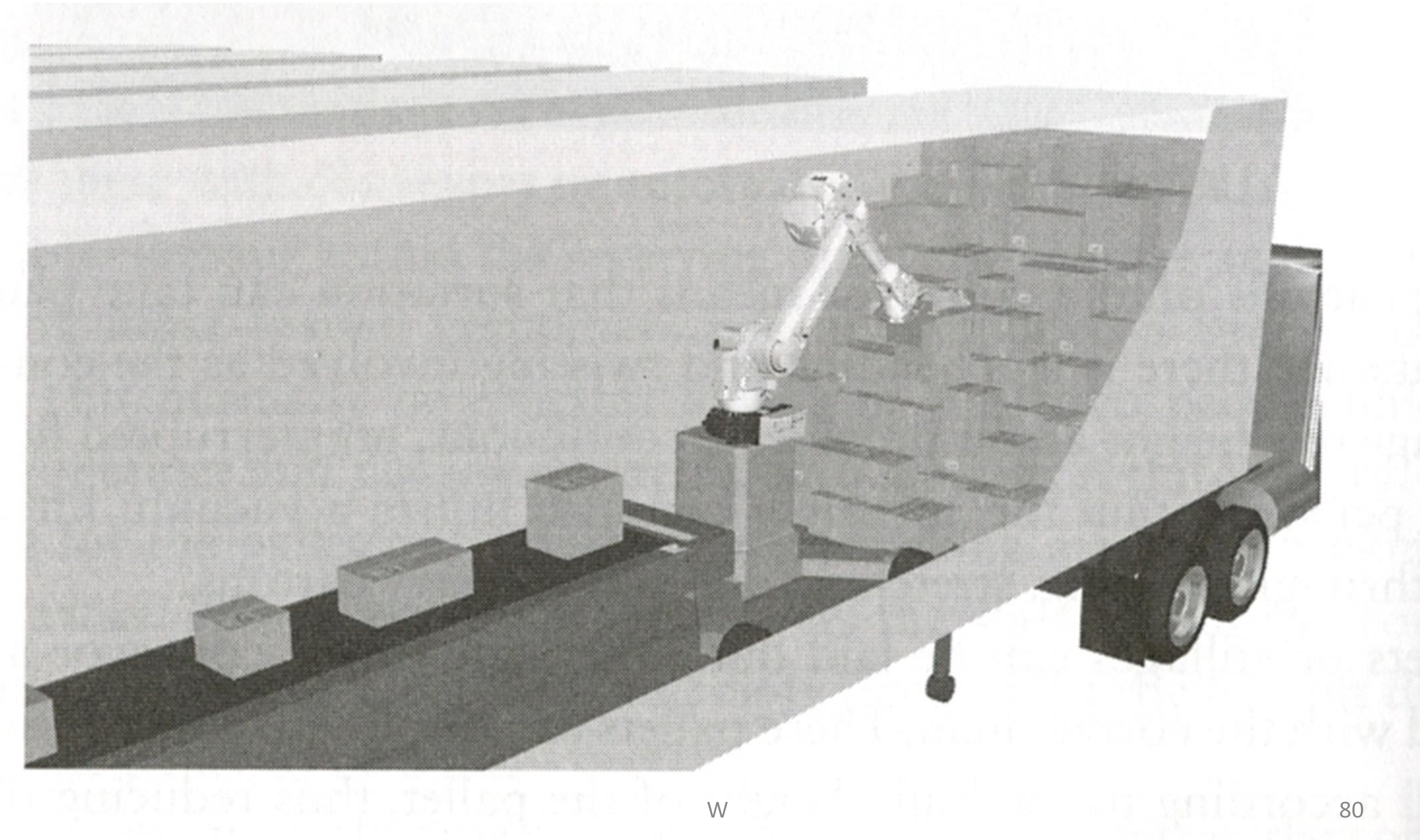
- The first step is to find the approximate storage location. Floor plans are useful for this.

Putting Goods into Warehouse *(Continued…)*



Offloading

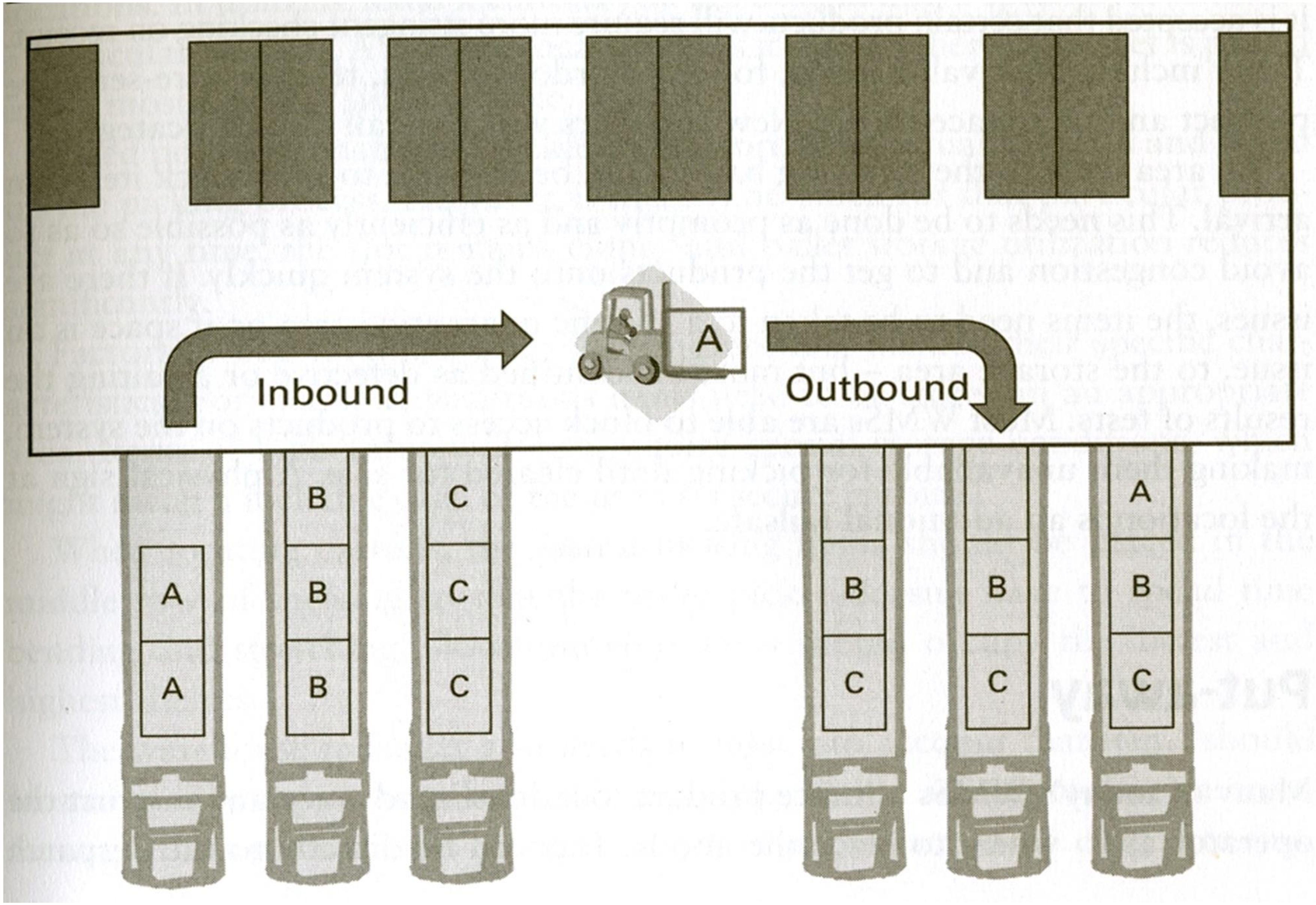
- Robotic unloading of pallets



Checking

Date received	Supplier	Product code	Purchase order no	Booking reference	Non-compliance
03/04/13	ACS	48145	266460	11228	Barcode does not scan
03/04/13	ACS	104658	266460	11228	Outer carton is > 20 kg. No warning on box
10/04/13	BFP	113144	261688	11317	Barcode on outer, not inner
10/04/13	QRS	102258	267456	11319	Inner quantity = 6 not 12 as expected
14/04/13	QRS	115119	267456	11424	Barcode does not scan
21/04/13	Tco Deli	110002	287547	11563	No price sticker as requested

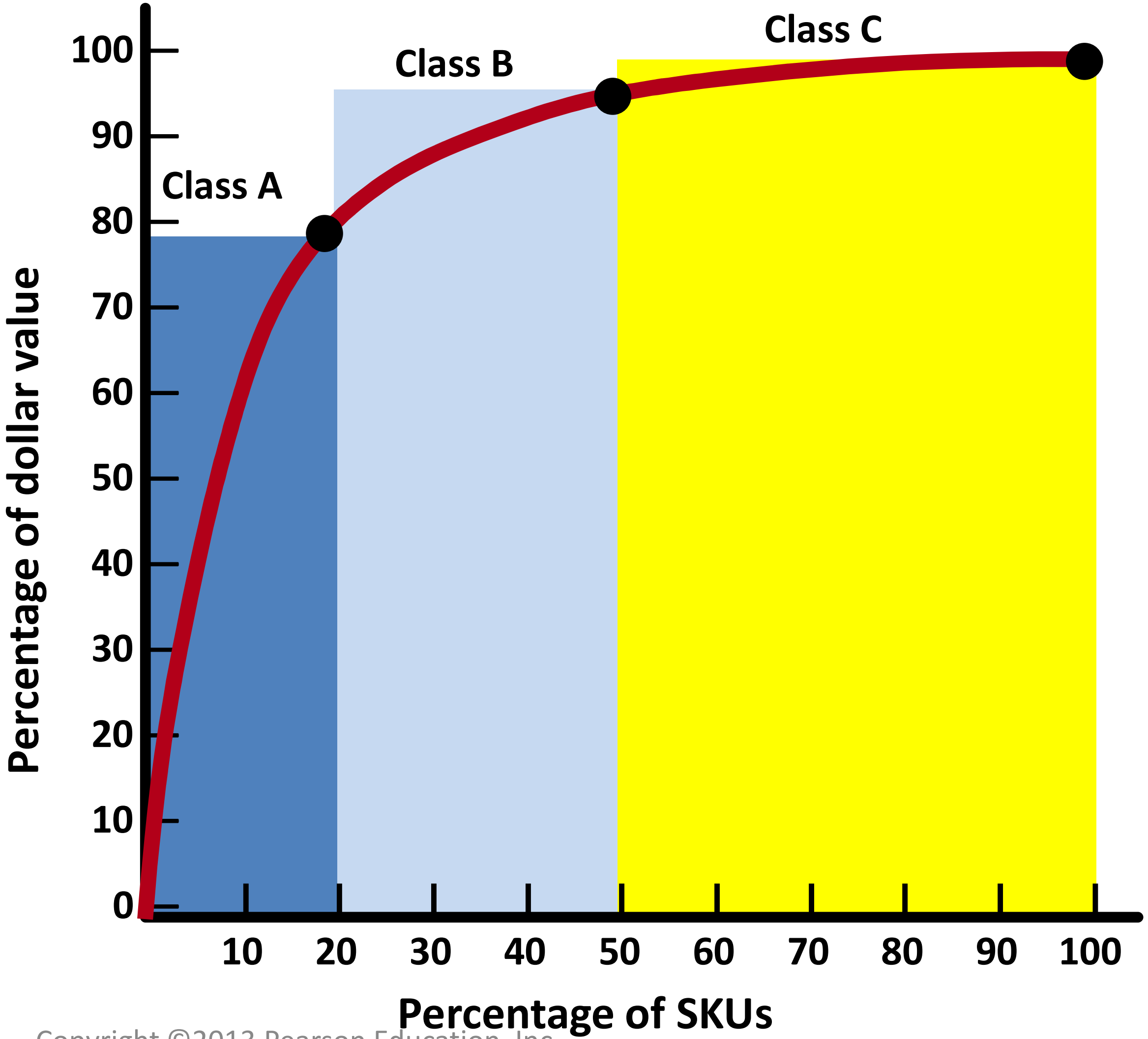
Cross-Docking



What is an ABC Analysis?

ABC Analysis

The planning and controlling of inventories in order to meet the competitive priorities of the organization.



Identifying Critical Inventory Items

- Thousands of items are held in inventory, but only a small % of them deserves management's closest attention and tightest control.

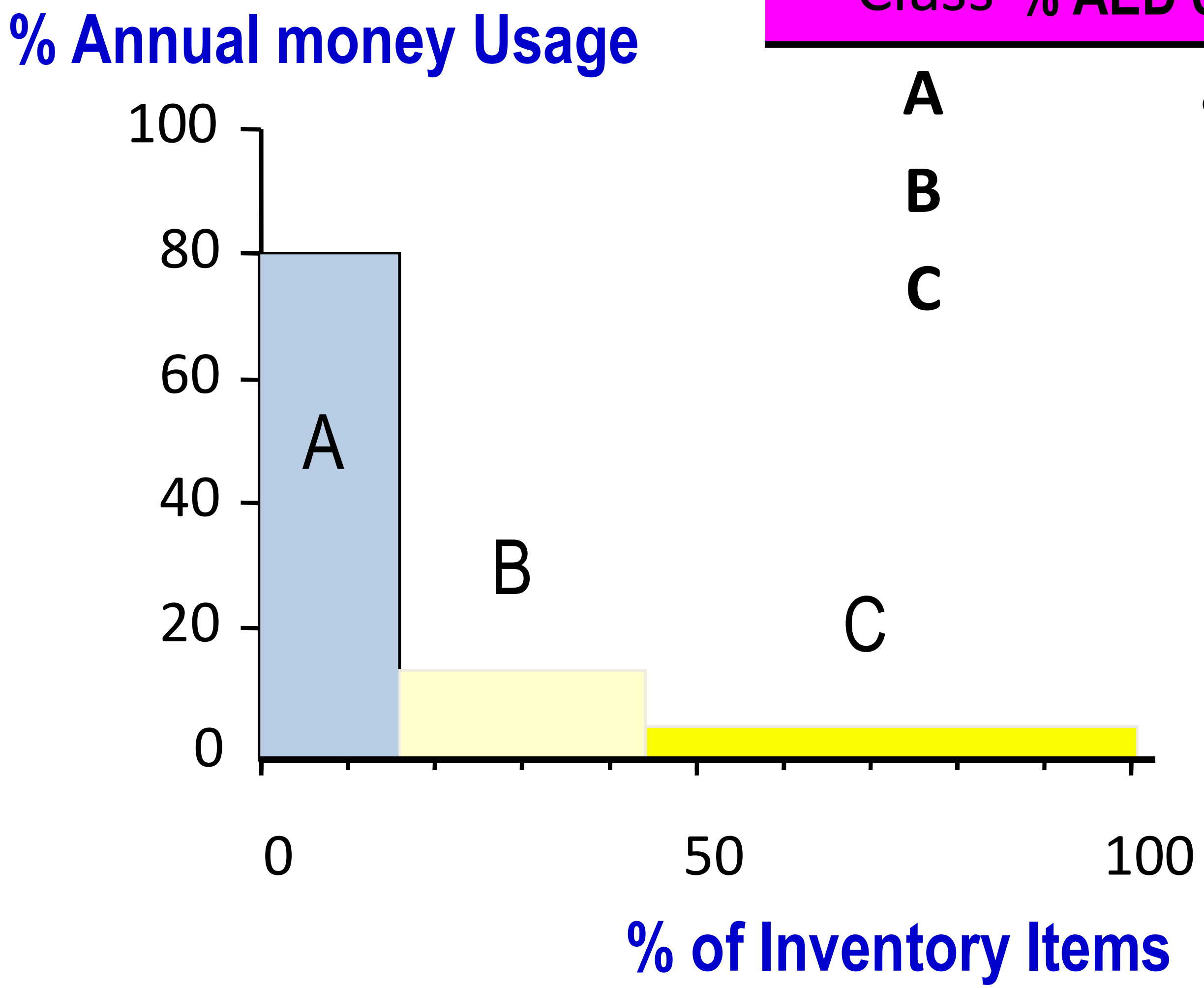
- **ABC analysis**: The process of **dividing items into three classes**, according to their money (e.g. AED or $) usage, so that managers can focus on items that have the highest money value.

ABC Analysis

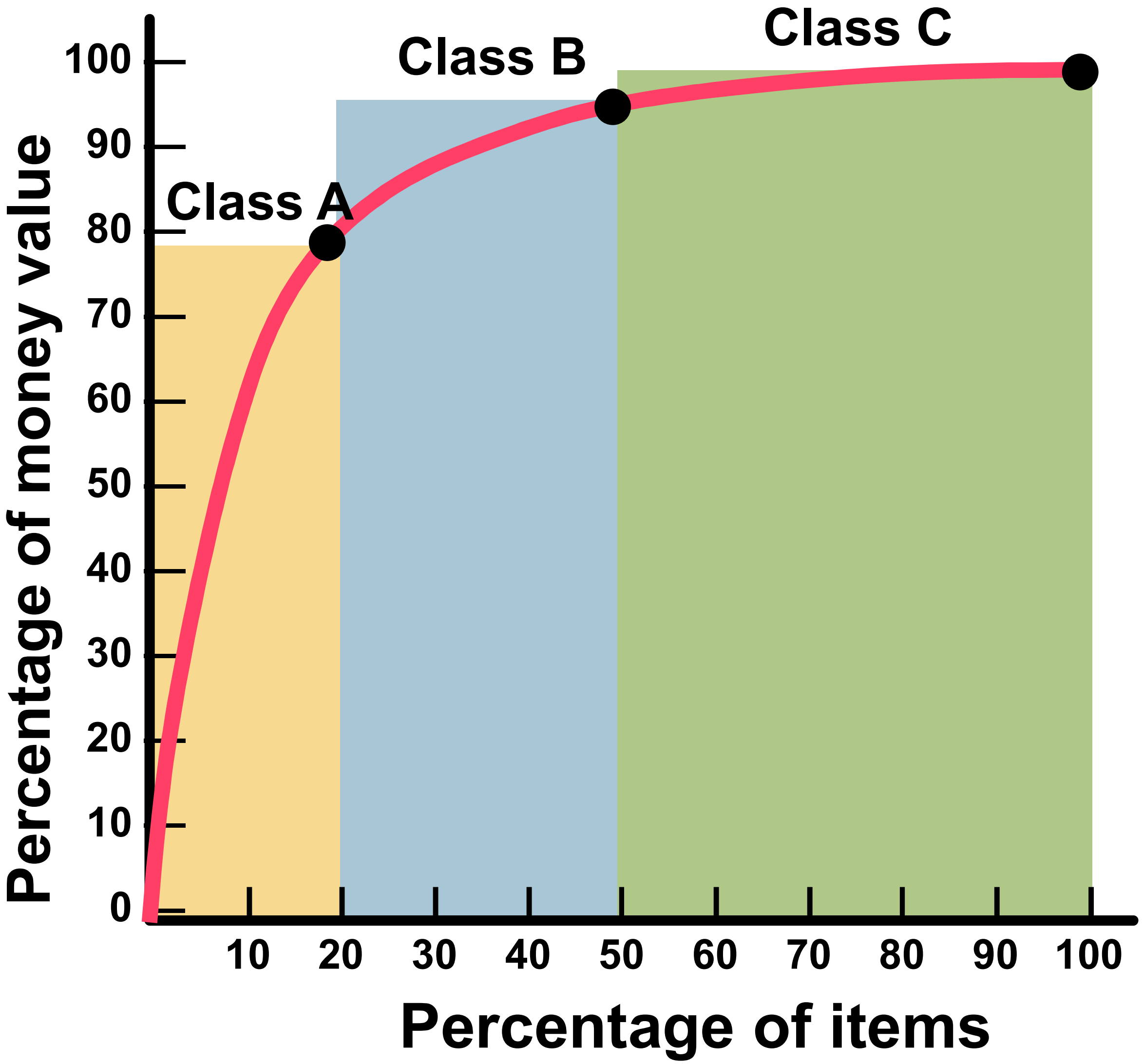
- Divides on-hand inventory into 3 classes
  - **A class, B class, C class**
- Basis is usually annual money (AED or $) volume
  - **AED or $ volume = Annual demand x Unit cost**
- Policies based on ABC analysis
  - Develop **class A** suppliers more
  - Give tighter physical control of **A** items
  - Forecast **A** items more carefully

ABC Classification of Items

Class	% AED or $ Vol	% Items
A	80	15-20
B	15	30
C	5	50-55



ABC Classification of Items *(Continued…)*



Storage equipment

- Trade-off is between speed, cost and capacity.

Recap: Type of Pallet Racking Storage System

- **Standard Aisle Pallet Racking** ► 100% access to every pallet
- **Standard Aisle Double Deep** ► FILO (First In Last Out)
- **Narrow Aisle Pallet Racking** ► 100% access to every pallet
- **Push Back** ► FILO (First In Last Out)
- **Drive In** ► FILO (First In Last Out)
- **Mobile** ► 100% access to every pallet
- **Pallet Live** ► FILO (First In Last Out)

https://www.youtube.com/watch?v=5N22nzgeKcg

https://www.youtube.com/watch?v=NYDE
4gb0

Adjustable Pallet Racking

Recap: Adjustable Pallet Racking

- Easily installed, cost effective and versatile
- Adjustable beam racking
- Allows 100% direct access to each pallet stored
- The most widely used of pallet storage systems.

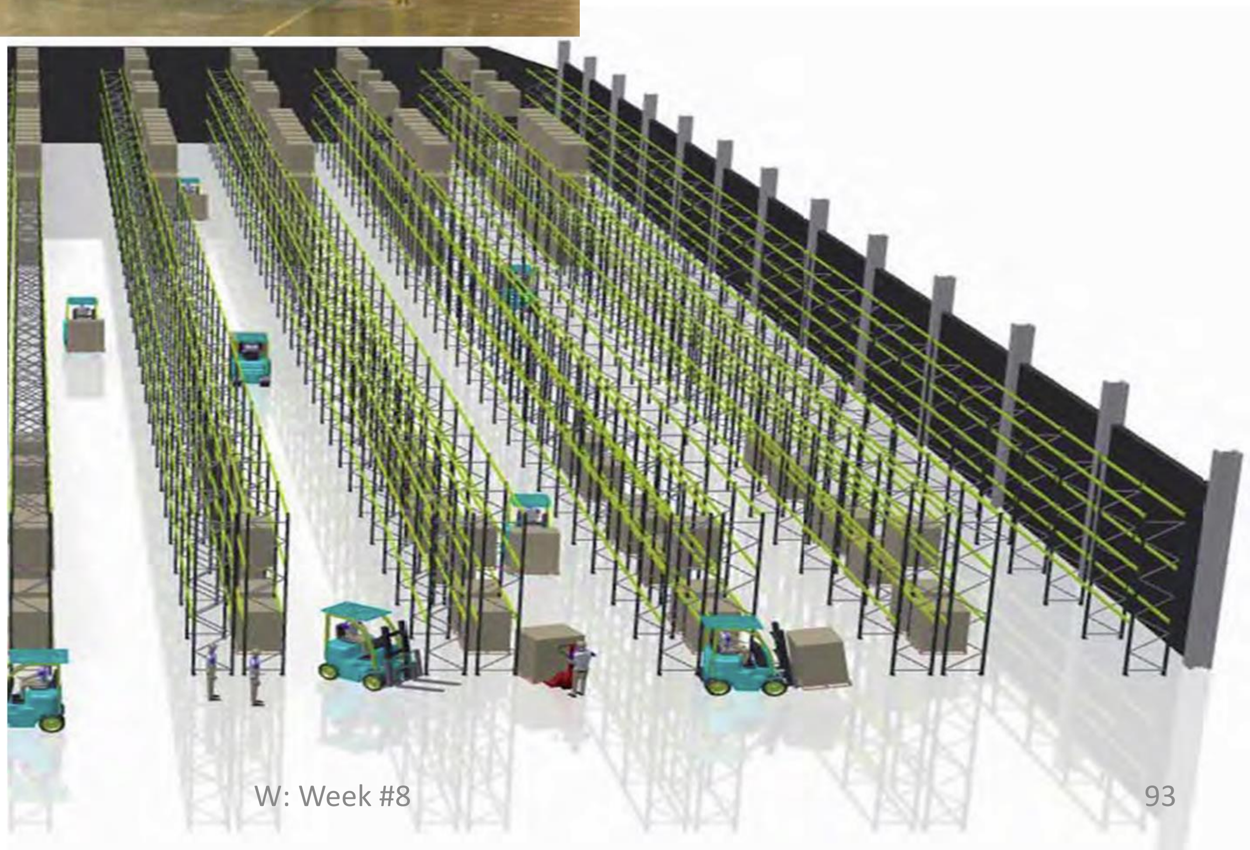
Recap: Adjustable Pallet Racking *(Continued…)*

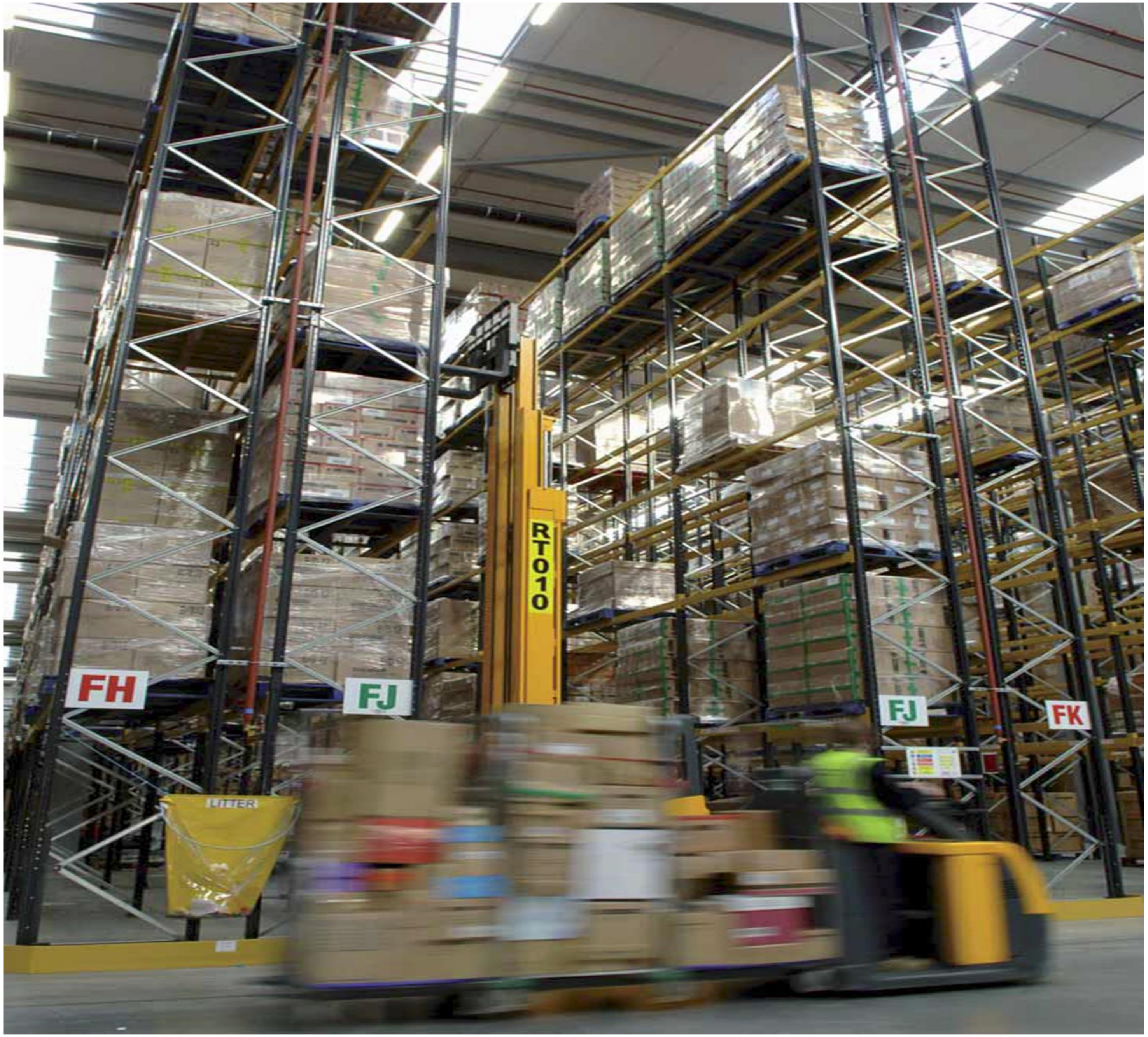
- **Why Adjustable beams?**

  - With adjustable beams, racking can be re-configured to accommodate changes in the type of goods stored and wide aisles allow access by all types of truck, **making specialized handling equipment unnecessary**.

- Although racking is adjustable, once the beams are slotted into position in the frame uprights, an inter-locking structure of great strength and rigidity is maintained.

Adjustable Pallet Racking





Adjustable Pallet Racking

https://www.youtube.com/watch?v=dskjmjLDZ2M

Double-Deep Pallet Racking

Recap: Double-Deep Pallet Racking

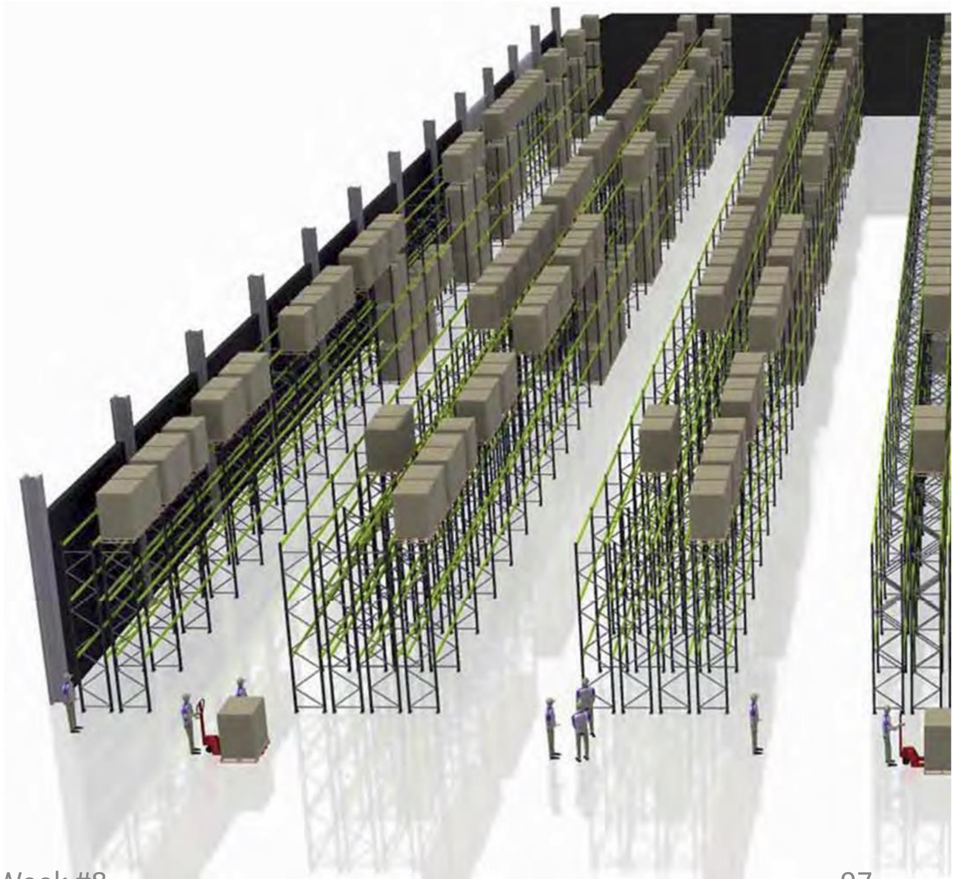
- A variant on standard adjustable beam racking
- As the name implies the racking allows **pallets to be stored two deep** but still accessible from the same aisle.

https://www.youtube.com/watch?v=6C5y8NHckco

Recap: Double-Deep Pallet Racking *(Continued…)*

- 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.

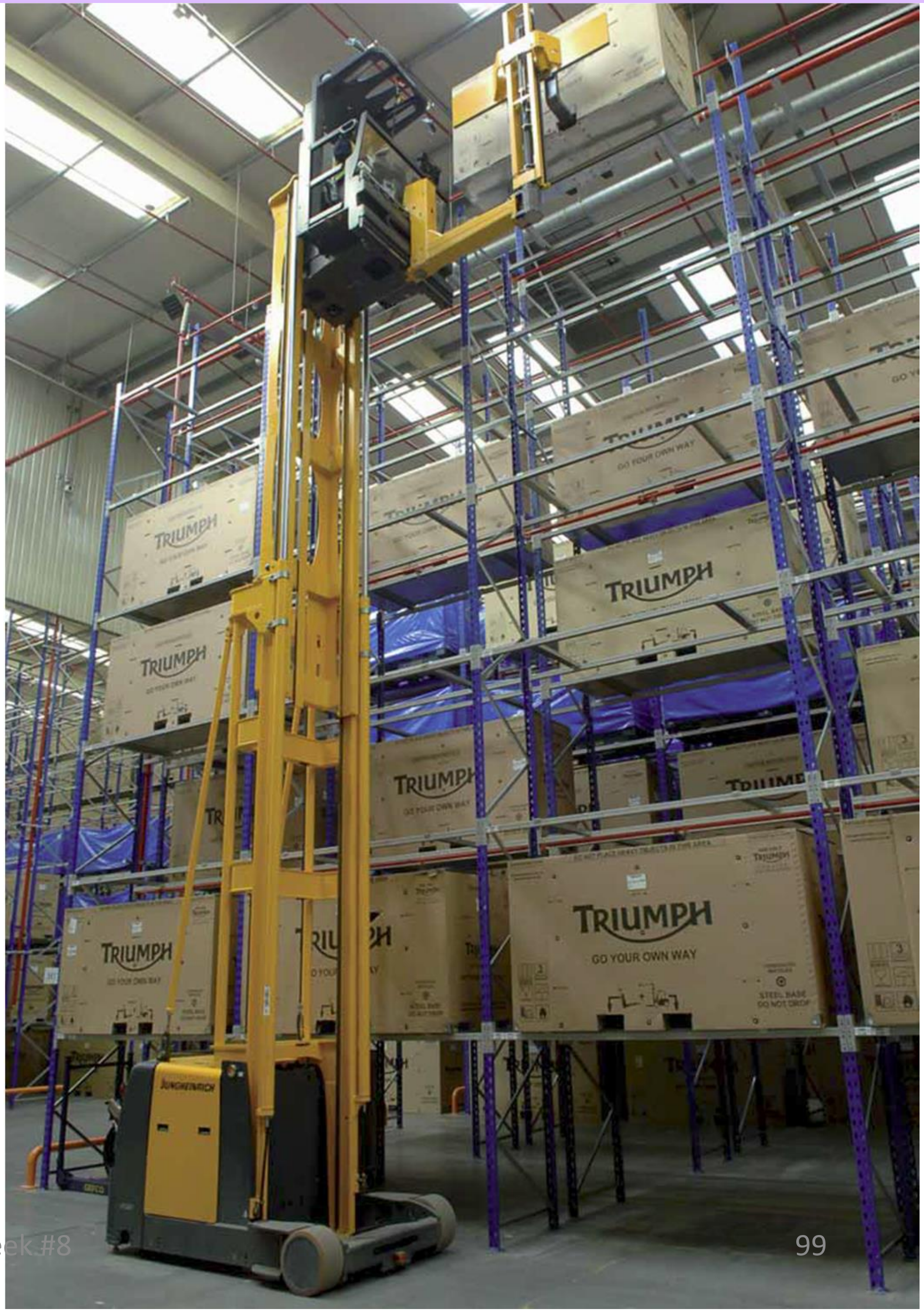
- Although the **speed of access to all of the pallet positions is restricted**, with an efficient stock management system this can easily be compensated for to take advantage of the benefits of **more storage space**.



Narrow Aisle Pallet Racking

Recap: Narrow Aisle Pallet Racking

- Allows fork lift trucks to operate in aisles of up to half the width required in conventional adjustable beam pallet racking



Recap: Narrow Aisle Pallet Racking *(Continued…)*

- Narrow aisle racking makes **excellent use of floor space**
- **Maximizes** the height at which goods can be stacked
- Uses **specialised lift trucks** in either ‘man-down’ or ‘man-up’ variants
- Narrow aisle racking is **precision designed** for **safe, efficient load handling** within the tight confines of these **space-efficient aisles**.

Recap: Narrow Aisle Pallet Racking *(Continued…)*

- Trucks are precisely guided into position as **guidance rails or wires at floor level are fitted**

- This improves safety whilst minimising the incidence of accidental damage to racking and improving the speed and accuracy of load handling.

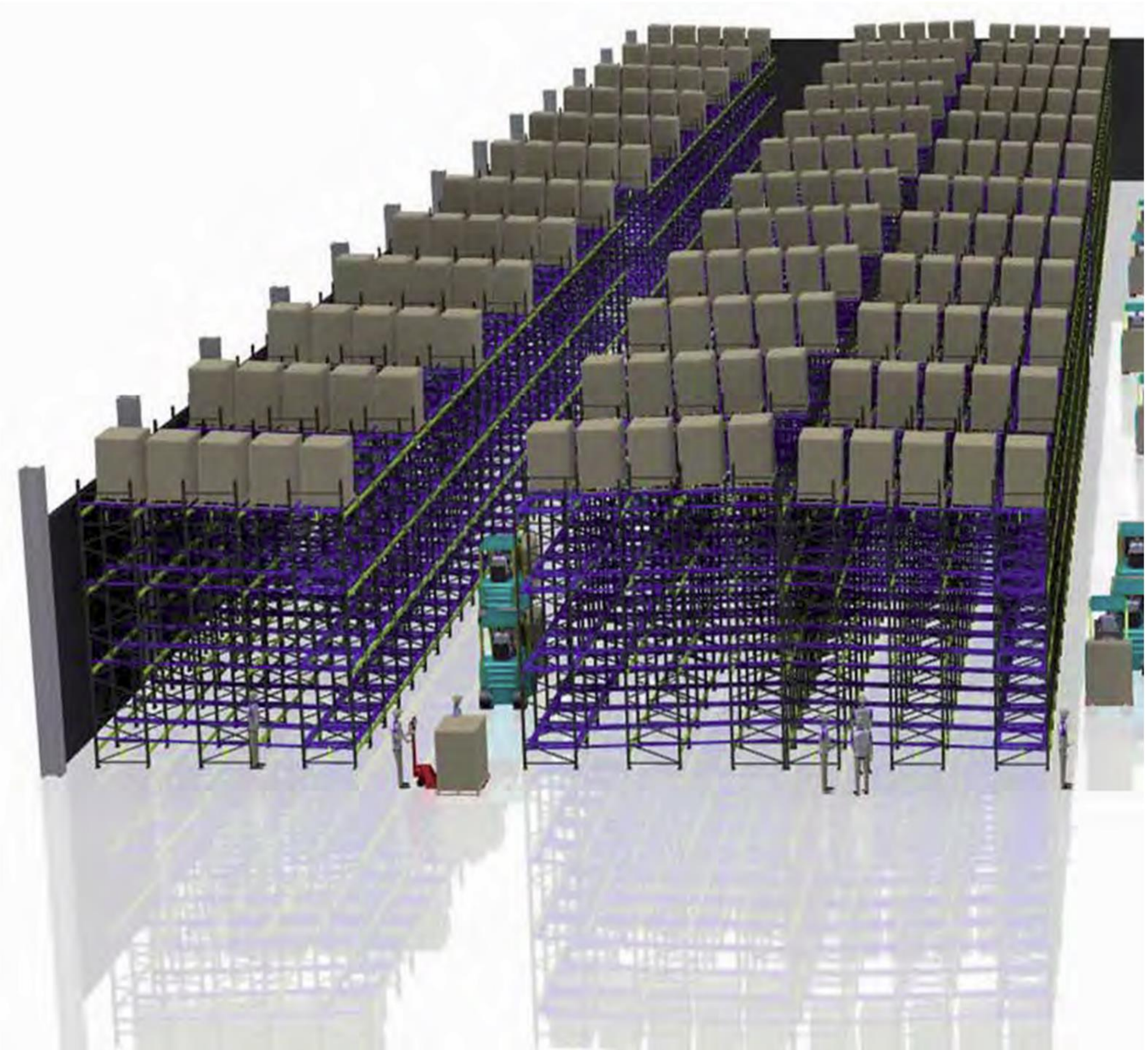
Narrow Aisle Pallet Racking

https://www.youtube.com/watch?v=jGE1M7eplO0

Push-Back Pallet Racking

Recap: Push-Back Pallet Racking

- Push-back racking is amongst the most **space and time efficient pallet storage systems** available.
  - Pallets are loaded in sequence onto wheeled carts or rollers and are **pushed back along inclined beds**
  - Pallets can be stored up to 10 deep
  - when a load is retrieved the remaining pallets roll forward into position at the picking face
  - “First in, Last out”
  - useful for bulk storage and handling



Push-Back Pallet Racking

Push-Back Pallet Racking

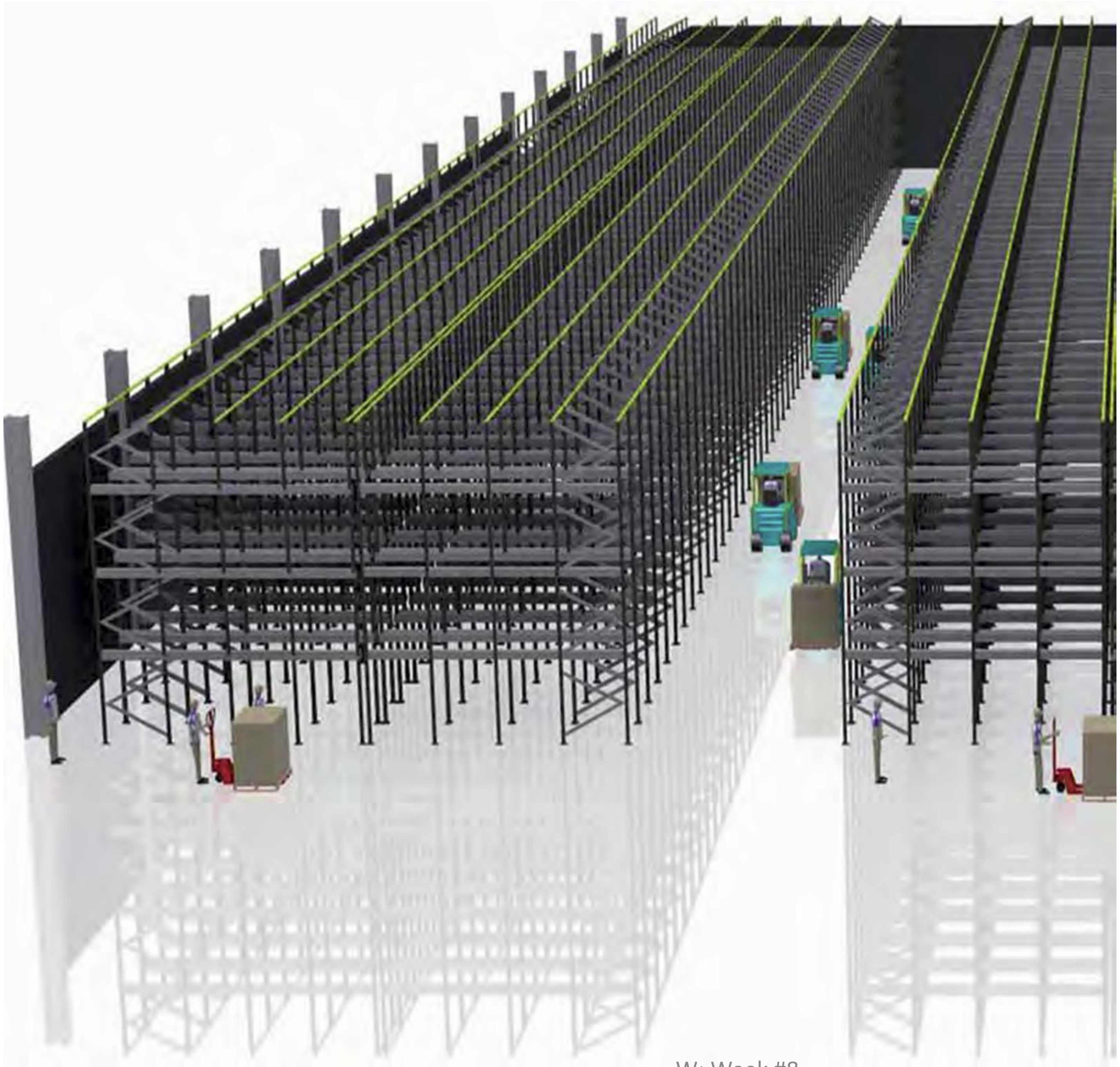
https://www.youtube.com/watch?v=xt6mQCoh3s0

https://www.youtube.com/watch?v=HkDODjEK-EY

Drive-In Pallet Racking

Recap: Drive-In / drive-through Pallet Racking

- **Minimal space** is used for access aisles and lanes
- Provides a **high-density** and very **space-efficient bulk storage** system
- With the **first pallet into a lane being the last out**, **stock selectivity is restricted**, but when loads are delivered and dispatched in batches, this is not a difficulty.
- Pallets are **stored on runners** in the depth of the racking and trucks enter to deposit or retrieve loads.



Drive-In Pallet Racking

https://www.youtube.com/watch?v=Zh5mNA3wpoA

Drive-In Pallet Racking

Mobile Pallet Racking

Recap: Mobile Pallet Racking

- With the **racking mounted on mobile chassis** which move along guide tracks set into the floor, the floor space for only one 'moving' operating aisle is required to access all pallet locations.

- This **space-saving design** makes mobile pallet racking particularly **suited to cold stores**, as the maximum amount of space can be utilised for storage.

- Operation is simple with chassis moving in a **cascade sequence** until the selected aisle is opened, all from a single push of a button.

- The system application is powered by efficient, industry standard, electric motors for maximum reliability

Mobile

Pallet

Racking

https://www.youtube.com/watch?v=K3tPx8oPlxE

Satellite or Shuttle racking

https://www.youtube.com/watch?v=TYbxHBZ8KDk&t=18s

https://www.youtube.com/watch?v=YbSGlnUpDI8

https://www.youtube.com/watch?v=QsSM711NJGE

Pallet Live

https://www.youtube.com/watch?v=MDUrhzW-OJ4

Warehouse Productivity Metrics

- Pounds or units per day
- Employees per pound moved
- Pounds unloaded per hour
- Pounds picked per hour
- Pounds loaded per hour
- Percentage of orders correctly filled
- Productivity ratio = pounds handled/day divided by labour hours/day
- **Throughput = Amount of material moved through the system in a given time period**

Warehouse process from replenishment to despatch

- Replenishment
- Value-adding services
- Indirect activities
- Stock management
- Stock or inventory counting
- Security
- Returns processing
- Despatch

Warehouse process from replenishment to despatch

➢ **Value-adding services**

The value adding services include the following:

1. **Labelling or relabeling**
2. **Pricing**
3. **Tagging**
4. **Packing**
5. **Bundling**
6. **Reconfiguration**
7. **Sub-assembly**
8. **Repair**

Warehouse process from replenishment to despatch

➢ **Indirect activities**

The Indirect activities include the following:

1. **Training**
2. **Optimum space utilization**
3. **Cleanliness of the warehouse**

Warehouse process from replenishment to despatch

- **Stock management**

Stock turn = cost of goods / average cost of goods stored

Warehouse process from replenishment to despatch

- **Stock counting**
  - **Cycle counting or perpetual counts**
  - **The count itself**

- **Security**

- **Returns processing**

Warehouse process from replenishment to despatch

- **Despatch**

- **Packing- pieces/item/eachs**
- **Packing- carton**
- **Loading**
- **Shipping**
- **Documentation**

https://www.youtube.com/watch?v=7LOAc11G5nQ
https://www.youtube.com/watch?v=iv-GAJqu6nM

https://www.youtube.com/watch?v=0E-Wy1fOdOw

Creating Value in Logistics Process

Warehousing contributes value in the logistics process

- **Traditionally viewed** as a place to hold or store inventory
- **Contemporary view** is the warehouse functions to mix inventory arrangements to meet customer requirements
  - **Storage of products is held to a minimum**

Creating Value in Logistics Process *(Continued..)*

- **Warehousing shifted from passive storage to strategic assortment**
- **Warehousing types evolved to accommodate the dynamic aspects**

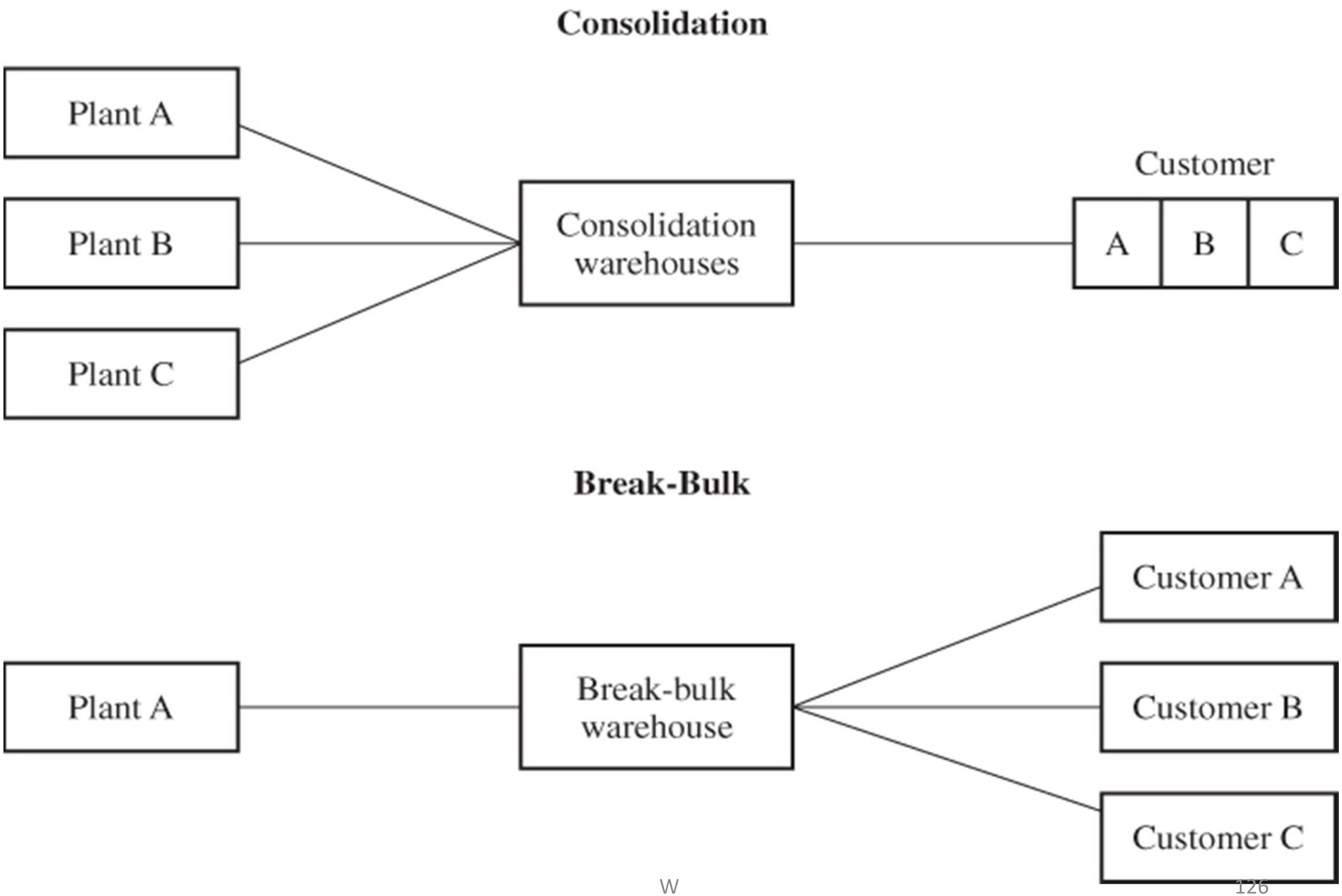
- Distribution centers
- Consolidation terminals
- Break-Bulk facilities
- Cross-docks

Consolidation and Break-Bulk Reduce Transportation Cost

- **Consolidation** occurs when a warehouse receives materials from a number of sources and combines them into exact quantities for a specific destination

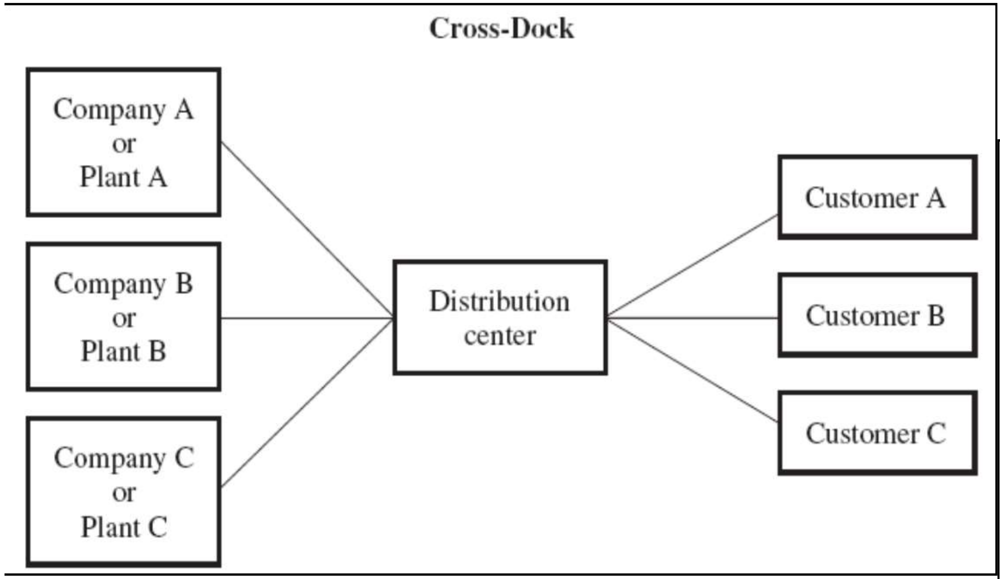
- **Break-bulk** occurs when a warehouse receives a single large shipment and arranges for delivery to multiple destinations

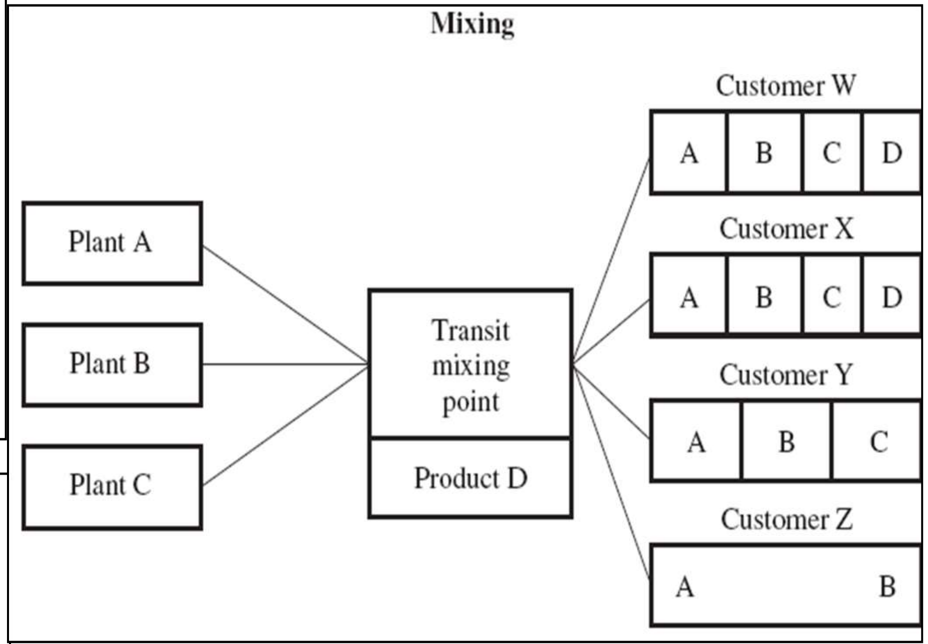
Consolidation and Break-Bulk Arrangements

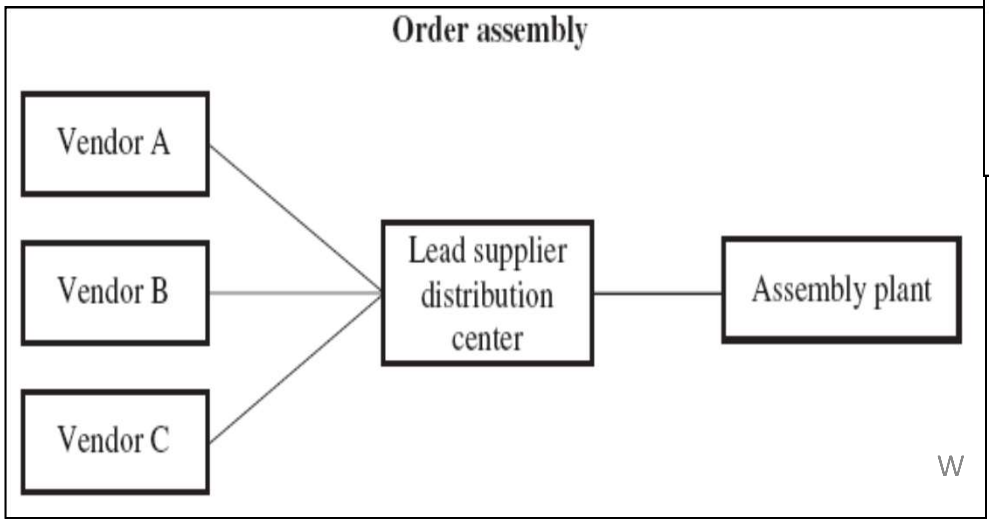


Sorting through Reconfiguring Freight

- Sorting involves reconfiguring freight as it flows from origin to destination







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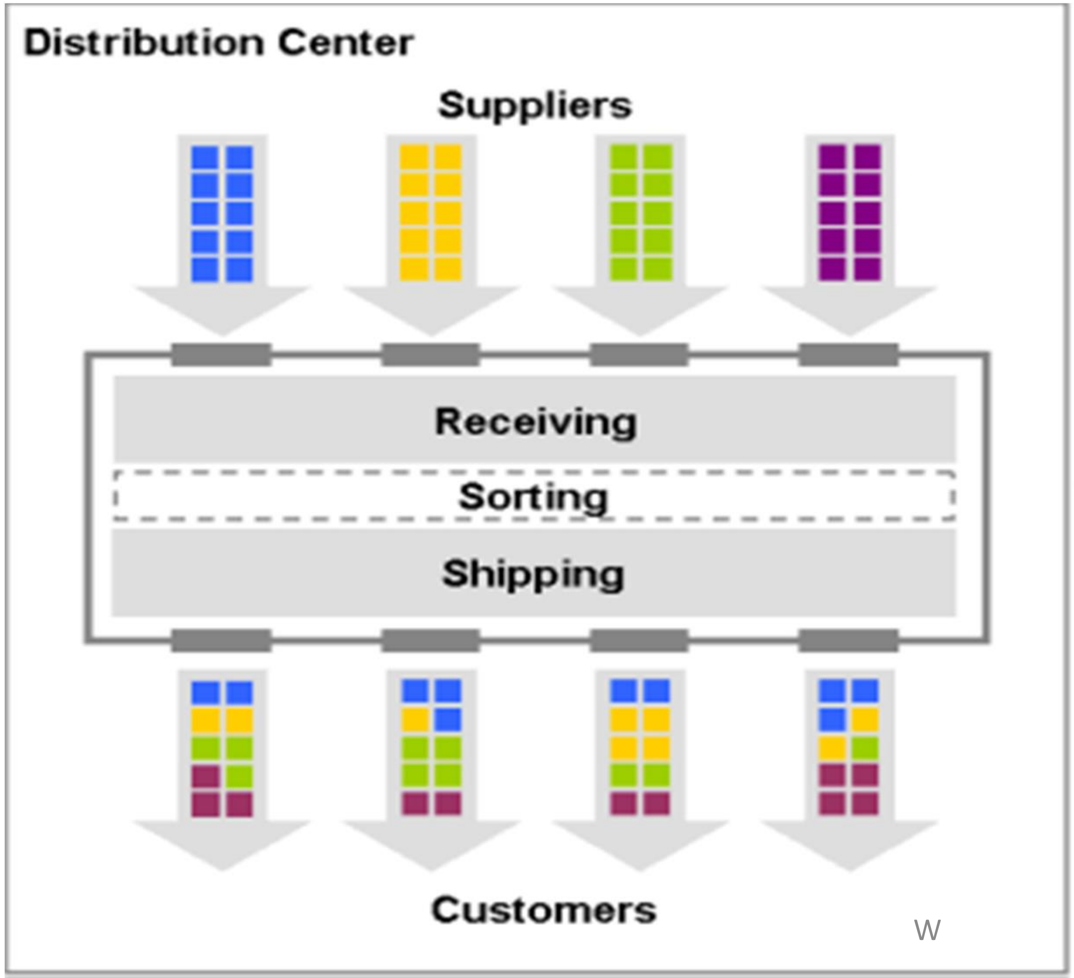
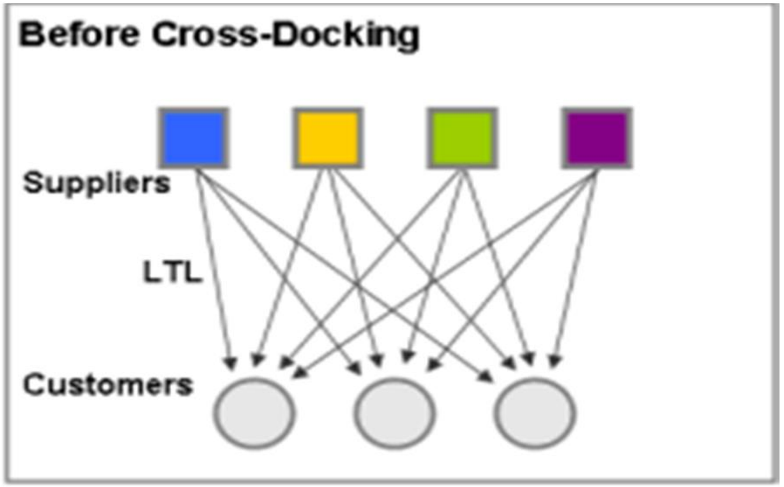
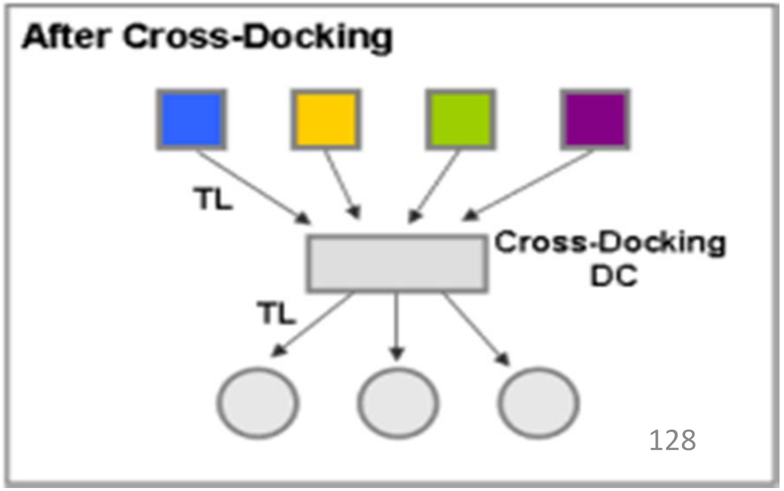
Value Addition through Cross-Docking

- Cross-docking is used extensively by retailers to replenish store inventories
- Cross-docking combines inventory from multiple origins into a pre-specified assortment for a specific customer







Value Addition through Cross-Docking (Continued…)

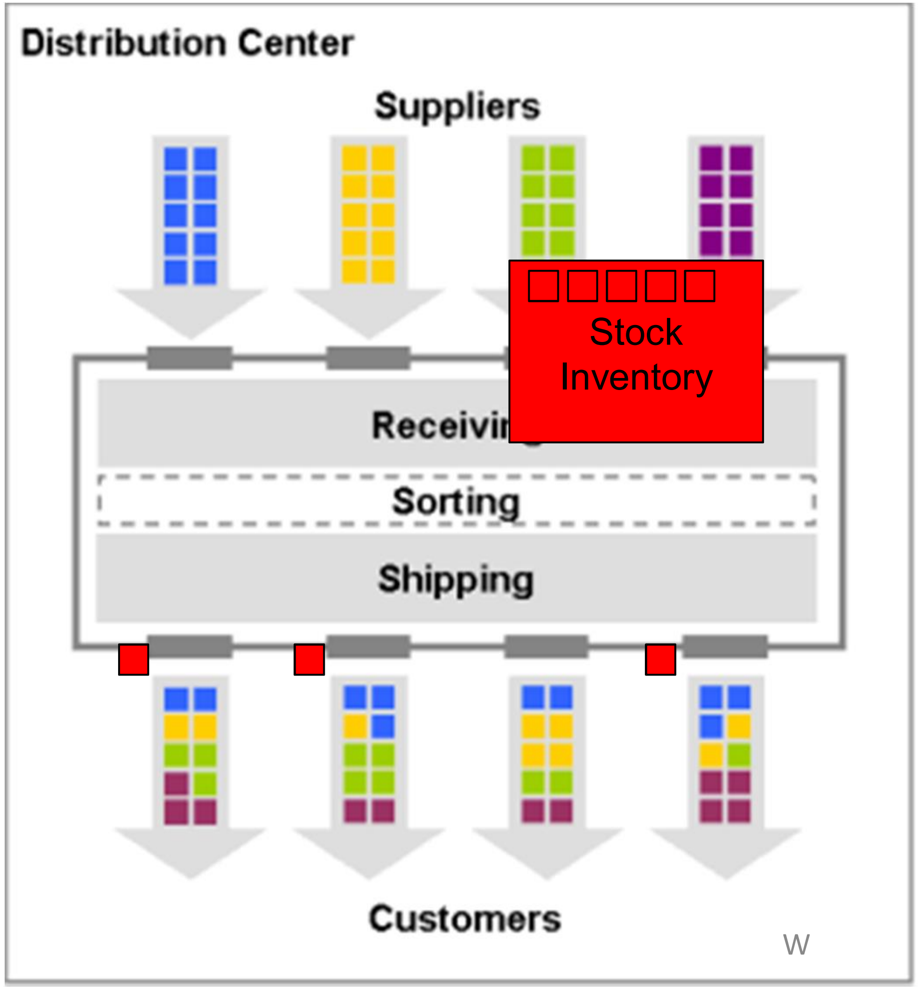
- **Successful cross-docking is highly dependent on the appropriate implementation of information technology**

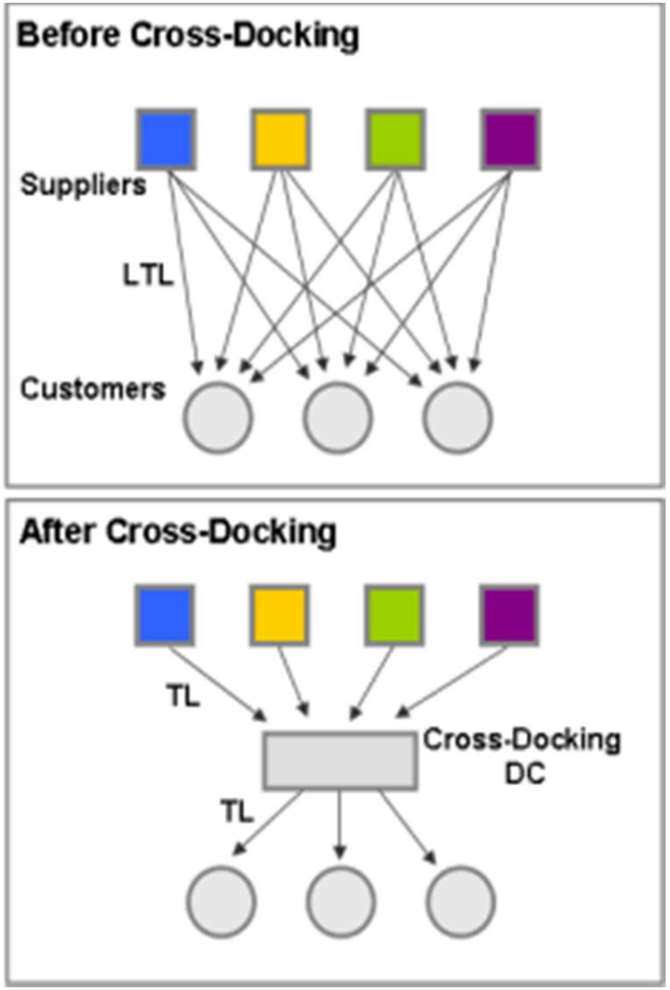
- Products are received, selected, repackaged, and loaded for shipment **without storage**

WalMart Distribution Center

Value Addition: Mixing

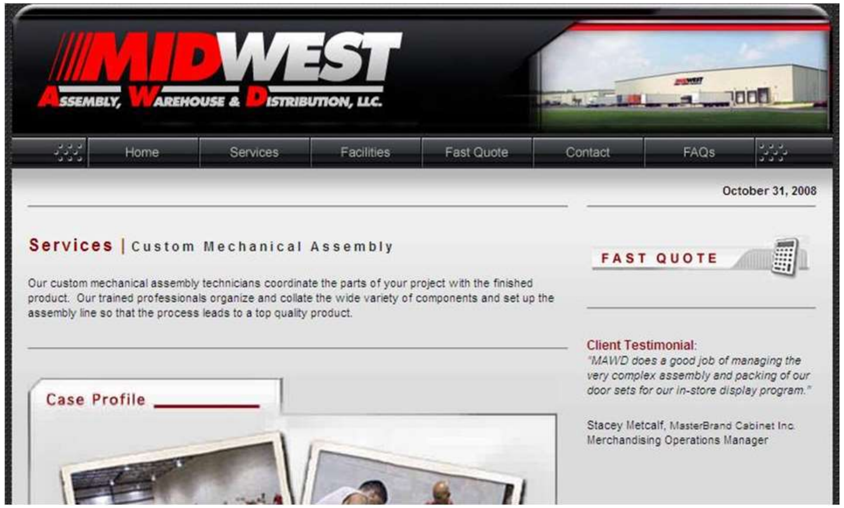
- Mixing combines inventory from multiple origins (like cross-docking) but also adds items that are regularly stocked at the mixing warehouse
- Mixing is usually performed at an intermediate location between origin and destination





Value Addition through Assembly

❖ Assembly supports manufacturing operations



- **Assembly** occurs when products or components from second-tier suppliers are assembled by a warehouse located near manufacturing plant

- Common assembly processes are packaging and color customizing

Value Addition: Reverse Logistics

- **Reverse logistics** include activities supporting
  - **Returns management**
    - Recalls or product that did not sell
  - **Remanufacturing and repair**
    - Repairing / refurbishing equipment
  - **Remarketing**
    - Selling used equipment
  - **Recycling**
  - **Disposal**

Other Warehouse Planning Issues

- Inventory **accuracy** is typically maintained by annual physical counts or counting portions of inventory on a planned basis
  - **Cycle counting** is the audit of selected inventory on a cyclic schedule
- **Audits** are common to maintain safety, assure compliance to regulations and help improve procedures
- **Security** issues involve protection from pilferage and damage

Safety and Maintenance Issues

❖ **Safety and maintenance** issues must also be considered when planning warehouse designs

- ❑ Accident prevention
  - – Comprehensive safety programs and training, accident investigation and follow up
- ❑ Environmental protection
  - – Spill (leak) kits and spill plans
- ❑ Maintenance
  - – Scheduled maintenance of building, material handling equipment, and collision damage prevention

ISO Pallets

- ❑ Number of pallet positions available in a given space depending on the type of pallet racking storage system used.

➢ **2 most popular pallet sizes (wooden pallets) →**

(i) 1200 entry x 1000

(ii) 1200 x 800 entry pallet.

(i) 1200 entry x 1000

Length	**Width**	**Height**
1200mm	1000mm	162mm

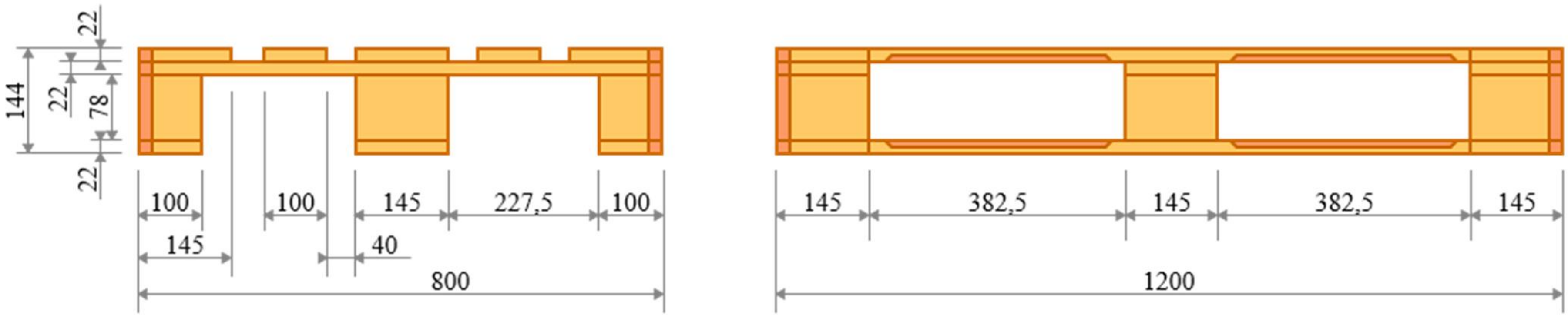
Tare weight → 28 kgs

- ❑ CHEP recommends a maximum rating of 1500 kgs as a safe working load and not to exceed 6000 kgs when stacking loaded pallets on a solid surface. Empty pallets can be stored 40 high.

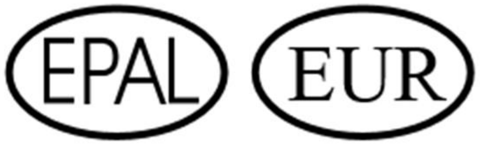
Features & Benefits of 1200 entry x 1000 Pallets

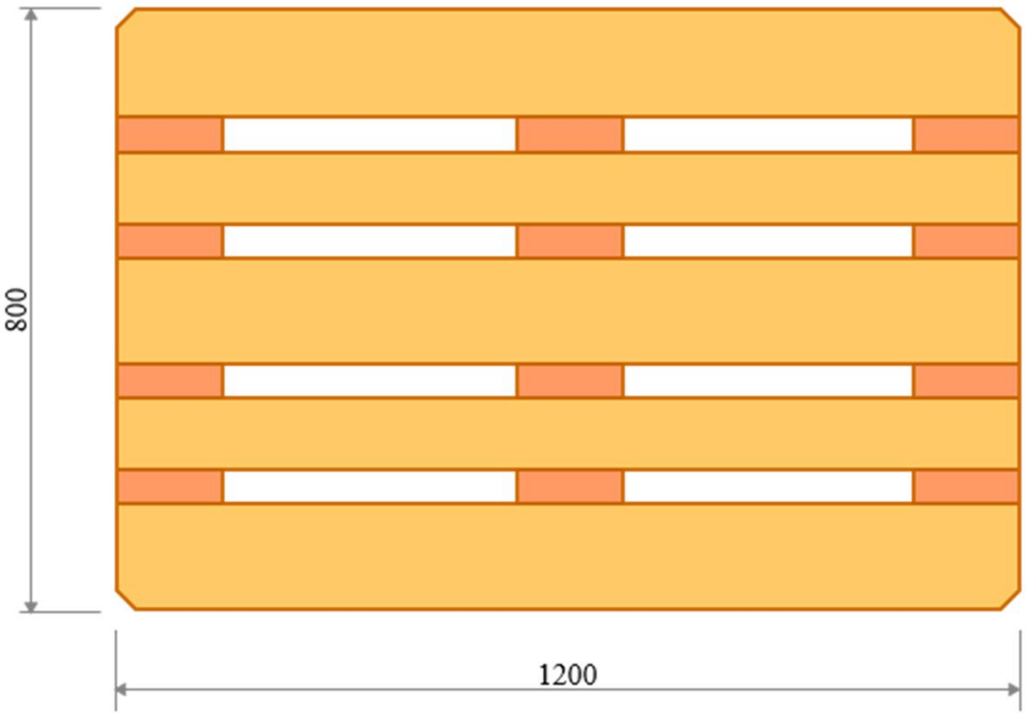
- ❑ **ISO standards**
- ❑ **Reduce** product damage and **increase load stability** through robust construction
- ❑ Increase operational productivity through consistent specification – pallet is **suitable for automated production and warehousing facilities**
- ❑ Enhance efficiencies during storage and transport with consistent **4-way entry** design ensuring compatibility with all standard equipment
- ❑ **Reduce health & safety risks to the workforce** – quality materials ensure pallets can be handled safely

Dimensions of 1200 entry x 800 Pallet



PALETTE EUR–EPAL ©





European Pallets and ISO Pallets: Relationship

EURO pallet type	Dimensions (W × L)		ISO pallet alternative
EUR, EUR 1	800 mm × 1,200 mm	31.50 in × 47.24 in	ISO1, same size as EUR
EUR 2	1,200 mm × 1,000 mm	47.24 in × 39.37 in	ISO2
EUR 3	1,000 mm × 1,200 mm	39.37 in × 47.24 in	
EUR 6	800 mm × 600 mm	31.50 in × 23.62 in	ISO0, half the size of EUR
	600 mm × 400 mm	23.62 in × 15.75 in	quarter the size of EUR
	400 mm × 300 mm	15.75 in × 11.81 in	one-eighth the size of EUR

Warehouse Management Systems

- Manages **warehouse inventory, space, equipment, and labour resources** to direct the **flow of materials and information from receiving and put-away to light assembly, order picking, value-added processing and shipment**

WMS and Order Selection

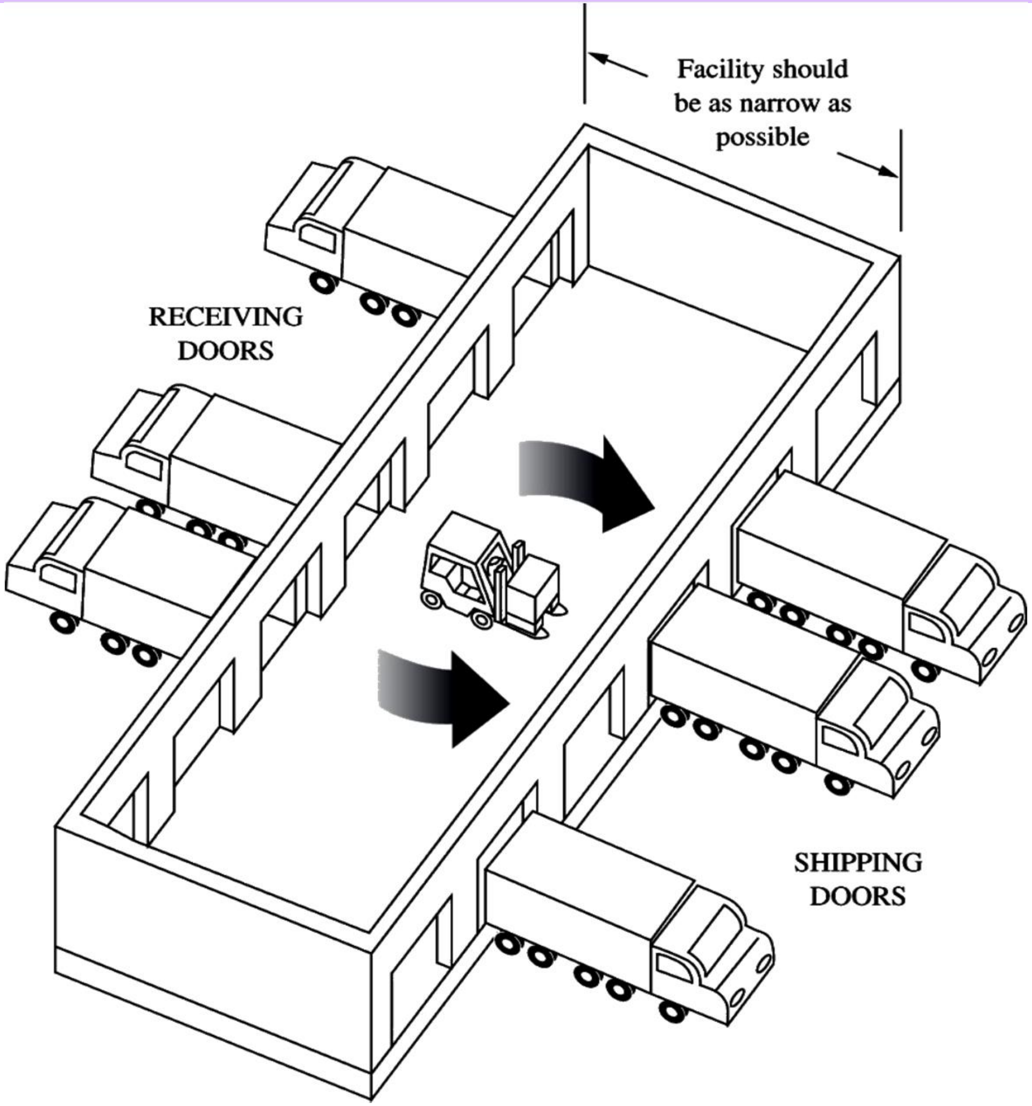
- One of the **main uses** of WMS is **order selection**.

- **Types of selection**:
    - Discrete selection
    - Wave picking / selection (batch)

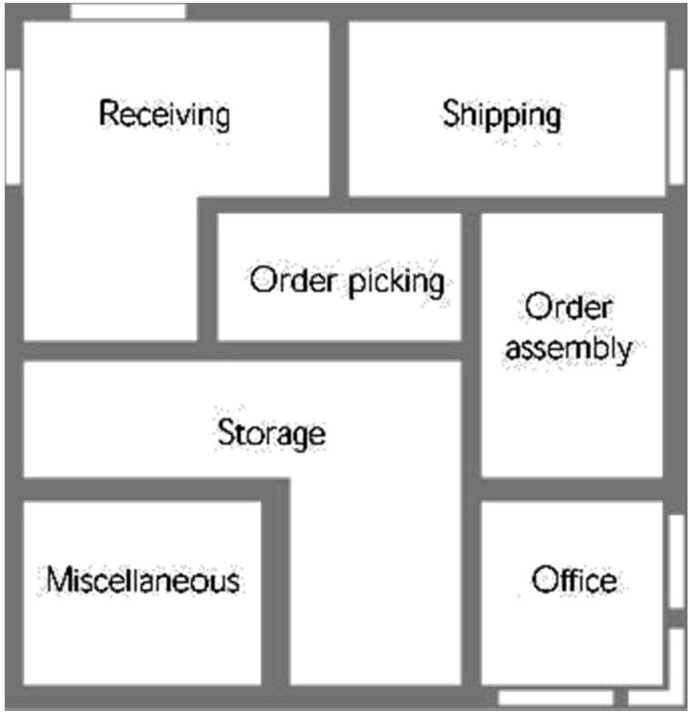
Core Processes of WMS

- Receiving
- Put-away
- Cycle-count
- Pick
- Task Management
- Quality Analysis
- Replenishment
- Pack
- Opportunistic cross dock
- Inventory Control
- Work order management
- Ship

A Typical Warehouse Layout



Ideal Facility for Pure Supplier Consolidation (Full Pallet Movement)



Warehouse space requirements

Order Picking Methods

What is Order Picking?

- Order picking involves the process of (i) **clustering** and **scheduling the customer orders**, (ii) **assigning stock** on locations to order lines, (iii) **releasing orders** to the floor, (iv) **picking the articles from storage locations** and the (v) **disposal of the picked articles**.

Order Picking Methods

- Paper pick lists
- Pick by label
- Pick by voice https://www.youtube.com/watch?v=yy53EMEmx_c https://www.youtube.com/watch?v=BcbhbGRXZRE
- Barcode scanning https://www.youtube.com/watch?v=CJW5D5SDAgw https://www.youtube.com/watch?v=Xe7UaH20n7A https://www.youtube.com/watch?v=86ttdESB9_g
- Radio Frequency identification https://www.youtube.com/watch?v=gEQJxNDSKAE
- Pick By light /Pick to light https://www.youtube.com/watch?v=tPIQpKi_-Ko

Why is Order Picking so Important?

- Order picking account for **55% of warehouse operations cost**, it can be broken down to:
  - Traveling 55%
  - Searching 15%
  - Extracting 10%
  - Paper work and other 20%
    (or electronic processing)

(**Note: These are % of total order picking cost**)

Order Picking

- It's the most costly activity because:
  - Labour intensive
  - Material & information system intensive
  - Decision support system and engineering projects intensive
  - Many error occur in order picking

- **Order picking** is the **highest priority in a warehouse** for productivity improvements

Order Picking *(Continued…)*

- Depend on **type of storage and retrieval** system
  - Person-to-item
  - Item-to-person
  - Manual or **ASRS**

Picking Strategies

- **Flow time** is a main indicator for **picking performance**

- **Short flow time** can lead to better service and responsiveness

- **Flow time** depend on
  - how large the unit load, serial or parallel pickers
  - Number of pickers

Picking Strategies *(Continued…)*

- If the total work to **pick and load** a truck is **small**, ***one picker*** may be assign to each order

- If the orders to **pick and load** are **large** or span distant region, ***several pickers*** are needed to **shorten the flow time**

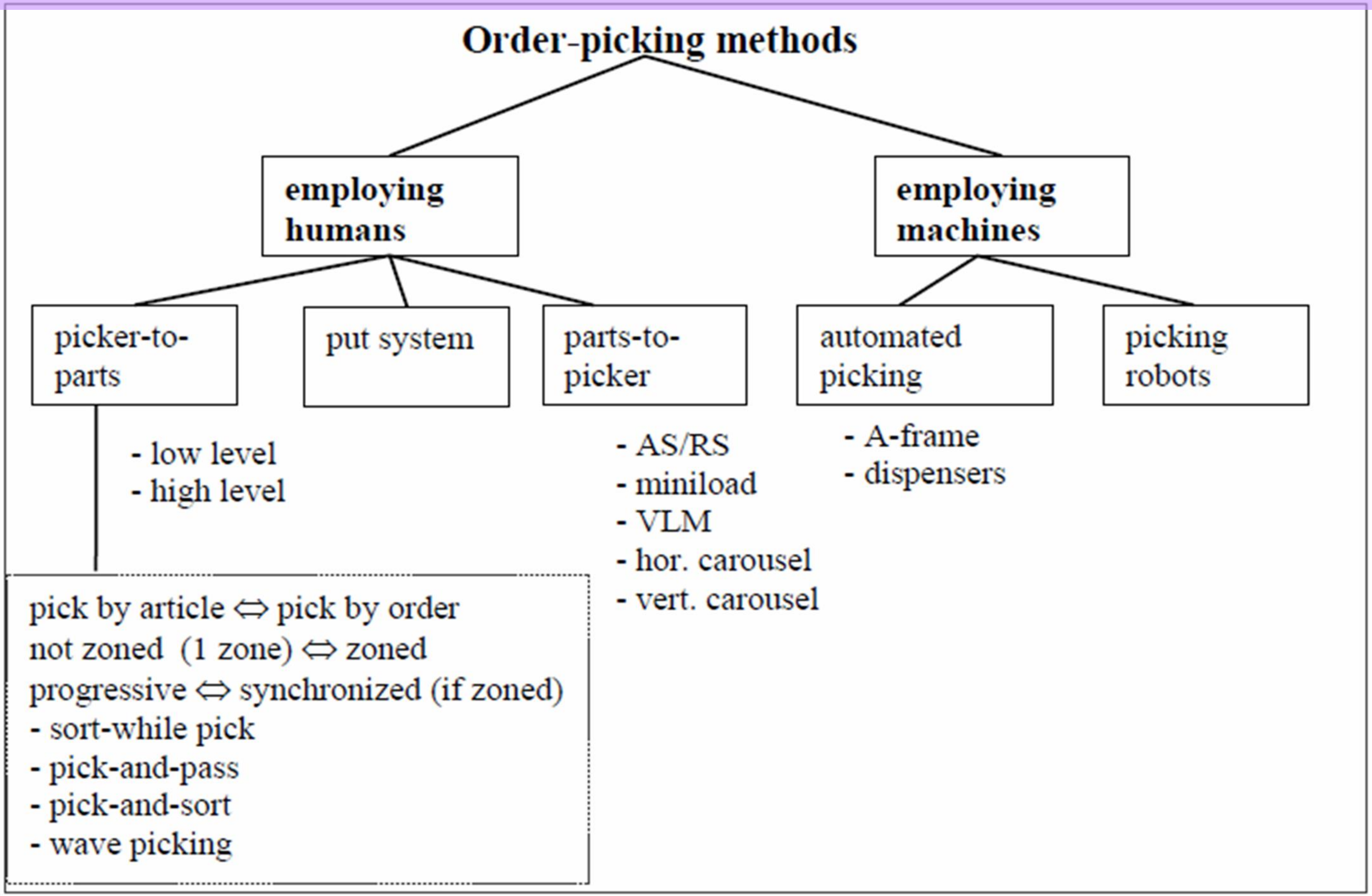
Picking Strategies *(Continued…)*

- For a warehouse **that move a lot of small products for each of many customers**, such as shipping to retail stores, order picking may be organized as an **assembly line**

Difference between Picking & Shipping

- **Shipping** generally handles **larger units than picking**
- **Shipping** is less labour intensive whereas **picking is more labour intensive**
- Goal of **Shipping** is to
  - minimise transportation cost
  - protect goods
  - ease load and unloading

Order Picking Methods



Source: De Koster, R., Le-Duc, T., and Roodbergen, K.J. (2007), 'Design and control of warehouse order picking: a literature review', *European Journal of Operational Research,* 182(2), pp. 481-501.

Order Picking Methods *(Continued…)*

- **Picker-to-parts** systems → the order picker walks or drives along the aisles to pick items (this system is most common)

  Pick to order
  Batch picking
  Wave picking
  Cluster picking
  Zone picking

- Two types of **picker-to-parts systems** →

  (i) low-level picking, and

  (ii) high-level picking.

- **Low-level order-picking systems** → the order picker picks requested items from storage racks or bins (bin-shelving storage), while travelling along the storage aisles.

Order Picking Methods *(Continued…)*

- **High-level order-picking systems** → Employ high storage racks
  - Order pickers travel to the pick locations on board of a lifting order-pick truck or crane.
  - The crane automatically stops in front of the appropriate pick location and waits for the order picker to perform the pick.
  - This type of system is called a **high-level** or a **man-aboard order-picking system**.

Order Picking Methods *(Continued…)*

- **Parts-to-picker systems →** include automated storage and retrieval systems (**AS/RS**),
  - Uses mostly aisle-bound cranes that retrieve one or more unit loads (pallets or bins; in the latter case the system is often called a miniload) and bring them to a pick position (i.e. a depot).
  - At this position the order picker takes the required number of pieces, after which the remaining load is stored again.
  - This type of system is also called a **unit-load or end-of-aisle order-picking system**.

Order Picking Methods *(Continued…)*

- The **automated crane** [i.e. storage and retrieval (S/R) machine] can work under different operating modes: **single, dual and multiple command cycles**.
  - **Single-command cycle** → either a load is moved from the depot to a rack location or from a rack location to the depot.
  - **Dual-command mode** → first a load is moved from the depot to the rack location and next another load is retrieved from the rack.

Order Picking Methods *(Continued…)*

- **Multiple command cycles** → the S/R machines have more than one shuttle and can pick up and drop off several loads in one cycle.

- Example, in a **four-command cycle** the S/R machine leaves the depot with two storage loads, stores them and returns with two retrieved loads.

Order Picking Methods *(Continued…)*

- Other systems use modular **vertical lift modules (VLM)**, or **carousels** that also offer unit loads to the order picker, who is responsible for taking the right quantity.

- **Put systems** (or **order distribution systems**) → consist of a retrieval and distribution process
  - *First, items have to be retrieved, which can be done in a parts-to-picker or picker-to-parts manner*
  - *Second, the carrier (usually a bin) with these pre-picked units is offered to an order picker who distributes them over customer orders **('puts' them in customer cartons)**.*

Order Picking Methods *(Continued…)*

- Put systems are popular in case a large number of customer order lines have to be picked in a short time window (**example at the Amazon Germany warehouse**)
- Can result in about **500 picks on average per order picker hour** (for small items) in well-managed systems
- Newly developed systems indicate that up to **1000 put handlings per picker hour** are feasible.

WMS and Order Selection

- One of the **main uses** of WMS is **order selection**.

- **Types of selection**:
  - Discrete selection
  - Wave picking / selection (batch)

Wave Picking / Wave Selection

- Wave picking is a process to support managing the work of a warehouse or distribution center (DC)

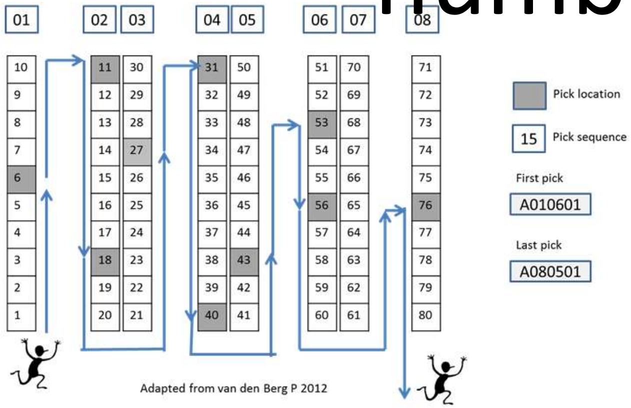
- Wave picking is an application of **short interval scheduling**, to **assign orders into groupings** (waves) and **release them together** so as to allow management to coordinate the several parallel and sequential activities required to complete the work.
  - Can be designed in a number of ways
  - Assigned responsibility for a specific portion of the warehouse
  - Fewer selection errors

Picking essentials

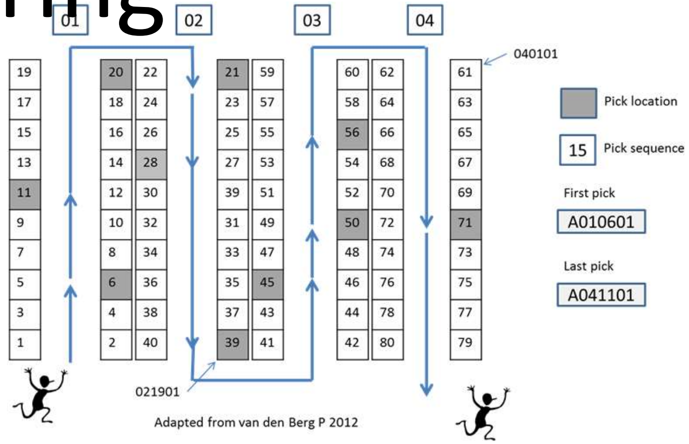
- Speed
  - Distance and ease of access
- Accuracy
  - Clear ID and instructions
- Layout
  - Picker to goods or goods to picker
  - Possible need for multiple pick faces for same product
- Equipment
  - Safety and efficiency

Pick face examples

Pick sequence and aisle numbering



Adapted from van den Berg P 2012



Adapted from van den Berg P 2012

Theoretical Pick route layouts

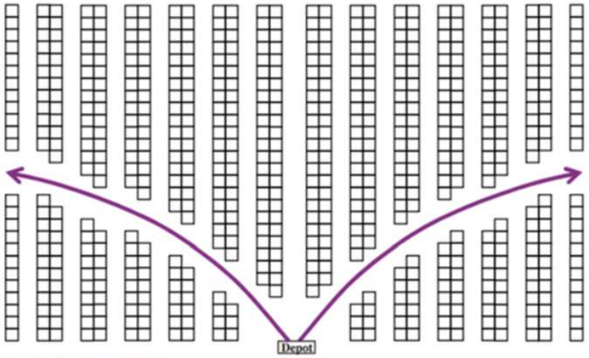


Figure 1 - Flying-V Layout

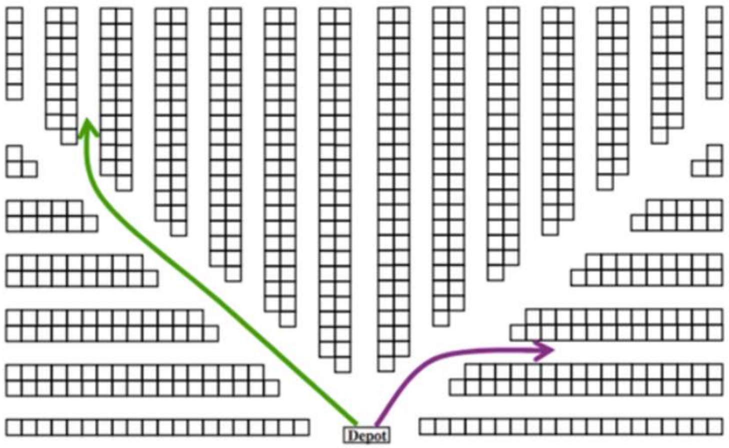


Figure 2 - Fishbone Layout

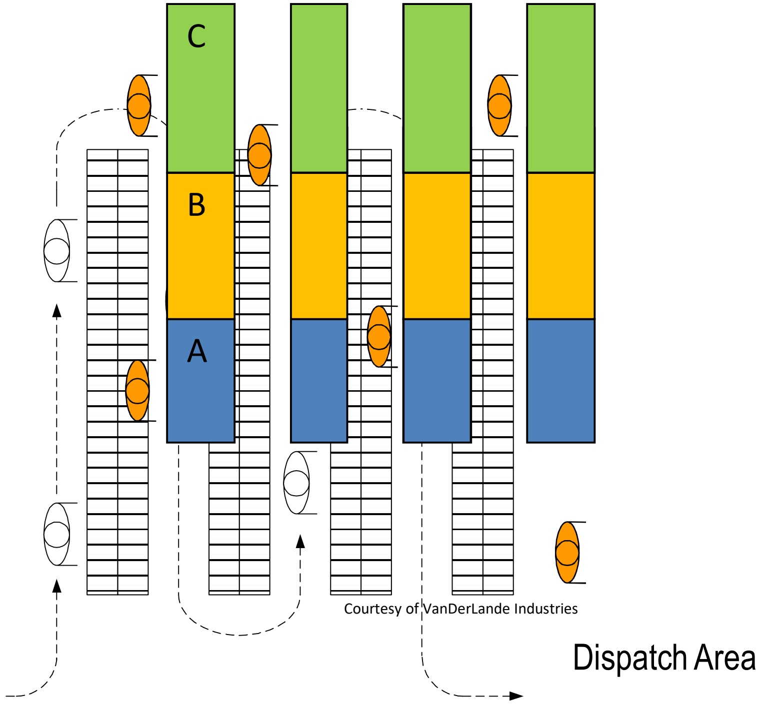
Roodbergen 2011

Picking procedures

- Pick by order
  - All lines are collected for a specific customer order
    - Minimal handling, order sizes are typically high.
- Pick by label
  - All lines are collected for a specific customer order and labels attached to each item during the picking process
    - Minimal handling, order sizes are typically high.
- Cluster picking
  - Take several individual orders out at the same time
    - Can be confusing without technology
- Pick by batches
  - Products collected for a large number of orders with the same product lines
    - Fewer runs but increased handling and sortation, mainly large quantities of small orders
- Pick by zones
  - Products are categorised into specific groups and picked from defined areas
    - Reduced walking distance, increased sortation
- Pick by waves
  - Large batches of orders are collected for defined time periods e.g. arrival of vehicle

ORDER PICKING – individual and cluster

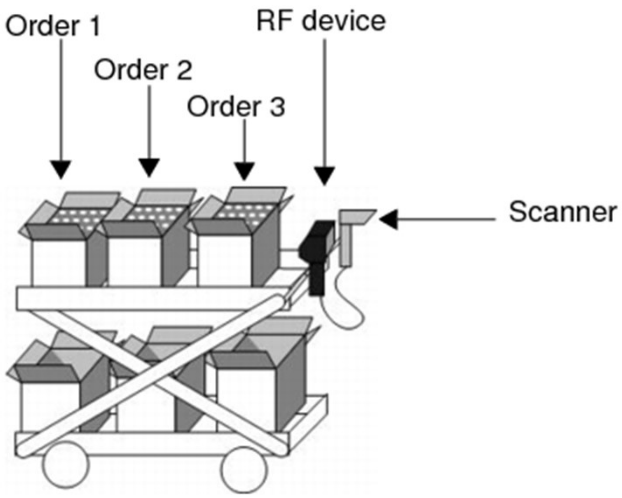
Area picking / U path picking



Pick by label

- Each operator is given a batch of labels detailing location, quantity etc - once all labels are attached to the products and placed in a carton or onto a pallet the individual order pick is complete

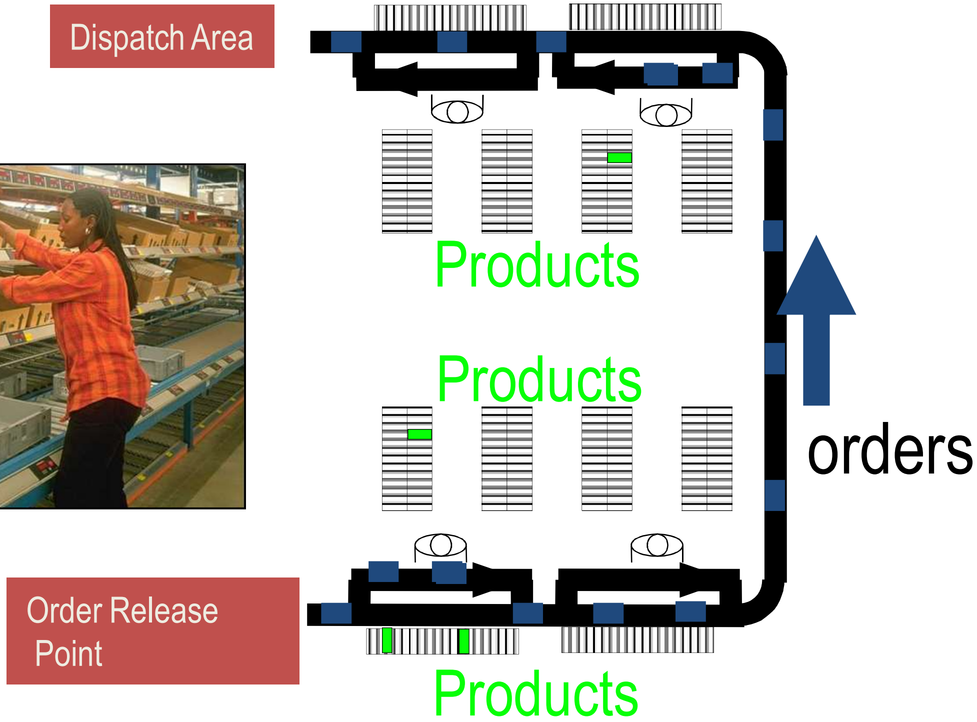
Cluster Picking method



(Photos by QAD, Kardex Remstar)

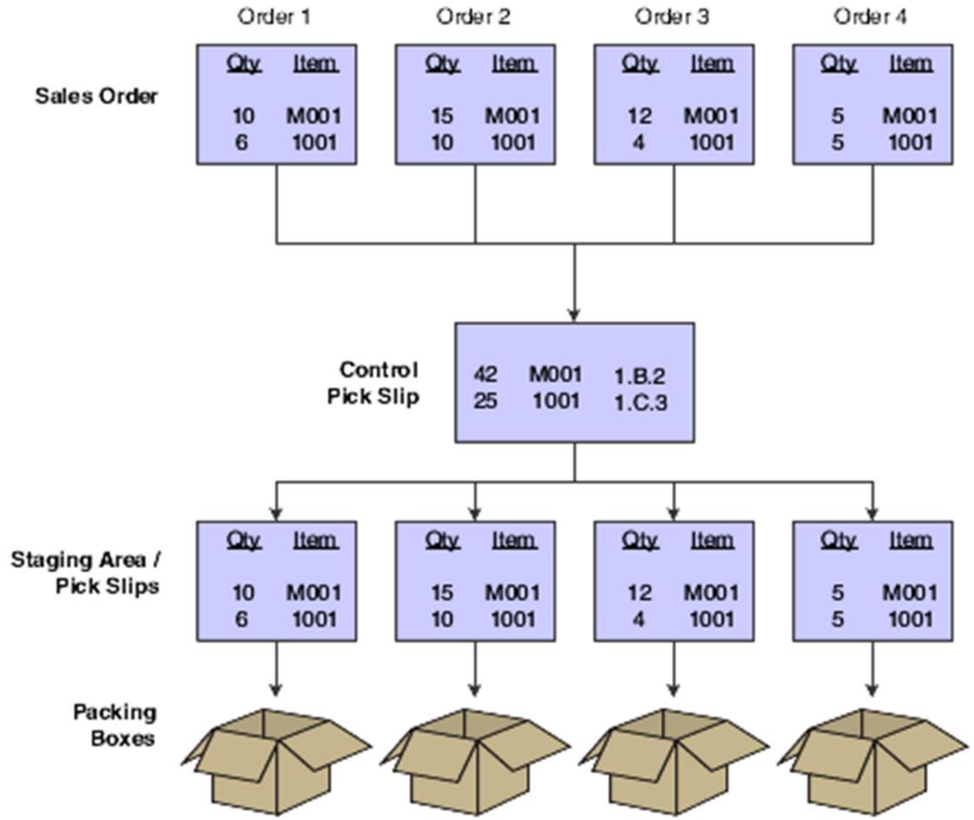
Zone picking

Can be simultaneous or sequential
Each person is allocated their own area



Courtesy of VanDerLande Industries

Batch picking



Oracle.com

Wave picking

- There are two basic planning elements and benefits of wave picking.
- To organize the sequence of orders and assignment to waves, consistent with routing, loading and planned departure times of shipping vehicles or production requirements, etc., to reduce the space required for shipping dock handling to assemble orders and load; and
- To assign staff to each wave and function within a wave, with the expectation that all the work assigned to each wave will be completed within the wave period and thus more effectively utilize the staffing throughout the shift.

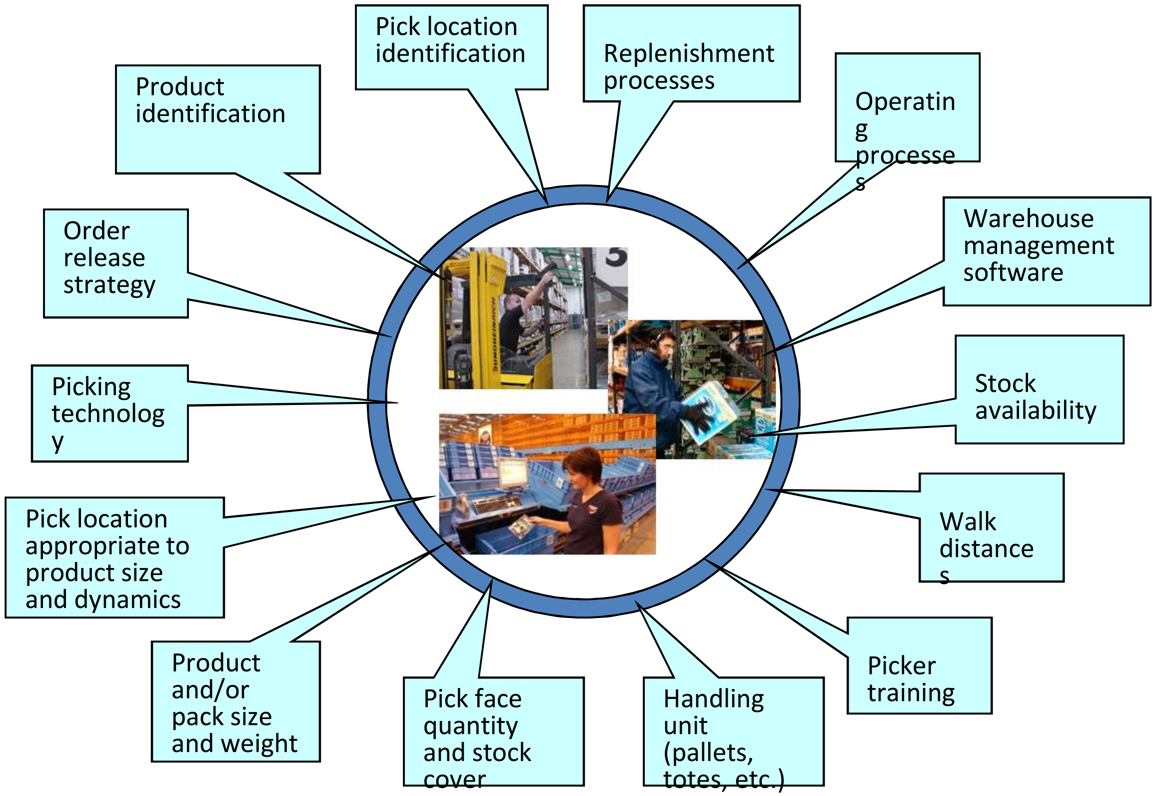
Goods to person

Increased use of automation – goods to person

Order distribution System (ODS) is a dynamic goods-to-person solution. It is especially strong in business processes where a large numbers of order lines are fulfilled from relatively low numbers of articles. Totes or cartons are transported by a conveyor system to operators who place goods into order totes controlled by put-to-light displays.

Courtesy of VanDerLande Industries

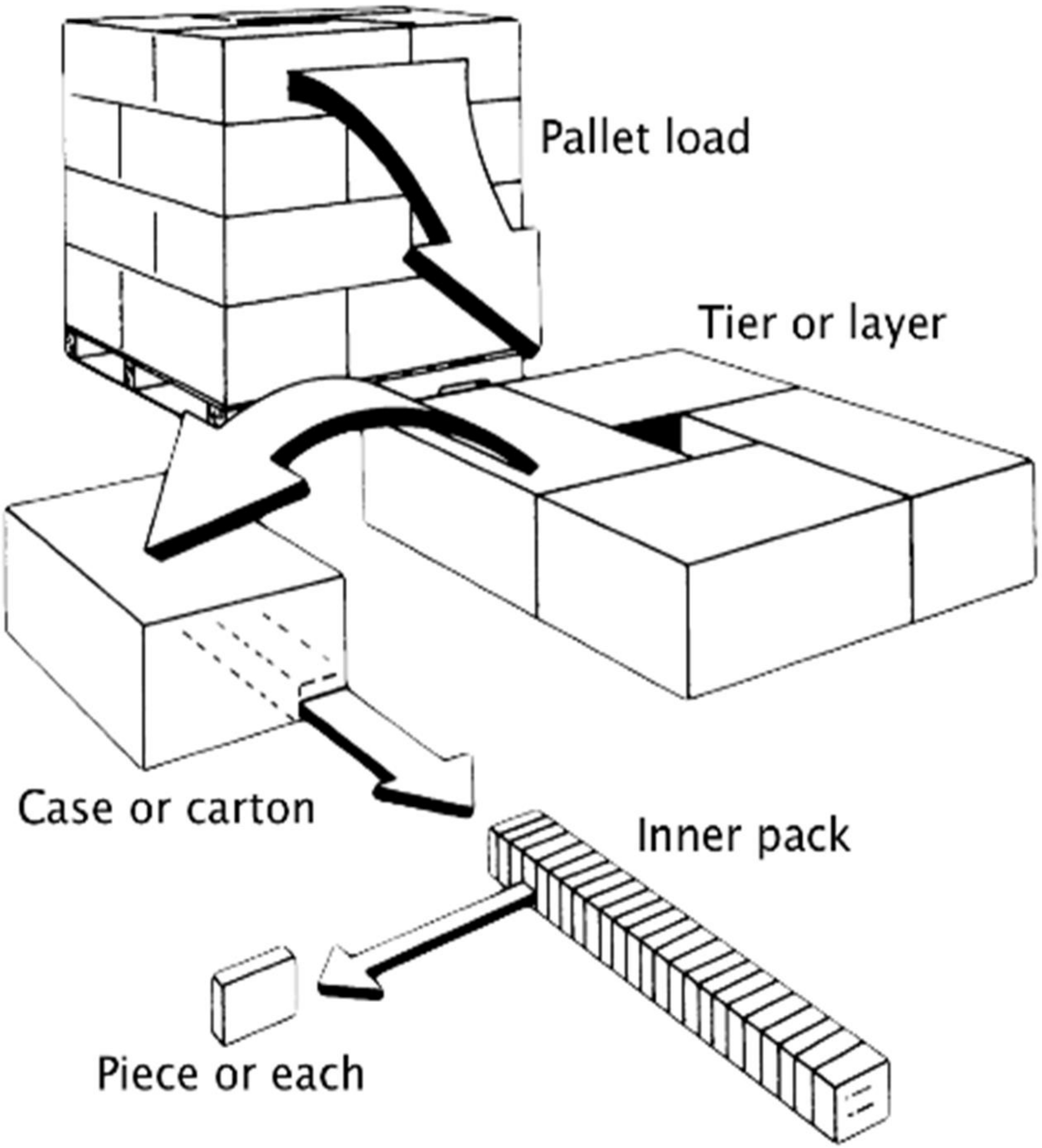
What affects picking performance?



Courtesy of The Logistics Business

Pick Preparation: Units handled in Warehouses

- A product is generally handled in **smaller units** as it moves down the supply chain.
- A **stock keeping unit**, or *SKU*, is the smallest physical unit of product that is tracked by the organization.
- **Upstream** in the SC, flow is in larger units, like **pallets**.
- Product is successively broken down into **smaller units as it moves downstream**.



Handling Equipment

Manual and mechanical handling equipment

Trolleys/ cages / Carts /Garment rails

Manual and mechanical handling equipment

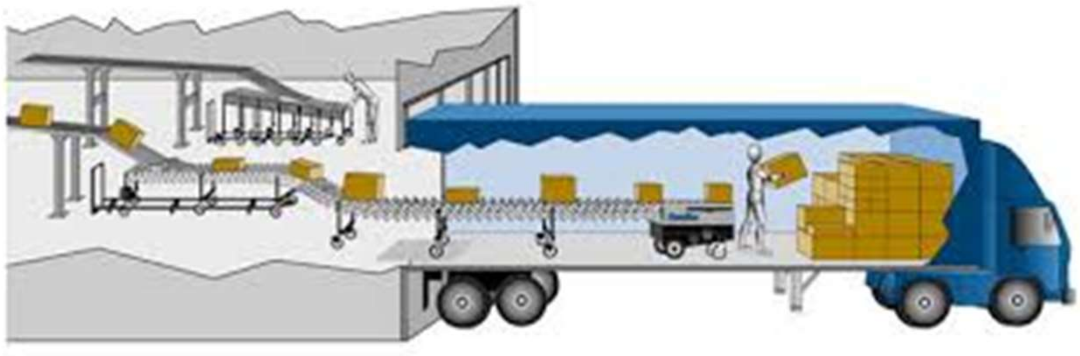
Hand pallet truck , pallet jack, powered pallet truck, manual stacker truck

Manual and mechanical handling equipment

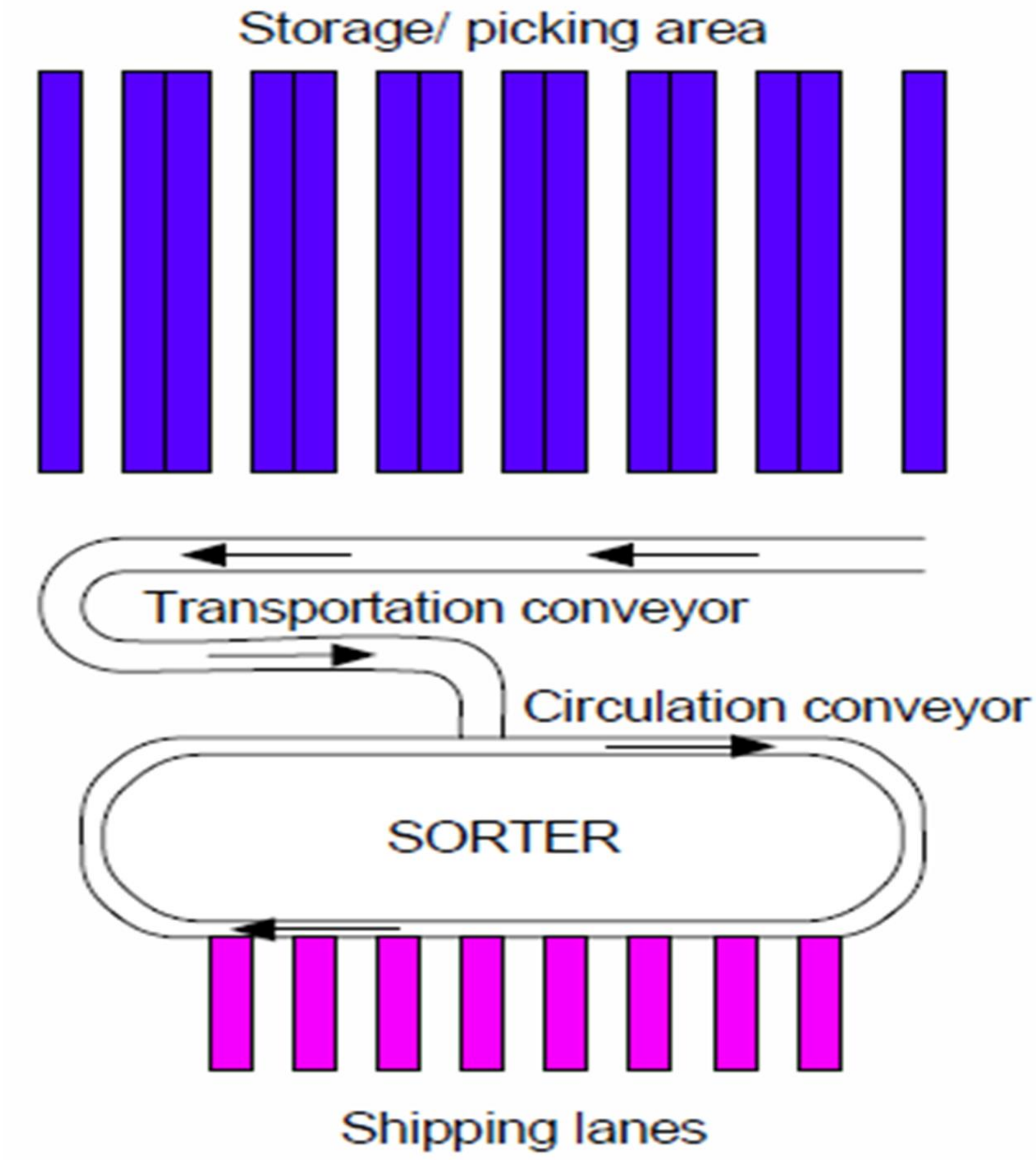
Forklift

Manual and mechanical handling equipment

Conveyors



Accumulation/Sorting (A/S) System



Trucks

- Hand truck
- Fork-lift truck
- Pallet truck
- Platform truck
- Counterbalanced truck
- Tractor-trailer truck
- AGV

Robots

- Point-to-point
- Contouring or continuous path
- Walkthrough or teach
- Lead through or teach pendant
- Hydraulic
- Servo-controlled

AGV in Warehouse

Smaller AGVs Working In Busy Warehouse

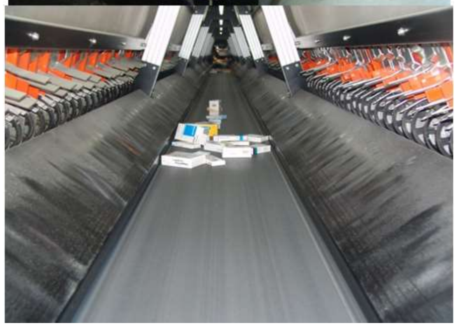
http://youtu.be/zhe6M255zcM

Warehouse automation and technology

Support systems	Semi-automation	Automated systems
Warehouse Management systems	Carousels/Vertical lift modules	AS/RS (Automated storage and retrieval systems)
Warehouse Control Systems	A frames	Cranes
		Shuttle systems
Bar codes and scanners	Pick and put to light	Conveyors
Radio frequency ID	Shuttle carts	Automated guided vehicles
Scanners and voice terminals		Robotics

Automated guided vehicle

A Frame – automatic pick



Courtesy of Knapp and SSI Schaeffer

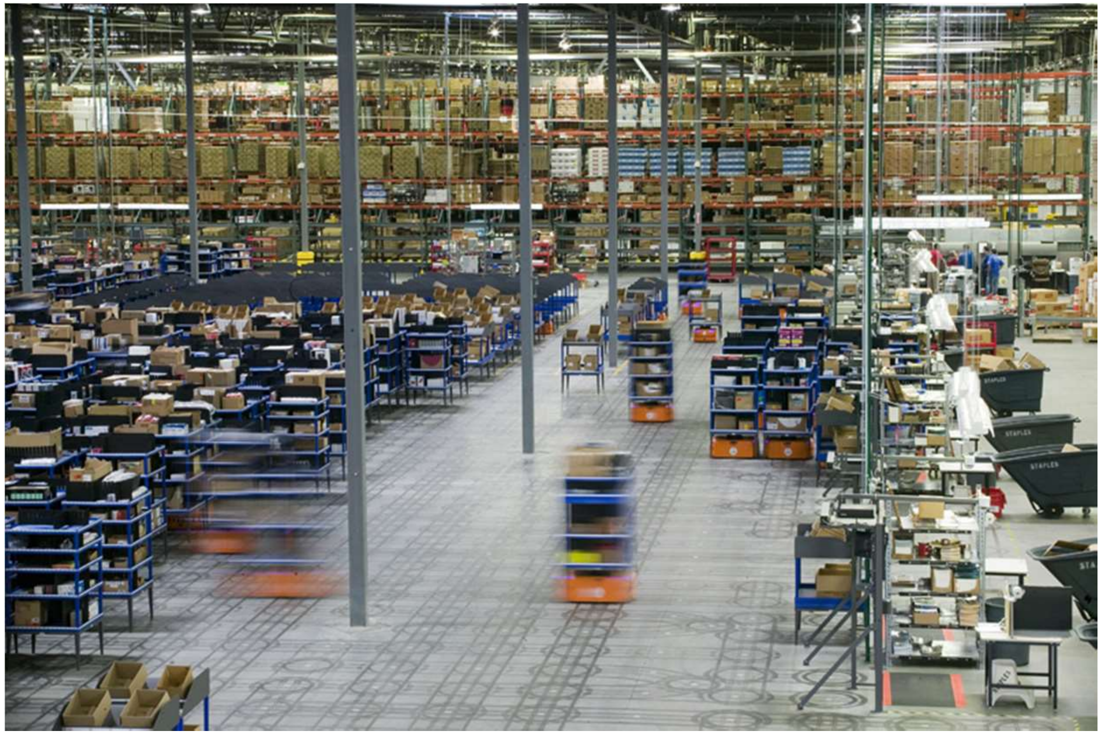
Other automation systems

- Cimcorp 3D shuttle
- No racks

More automation

- Swisslog Autostore

Robo pick by Kiva

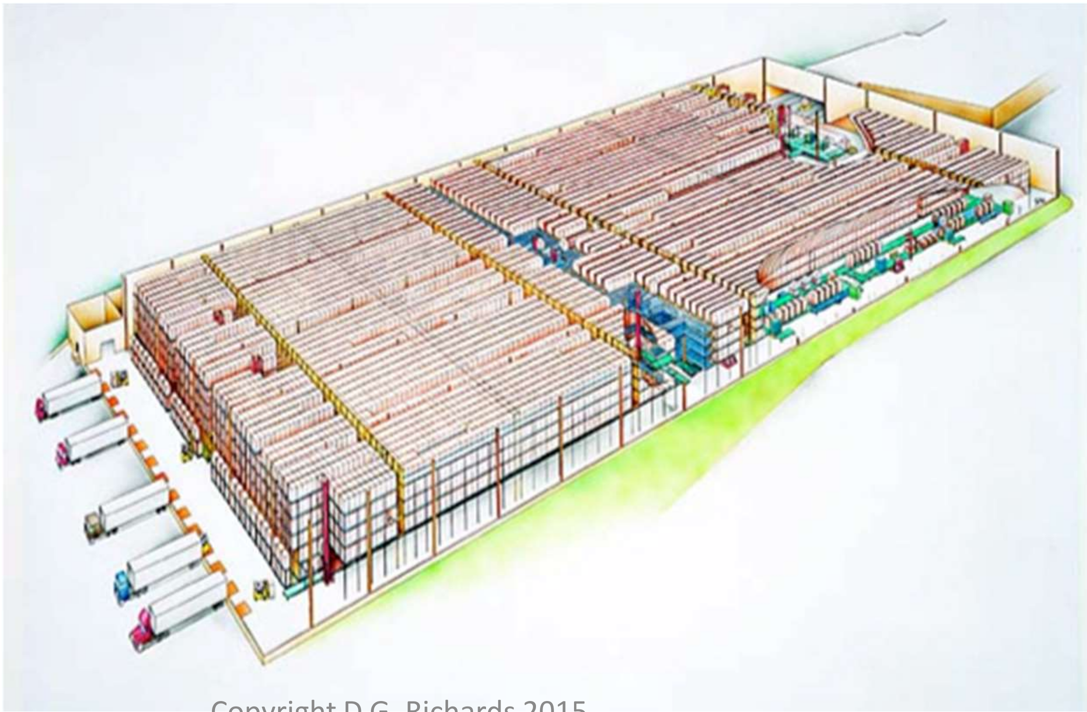


10,000 sq. metres - $4 - $6 million

Automation in pallet storage

- Proctor and Gamble – Activ pallet sequencer

  by Retrotech



A variety of trucks to choose from

Courtesy of Toyota

Vertical movement






(Courtesy of Atlet, Toyota, Central Training and Flexi),

Horizontal movement

Courtesy of Demag, AS Conveyor Systems and Seegrid),

Pallet movers

Product type	Lift height	Aisle width (m) Approx.	Lift capacity in kg from	To	Cost from (£)	To (£)
Hand pallet truck, jack	N/A	1.8 m	2,300 kg	3,000 kg	300	1,000
Powered pallet truck	N/A	2.8 m	1,200	3,000	2,800	16,000
Powered pallet stacker	1.35–6.3 m	2.2–3.0 m	1,000	1,600	5,000	18,000
Reach truck	4.5–12.5 m	2.65–3.15 m	1,400	2,500	15,000	30,000
Counter-balance truck	3.0–6.5 m	3.0–7.0 m	1,300	5,000	12,000	20,000
Low-level order picker	N/A	1.636 m	1,800	2,500	7,000	12,000
Medium-level order picker	2.0–4.7 m	1.59 m	1,000	1,200	10,000	18,000
High-level order picker	4.7–9.5 m	1.664 m	1,000	1,200	19,000	32,000
Combination truck or VNA	14.8 m	1.6–2.3 m	1,000	1,500	40,000	80,000
Articulated forklift truck	Up to 12 m	1.6–2.1 m	1,000	2,000	29,000	35,000

Prices and data at July 2013 UK only

Warehouse Storage Justification

- **Counterbalance Forklift Truck**
  - Gas/Diesel
  - LPG
  - Battery electric

The Conventional Way

Warehouse Storage Justification

- **Electric Reach Truck**
  - Battery electric
  - Compact frame and reach forks/mast provide for a smaller aisle.

Narrow-Aisle Sys

Warehouse Storage Justification

- **Electric Very-Narrow-Aisle (VNA) Truck**
  - Battery electric
  - Lateral fork movement allows specification of aisles a fraction larger than the size of pallet.

Very-Narrow-Aisle System

Warehouse Storage Justification

CONVENTIONAL SYSTEM	NARROW AISLE SYSTEM	VERY NARROW AISLE SYSTEM
Gas, LPG or Electric Trucks	Electric Reach Trucks	Electric Very Narrow Aisle Trucks
Clear aisle 4200mm	Clear aisle 2700mm	Clear aisle **1650mm**
Top beam 4775mm	Top beam 4775mm	Top beam 4775mm
Stack 4 high (1 on the ground; 3 in the air)	Stack 4 high (1 on the ground; 3 in the air)	Stack 4 high (1 on the ground; 3 in the air)
Single command system	Dual command system	**Dual** command system
The truck loads & unloads trailers, loads & unloads rack plus pick up & deliver to manufacturing	The truck pick up & deposits loads from staging and pick & deposits loads in the rack systems	The truck pick up & deposits loads from staging and pick & deposits loads in the rack systems
80% Travel. 20% Lift	60% Travel. 40% Lift	**50%** Travel. **50%** Lift†
66% Aisle	51% Aisle	**39%** Aisle

Special equipment - Slip sheet attachment

Courtesy of Bridgestone

Courtesy of Bluewater Forklift

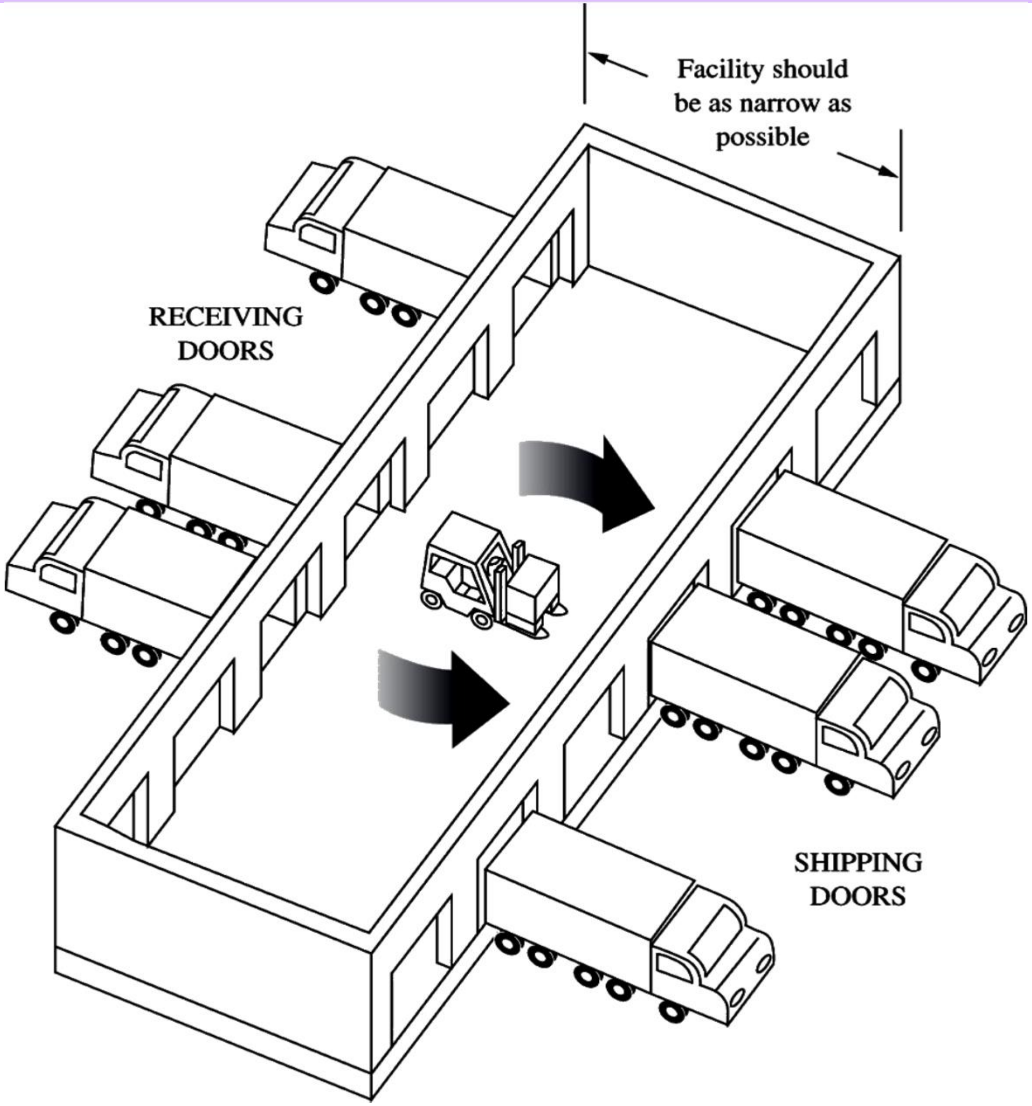
Courtesy of easy rack

Warehouse Space Calculations

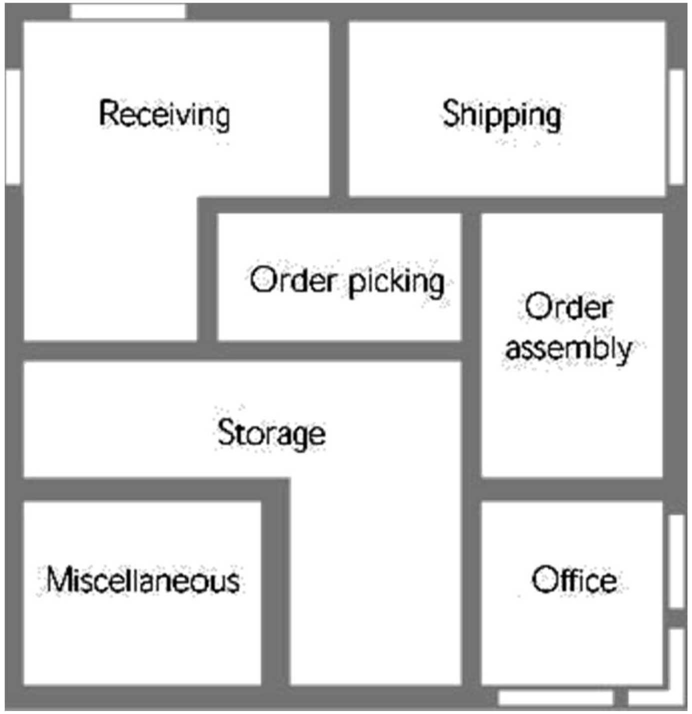
The Main floor-space areas within the warehouse

- Receiving Area
- Inspection Area
- Reserve storage area
- Carton-pick area
- Item-pick are
- Value adding services area
- Packing area
- Despatch area
- Cross dock area
- Empty pallet area
- Warehouse offices
- Restroom

A Typical Warehouse Layout



Ideal Facility for Pure Supplier Consolidation (Full Pallet Movement)



Warehouse space requirements

Warehouse Space Calculations

- Modern companies use computer assisted warehouse design programs for warehouse space calculations

- However, there are a number of simple ways to calculate the space required for specific operations.

- Let us calculate **dock space** and **racked pallet storage**.

Calculation of Dock Space Requirements

- The formula for this is as follows (*this is a rule-of-thumb*):

- **Dock Space =**

$$\text{Roundup}\ \frac{\{\text{Number of loads received}\ \times\ \text{Hours/load}\}}{\text{length of shift}}\ \text{x (size of load x space/pallet)}$$

Dock Space Requirements *(Continued…)*

- Data provided for the warehouse:
  - The warehouse is receiving 20 loads per day
  - Each load is 26 pallets
  - Each pallet is 1 m × 1.2 m
  - 45 minutes is taken per load to unload vehicle
  - 30 minutes is taken per load to stage prior to put-away
  - 8 hours per day work shift

Dock Space Requirements *(Continued…)*

❖ Calculation of the Dock Space:

- **Dock Space =**

$$\text{Roundup}\ \frac{\{\text{Number of loads received}\ \times\ \text{Hours/load}\}}{\text{length of shift}}\ \text{x (size of load x space/pallet)}$$

- {Roundup (20 × 1.25)/8} × (26 × (1.2 × 1.0))

  = 3.125 × 31.2

  = 4 × 31.2

  = 124.8 square metres.

➢ **Dock space from the formula = 124.80 sq. metres**

Dock Space Requirements *(Continued…)*

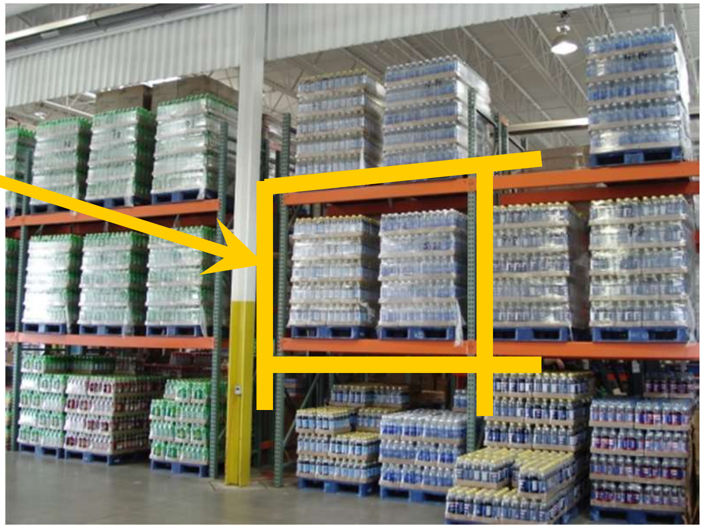
- **Add double the space for working and travel area** = 249.60 square metres

- Total space required = (124.8 + 249.60) square metres = **374.40 square metres**

Pallet Storage Calculation

Recap: Picking Method – Warehouse Layout

- Each section of racking is called a **"bay."**
- Each bay usually holds **2 or more pallets.**
- Racking is usually **1 to 6 bays high** (depending on how much space is available in the warehouse.
- Each bay usually has **a label with a identification number**.



Recap: Picking Method – Warehouse Layout

3 inches for each pallet

- Each section must **have 3” on each side** (front and back) free for the pallets to “hang over” the racking.
- This is a **OSHA* Standard**

*OSHA = Occupational Safety & Health Administration

Recap: Picking Method – Warehouse Layout *(Continued…)*

- This is an example of what happens when the racking does not have 3” on each side!
- A standard pallet is usually 40” wide by 48” deep
- Most pallets cannot be stacked higher than 60”

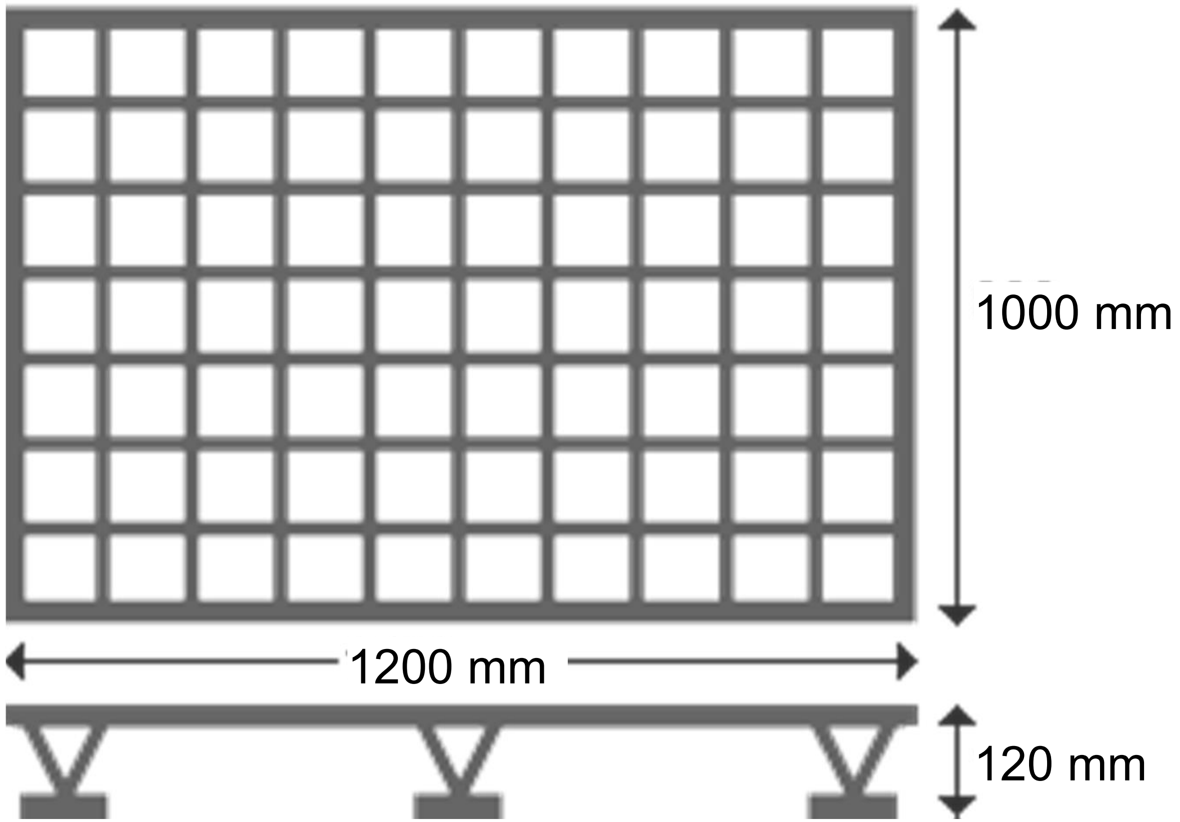
Pallet Storage Calculation

- This tool enables operators to calculate the number of pallets which can be stored within a particular cubic area.

- It works on the basis of calculating width, length and height modules within the warehouse.

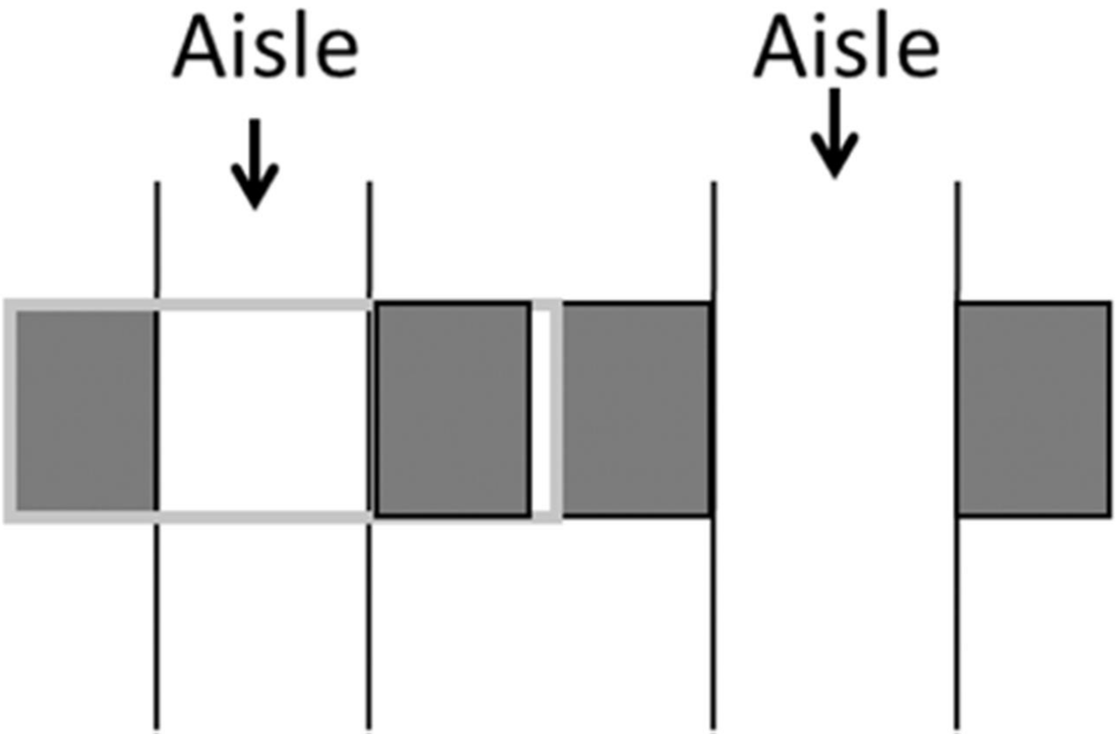
Pallet Dimension for 1200mm x 1000mm

- 1200 x 1000 mm pallet dimensions



Pallet Storage Calculation (Module Width)

➢ **Width of module**



The sequence is pallet – aisle – pallet – clearance

Pallet Storage Calculation (Module Width) *(Continued…)*

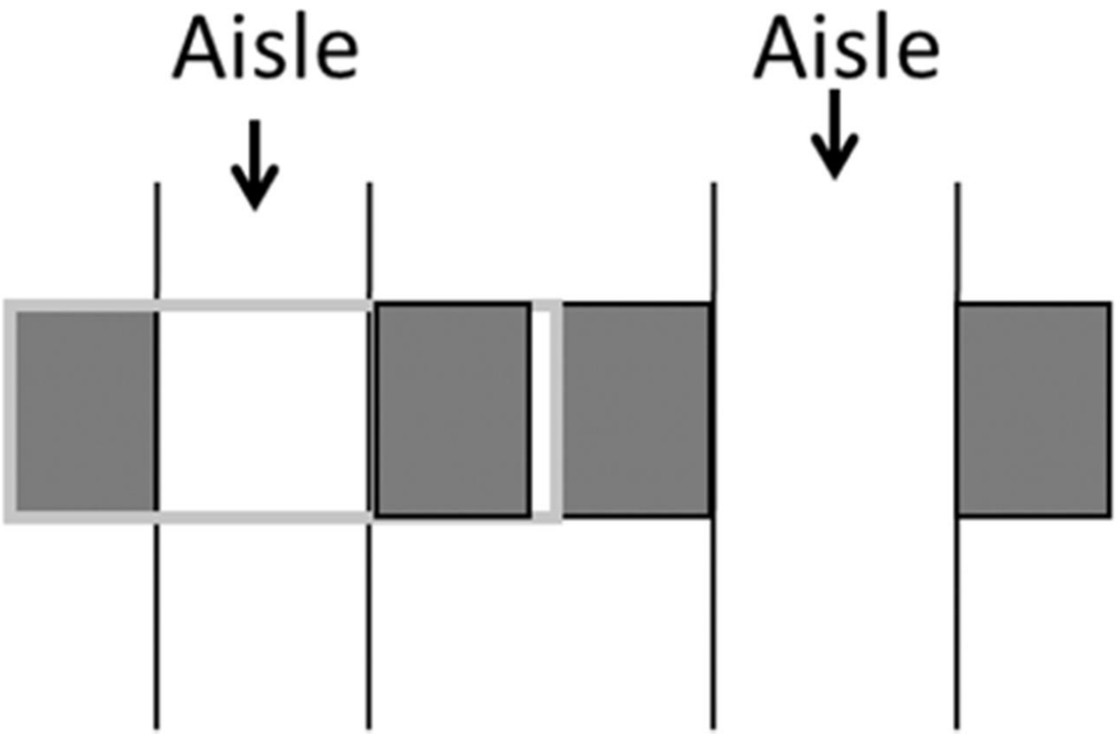
- A **module width** is calculated as follows:
  - **Module Width = Width of aisle + 2 Pallet Lengths (short side) + Clearance**

❖ **Example, given the following data:**

- Pallet size = 1200 mm × 1000 mm
- **Aisle = 2,500 mm** (variable with type of Mechanical Handling Equipment used)
- **Two pallets short side** = 2 × 1,000 mm = 2,000 mm
- **Clearance = 100 mm between back to back pallets**

Pallet Storage Calculation (Module Width)

- **Therefore, Width of module** = width of aisle + 2 pallet lengths (short side) + 100 mm = 4,600 mm



Pallet Storage Calculation (Module Length)

- A **module length** is calculated as follows:
  - **Module Length = Width of upright + Clearance + 2 Pallets (long side)**

- **Example, given the following data:**
  - Pallet size = 1200 mm × 1000 mm
  - **Two pallets long side** = 2 × 1,200 mm = 2,400 mm
  - **Clearance = 100 mm between back to back pallets**
  - **Rack upright plus clearance = (120 mm + 3 × 100 mm) = 420 mm**

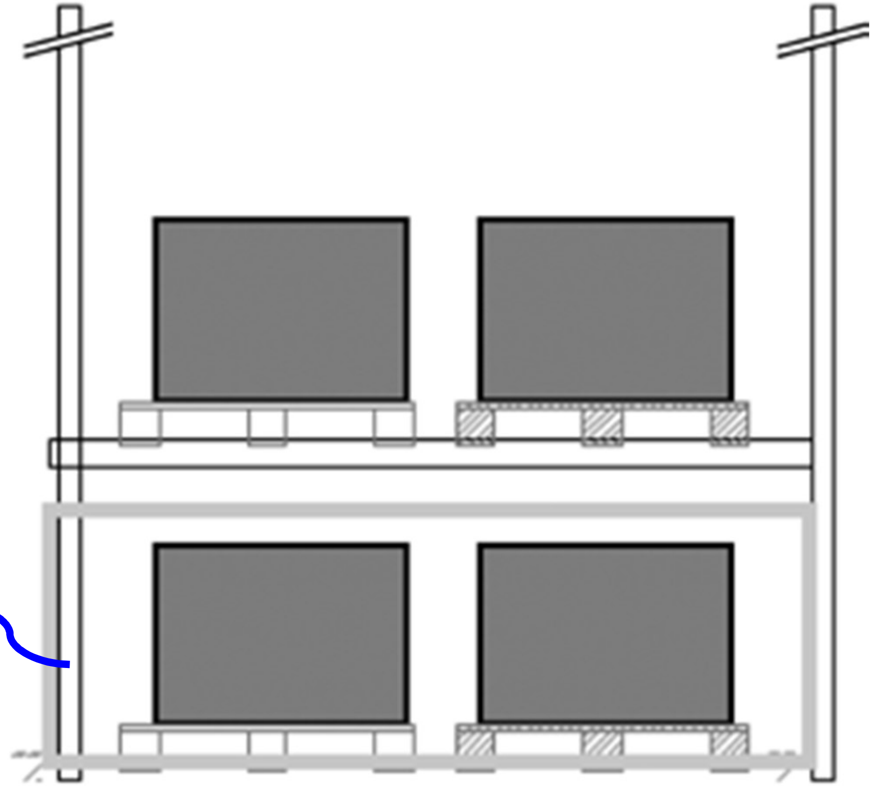
Width of one side of the rack

Pallet Storage Calculation (Module Length) *(Continued…)*

- Therefore, **Length of module** = [Width of upright + Clearance + 2 Pallets (long side)]

  = [120 mm + (3 × 100 mm)+ (2 × 1,200 mm)] = 2,820 mm.

Width of one side of the rack = 120 mm



The sequence is (upright–clearance – pallet – clearance – pallet – clearance)

Height of Module

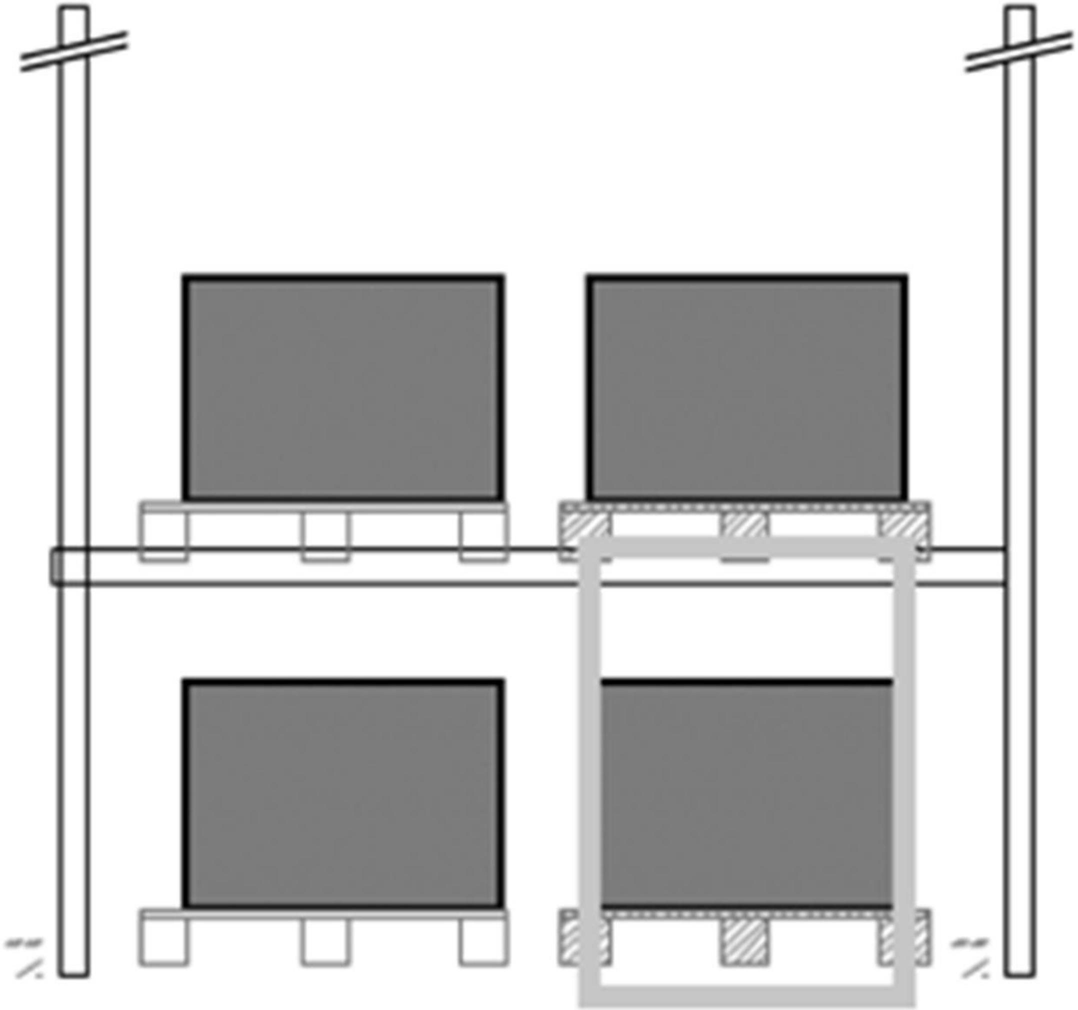
- **Module Height** = (Pallet height including the load height + Clearance above pallet + APR beam width)

  - Pallet height including the load height = 1,350 mm
  - Clearance above pallet = 150 mm
  - APR beam width of 140 mm

- Therefore, **Height of module** = (Pallet height including the load height + Clearance above pallet + **APR beam width**)

  = (1,350 mm + 150 mm+ 140 mm) = **1,640 mm**.

Height of Module *(Continued….)*



The sequence is (pallet and goods – clearance – beam height)

Total Number of Pallets

- **Total pallets stored** within cubic capacity of a warehouse section, excluding receiving and despatch areas, gangways and other areas **=**

(No. of width modules × pallets in module width) X (No. of length modules × pallets in module length) X (No. of height modules) = No. of pallets into cube volume of warehouse

Total Number of Pallets *(Continued…)*

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

  - Width calculation = 48 m/4.6 m = 10 modules

  - Length calculation = 120 m/2.82 m = 42 modules

  - Height calculation = 10 m/1.64 m = 6 modules

- Therefore total number of pallets **= (10 × 2) × (42 × 2) × (6) = 10,080** pallet located in this warehouse storage area.

Total Number of Pallets *(Continued…)*

- A number of free resources are available which can also calculate the no. of pallets that can be stored within a specific area

- UK example: http://www.redirack.co.uk/palletcalc.php

Layout

- Layout - The physical arrangement of human and capital resources
- Operation - A group of resources performing all or part of one or more processes
- Layout involves three basic steps
  1. Gather information
  2. Develop a block plan
  3. Design a detailed layout

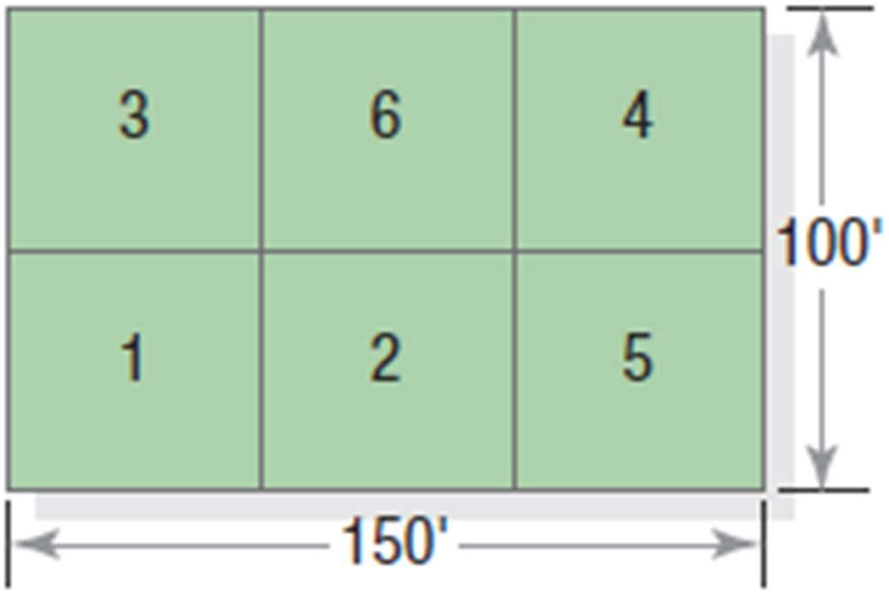
Layout

- Gather information on:
  - Space requirements
  - Available space
  - Closeness Factors

Department	Area Needed (ft^2)
1. Administration	3,500
2. Social services	2,600
3. Institutions	2,400
4. Accounting	1,600
5. Education	1,500
6. Internal audit	3,400
	Total 15,000

Layout

- Develop a Block Plan



Layout

- Use a Closeness Matrix

CLOSENESS FACTORS

Department	1	2	3	4	5	6
1. Administration	—	3	6	5	6	10
2. Social services		—	8	1	1	
3. Institutions			—	3	9	
4. Accounting				—	2	
5. Education					—	1
6. Internal audit						—

Layout

- **Euclidian distance is the straight-line distance between two possible points**

$$d_{AB} = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}$$

where

d_{AB} **= distance between points** ***A*** **and** ***B***
x_A **=** ***x*****-coordinate of point** ***A***
y_A **=** ***y*****-coordinate of point** ***A***
x_B **=** ***x*****-coordinate of point** ***B***
y_B **=** ***y*****-coordinate of point** ***B***

Layout

- **Rectilinear distance measures the distance between two possible points with a series of 90-degree turns**

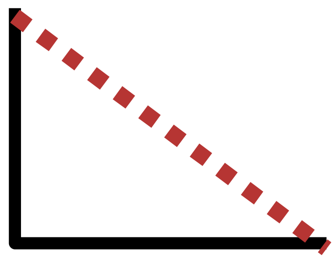
$$d_{AB} = |x_A - x_B| + |y_A - y_B|$$

Application 3.1

What is the distance between (20,10) and (80,60)?

Euclidian Distance

$$d_{AB} = \sqrt{(20-80)^2 + (10-60)^2}$$



$$= 78.1$$

Rectilinear Distance

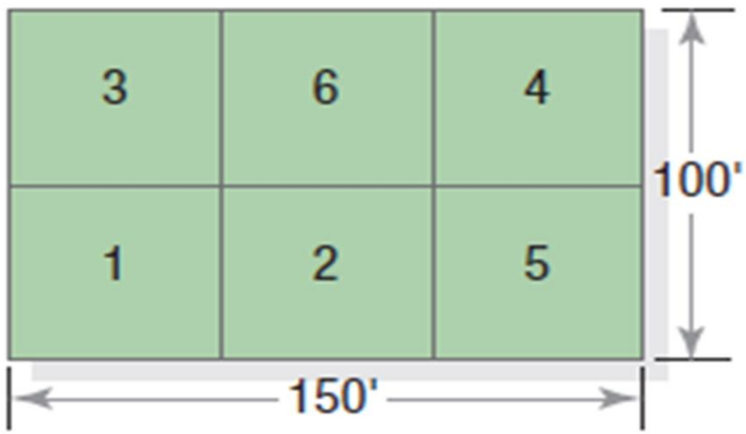
$$d_{AB} = |20-80| + |10-60| = 110$$

Example 3.1

Develop an acceptable block plan for the Office of Budget Management that locates departments with the greatest interaction as close to each other as possible.

CLOSENESS FACTORS

Department	1	2	3	4	5	6
1. Administration	—	3	6	5	6	10
2. Social services		—	8	1	1	
3. Institutions			—	3	9	
4. Accounting				—	2	
5. Education					—	1
6. Internal audit						—



Example 3.1

How much better is the proposed block than the current block plan?

The following table lists pairs of departments that have a nonzero closeness factor and the rectilinear distances between departments for both the current plan and the proposed plan

3	6	4
1	2	5

Current Block Plan

6	2	3
1	4	5

Proposed Block Plan

Example 3.1

Department Pair	Closeness Factor (*w*)	Current Plan: Distance (*d*)	Current Plan: Weighted-Distance Score (*wd*)	Proposed Plan: Distance (*d*)	Proposed Plan: Weighted-Distance Score (*wd*)
1, 2	3				
1, 3	6				
1, 4	5				
1, 5	6				
1, 6	10				
2, 3	8				
2, 4	1				
2, 5	1				
3, 4	3				
3, 5	9				
4, 5	2				
5, 6	1				

Example 3.1

		Current Plan		Proposed Plan	
Department Pair	Closeness Factor (*w*)	Distance (*d*)	Weighted-Distance Score (*wd*)	Distance (*d*)	Weighted-Distance Score (*wd*)
1, 2	3	1	3	2	6
1, 3	6	1	6	3	18
1, 4	5	3	15	1	5
1, 5	6	2	12	2	12
1, 6	10	2	20	1	10
2, 3	8	2	16	1	8
2, 4	1	2	2	1	1
2, 5	1	1	1	2	2
3, 4	3	2	6	2	6
3, 5	9	3	27	1	9
4, 5	2	1	2	1	2
5, 6	1	2	2	3	3
			Total 112		Total 82

Example 3.1

◉ Rectilinear Distances ○ Euclidean Distances

Department Pair	Closeness Factor	Distance	Score
1, 6	10	1	10
3, 5	9	1	9
2, 3	8	1	8
1, 3	6	1	6
1, 5	6	2	12
1, 4	5	3	15
1, 2	3	2	6
3, 4	3	2	6
4, 5	2	1	2
2, 4	1	1	1
2, 5	1	2	2
5, 6	1	3	3
		Total	80

6	2	4
1	3	5

Excel Solver evaluation of solution

1. A warehouse receives 40 loads per day. Each load contains 36 pallets. Each pallet is designated by 1000 mm × 1200 mm. In order to unload the vehicle 65 minutes is taken per load. To stage prior to put-away 40 minutes is taken per load. Assume 8 hours per day work shift determine:

- dock space required for the loads, and
- total space required considering working and travel area within the warehouse.

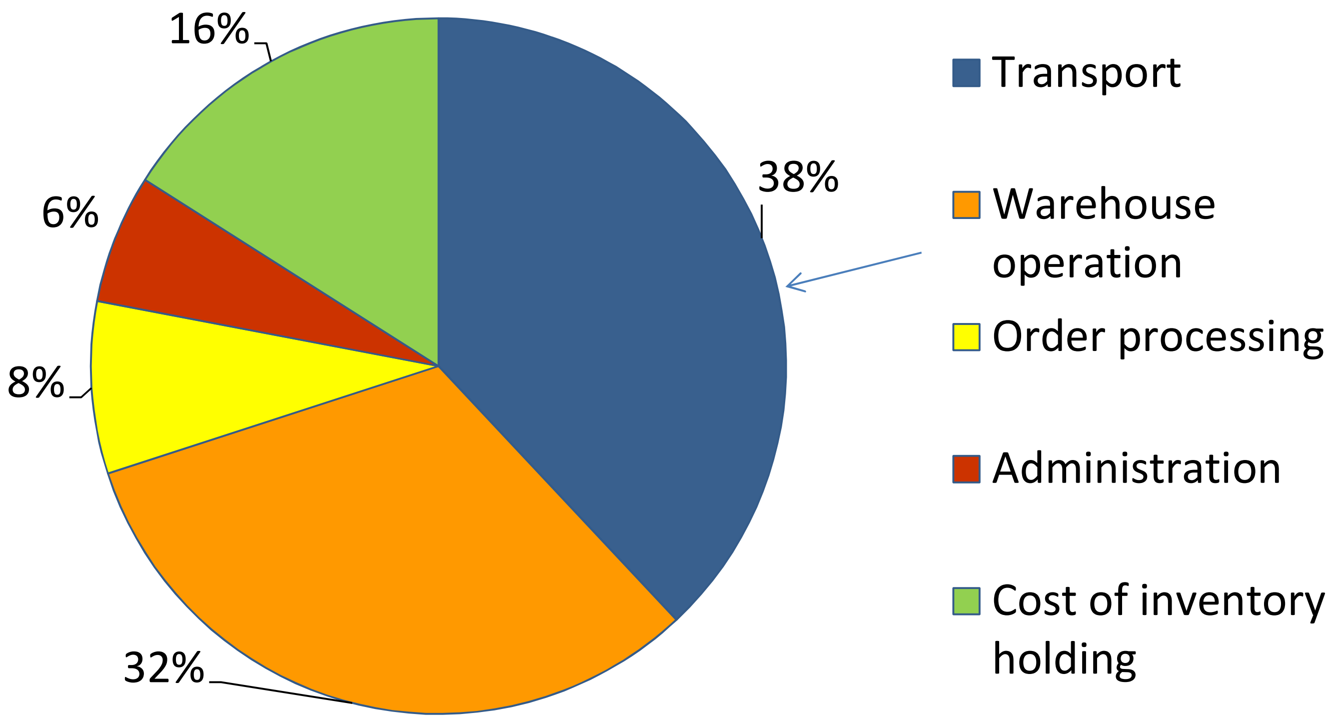
2. ISO pallets having dimension of 1200 x 1000 mm each are used in one warehouse. It is given that the width of the aisle between the racks is given as 2000 mm. Width of one side of the rack is given as 120 mm. Adjustable pallet beam width is 140 mm. The clearance above the pallet is 200 mm. Pallet including the load height is 1400 mm. Assume a standard clearance of 150 mm between back to back pallets.

-
- Calculate the module width.
- Calculate the module length.
- Calculate the module height.
- Calculate the total number of pallets required within the cubic capacity of the warehouse excluding receiving and dispatch areas, gangways and other areas. Assume the warehouse section is having a width of 60 metres, a length of 145 metres and a height of 12 metres.

Warehouse Costs

Section 9

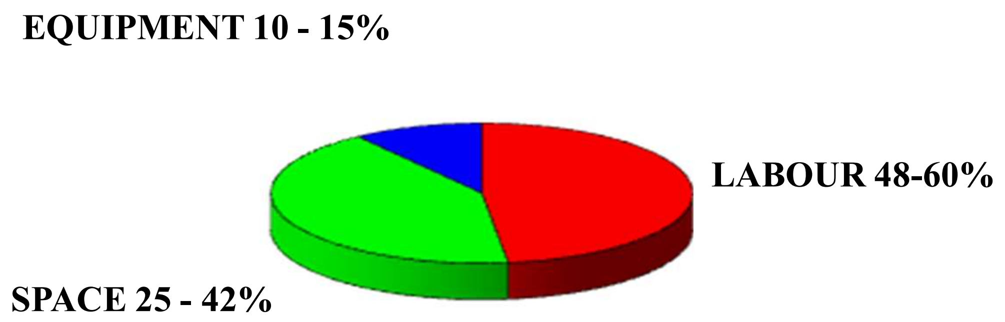
Logistics – Cost factors



Holding cost includes loss, obsolescence, interest, insurance and d

Warehouse costs

UK Chartered Institute of Logistics and Transport Survey stated that between 24% and 35% of Logistics costs relate to warehouse activity and can be between 2% and 5% of the cost of sales.



Warehouse Costs

A Labour

Salary, Overtime, NHI, Pension, insurance, PPE, holiday pay, sick pay, training

Agency labour

B Equipment

Fork lift truck lease or rental, depreciation and interest, maintenance, energy

Automated equipment depreciation and interest

Cleaning equipment, stretch-wrap machines

Scanners, voice units, pick to light systems depreciation and interest

Pallets and packaging material

C Storage

Facility - lease, rent or depreciation and interest, rates, taxation, insurance, maintenance, landscaping, cleaning, security, sprinkler depreciation and maintenance, alarms, pest control, waste disposal

Equipment – Rack and shelving depreciation, maintenance, inspection

D Utilities

Heat, air conditioning, lighting, water

E Overheads

Management, supervision, administration, office equipment depreciation and interest, IT hardware and software rental or depreciation and interest, maintenance, training, communication costs, legal and professional, taxation and licences, travel expenses, insurance and claims, claim losses due to damages, shortages, errors

Variable costs

Methods of allocating costs

- Traditional
  - Overhead allocation by %

- Activity Based Costing

Traditional costing methods

Traditional costing models tend to allocate overhead costs arbitrarily.
The following table shows a typical warehouse cost structure.

Space Costs	**1,677,000**
Space as a % of total warehouse cost	*54%*
Direct Labour costs	**1,200,000**
Labour as a % of total warehouse cost	*39%*
Equipment costs	**215,000**
Equipment as a % of total warehouse cost	*7%*
Total Direct costs	**3,092,000**
Overheads costs	**742,000**
TOTAL COST	**3,834,000**
Overhead as a % of direct cost	**24.00%**

Exercise – Calculation of rates

- **<u>Data</u>**
- **Warehouse capacity – 2,000 pallets**
- **Average occupancy – 75%**
- **Stock turnover – Every 4 weeks**

- **<u>Costs</u>**
- **Storage costs - £46,800 per annum**
- **Handling costs - £140,400 per annum**
- **Overhead costs - £100,000 per annum**
- **Profit required – 10% per activity**

1. **Calculate the average stockholding**
2. **Calculate the average number of pallets received and despatched each week**
3. **Calculate the handling charge per pallet inbound and outbound inc O/H and profit**
4. **Calculate the storage charge per occupied pallet per week inc O/H and profit**

Answer

1. Stockholding - 75% of 2,000 = 1500

2. Stock throughput – 13 turns (52/4) = 19,500
   Weekly despatch – 19,500/52 = 375

3. Total warehouse cost excl. Overhead and profit = £187,200
   Overhead allocation – storage = £46,800/£187,200 = 25%
   Therefore overhead allocation - handling = 75%

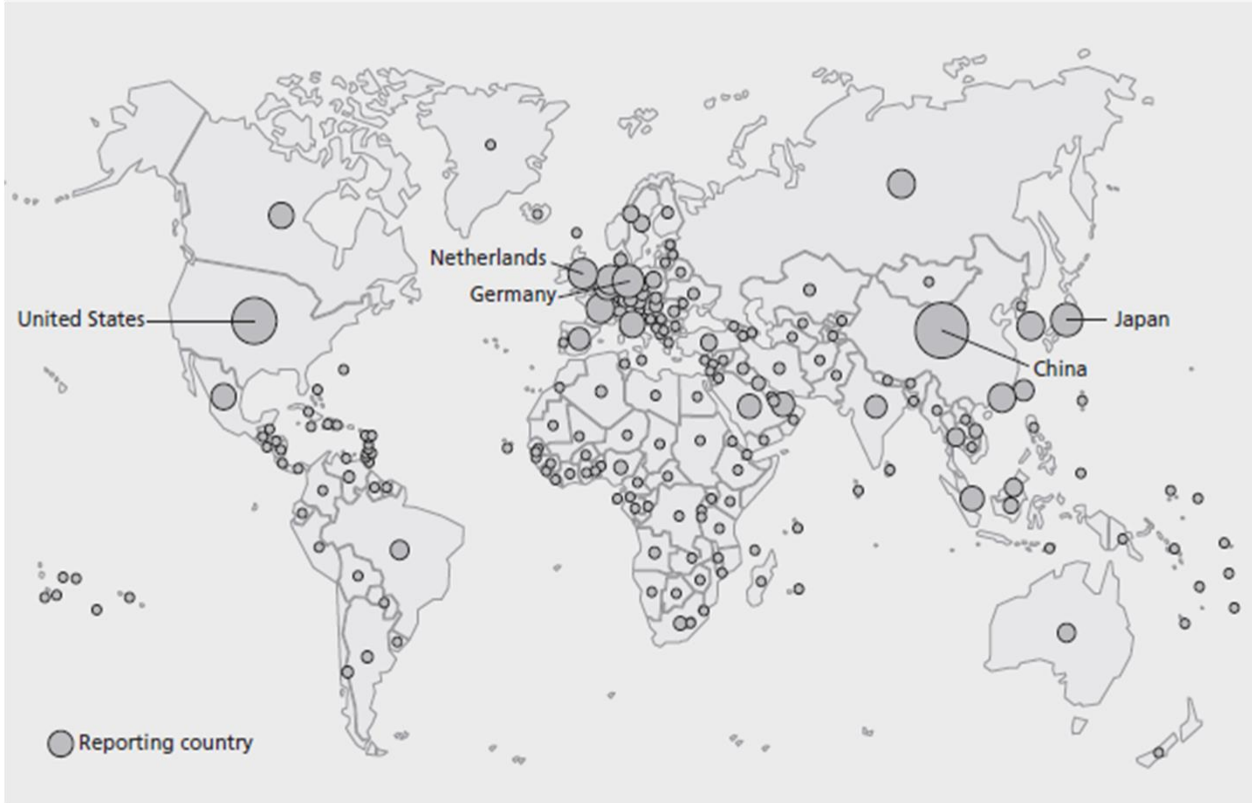
   Handling charge = (£140,400 + £75,000) + 10% = £236,940
   RH&D Charge per pallet = £236,940/19,500 = £12.15

4. Storage charge = (£46,800 + £25,000) + 10% = £78,980
   Charge per pallet per week = £78,980/52/1500 = £1.01

GLOBAL SUPPLY CHAINS: THE ROLE AND IMPORTANCE OF TRANSPORTATION

Export-Trade Flows of Merchandise

FIGURE 1-1 Export-Trade Flows of Merchandise



Economy	Million US Dollars
China	2,209,626.00
United States	1,578,971.70
Germany	1,452,795.40
Japan	715,097.20
Netherlands	663,524.30
France	579,646.90
Korea, Republic of	559,632.00
United Kingdom	541,348.00
Hong Kong, China	535,546.00
Russian Federation	523,327.00
Italy	517,673.30
Belgium	468,817.80

Import-Trade Flows of Merchandise

FIGURE 1-2 Import-Trade Flows of Merchandise

Economy	Million US Dollars
United States	2,329,059.80
China	1,949,992.00
Germany	1,188,883.80
Japan	833,166.10
France	681,016.00
United Kingdom	655,318.60
Hong Kong, China	622,276.40
Netherlands	589,768.10
Korea, Republic of	515,586.00
Italy	477,391.50
Canada	474,270.00
India	466,042.10
Belgium	450,706.00

The Economic Basis and Logic of Improved Global Trade

- Absolute advantage
  - Access to certain materials or products not available domestically
- Comparative advantage
  - Differences in the cost of producing products in different countries

Contributing Factors for Global Flows and Trade

1. Population size and distribution
2. Urbanization
3. Land and resources
4. Technology and information
5. Globalization

Population = Labor

TABLE 1-4 Top Ten Countries With the Highest Population

	COUNTRY	2000 POPULATION	2010 POPULATION	2014 POPULATION	2050 EXPECTED POPULATION
1	China	1,268,853,362	1,330,141,295	1,355,692,576	1,303,723,332
2	India	1,004,124,224	1,173,108,018	1,236,334,631	1,656,553,632
3	United States	282,338,631	310,232,863	318,892,103	439,010,253
4	Indonesia	213,829,469	242,968,342	253,609,643	313,020,847
5	Brazil	176,319,621	201,103,330	202,656,788	260,692,493
6	Pakistan	146,404,914	184,404,791	196,174,380	276,428,758
7	Nigeria	123,178,818	152,217,341	177,155,754	264,262,405
8	Bangladesh	130,406,594	156,118,464	166,280,712	233,587,279
9	Russia	146,709,971	139,390,205	142,470,272	109,187,353
10	Japan	126,729,223	126,804,433	127,103,388	93,673,826
	Top Ten	3,618,894,827	4,016,489,082	4,176,380,247	4,950,140,178
	Rest of the world	2,466,012,769	2,829,120,878	3,005,478,372	4,306,202,522
	Total	6,084,907,596	6,845,609,960	7,181,858,619	9,256,342,700
	Internet world stats, Usuge and Population Statistics				
	Miniwatts Marketing Group				

Image courtesy of Gijsbert Koren

Urbanization

- The rise of "megacities" – By 2030, 60% of the world's population will live in urban areas (vs. 47% in 2000)
- Change most rapid in underdeveloped countries – Urban sustainability challenges

Land and Resources

Crop & forest Land

Water

Food

Energy

Critical role of technology in mitigating resource scarcity

Image courtesy (left to right) of NRCS (USDA), U.S. Chamber, Agricultural Law blog, and Glacial Energy

Technology and Information *(continued)*

- Technological "Game Changers"

The Internet

Industrial robotics

Digitization of manufacturing – Additive manufacturing or 3-D printing

Image courtesy (top to bottom) of U.S. BLS, Gizmag, and 3dprint

Globalization

Globalization (Economic integration) → Increased global flows of goods & services (Comparative advantage) → Global Interdependence

- <u>Benefits</u> (Macro-level view)
  - Lower prices
  - Wider availability of goods and services
  - Land and resource development
  - New employment opportunities
  - BRIC and VISTA countries

<u>Challenges</u> (Micro-level view)
- Increased level of complexity and competition
- Shorter product life cycles
- New forms of competition
- New business models

Development of Supply Chain Concept

1990s Supply Chain Management

The extended enterprise or boundary spanning perspective, focusing on system of connected networks between the original vendor and the ultimate final consumer

1980s Business Logistics / Integrated logistics

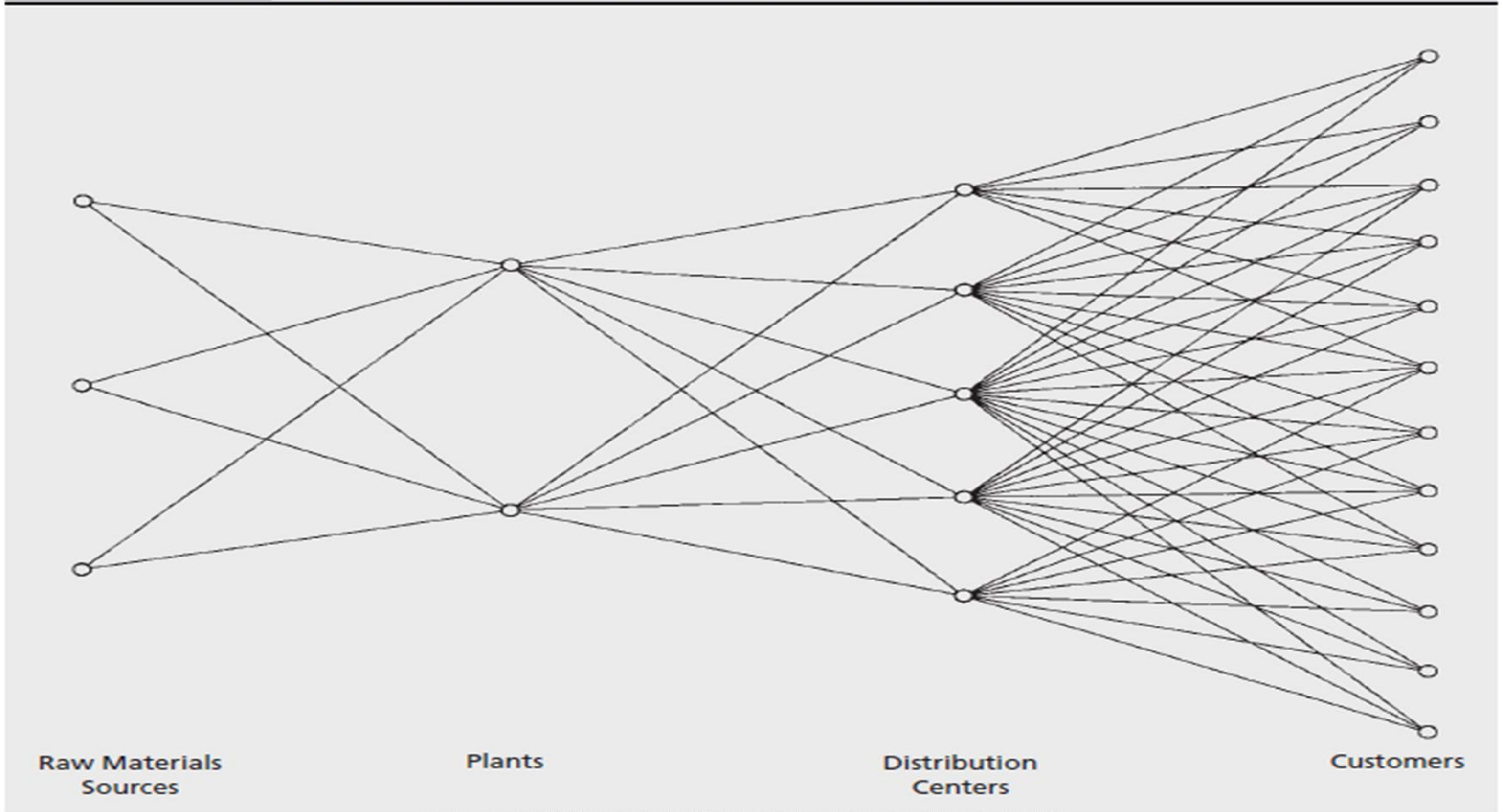
Focus on coordination between the outbound and the inbound sides of logistics, analyzing both trade-offs for total cost and the value of demand aspects of customer service effectiveness

1960s Physical Distribution

Focus on system costs and trade-off among transportation, inventory levels, warehousing, protective packaging, materials handling, and customer service

Logistics Network

FIGURE 1-6 Typical Logistics Network—Materials Management



Product/Service Flows

Image courtesy of AST&L

- Product flow is directly dependent on effective transportation for timely, reliable, and damage-free product delivery to customers.

- Importance of reverse logistics systems for returning products
  - Different network designs (location, size, and layout of facilities)
  - Growing number of specialized logistics and transportation service providers

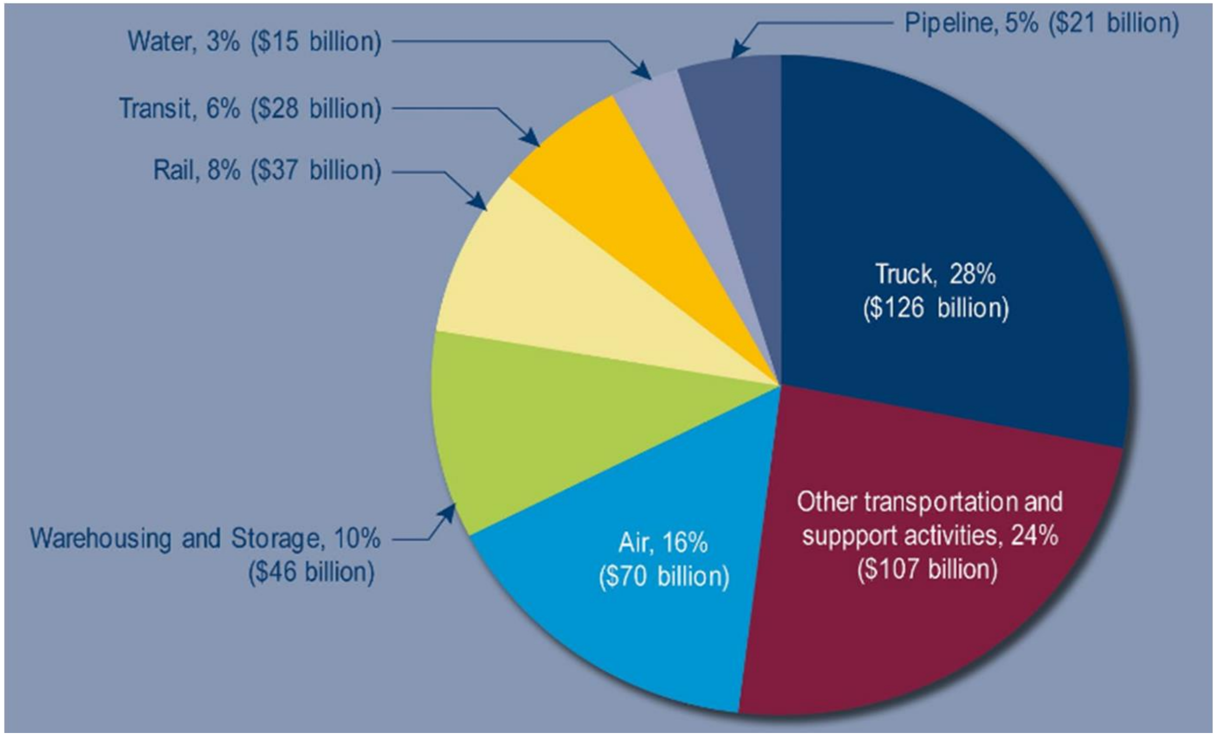
Information Flows

- Demand or sales data as a trigger or signal for the logistics or supply chain system to respond to a customer order
- Long intervals between orders create demand uncertainty, resulting in higher inventory (safety stock) or stock out costs
- The "bull whip effect" phenomenon

Order variability increases with the "distance" from the market or customer even when customer demand does not vary.

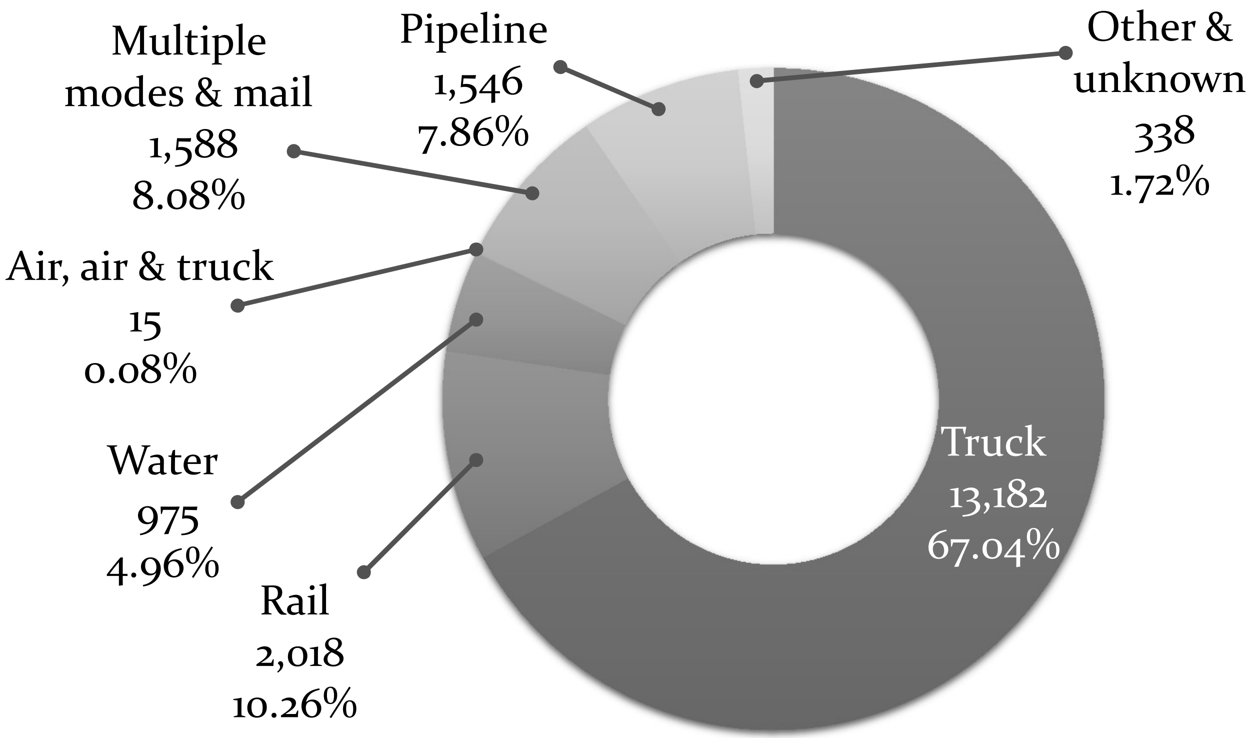
Transportation Importance to GDP

For-Hire Transportation Services Contribution to GDP by Mode: 2011



Source: Freight Facts and Figure 2013, Figure 4-1

Freight Transport Modal Split by Weight
(Millions of Tons, 2012)



Source: Freight Facts and Figure 2013, Table 2-1. Weight of shipments by mode

Value of Transportation Service

The impact of transportation costs and service on the demand for the product

Landed Cost Example

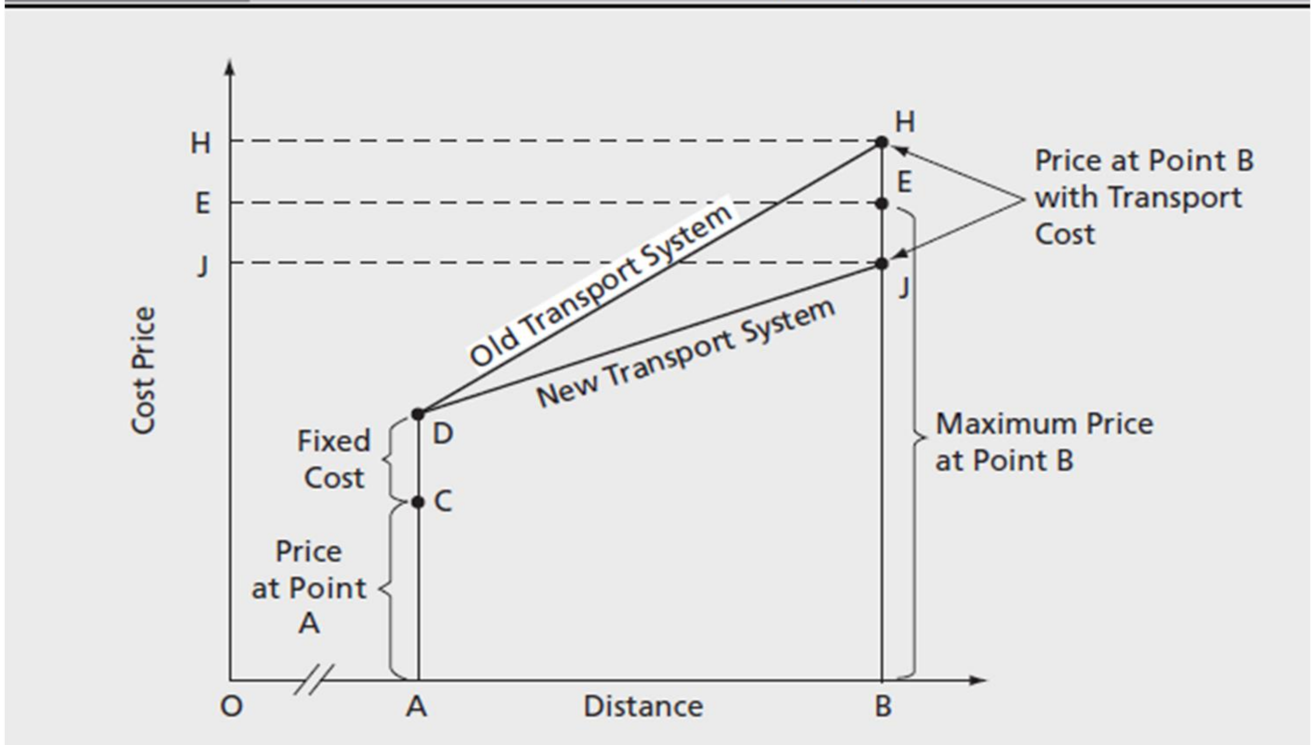
1 + 2 + 3 + 4 + 5 + 6 = 7

1. Production cost of overseas supplier
2. Overseas warehouse & transport costs
3. Export tariffs
4. International freight transportation costs
5. Import duties
6. Buyer warehouse & transport costs
7. Landed costs at buyer facility

Adapted based on image courtesy of Transways

Landed Cost Impact on Value of Goods

FIGURE 2-4 Landed Cost with Old and New Transport Systems



Adapted based on image courtesy of Transways

Utilities of Transportation

Place utility

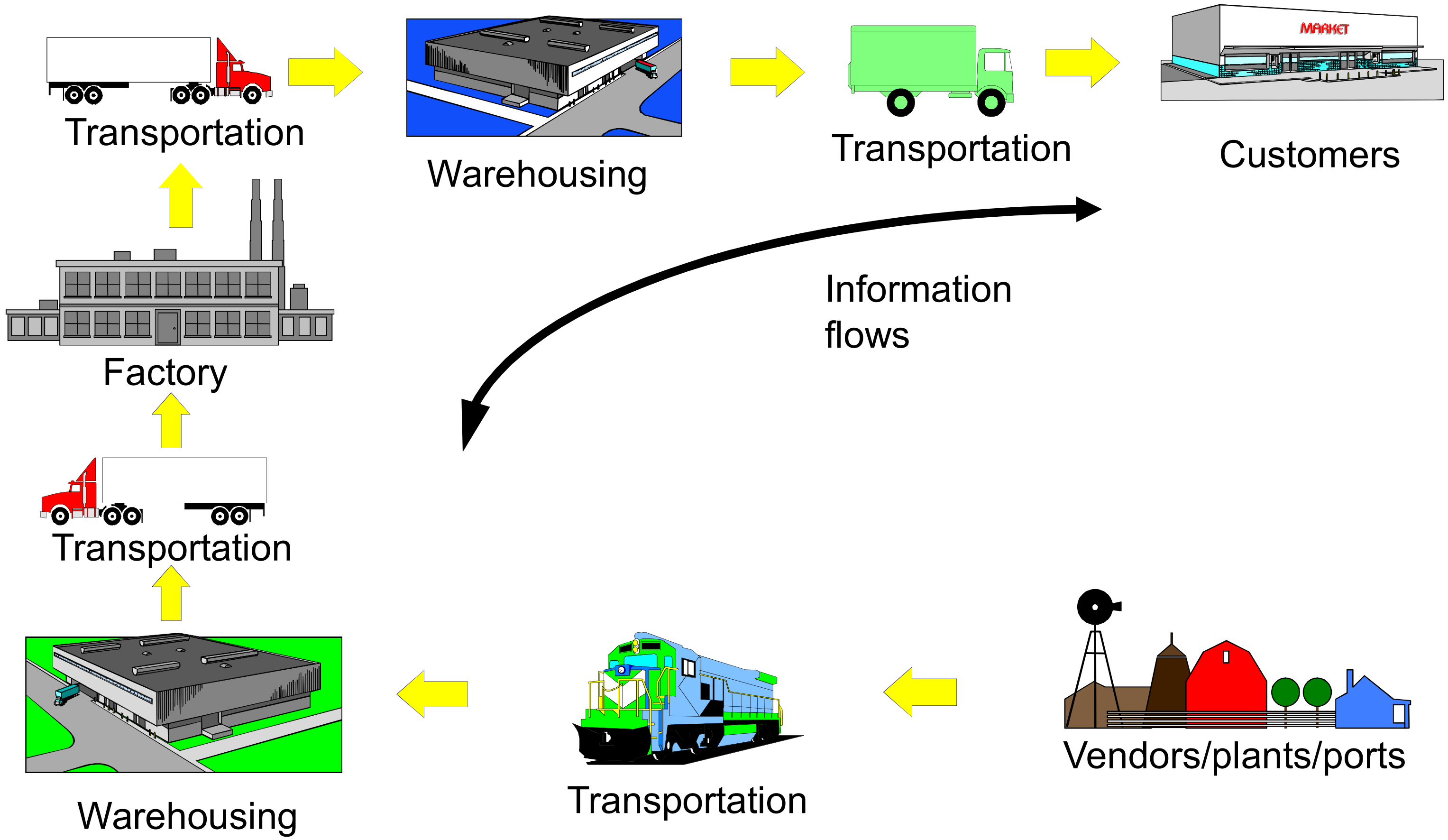
Time utility

Quantity utility

Cost utility of large-scale production

Logistics and Supply Chains – An Overview

Distribution Channel overview



Distribution Channels

What is a distribution channel?

A set of interdependent organizations (intermediaries) involved in the process of making a product or service available for use or consumption.

Channel decision

- Can affect other marketing decisions or logistics and supply chain strategies
- Involve long term commitments

Role of Intermediaries

- Greater efficiency in making goods available to target markets
- Intermediaries provide
  - Contacts
  - Experience
  - Specialization
  - Scale of operation
- Match supply and demand

Logistics – Definition

Informal definition

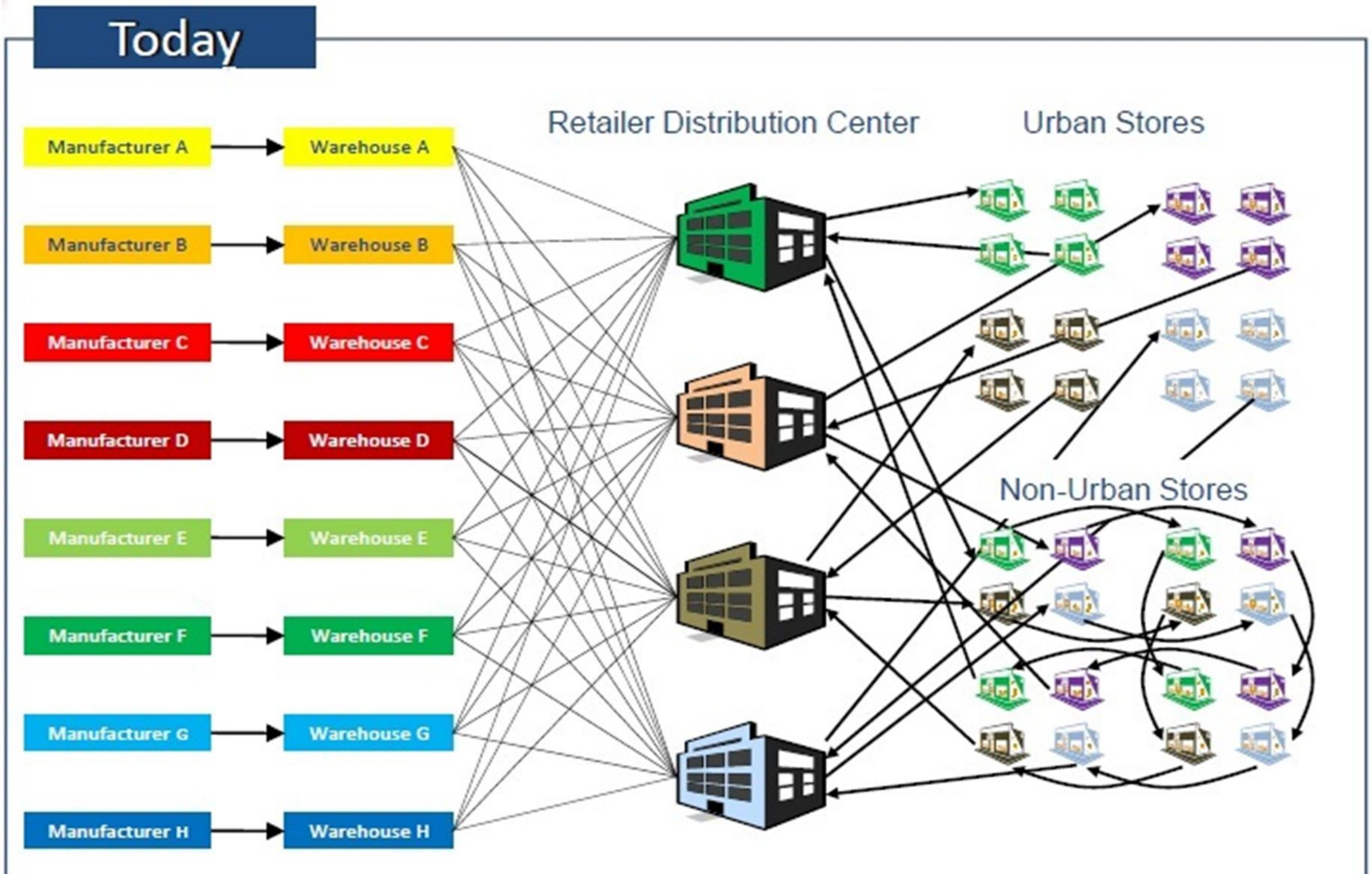
Organise the provision of resources (e.g. raw materials, equipment) and their movement to where they are needed

Formal definition

"The task of coordinating material flow and information flow across the supply chain to meet end-customer needs."

Source: Harrison, A., and van Hoek, R. (2011), Logistics Management and Strategy: Competing through the supply chain, Fourth Edition, Pearson.

What is a Supply Network?

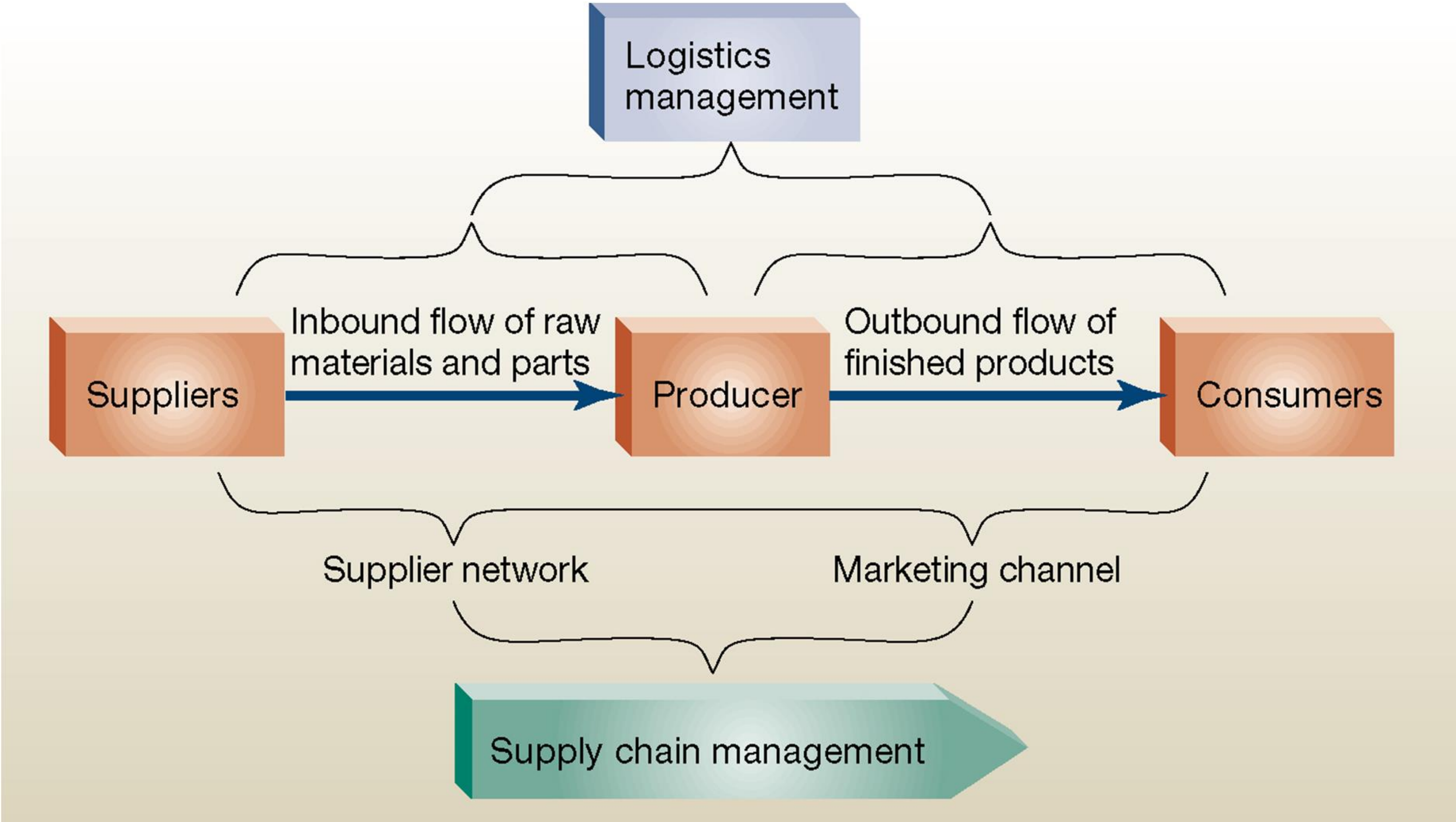


Logistics: A Better Definition

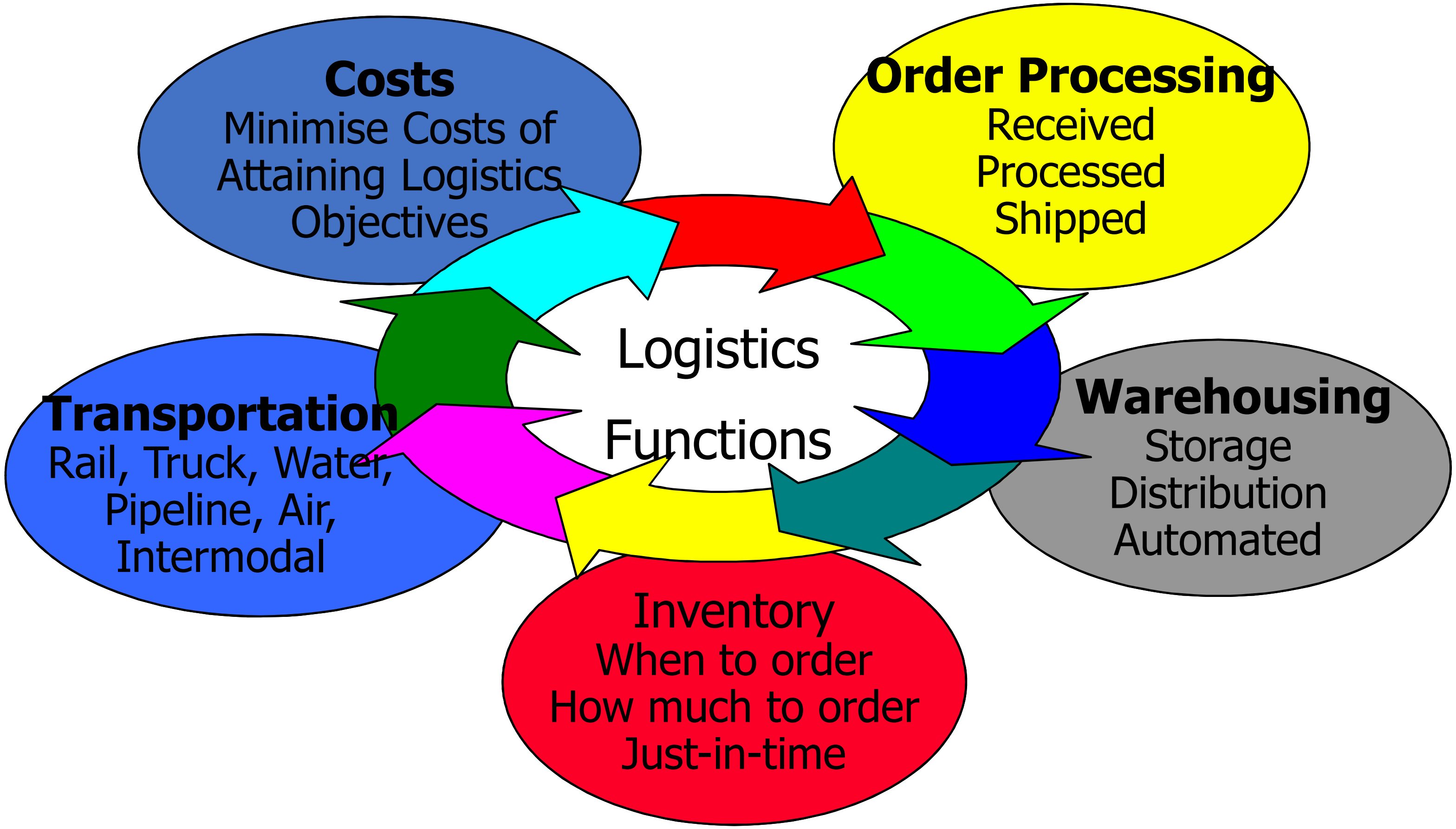
"Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability are maximised through the cost-effective fulfilment of orders."

Source: Christopher, M. (2011), *Logistics & Supply Chain Management*, Fourth Edition, Pearson.

Distribution channels, Logistics & Supply Chain management



Logistics Functions



- **Design logistics system to minimise costs of attaining objectives**

Logistics / Distribution Channel Mission

Getting the *right goods* or *services* to the *right place*, at the *right time*, and in the *desired condition* at the lowest cost and highest return on investment.

Five “Right”s of Logistics

- Right Items, needed for consumption or production,
- Right Place
- Right Time
- Right Condition
- Right Cost

Transportation Modes

Rail
Nation's largest carrier, cost-effective for shipping bulk products

Truck
Flexible in routing & time schedules, efficient for short-hauls of high value goods

Water
Low cost for shipping bulky, low-value goods, slowest form

Pipeline
Ship petroleum, natural gas, and chemicals from sources to markets

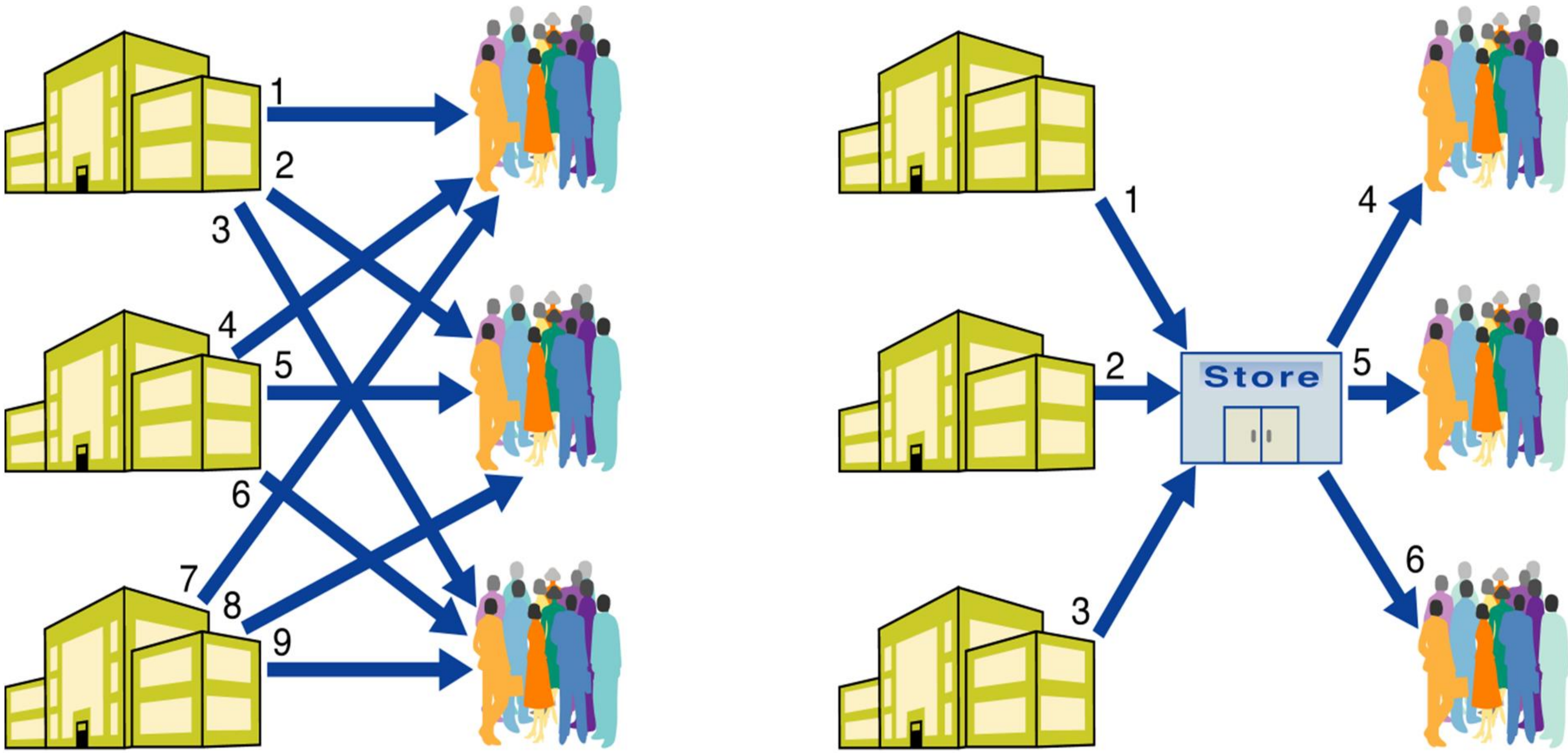
Air
High cost, ideal when speed is needed or to ship high-value, low-bulk items

Transportation Modes: Advantages and disadvantages

MODE	RELATIVE ADVANTAGES	RELATIVE DISADVANTAGES
Rail	• Full capability • Extensive routes • Low cost	• Some reliability, damage problems • Not always complete pickup and delivery • Sometimes slow
Truck	• Complete pickup and delivery • Extensive routes • Fairly fast	• Size and weight restrictions • Higher cost • More weather sensitive
Air	• Fast • Low damage • Frequent departures	• High cost • Limited capabilities
Pipeline	• Low cost • Very reliable • Frequent departures	• Limited routes (accessibility) • Slow
Water	• Low cost • Huge capacities	• Slow • Limited routes and schedules • More weather sensitive

Checklist for Choosing Transportation Modes

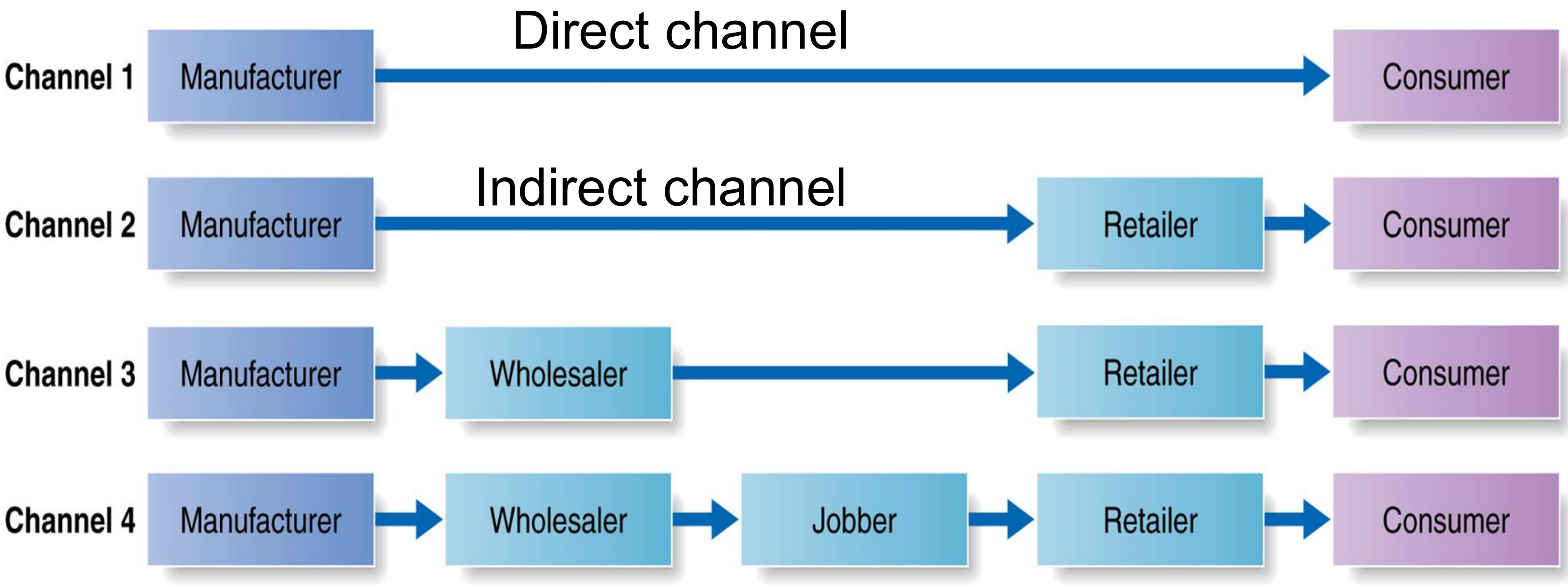
Marketing Intermediary reduces the number of distribution channel transactions



A. Number of contacts without a distributor
$M \times C = 3 \times 3 = 9$

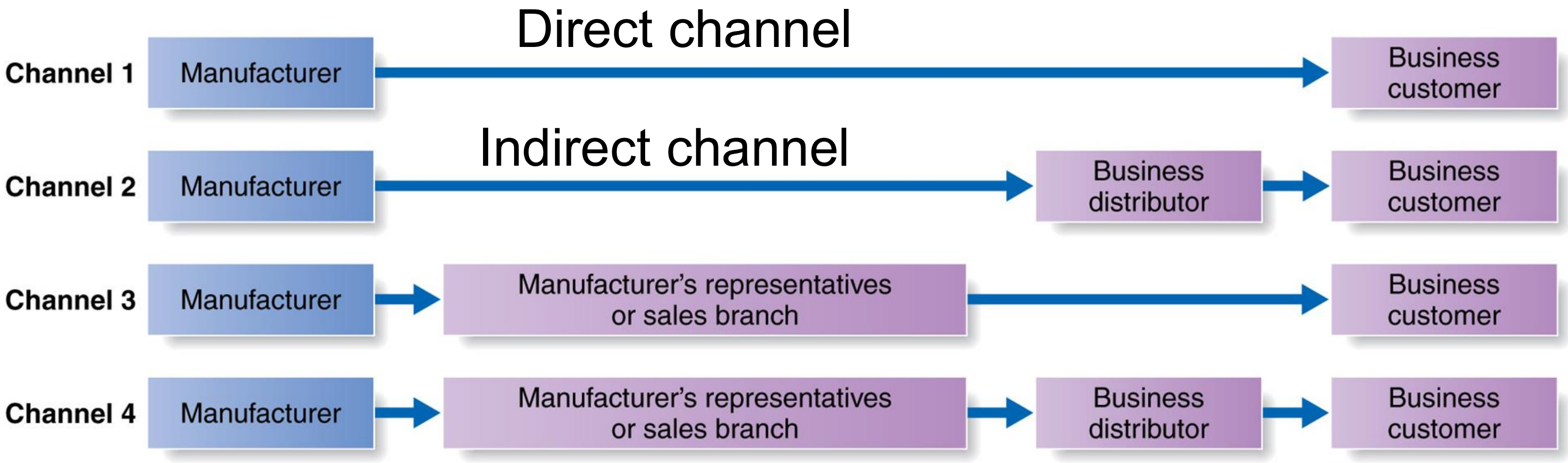
B. Number of contacts with a distributor
$M + C = 3 + 3 = 6$

Consumer Distribution Channels



A. Consumer marketing channels

Business Marketing Channels



B. Business marketing channels

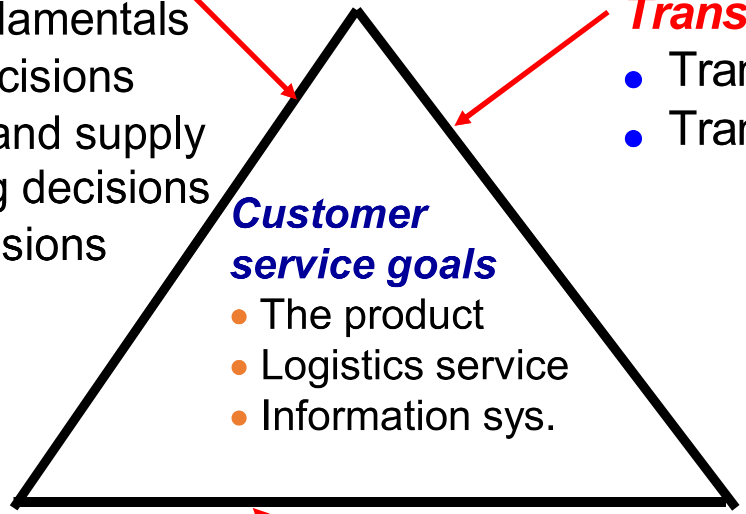
Decision-Making Areas in Logistics

Decision area	*Strategic*	*Tactical*	*Operational*
Transportation	Mode selection	Seasonal equip-ment leasing	Dispatching
Inventories	Location, Control policies	Safety stock levels	Order filling
Order processing	Order entry, transmittal, and processing system design		Processing orders, Filling back orders
Purchasing	Development of supplier-buyer relations	Contracting, Forward buying	Expediting
Warehousing	Handling equipment selection, Layout design	Space utilization	Order picking and restocking
Facility location	Number, size, and location of warehouses		

The Logistics Strategy Triangle (4 problem areas)

Inventory Strategy
- Forecasting
- Storage fundamentals
- Inventory decisions
- Purchasing and supply scheduling decisions
- Storage decisions

Transport Strategy
- Transport fundamentals
- Transport decisions



Location Strategy
- Location decisions
- The network planning process

Shipping Transaction

❖ **Freight:** The transported material

- ❖ **Shipper / Consignor / (Freight) Originator:** The shipping party
- ❖ **Consignee / Freight Receiver:** The receiving party
- ❖ **Carrier:** The firm that provides the transportation service
- ❖ **Freight bill-of-lading (freight bill):** A document serving as a contract between the shipper and the carrier, specifying the obligations of both parties. In particular, it specifies:

https://www.youtube.com/watch?v=YVD4v-pIRdA

- – The Consignee
- – The **FOB (free-on-board) point,** i.e., the point where the freight changes ownership (origin or destination)
- – The **FOB terms-of-sale**
  - Who arranges for transport and carrier
  - Who pays for transport (collect, prepaid, prepaid and charged back)
  - FOB point
  - Loss & Damage terms and potential insurance

https://www.youtube.com/watch?v=ae9oVibkBZ4

Freight Types

- **Bulk cargo:** Cargo that is stowed loose on transportation vehicles, a tank or hold without any packaging; handled by pump, scoop, conveyor or shovel. Examples: grain, coal, petroleum and chemicals.
- **Break-bulk cargo:** Cargo in between bulk and containerized, that must be handled piece-by-piece by terminal workers; often stored in bags or boxes and stacked on **pallets**.
- **Containerized cargo:** Cargo filling an entire container that is handled as a single unit.
- **Container:** A single, rigid, sealed, reusable metal box in which freight is shipped by vessel, truck or rail. Usually 8x8 ft in width & height, 20 to 55 ft long. Some container types include: standard, high cube, hard top, open top, ventilated, insulated, refrigerated, etc.

Dunnage: Wood and packaging materials used to keep cargo in place inside a container or transportation vehicle.

https://www.youtube.com/watch?v=rJEz7jszEBI

Freight Units

- Freight is typically measured by **weight**:
  - Short ton (American) 2000 lbs
  - Long ton (English) 2240 lbs
  - Metric ton 2204.6 lbs (1000 kgs)
- or sometimes by **cube**, i.e., volume.

- Transportation equipment (vehicles, vessels, etc.) has pre-specified weight and volume capacities; e.g.,
  - **Deadweight:** The number of long tons that a vessel can transport of cargo, supplies and fuel.
  - **TEU (Twenty-foot Equivalent Unit):** Method for specifying a vessel load or capacity in units of containers that are 20ft long. (e.g., a 3000 TEU vessel can accommodate - at most - 1500 numbers of 40ft containers).
  - **FEU (Forty-foot Equivalent Unit)**
  - **Slot:** A place for a container onboard a container ship (typically, one TEU).

Carrier Types

- **Private carrier:** Owned and operated by a shipper. Usually refers to private trucking fleets. More advantageous solution for high density / short distance or special-need shipments.(e.g., Safeway)

- **Common carrier:** A for-hire carrier providing services to general public.

Carrier Types *(Continued…)*

- Parcel / express carriers (UPS, FedEx, TNT, DHL)
- LTL (Less Than Truckload) Trucking (Yellow, Consolidated Freightways)
- LCL (Less than Container Load) https://www.youtube.com/watch?v=C0J4AlMmelg
- FTL (Full Truck Load) trucking (Hunt, Schneider)
- CL (Container Load)
- Rail carrier (Norfolk Southern)
- Air carriers (Delta, Flying Tigers)
- Ocean carrier (SeaLand, American President Lines)
  - Liner Shipping: vessels sailing between ports on regular schedule, which is published and available to public.
  - Tramp shipping: Vessels calling at different ports upon availability of cargo (used primarily for bulk shipping)
- Pipeline

Mediators and Integrators

- **Freight forwarder:** An agency that receives freight from the shipper and then arranges for transportation with one or more carriers for transport to the consignee. Typically, consolidates freight from many shippers to obtain better rates. Also, often provide pickup and delivery services, as well as other shipping services: packaging, temporary storage, customs clearing.
- **Transportation Broker:** An agency that obtains negotiated large-volume transportation rates from carriers and resells this capacity to shippers. No additional services are provided, though.
- **NVOCC (Non Vessel-Operating Common Carrier):** Owns no vessels, but provides ocean shipping freight-forwarding services.
- **Shipper's Association:** Not-for-profit association of shippers using collective bargaining and freight consolidation to obtain lower, high-volume transportation rates. Avoids premium charge paid to forwarders. Only non-competitive shippers may associate, due to monopoly restrictions.
- **3PL:** A third-party, or contract, logistics company, used to outsource logistics services. It can also handle: Purchasing, Inventory management/warehousing, transportation and order management (e.g., Schneider Logistics, Ryder Logistics, UPS Logistics)

http://www.uaesa.ae/

- **Integrators:** Companies providing door-to-door domestic and international air- freight service. Owns and operate aircraft as well as ground delivery fleet of trucks (e.g., UPS, FedEx, Emery Worldwide).

Transportation Systems

- **Direct Shipping:** Shipment travels directly from consignor to consignee. Used primarily for TL shipping.

- **Dead-head:** A portion of a transportation trip in which no freight is conveyed – an empty move.

- **Hub-and-spoke:** Large hub terminals are employed for freight consolidation. Medium-volume services are used for spoke-to-hub collection and hub-to-spoke distribution. Air freight, parcel shipping, LTL and, more recently, ocean shipping is organized in this manner.
- **Pickup and delivery (cartage):** Local hauling of freight
- **Longhaul (or Linehaul):** Terminal-to-terminal freight movements
- **Milk runs:** A vehicle route in which a truck delivers (picks up) freight from (for) a single terminal to (from) a number of consignees.
- **Interline / Intermodal shipment:** Shipment employing more than one carrier / transportation mode.

Charging Patterns for Common Carriers

- **Related to shipment size**
  - **LTL and LCL shipments**: Minimum total rate for quantities below a minimum threshold, then several weight categories with different rates.
  - **TL and CL shipments**: Rate depends only on equipment size ordered.
  - **Time-volume rates**: Encourages shippers to send minimum quantities regularly, in an effort by carriers to ensure regular flow of business.

Charging Patterns for Common Carriers *(Continued…)*

❖ **Related to distance**

- **Uniform rates:** Independent of distance (e.g., USPS priority mail)
- **Proportional rates:** Fixed rate + variable rate per distance (truckload rates)
- **Tapered rates:** Increase with distance but at decreasing rate (air transportation)
- **Blanket rates:** Constant rates for certain intervals of distance (e.g., UPS rates, bulk cargo).

Factors affecting the choice of Mode and Carrier

- ❑ Door-to-door cost
- ❑ Loss and damage: likelihood
- ❑ Loss and damage: claims handling
- ❑ Transit time reliability
- ❑ Rate negotiation experiences
- ❑ Shipment tracking / tracing
- ❑ Door-to-door transit time
- ❑ Pickup / delivery service quality
- ❑ Single-line service availability (no interlines)
- ❑ Equipment availability

Motor Carrier

The Development of the Motor Carrier Industry

Images courtesy of Forbes

- Started around World War I, when converted automobiles were used for pickup and delivery in local areas.
- The interstate system of highways developed from the 1950s to 1991.
- Motor carriers steadily replaced railroads as the mode of choice for freight transportation.
- Dominant mode of freight transportation today.

The Significance of the Motor Carrier Industry

9.4 billion tons

Transported by motor carriers in 2012

68.5%

Of the total domestic movements by motor carriers in 2012

6.9 million people

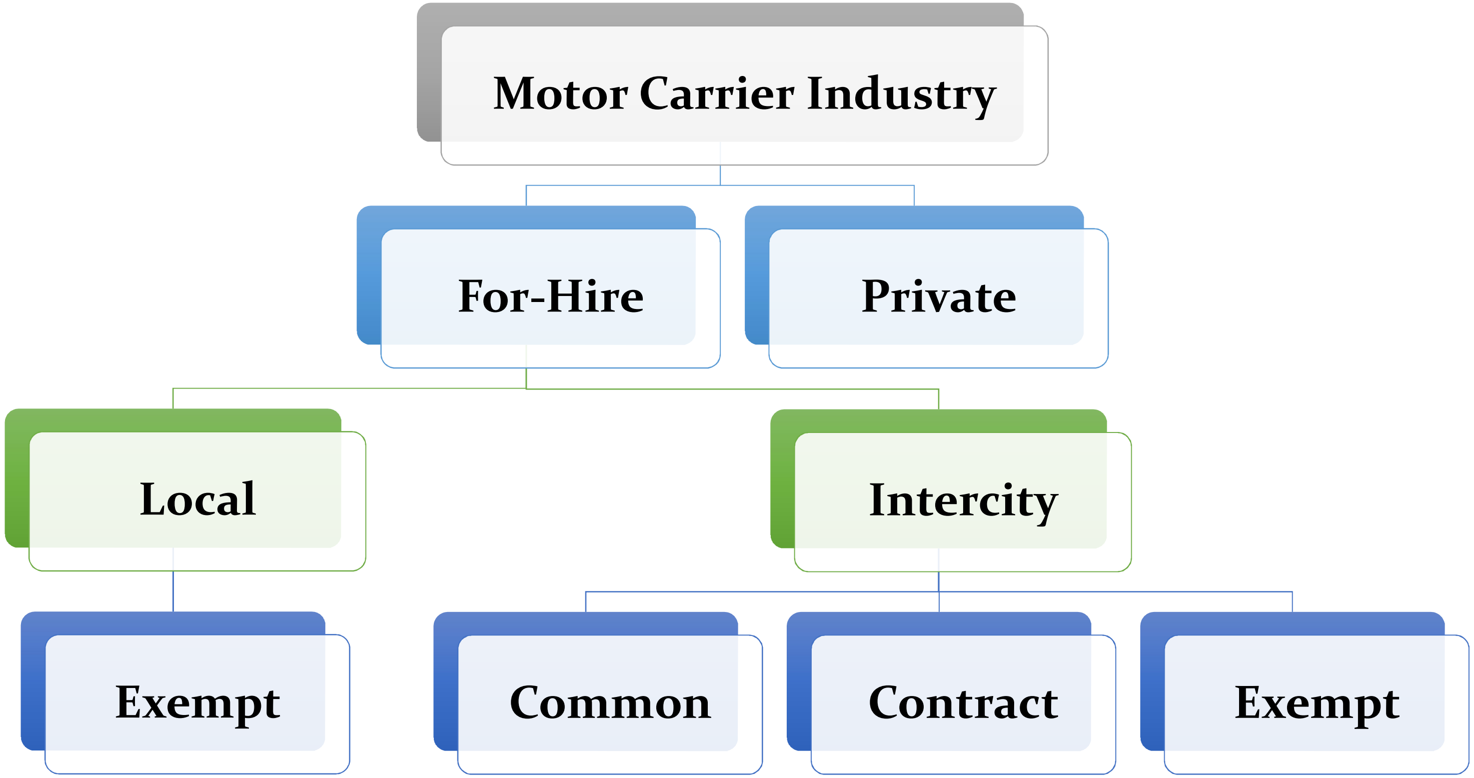
Employed in the motor carrier industry in 2011

397.8 billion miles

Travelled by motor carriers for business purposes in 2010

Types of Motor Carriers

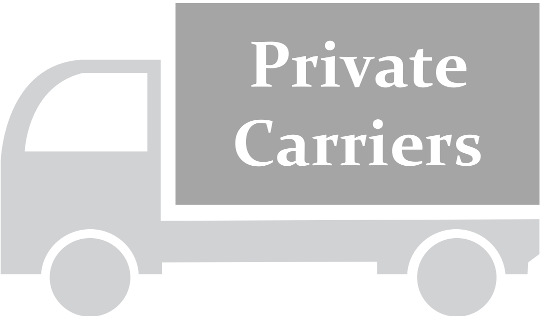
Types of Motor Carriers



Types of Motor Carriers

For-hire vs. Private Carriers

- Provide services to the public.
- Charge a fee for the service.

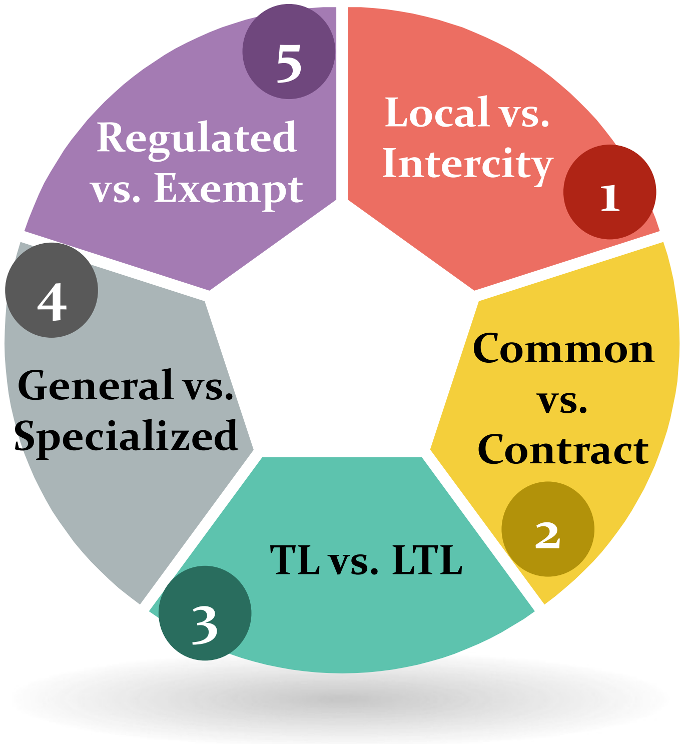


- Provide a service to the industry or company that owns or leases the vehicles.
- Do not charge a fee, but incur cost.
- Transport commodities for hire as exempt for-hire carriers.

Images courtesy of (left to right) Vintage Wall, NPTC

Types of Motor Carriers

Classification of For-hire Carriers

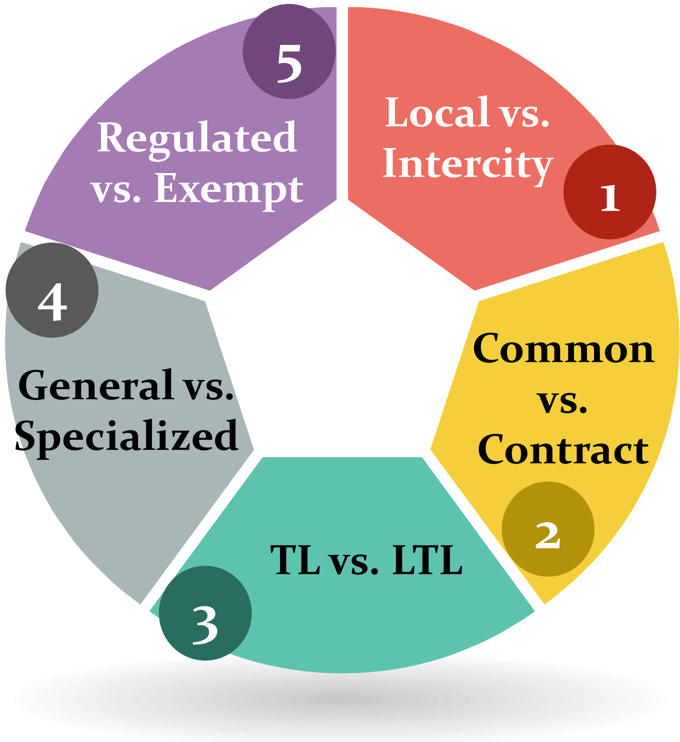


1

* Local carriers pick up and deliver freight within the commercial zone of a city.
* Intercity carriers operate between specifically defined commercial zones.
* Local carriers and intercity carriers often work in conjunction.

Types of Motor Carriers

Classification of For-hire Carriers *(continued)*

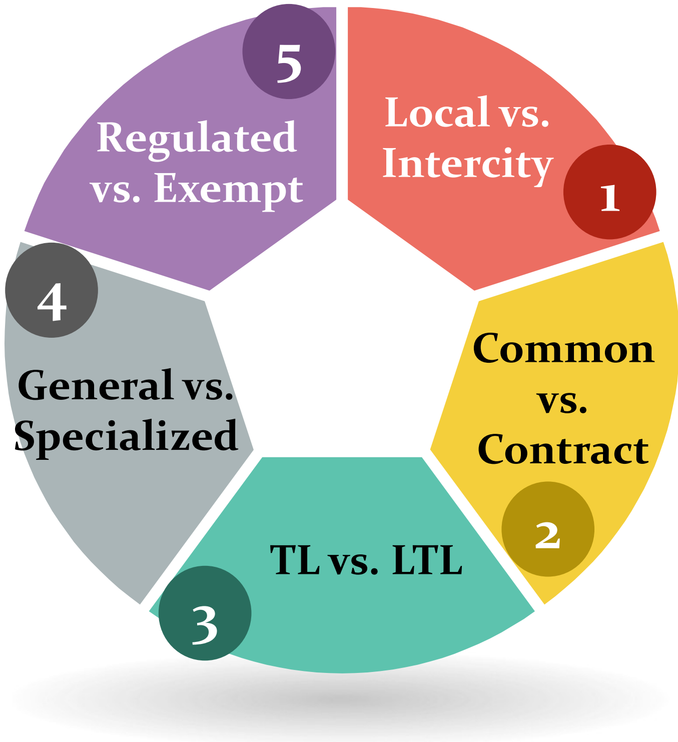


2

- Common carriers are required to serve the general public upon demand, at reasonable rates, and without discrimination.
  - Further classified by the type of commodity authorized to haul
- Contract carriers serve specific shippers with whom the carriers have a continuing contract.
  - Dedicated carriage over "dedicated" regular routes

Types of Motor Carriers

Classification of For-hire Carriers *(continued)*

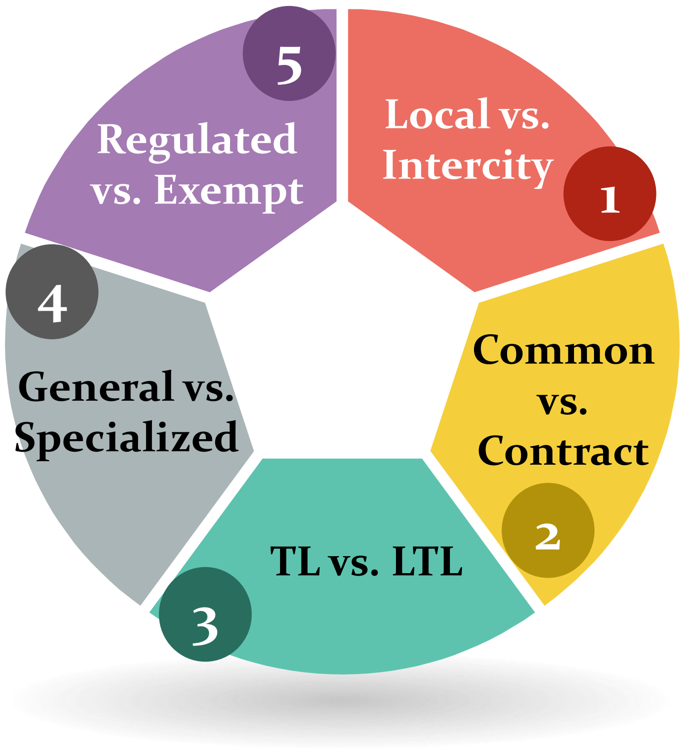


3

- TL carriers provide service to shippers who tender sufficient volume to meet the minimum weights required for a truckload shipment.
- LTL carriers provide service to shippers who tender shipments lower than the minimum truckload quantities
  - "Heavy LTL" motor carriers (upper end of LTL shipments)

Types of Motor Carriers

Classification of For-hire Carriers *(continued)*

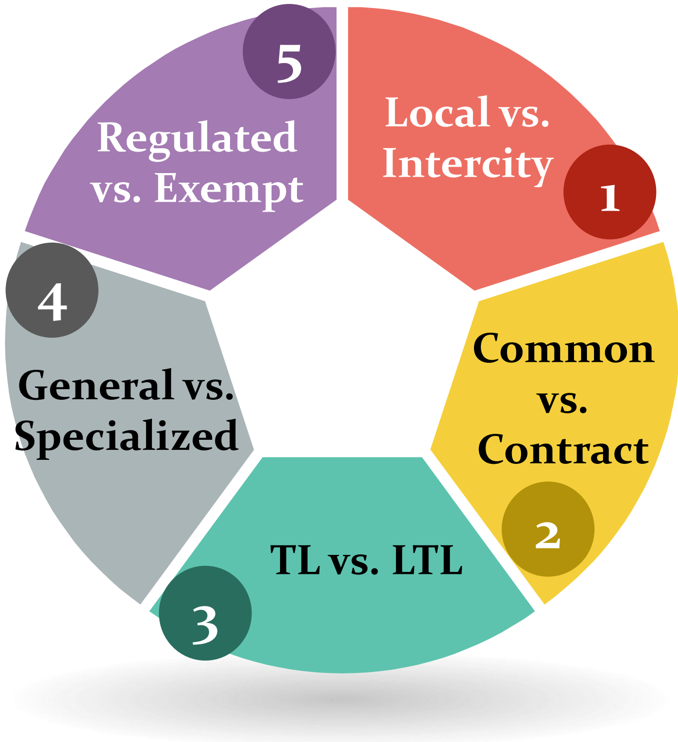


4

- Specialized motor carriers haul a special commodity such as:
  - Odd-sized and/or heavy freight
  - Liquids products
  - Freight requiring controlled temperature
  - Hazardous materials

Types of Motor Carriers

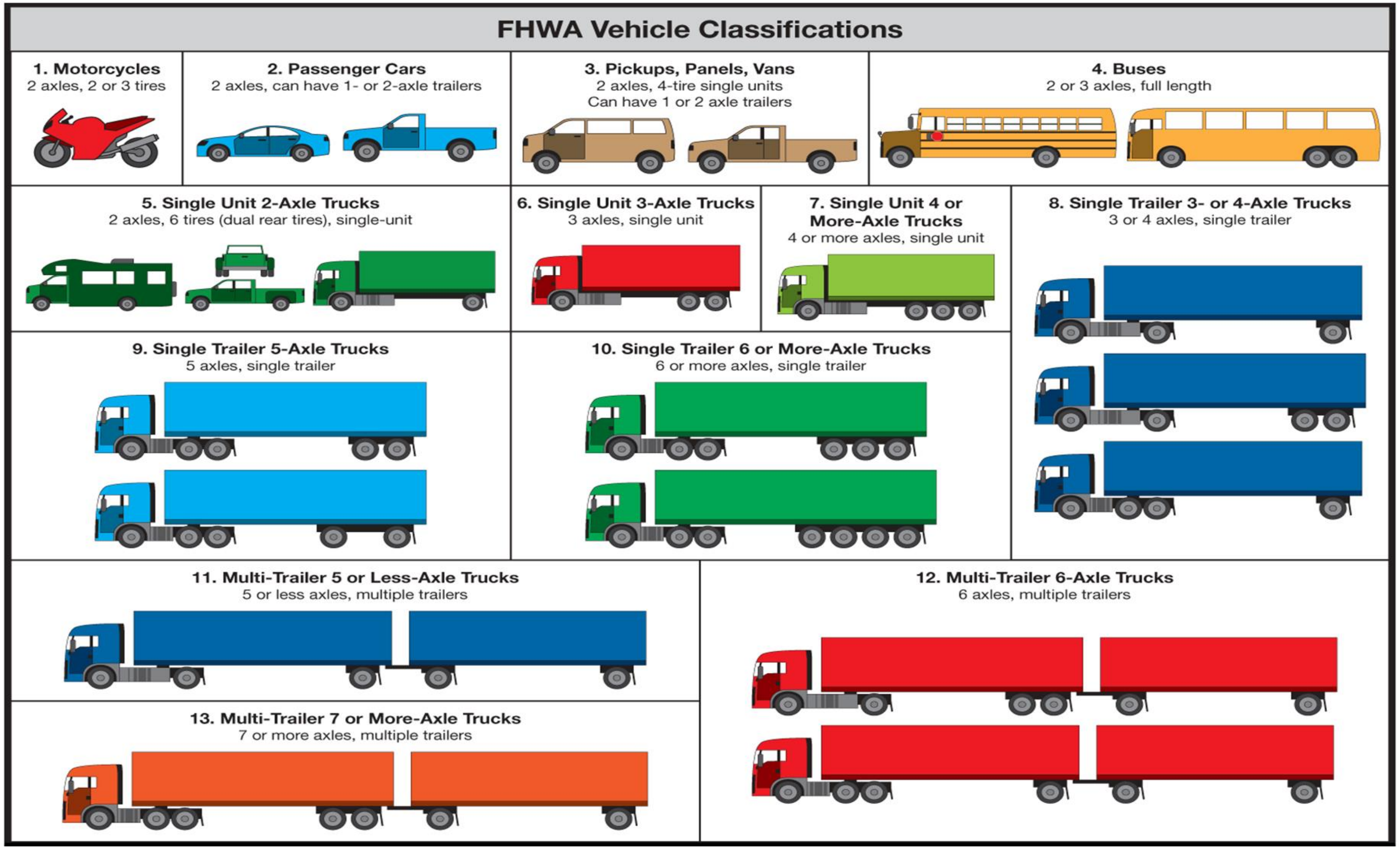
Classification of For-hire Carriers *(continued)*



5

- An exempt for-hire motor carrier transports exempt (unregulated) commodities owned by others for compensation.
- The exempt commodities usually include unprocessed or unmanufactured goods, fruits and vegetables, and other items of little or no value.

Source: Federal Motor Carrier Safety Administration



Images courtesy of Texas Department of Transportation

Operating and Service Characteristics:

Special vehicles designed to meet special shipper needs.

Dry van: Standard trailer or straight truck with all sides enclosed.

Tank trailer: Used to haul liquids like petroleum products.

Open top: Trailer top is open to permit loading through the top.

Refrigerated vehicles: Cargo unit has controlled temperature.

Flatbed: Trailer has no top or sides, used extensively to haul steel.

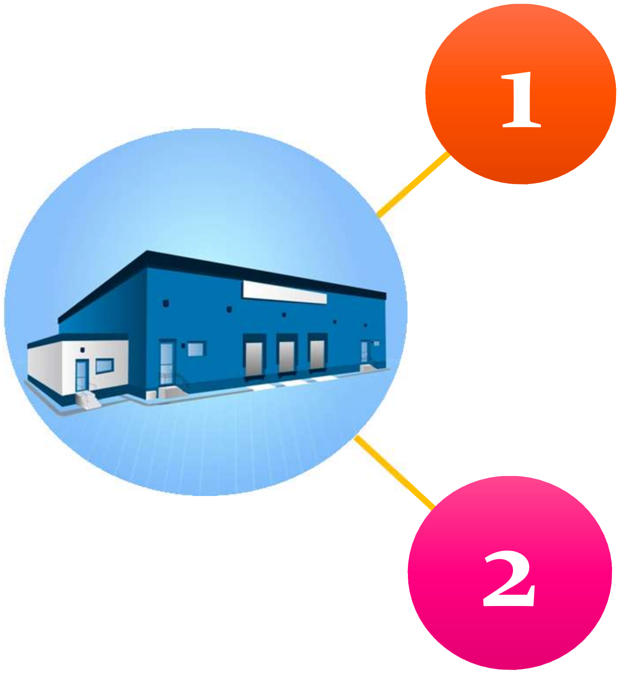
High cube: Cargo unit is higher than normal to increase cubic capacity.

Images courtesy of (left to right/top to bottom) BDJ Trucking, Distribution Unlimited, Doc's Trucking, Overdrive, Xpress2, GM

Operating and Service Characteristics:
Terminals

- **Pickup and Delivery Terminals** (PUD), also called satellite or end-of-the-line (EOL) terminals, most commonly found in the LTL hub-and-spoke system .
- **Break-bulk Terminals,** commonly found in the LTL hub-and-spoke system .
- **Relay Terminals** necessitated by the maximum hours of service regulation that is imposed on drivers.

Operating and Service Characteristics:
Terminal Management Decisions



- **Number of Terminals**
  - The degree of market penetration and customer service desired
  - Terminal size vs. peddle run distance tradeoffs
- **Location of Terminals**
  - Hours-of-service regulation
  - Consideration of backhauls between terminals
  - Market penetration and customer service desired

Current Issues

1. Safety
2. Technology
3. LTL Rates
4. Financial Stability

Drivers of Carbon Emissions and Reduction Potentials

Part of supply chain	Driver of emissions	Ways to reduce emissions (examples)
Ocean transportation	• Volume moved • km covered	• Higher container utilisation • Use of more eco-friendly carriers
Air transportation	• kg moved • km covered	• Air to Sea-Air conversion
Port moves	• Number of containers	• Higher container utilisation • 20' to 40' conversion
Domestic distribution	• Transportation mode (truck vs. rail) • km covered • Volume moved	• Higher utilisation of delivery trucks/vans • Double-decker trailers • Increased use of rail • Use of bio-fuel
Warehousing	• Number of days in warehouse • Number of CBM	• Reduce safety stock • DC bypassing

Calculating the "Carbon Footprint" for ocean shipping

$$CO_2 \text{ Emissions} = \text{Distance} \times \text{No. of TEU} \times \text{Emission Factor}$$

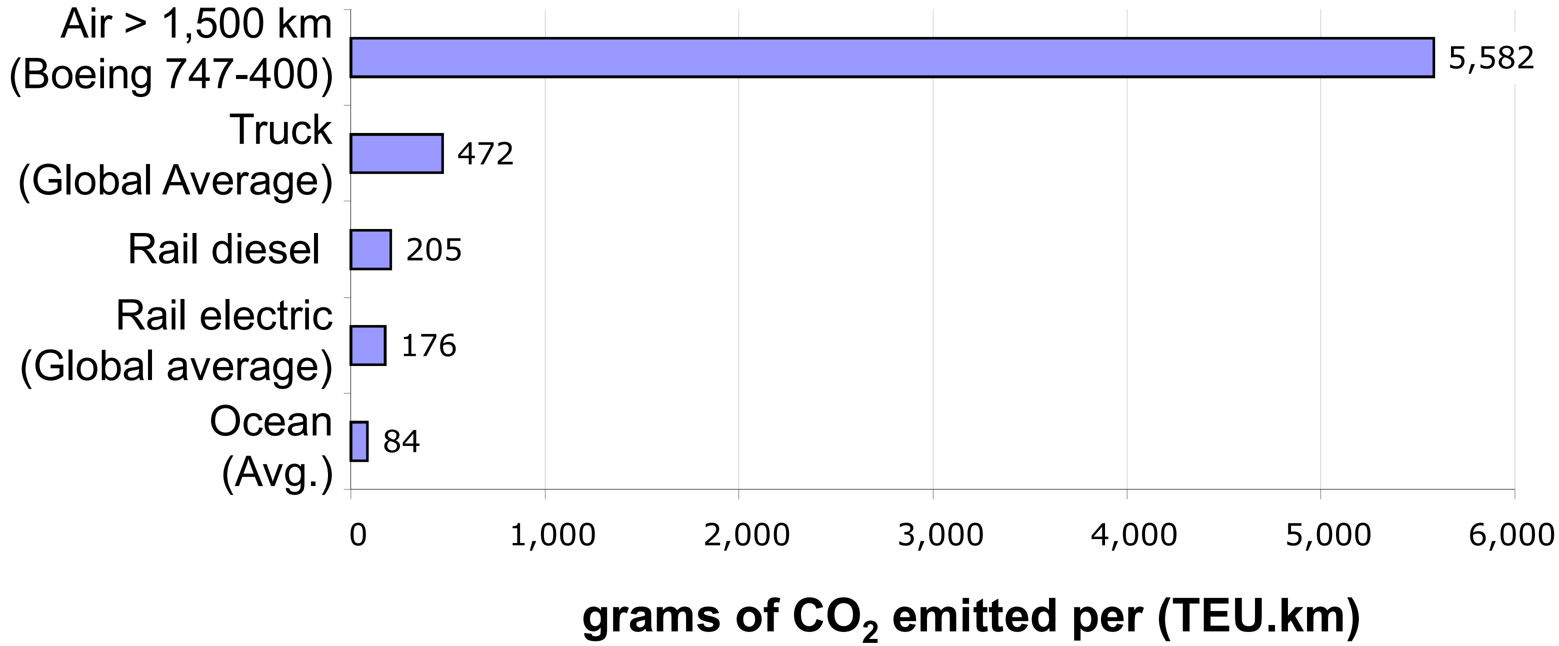
$$\text{g of } CO_2 = \text{km} \times \text{TEU} \times [\text{g of } CO_2 / (\text{TEU} \times \text{km})]$$

Emissions factor is weighted average of all ships on that particular route.

Basis: Greenhouse Gas Protocol '**Distance-based methodology**' for calculating CO_2 emissions.

CO_2 Emissions by Mode of Transportation

Ocean shipping has the lowest environmental impact for long distance transportation.



Recap: Green+Logistics or Green/Logistics?`

Green

Logistics

- Environmental efficiency
- Recycling
- Compliance

- Distributional efficiency
- Save time / money

Convergence?

Railroad

Development of the US Railroad Industry

Images courtesy of pixgood.com

- Dominant mode from 1850s to World War II, playing a pivotal role in US economic development

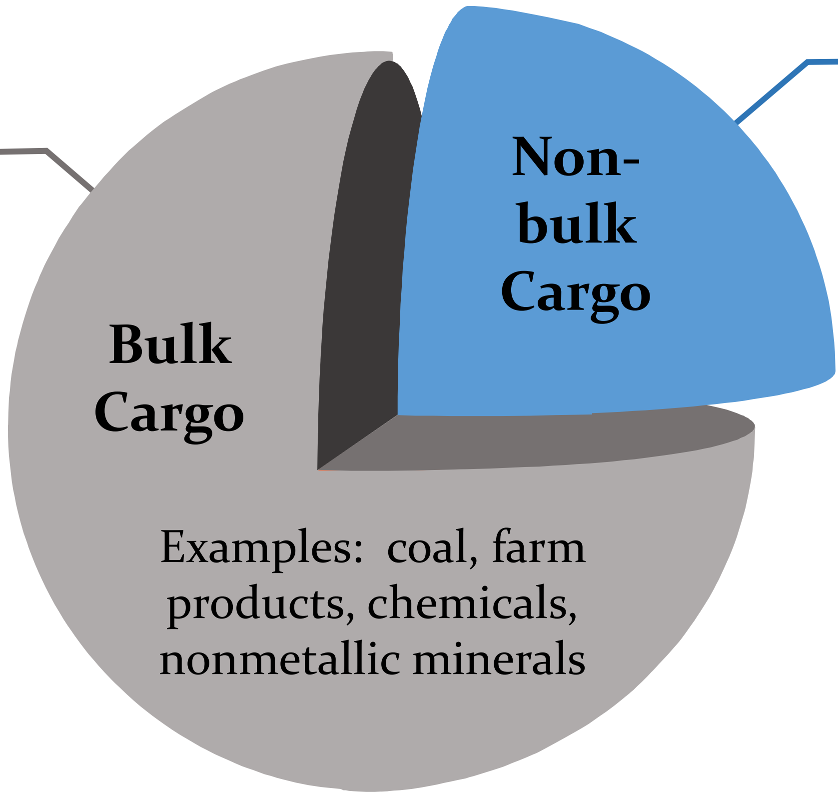
- Domination begins to wane after 1920 due to:
  - Public funding for roads, inland waterways, and air transport
  - Changes in economy and shipper service-related needs
  - Financial plight and economic regulation

- Improved price and service competitiveness after economic deregulation (The Staggers Rail Act), continuing to be a vital part of US economy today

Operating and Service Characteristics

Commodities Hauled

More than 74 percent of total rail carloadings in 2012 involved the movement of bulk materials.



Notable trend toward movements of intermodal containers and trailers, carrying high-value finished products.

Operating and Service Characteristics

Constraints and Strengths

Strengths

* Large carrying capacity (few size or weight constraints).
* Capable of handling almost any type of cargo.
* Railroads assume liability for loss & damage.

Constraints

* Fixed rights-of-way impedes door-to-door service.
* Through service prone to delays in delivery.
* Relatively high percentage of goods damaged in transit.

Operating and Service Characteristics

Equipment – Types of Rail Car

Boxcar: Standardized roofed freight car with sliding doors on the side used for general commodities (plain); can be specially modified (equipped) for specialized merchandise, such as automobile parts.

Hopper car: A freight car with the floor sloping to one or more hinged doors used for discharging bulk materials.

Covered hopper: A hopper car with a roof designed to transport bulk commodities that need protection from the elements.

Images courtesy of Greenbrier Companies, justrains.com, and Greenbrier Companies

Operating and Service Characteristics

Equipment – Types of Rail Car *(continued)*

Flatcar: A freight car with no top or sides used primarily for TOFC service, and movements of machinery and building materials.

Refrigerated car: A freight car with refrigeration equipment for temperature control.

Gondola: A freight car with a flat bottom, fixed sides, and no top used primarily for hauling bulk commodities.

Tank car: Specialized car used for the transport of liquids and gases

Images courtesy of Pacific Western Rail System, tunaruna.com, Greenbrier Companies

Operating and Service Characteristics

Intermodal (Piggyback) Services

TOFC	COFC

Trailer on Flatcar

* Transports highway trailers on railroad flatcars.
* Combines line-haul efficiencies of rail with the flexibility of motor transport.
* On-time deliveries, regularly scheduled departures, and fuel efficiency major reasons for growth.

Container on Flatcar

* Transports shipping containers on railroad flatcars.
* Land-bridge operations key component of international trade.
* Double-stack container trains greatly improves rail equipment and train productivity.

Images courtesy of traingeek.ca and intermodalarchive.org

Airlines

Development of the Airline Industry

Images courtesy of imgkid.com

- In 1903, Wilbur and Orville Wright made their first flight and sold their invention to the federal government.
- In 1908 the development of air transportation began. The use of airplanes for mail transport marked the beginning of the modern airline industry.
- Today, airline travel is a common form of transportation for long-distance passenger and freight travel, especially when time is of the essence.

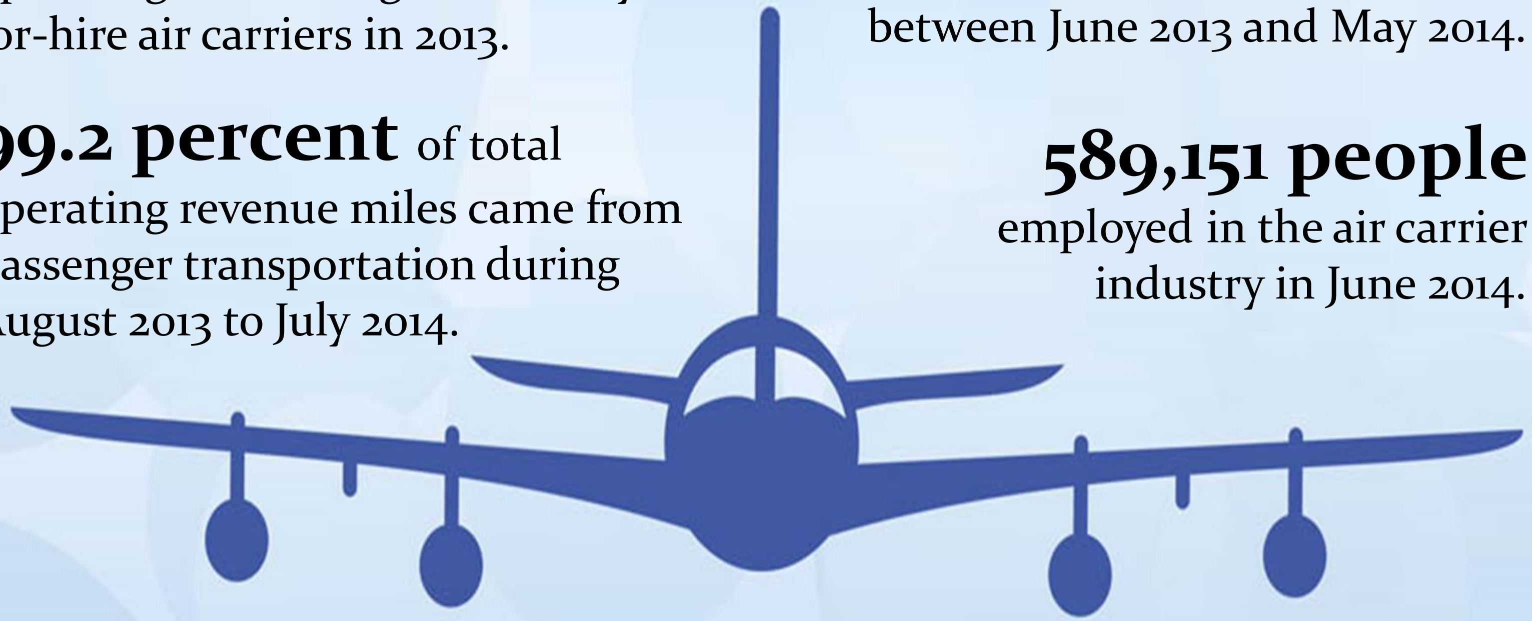
Significance of the Airline Industry

$199.7 billion of operating revenues generated by for-hire air carriers in 2013.

99.2 percent of total operating revenue miles came from passenger transportation during August 2013 to July 2014.

93.1 billion revenue ton-miles transported by air carriers between June 2013 and May 2014.

589,151 people employed in the air carrier industry in June 2014.



Operating and Service Characteristics

Constraints and Strengths

Strengths

* High terminal-to-terminal speed
* Reliability (low transit time variation)
* Low rates of damages

Constraints

* Limited accessibility.
* Reduced frequency of flights.
* High service rates.
* Added access and terminal time and cost significant for short distances (under 800 miles).

Operating and Service Characteristics

Equipment – Types of Aircrafts

There are several different sizes of airplanes in use, from small commuter planes to huge, wide-body, four-engine planes used by the nationals.

Example: Delta Airlines Fleet

Images courtesy of Delta Airlines

Operating and Service Characteristics

Terminals (Airports)

- Government (state and local) invest and operate airports and airways.
- Certain airports in the carriers' scope of operation become hubs, similar to the motor carrier's break-bulk terminal.
- Air carriers pay for the use of the airport through:
  - Landing fees
  - Rent and lease payments for space
  - Taxes on fuel and airline tickets
  - Aircraft registration taxes

Images courtesy of Passenger Terminal Today.com

- Airport terminals provide services to passengers, such as restaurants, banking centers, souvenir and gift shops, and snack bars.
- Users pay a tax on airline tickets and air freight charges.

Water Transportation

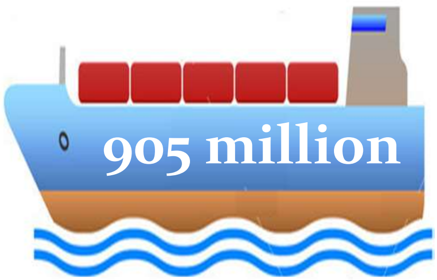
Development of Water Transportation

Images courtesy of pixshark.com

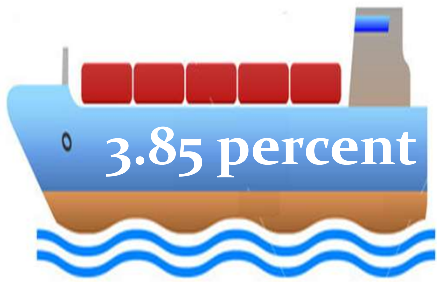
- The first principle form of long distance freight and people transport, played an important role in the early development of the United States and settlements.
- Continued to be the most important and efficient form of transportation available until the railroads were developed in the mid-18th century.
- Today, water transport remains viable for the movement of basic raw materials, and plays a primary role in global commerce transportation.

Significance of Water Transportation

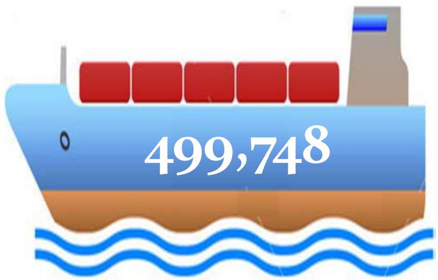
The relative importance of water carriers' in the US transportation system declined somewhat over the past decade due to shift from manufacturing- to a service-based economy, and a supply chain emphasis on speed.



Short tons carried by domestic water carriers in 2012.



Of the total expenditures of for-hire transportation included in GDP was accounted for by water carriers.



Ton-miles of total US freight carried by domestic water carriers in 2011.

People employed for water transportation in 2010.

Overview of the Water Transport Industry

Industry Classification by Waterway Used

1 Great Lakes Carriers

* Provide services between ports on Great Lakes.
* Lake ships tend to remain on lakes.
* Lake ships can access Atlantic and Gulf coast ports via St. Lawrence Seaway (classified as a coastal operation).

2 Coastal Carriers

* Operate ocean-going ships and barges along Atlantic, Pacific, and Gulf of Mexico coasts.
* Move large quantities of crude oil from Alaska ports to refineries along the Pacific Coast.

3 Inter-coastal Carriers

* Operate ocean-going ships and barges between East Coast and West Coast ports via the Panama Canal.
* Move large quantities of petroleum, crude & refined between the Atlantic and Gulf of Mexico.

Operating and Service Characteristics

Constraints and Strengths

Strengths

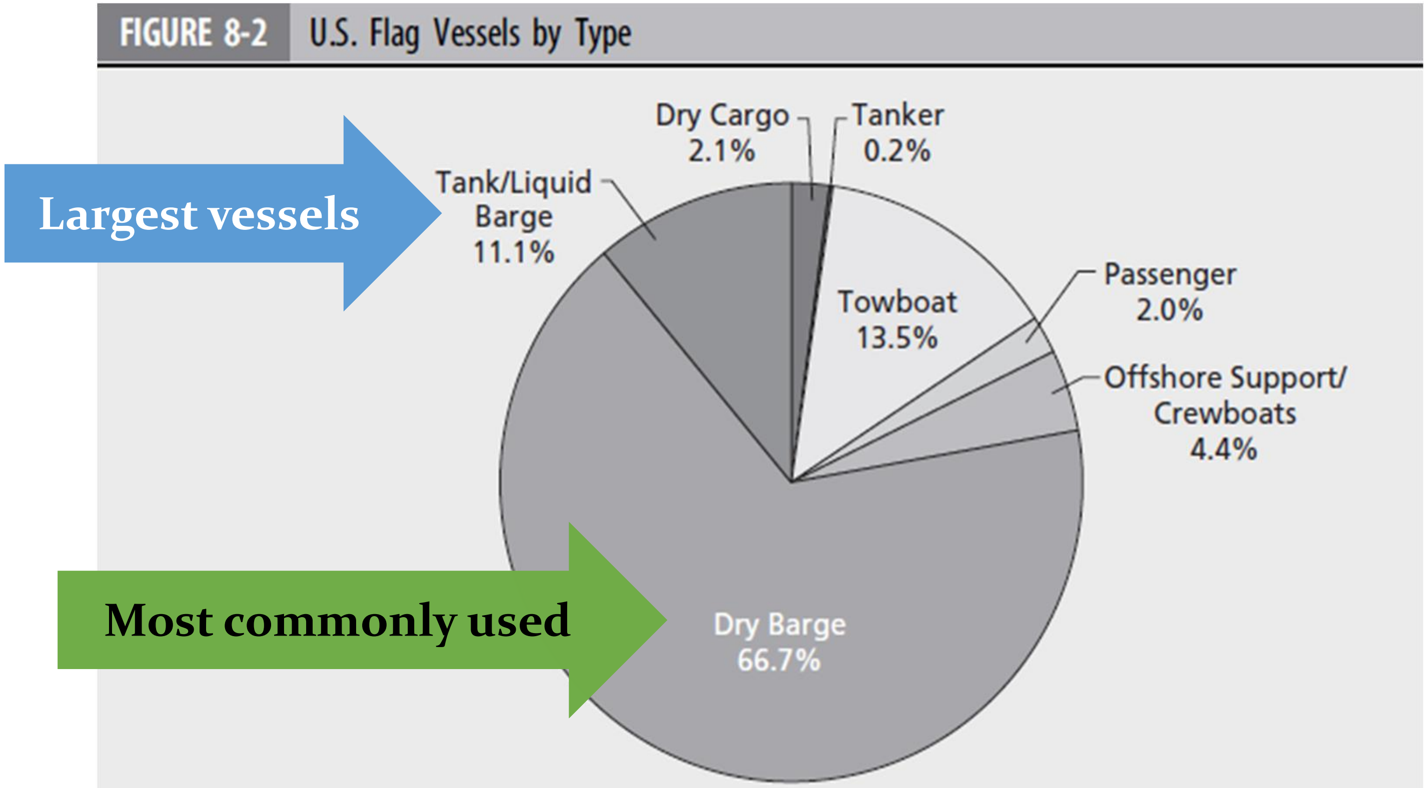
* Low cost transport service for large volumes over medium to long distances
* Relatively large carrying capacity
* Fuel efficient

Constraints

* Speed of service (slowest mode for dry cargoes)
* Vulnerable to ice, flood, and drought conditions
* Accessibility limitations
* Packaging requirements for high-value goods

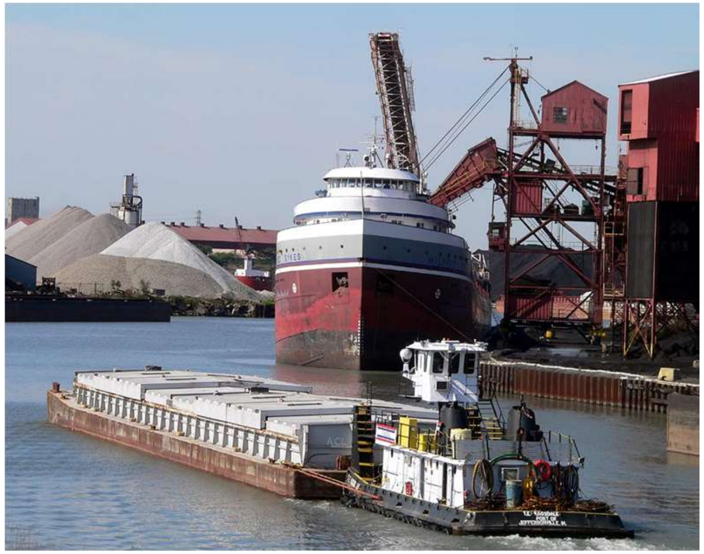
Operating and Service Characteristics

Types of Vessels



Operating and Service Characteristics

Terminals *(continued)*



Images courtesy of Great Lakes & Seaway Shipping Online

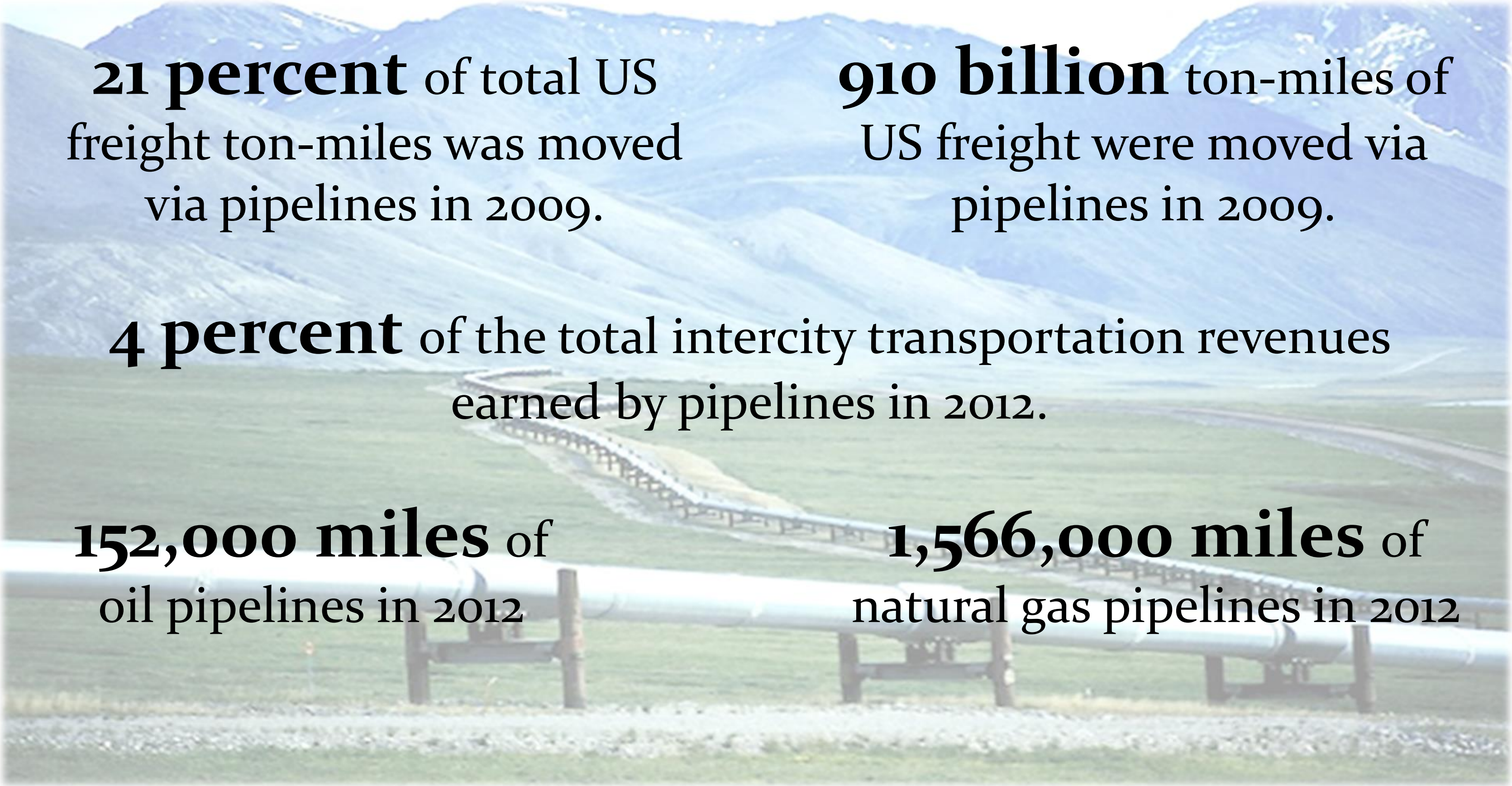
- Ship terminals require significant capital investment.
- Most ports and terminals are publicly provided and operated.
- Large bulk commodity shippers may own and operate private terminals.
- Recent improvements focus on the mechanization of materials-handling systems.

Development of Pipeline Industry

Images courtesy of Hi-tech Online

- In 19^{th} century, pipelines were originally used to feed other modes of transportation, e.g. railroads or water.
- In early 20^{th} century, most pipelines were owned by large oil companies that often used them to control the oil industry.
- After WWII, pipelines were ordered to operate as common carriers (the Champlin Oil Case)

Significance of Pipelines



21 percent of total US freight ton-miles was moved via pipelines in 2009.

910 billion ton-miles of US freight were moved via pipelines in 2009.

4 percent of the total intercity transportation revenues earned by pipelines in 2012.

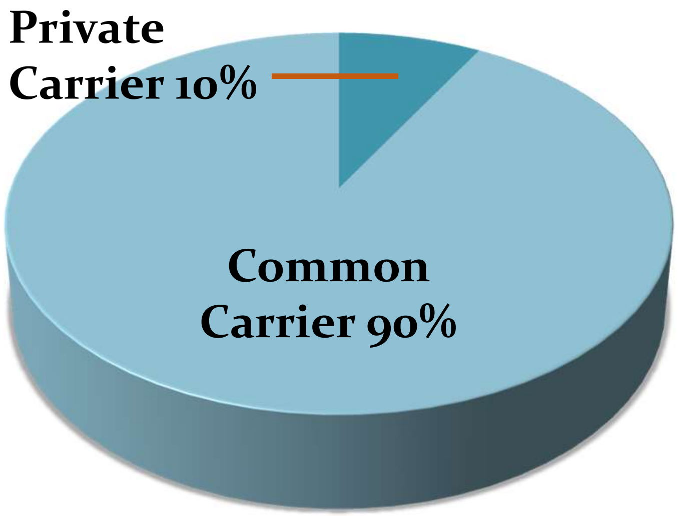
152,000 miles of oil pipelines in 2012

1,566,000 miles of natural gas pipelines in 2012

Overview of the Pipeline Industry

Ownerships and Type of Carriers

The for-hire carriers dominate the pipeline industry.

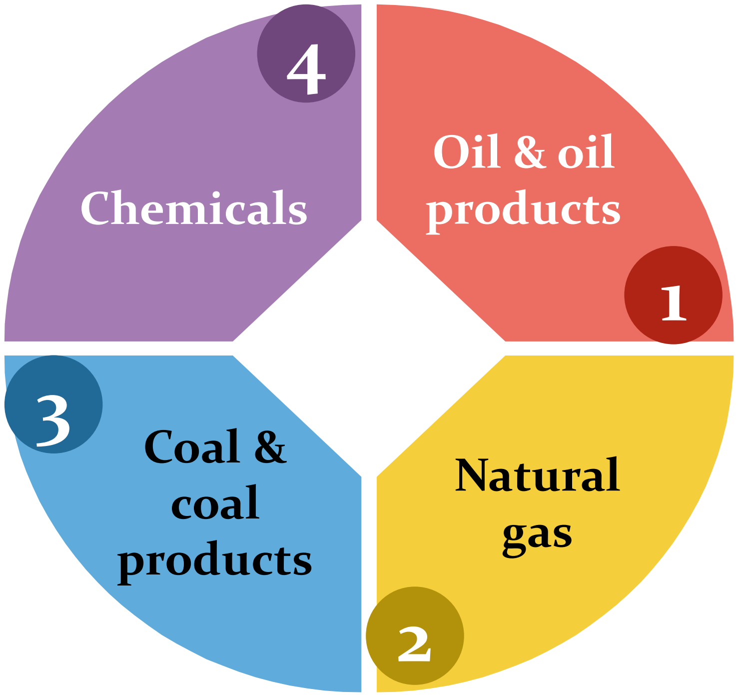


Owners of pipelines

- Individual, vertically integrated oil companies.
- Jointly owned pipeline companies.
- Others
  - Railroads
  - Independent oil companies
  - Other industrial companies

Operating and Service Characteristics

Commodities Hauled



- Pipelines are limited in the markets they serve and commodities they can haul.
- Pipelines are the only mode that are unidirectional with no backhaul.

Operating and Service Characteristics

Constraints and Strengths

Strengths

- Low service rates
- Low loss and damage rates
- Warehousing function (3-5 mph)
- High delivery dependability

Constraints

- Limited responsiveness due to slow speed
- Limited geographic flexibility
- Limited variety of products carried

https://www.youtube.com/watch?v=wgHqzv-Pxss
https://www.youtube.com/watch?v=MXUFGbnqYm8
https://www.youtube.com/watch?v=VueHMW4Wrn4

Distribution

Distribution Channels

- A **distribution channel** - set of independent organizations involved in the process of **making a product or service available** to the consumer or business user

- Used to move the customer towards the product **or** the product to the customer

- Organic development of an industry

Distribution

Today "distribution" in the hospitality industry generally references transient sales today

Revenue management and distribution merging together

Internet marketing includes distribution issues

Distribution Channel Functions

- *Information:* consumer behavior “search stage”
- *Promotion:* messaging
- *Negotiation:* price and other terms
  - (how is this done online?
- *Physical distribution:* think e-tickets?
- *Prospecting:* finding, communicating, and tracking prospective buyers

Push vs. Pull strategies

- Pushing the product "down" through the distribution channel TO the customer
  - Incentives to travel agents and intermediaries

- Pulling the customer "up" through the distribution to the channel
  - Traditional media/private sales/CRM

Why Use Intermediaries?

- History of travel

- Selling through wholesalers and retailers usually is much more **efficient and cost effective** than direct sales

E-Commerce & E-Marketing

- **E-commerce** involves buying and selling processes supported by electronic means, primarily the Internet

- **E-marketing** is company efforts to communicate about, promote, and sell products and other services over the Intranet; also web or Internet Marketing

- Not easy to separate but different issues

E-Commerce Domains

- B2C (business to consumer)
  - Branded websites
- B2B (business to business)
  - Passkey
- C2B (consumer to business)
  - User groups
- C2C (consumer to consumer)
  - Blogs; review sites are blends of above

Figure 2-6 *Nodes and Links in a Logistics System*

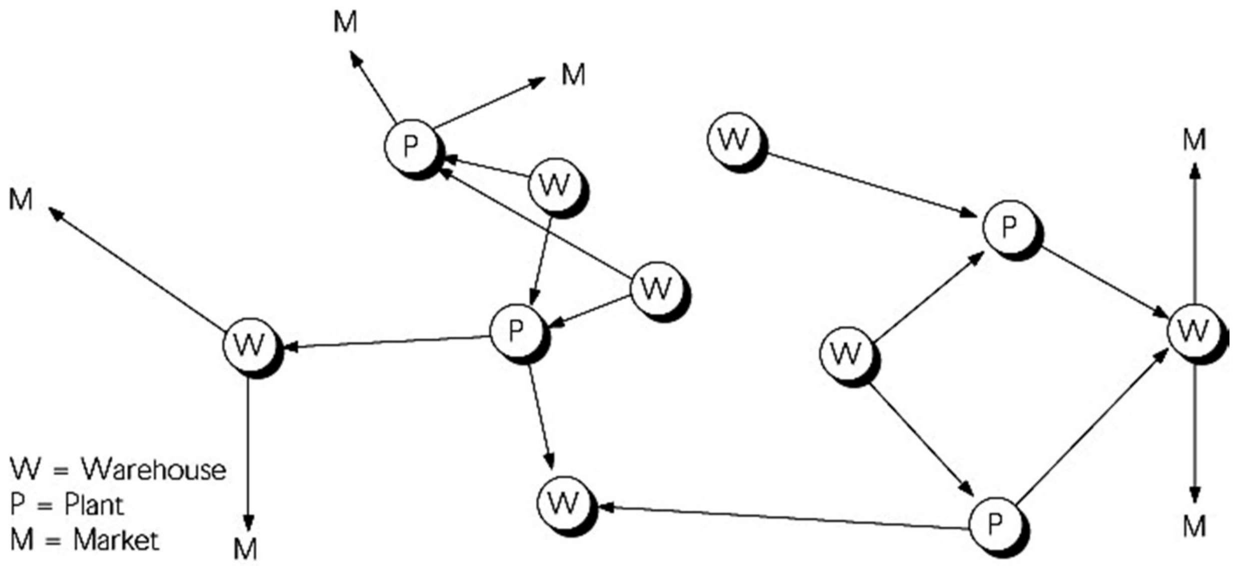


Figure 2-7
A Simple Logistics Channel

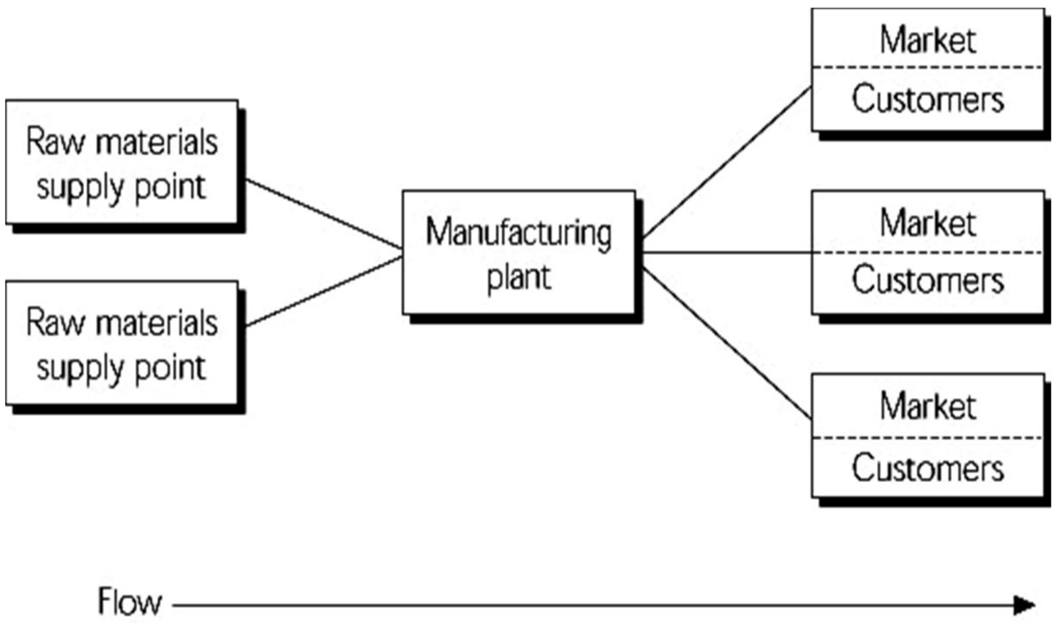


Figure 2-8
A Multi-Echelon Logistics Channel

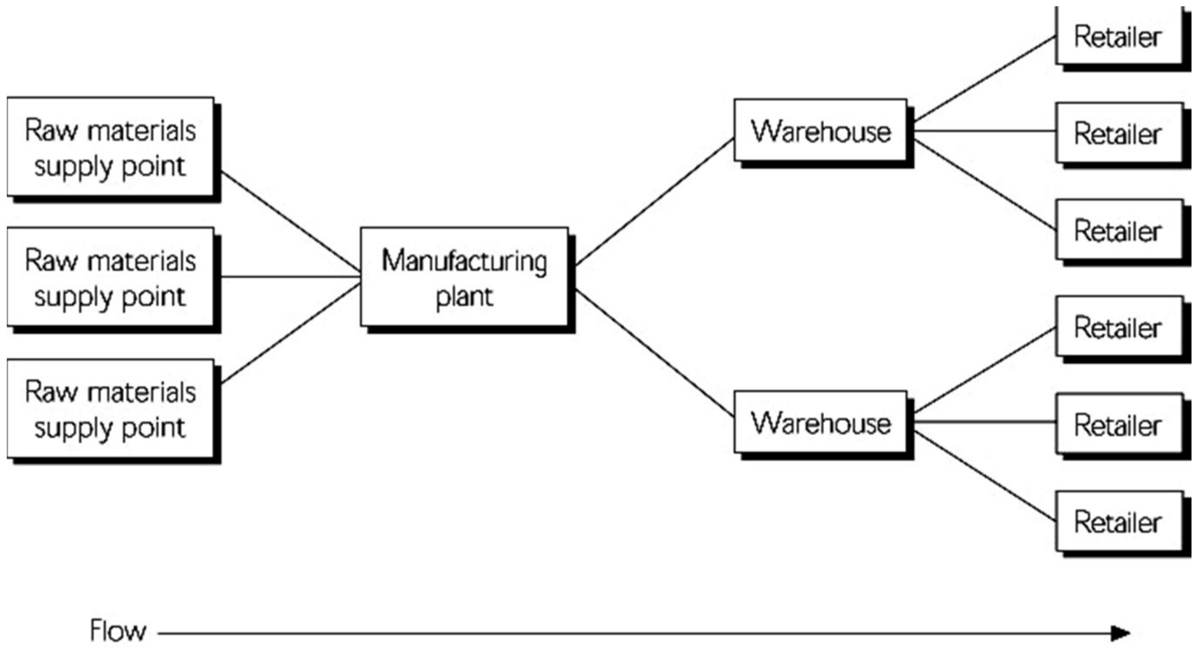
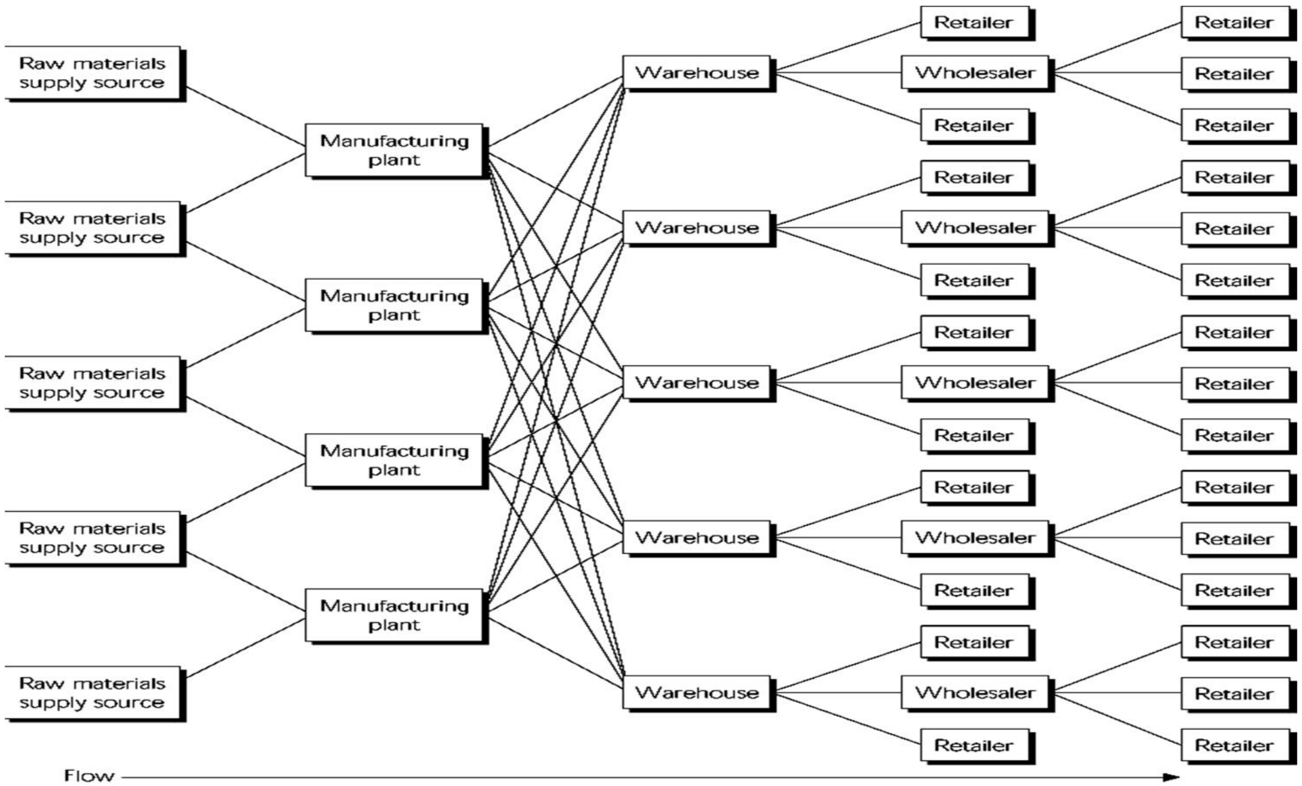


Figure 2-9
A Complex Logistics Channel



Logistics and Systems Analysis

- Cost Perspective
  - Keep in mind that the most efficient systems are not always comprised of each system component operating at its lowest possible cost.
  - The critical concern is to have the entire system operating at its lowest total cost.

Logistics and Systems Analysis

- Level of Optimality
  - There are often constraints working which result in sub-optimal outcomes.
  - Additionally, logistics systems must work in harmony with marketing, finance, production, etc.--- this may also result in sub-optimal logistics performance.
  - See Figure 2-10 on next slide.

What is a Marketing Channel?

- This is a set of interdependent organizations involved in the process of making a product or service available for use or consumption

Intermediaries involved in this process

- Agents – acting on behalf of buyer or seller but do not take title of the goods
- Facilitators – transporters, C&Fs, banks, ad agencies

Advantages of a distribution system

- Key external resource
- Takes years to build
- Significant corporate commitment to a large no. of firms
- Commitment to a set of policies that nourishes long term relationships

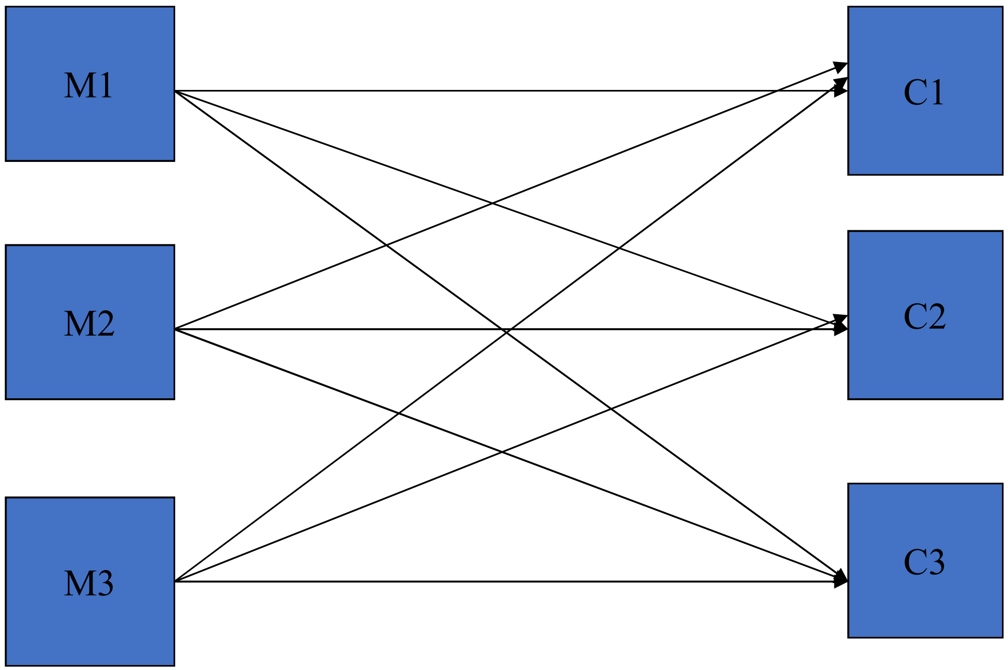
Why would a manufacturer not like to do his own distribution?

- Lacks the financial resources to do direct marketing
- Cannot have the infrastructure to make the product widely available and near the customer
- Trading profits could be less than manufacturing profits

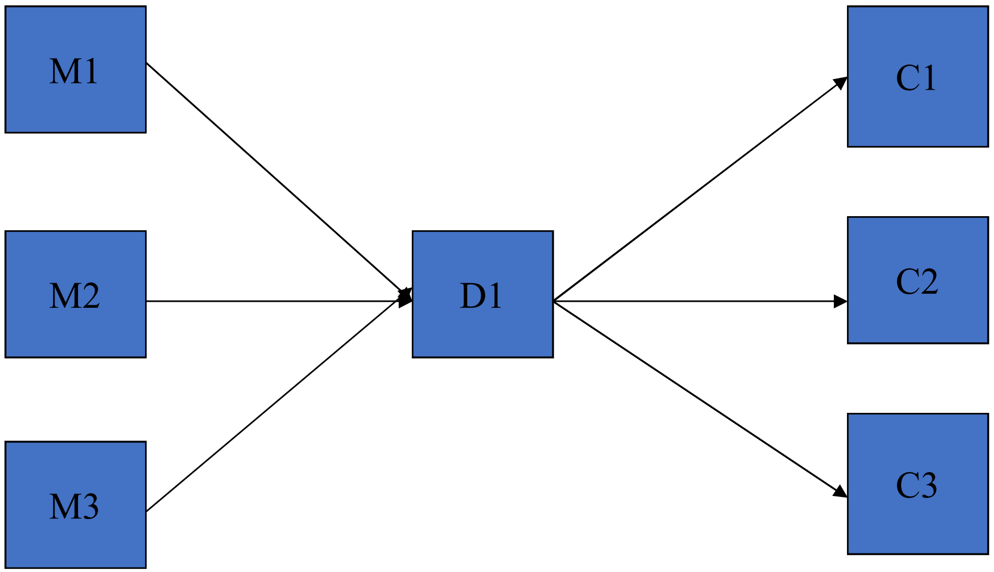
Manufactures typically produce a large quantity of a limited variety of goods

Consumers usually desire a small quantity of a wide variety of goods

If all manufacturers tried to reach all consumers



If they tried to go through an intermediary



Channel functions

- Gathers information on customers, competitors and other external market data
- Develop and disseminate persuasive communication to stimulate purchases
- Agreement on price and other terms so that transfer of ownership can be effected
- Placing orders with manufacturers

Channel functions (cont’d)

- Acquire funds to finance inventories and credit in the market
- Assume responsibility of all risks of the trade
- Successive storage and movement of products
- Helps buyers in getting their payments through with the banks
- Oversee actual transfer of ownership

Channels can be

- Forward
- Backward

Channel Alternatives

- Types of available business intermediaries
- No. of intermediaries needed
- Terms and responsibilities of each channel member

Types of intermediaries

- Distributors
- Wholesalers
- Retailers
- Department stores

Channel management

- Selecting channel members
- Training channel members
- Motivating channel members

Adding channels

Advantages

- Increased market coverage
- Lower channel costs
- More customised selling

Disadvantages

- Increases selling costs
- Increases channel control
- Breeds channel conflict

Channel conflict

- Interest of different business interests do not necessarily coincide
- Conflicts can occur at various levels

  vertical

  horizontal

  multichannel

Conflict causes

- Goal incompatibility
- Differences in perception
- Great dependence

Retailing

Includes all activities involved in selling goods or services directly to final consumers.

Retail sales effectiveness

- No. of people passing by on an average day
- % who enter the store (footfalls)
- %entering who buy
- Amount spent per buyer

Store Brands

- With the increase in size and buying strength of retailers, companies are forced to now customize products for them. These are known as store brands. They may compete at the store with the company’s own brands.

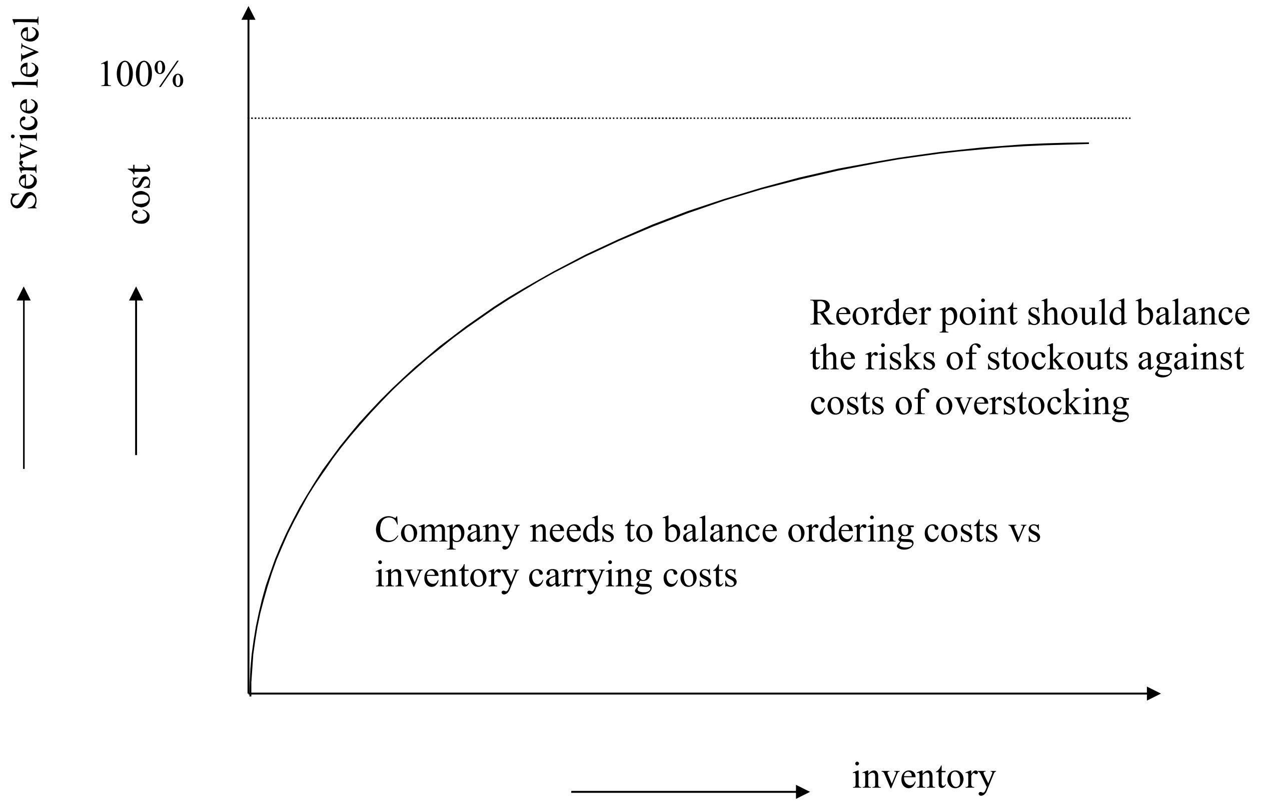
What is wholesaling?

- It includes all activities involved in selling goods and services for resale or business use. They are the intermediaries between manufacturers and retailers.

Characteristics of wholesalers

- Less attention to promotion, atmosphere and location
- Transactions are usually large and cover a wider geographical area
- Could have different tax implications, regulations,etc. because of its status as a wholesaler

Inventory vs Service levels



Designing the Distribution Network in a Supply Chain

The Role of Distribution in the Supply Chain

- ***Distribution***: the steps taken to move and store a product from the supplier stage to the customer stage in a supply chain
- Distribution directly affects cost and the customer experience and therefore drives profitability
- Choice of distribution network can achieve supply chain objectives from low cost to high responsiveness
- Examples: Wal-Mart, Dell, Proctor & Gamble, Grainger

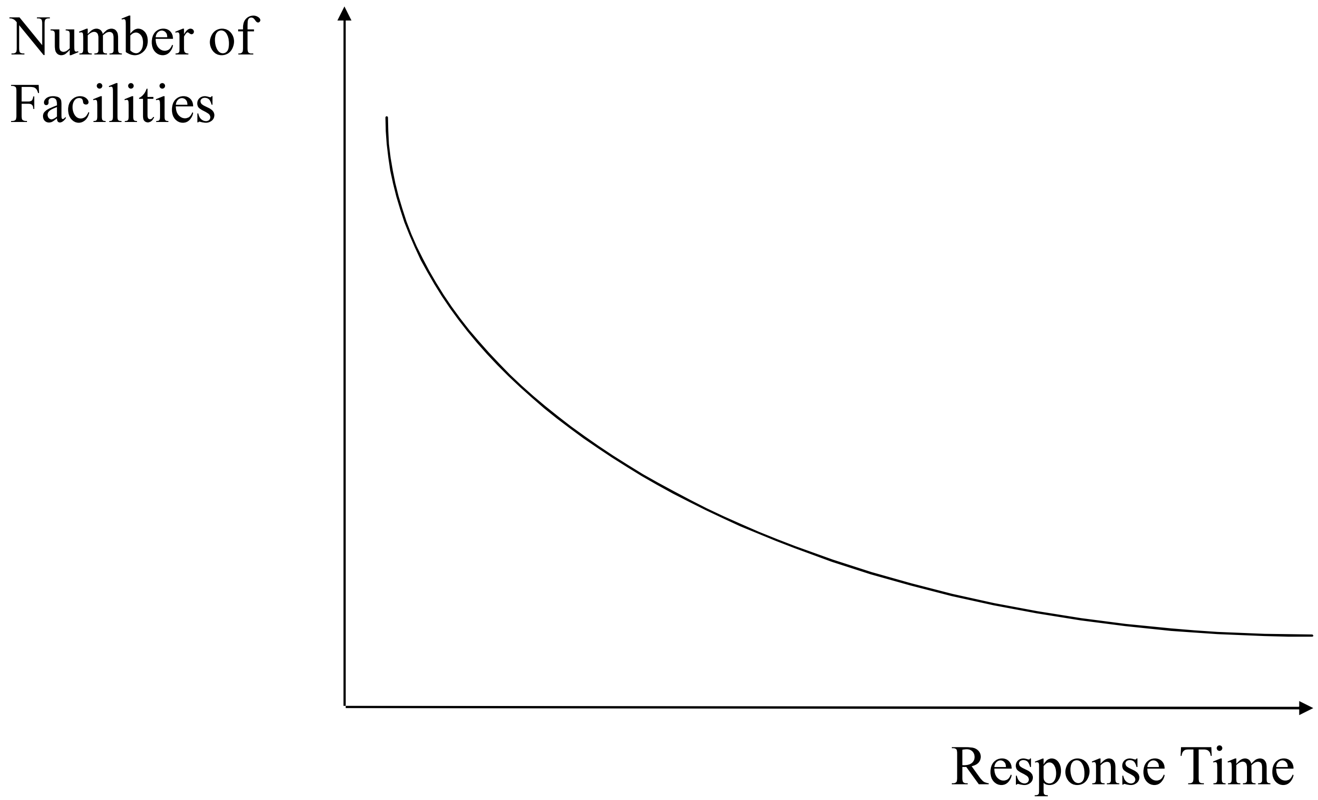
Factors Influencing Distribution Network Design

- Distribution network performance evaluated along two dimensions at the highest level:
  - Customer needs that are met
  - Cost of meeting customer needs
- Distribution network design options must therefore be compared according to their impact on customer service and the cost to provide this level of service

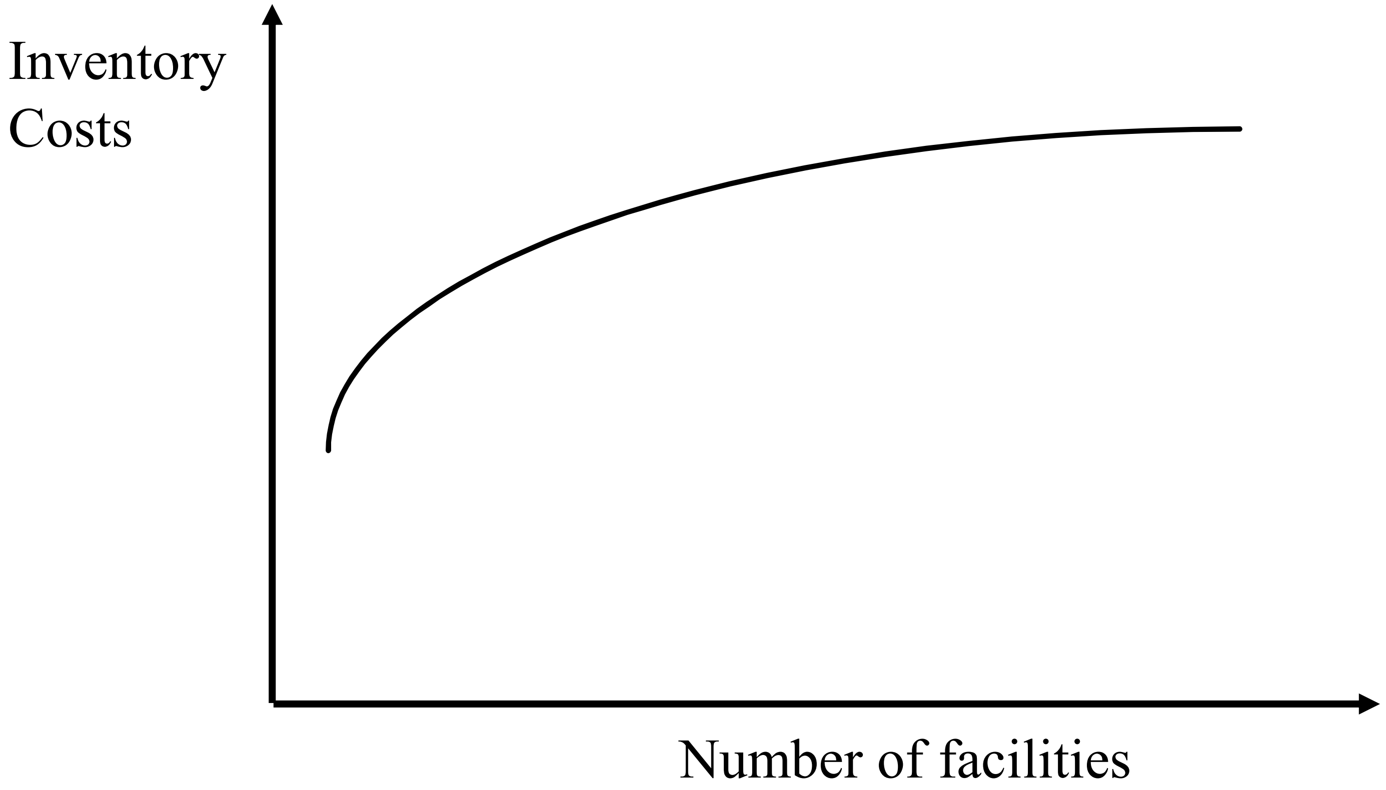
Factors Influencing Distribution Network Design

- Elements of customer service influenced by network structure:
  - Response time
  - Product variety
  - Product availability
  - Customer experience
  - Order visibility
  - Returnability
- Supply chain costs affected by network structure:
  - Inventories
  - Transportation
  - Facilities and handling
  - Information

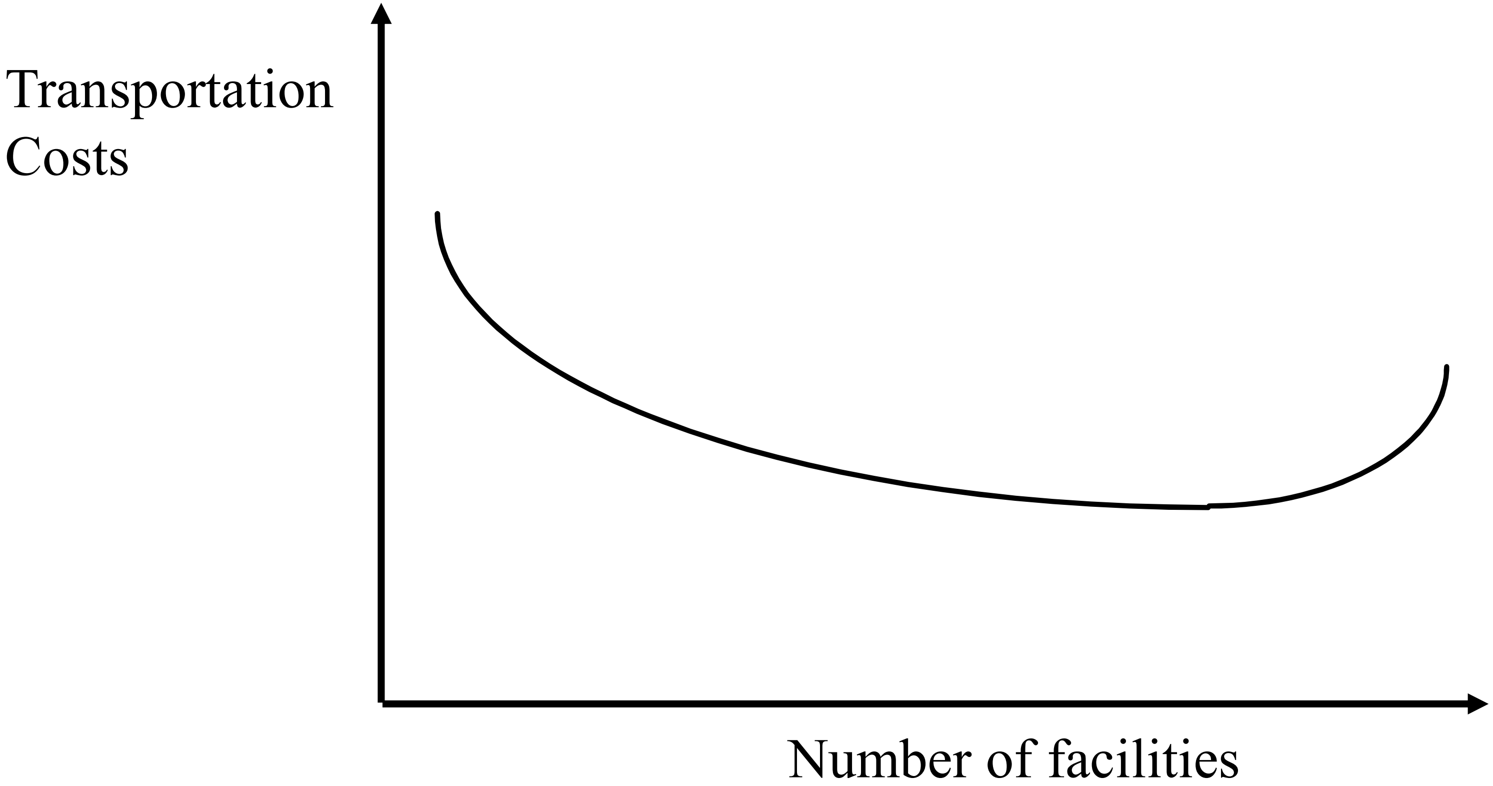
Service and Number of Facilities (Fig. 4.1)



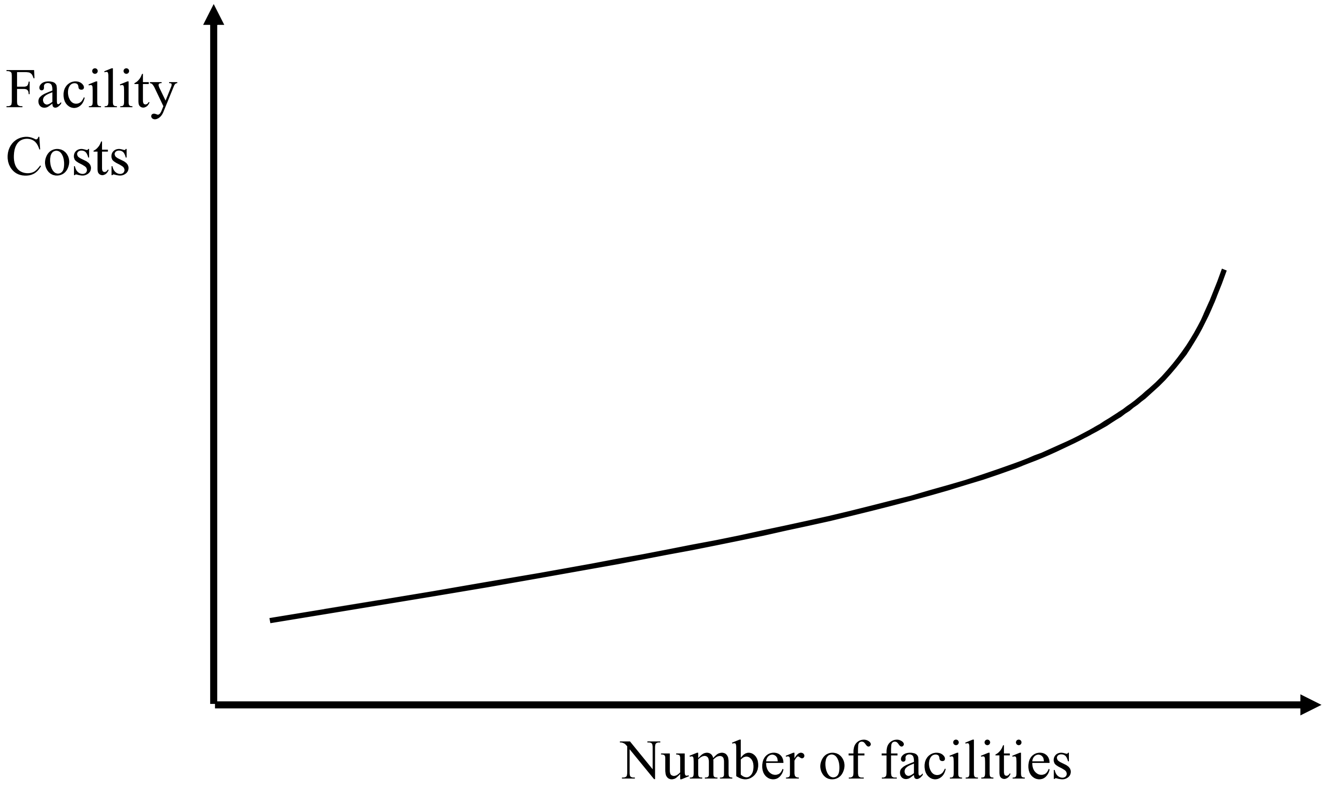
Inventory Costs and Number of Facilities (Fig. 4.2)



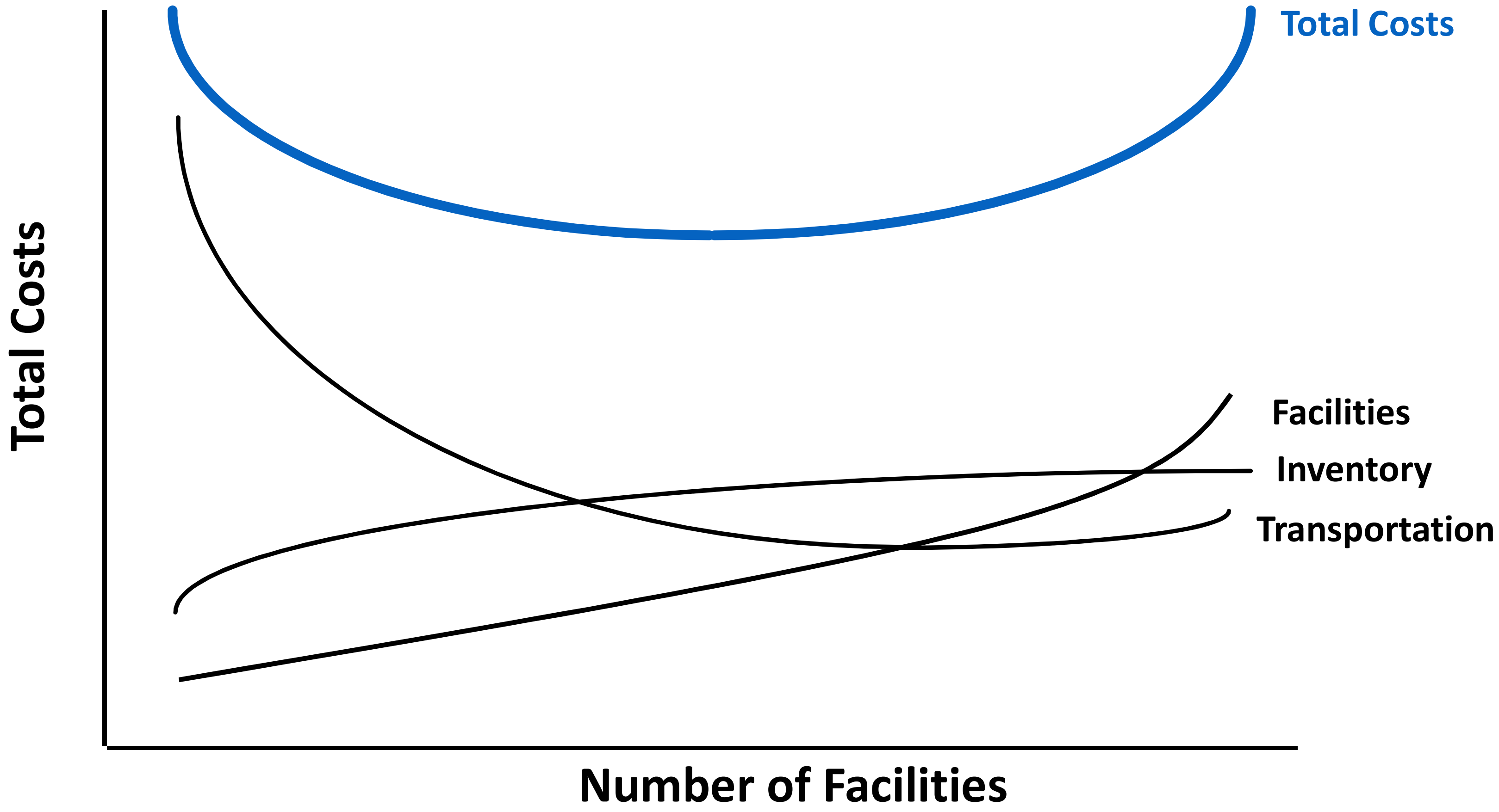
Transportation Costs and Number of Facilities (Fig. 4.3)



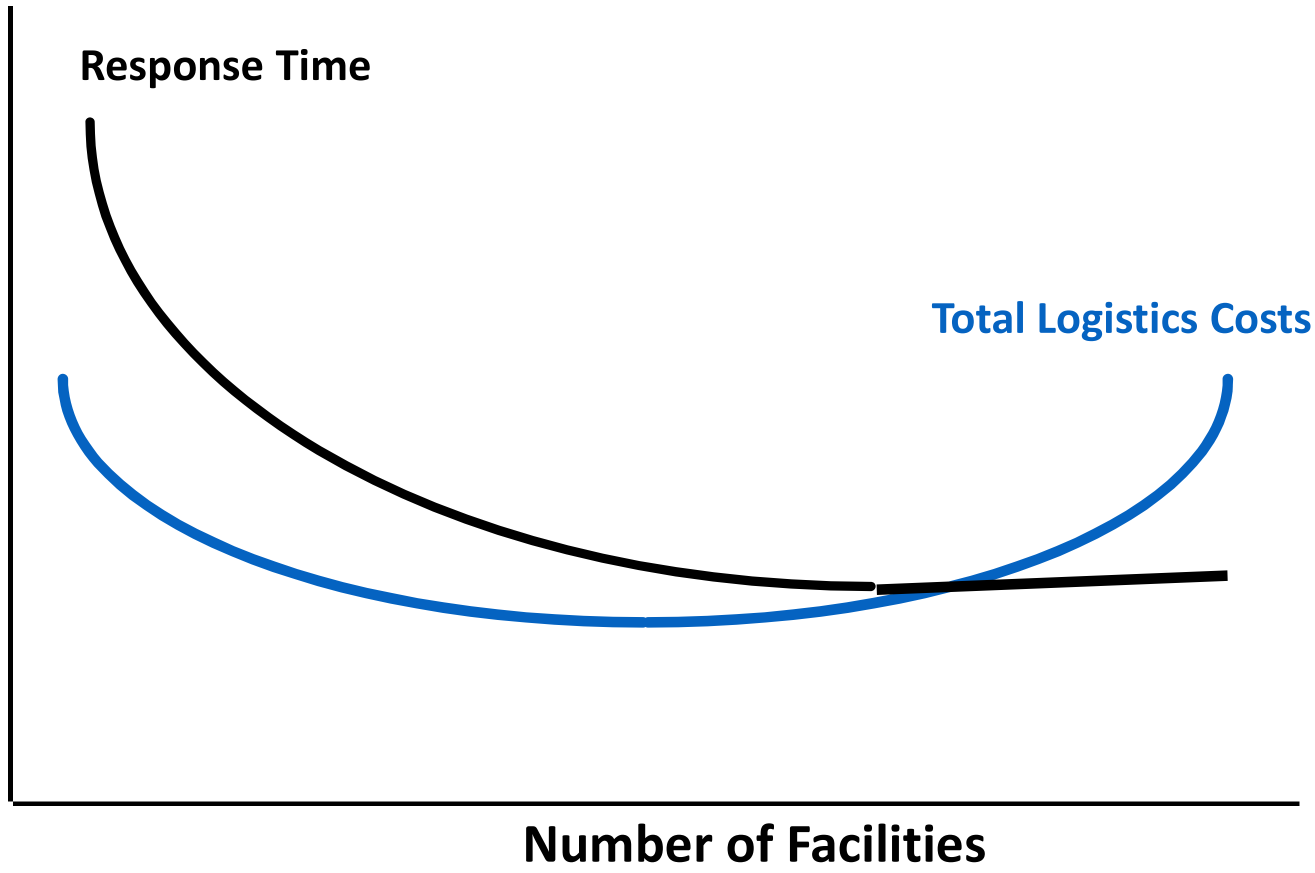
Facility Costs and Number of Facilities (Fig. 4.4)



Total Costs Related to Number of Facilities



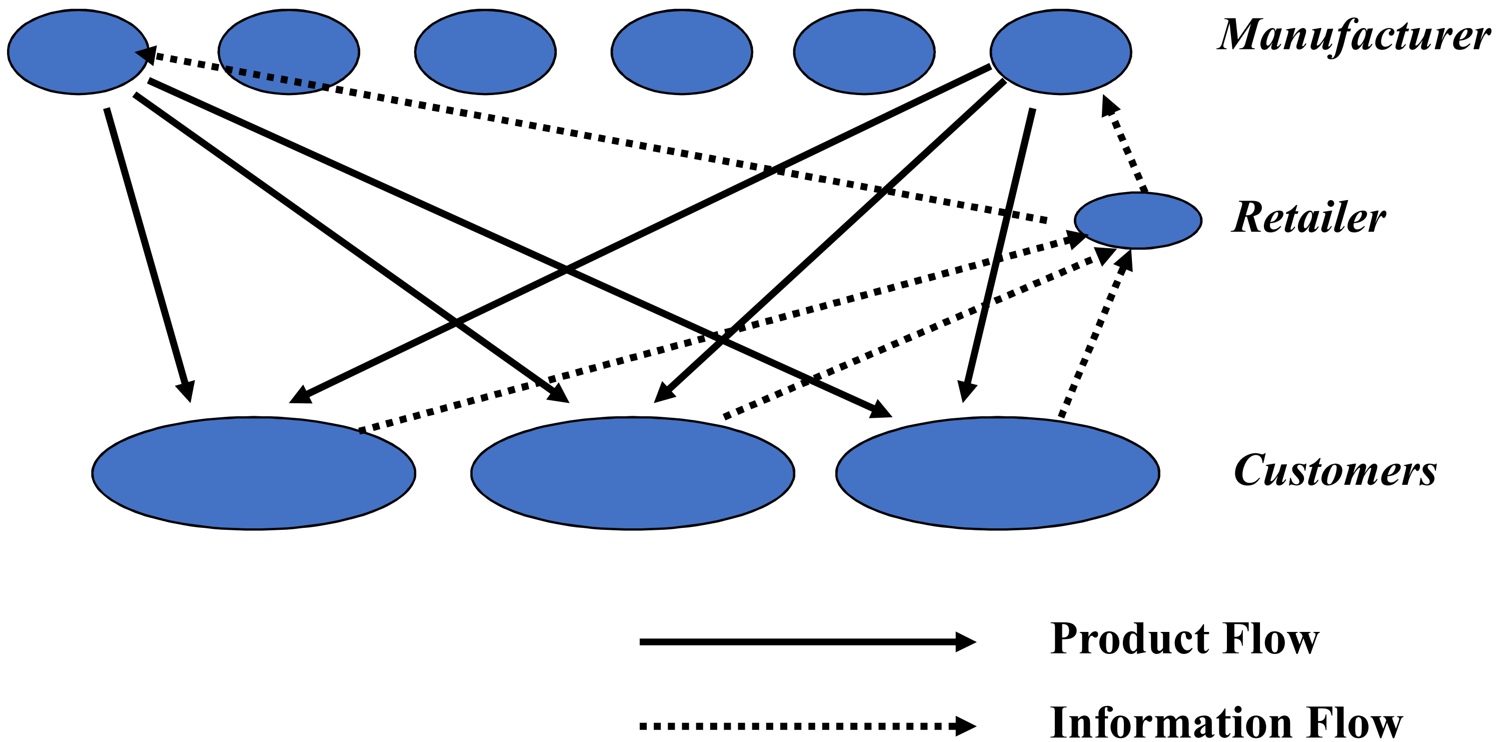
Variation in Logistics Costs and Response Time with Number of Facilities (Fig. 4.5)



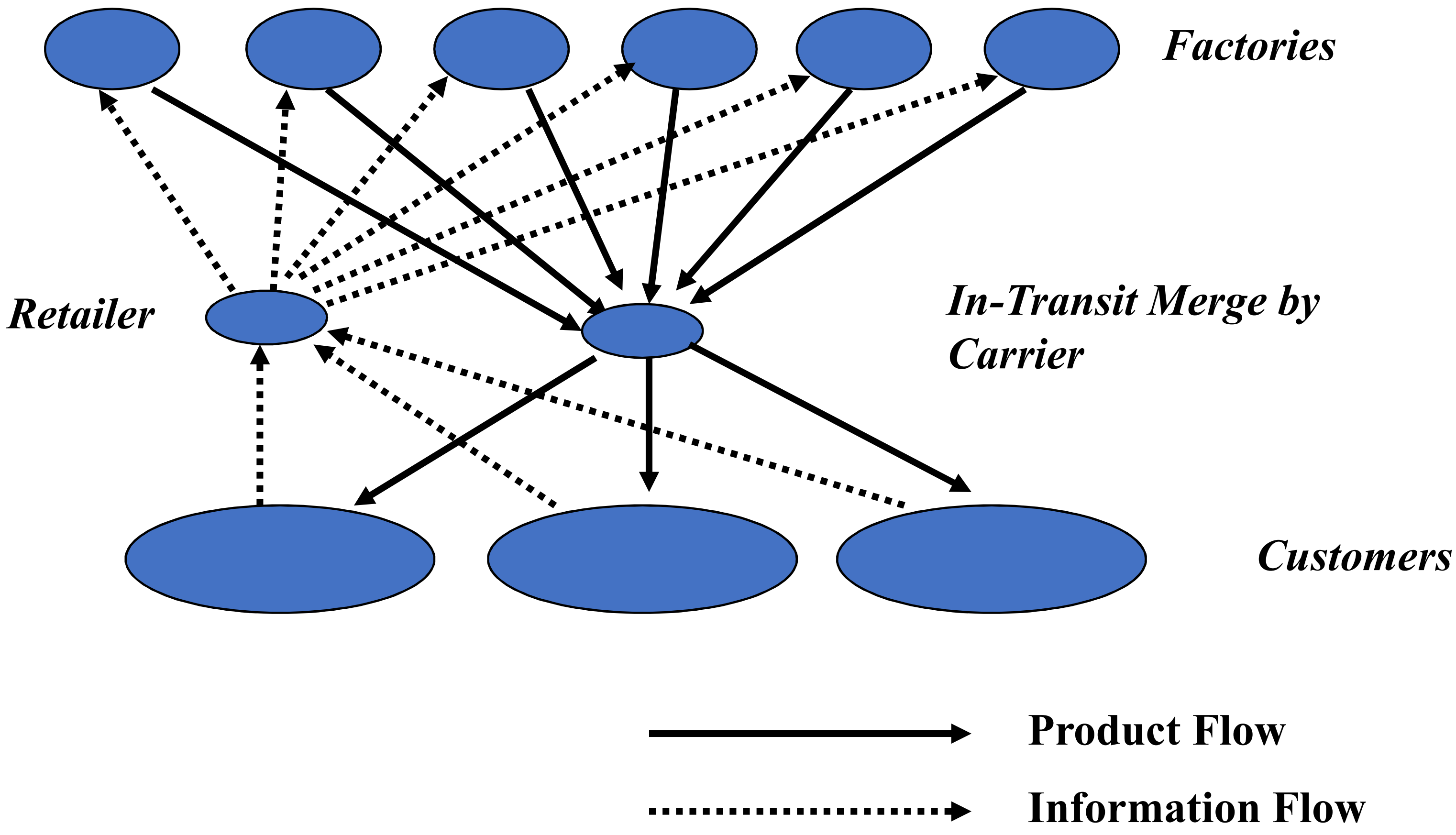
Design Options for a Distribution Network

- Manufacturer Storage with Direct Shipping
- Manufacturer Storage with Direct Shipping and In-Transit Merge
- Distributor Storage with Carrier Delivery
- Distributor Storage with Last Mile Delivery
- Manufacturer or Distributor Storage with Consumer Pickup
- Retail Storage with Consumer Pickup
- Selecting a Distribution Network Design

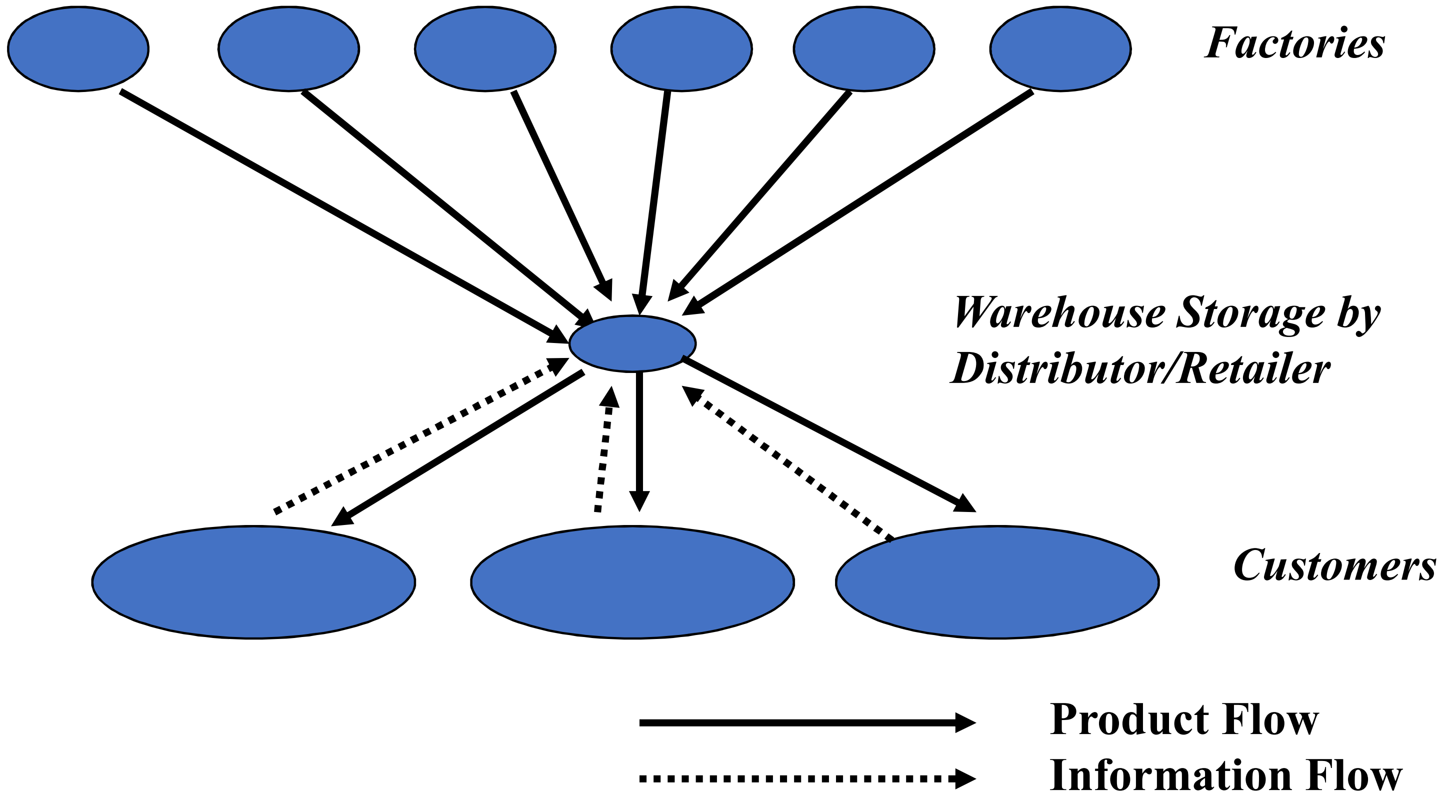
Manufacturer Storage with Direct Shipping (Fig. 4.6)



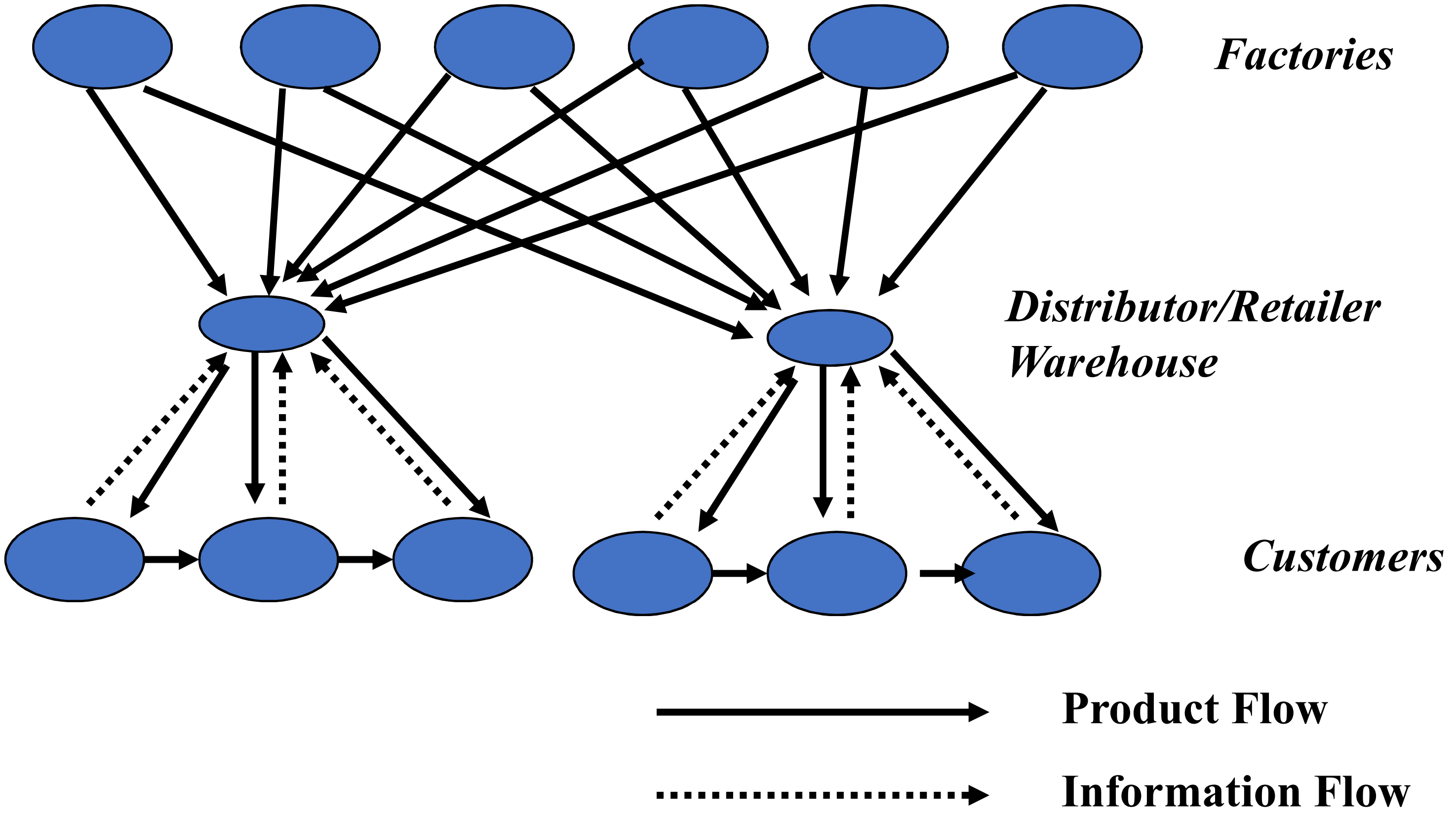
In-Transit Merge Network (Fig. 4.7)



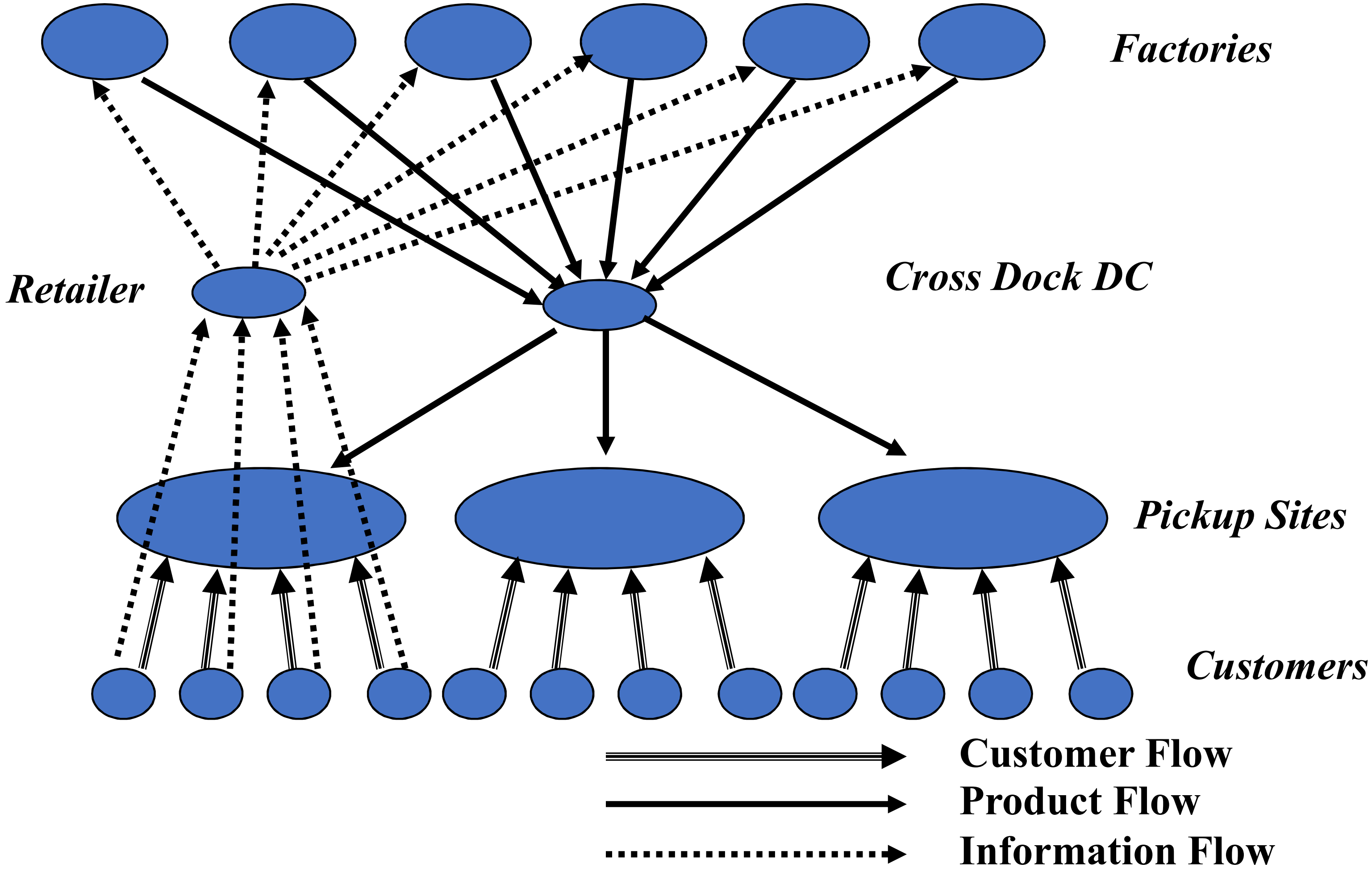
Distributor Storage with Carrier Delivery (Fig. 4.8)



Distributor Storage with Last Mile Delivery (Fig. 4.9)



Manufacturer or Distributor Storage with Customer Pickup (Fig. 4.10)



E-Business and the Distribution Network

- Impact of E-Business on Customer Service
- Impact of E-Business on Cost
- Using E-Business: Dell, Amazon, Peapod, Grainger

Network Design Decisions

- Facility role
  - What role, what processes?
- Facility location
  - Where should facilities be located?
- Capacity allocation
  - How much capacity at each facility?
- Market and supply allocation
  - What markets? Which supply sources?

Factors Influencing Network Design Decisions

- Strategic factors
- Technological factors
- Macroeconomic factors
  - Tariffs and tax incentives
  - Exchange-rate and demand risk
  - Freight and fuel costs
- Political

Factors Influencing Network Design Decisions

- Infrastructure factors
- Competitive factors
  - Positive externalities between firms
  - Locating to split the market
- Customer response time and local presence
- Logistics and facility costs

Competitive Factors

- Positive externalities between firms
  - Collocation benefits all

Figure 5-1

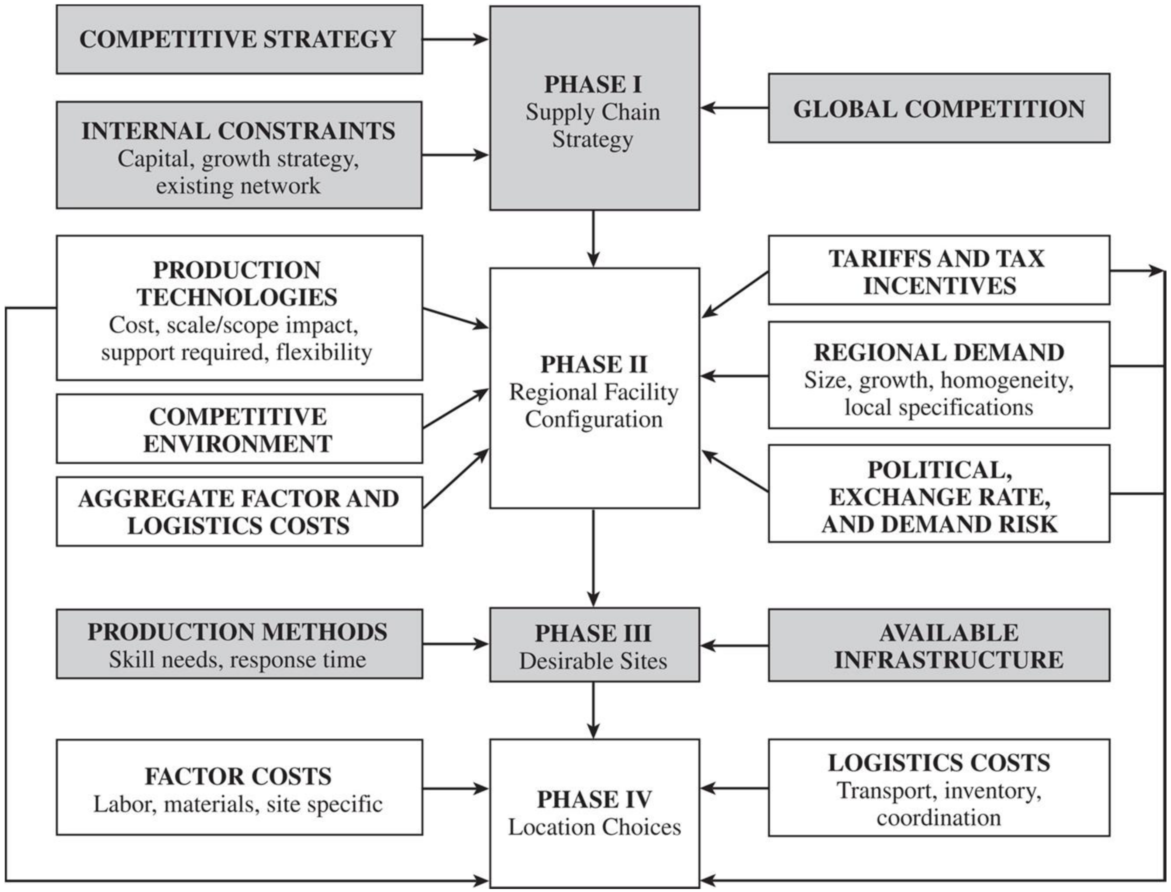
– Locating to split the market

- Locate to capture largest market share

$$d_1 = a + \frac{1 - b - a}{2} \quad \text{and} \quad d_2 = \frac{1 + b - a}{2}$$

Framework for Network Design Decisions

Figure 5-2



Capacitated Plant Location Model

n = number of potential plant locations/capacity

m = number of markets or demand points

D_j = annual demand from market j

K_i = potential capacity of plant i

f_i = annualized fixed cost of keeping plant i open

c_{ij} = cost of producing and shipping one unit from plant i to market j (cost includes production, inventory, transportation, and tariffs)

y_i = 1 if plant i is open, 0 otherwise

x_{ij} = quantity shipped from plant i to market j

$$Min \sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$$

subject to

$$\sum_{i=1}^{n} x_{ij} = D_j \quad \text{for } j = 1, \ldots, m$$

$$\sum_{j=1}^{m} x_{ij} = K_i y_i \quad \text{for } i = 1, \ldots, n$$

$$y_i \in \{0,1\} \quad \text{for } i = 1, \ldots, n, x_{ij} \geq 0$$

Network Optimization Models

- Allocating demand to production facilities

n = number of factory locations

m = number of markets or demand points

D_j = annual demand from market j

K_i = capacity of factory i

c_{ij} = cost of producing and shipping one unit from factory i to market j

x_{ij} = quantity shipped from factory i to market j

$$Min \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$$

subject to

$$\sum_{i=1}^{n} x_{ij} = D_j \quad \text{for } j = 1, \ldots, m$$

$$\sum_{j=1}^{m} x_{ij} = K_i \quad \text{for } i = 1, \ldots, n$$

Capacitated Plant Location Model

- Merge the companies
- Solve using location-specific costs

y_i = 1 if factory i is open, 0 otherwise
x_{ij} = quantity shipped from factory i to market j

$$Min \sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$$

Capacitated Model With Single Sourcing

- Market supplied by only one factory
- Modify decision variables

y_i = 1 if factory i is open, 0 otherwise
x_{ij} = 1 if market j is supplied by factory i, 0 otherwise

$$Min \sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} D_j c_{ij} x_{ij}$$

subject to

$$\sum_{i=1}^{n} x_{ij} = 1 \text{ for } j = 1, \ldots, m$$

$$\sum_{j=1}^{m} D_i x_{ij} \leq K_i y_i \text{ for } i = 1, \ldots, n$$

$$x_{ij}, y_i \in \{0,1\}$$

Locating Plants and Warehouses Simultaneously

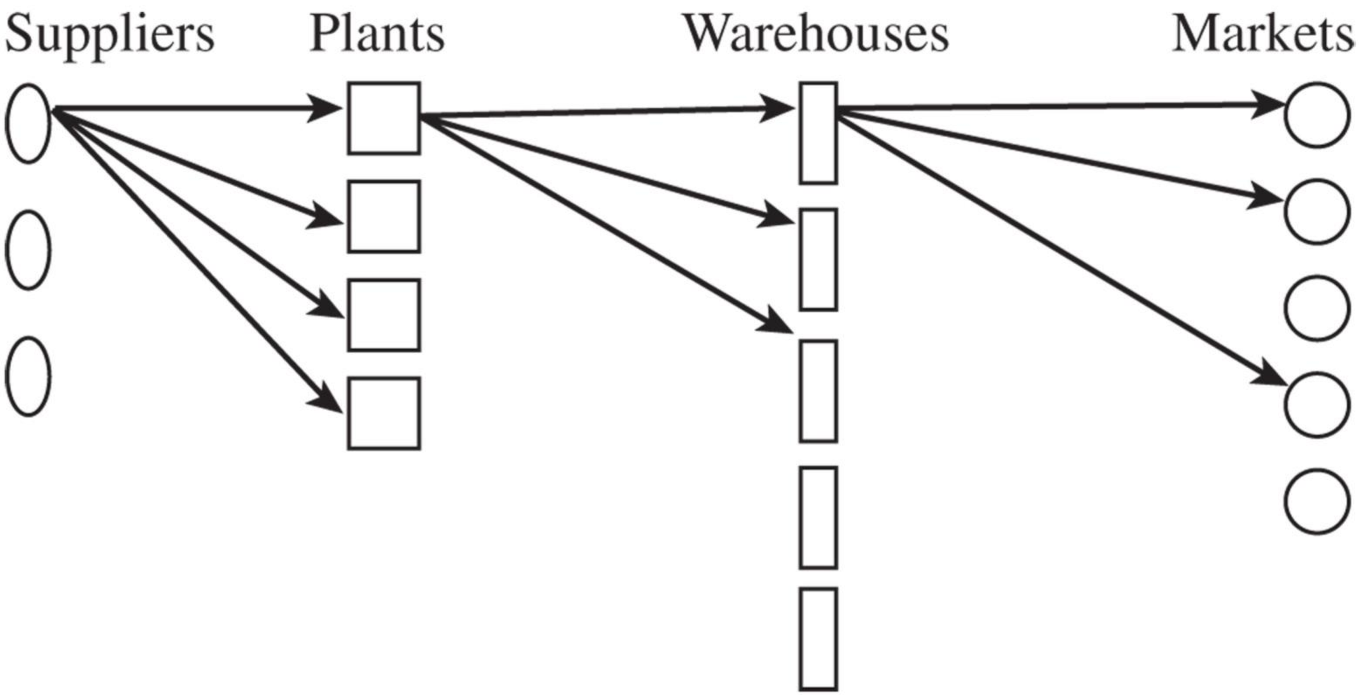


Figure 5-13

Locating Plants and Warehouses Simultaneously

- Model inputs

m = number of markets or demand points
n = number of potential factory locations
l = number of suppliers
t = number of potential warehouse locations
D_j = annual demand from customer j
K_i = potential capacity of factory at site i
S_h = supply capacity at supplier h
W_e = potential warehouse capacity at site e
F_i = fixed cost of locating a plant at site i
f_e = fixed cost of locating a warehouse at site e
c_{hi} = cost of shipping one unit from supply source h to factory i
c_{ie} = cost of producing and shipping one unit from factory i to warehouse e
c_{ej} = cost of shipping one unit from warehouse e to customer j

Locating Plants and Warehouses Simultaneously

- Goal is to identify plant and warehouse locations and quantities shipped that minimize the total fixed and variable costs

Y_i = 1 if factory is located at site i, 0 otherwise
Y_e = 1 if warehouse is located at site e, 0 otherwise
x_{ej} = quantity shipped from warehouse e to market j
x_{ie} = quantity shipped from factory at site i to warehouse e
x_{hi} = quantity shipped from supplier h to factory at site i

$$Min \sum_{i=1}^{n} F_i y_i + \sum_{e=1}^{t} f_e y_e + \sum_{h=1}^{l} \sum_{i=1}^{n} c_{hi} x_{ie} + \sum_{e=1}^{t} \sum_{j=1}^{m} c_{ej} x_{ej}$$

Locating Plants and Warehouses Simultaneously

subject to

$$\sum_{i=1}^{n} x_{hi} \le S_h \quad \text{for } h = 1,\ldots,l$$

$$\sum_{h=1}^{l} x_{hi} - \sum_{e=1}^{t} x_{ie} \ge 0 \quad \text{for } i = 1,\ldots,n$$

$$\sum_{e=1}^{t} x_{ie} \le K_i y_i \quad \text{for } i = 1,\ldots,n$$

$$\sum_{i=1}^{n} x_{ie} - \sum_{j=1}^{m} x_{ej} \ge 0 \quad \text{for } e = 1,\ldots,t$$

$$\sum_{j=1}^{m} x_{ej} \le W_e y_e \quad \text{for } e = 1,\ldots,t$$

$$\sum_{e=1}^{t} x_{ej} = D_j \quad \text{for } j = 1,\ldots,m$$

$$y_i, y_e \in \{0,1\}, x_{ej}, x_{ie}, x_{hi} \ge 0$$

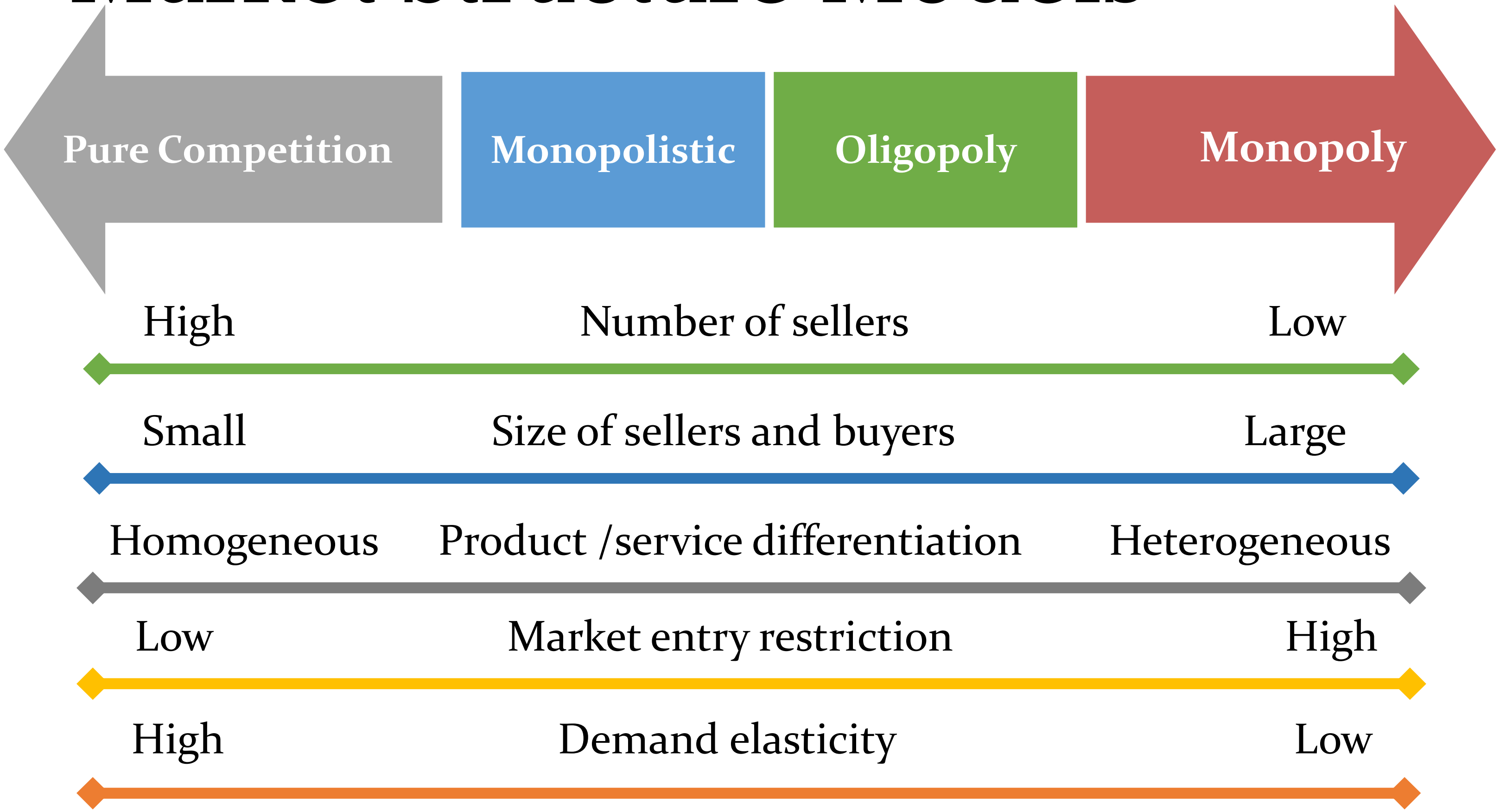
Accounting for Taxes, Tariffs, and Customer Requirements

- A supply chain network should maximize profits after tariffs and taxes while meeting customer service requirements
- Modified objective and constraint

$$Max \sum_{j=1}^{m} r_j \sum_{i=1}^{n} x_{ij} - \sum_{i=1}^{n} F_i y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$$

$$\sum_{i=1}^{n} x_{ij} \leq D_j \quad \text{for } j = 1,\ldots,m$$

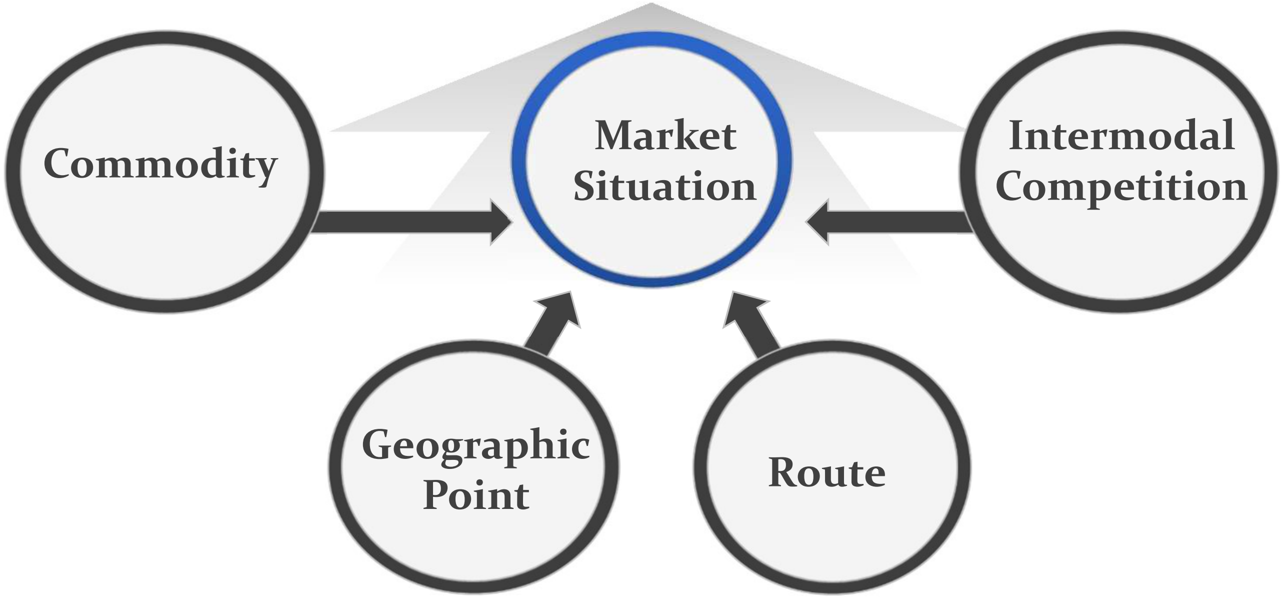
Market Structure Models



The Unique Nature of Transportation Markets

All four types of markets can be found in transportation industries, depending on particular market situations.

Relevant Market Area Concept



Cost-of-service Pricing
vs.
Value-of-service Pricing

Cost-of-service Pricing

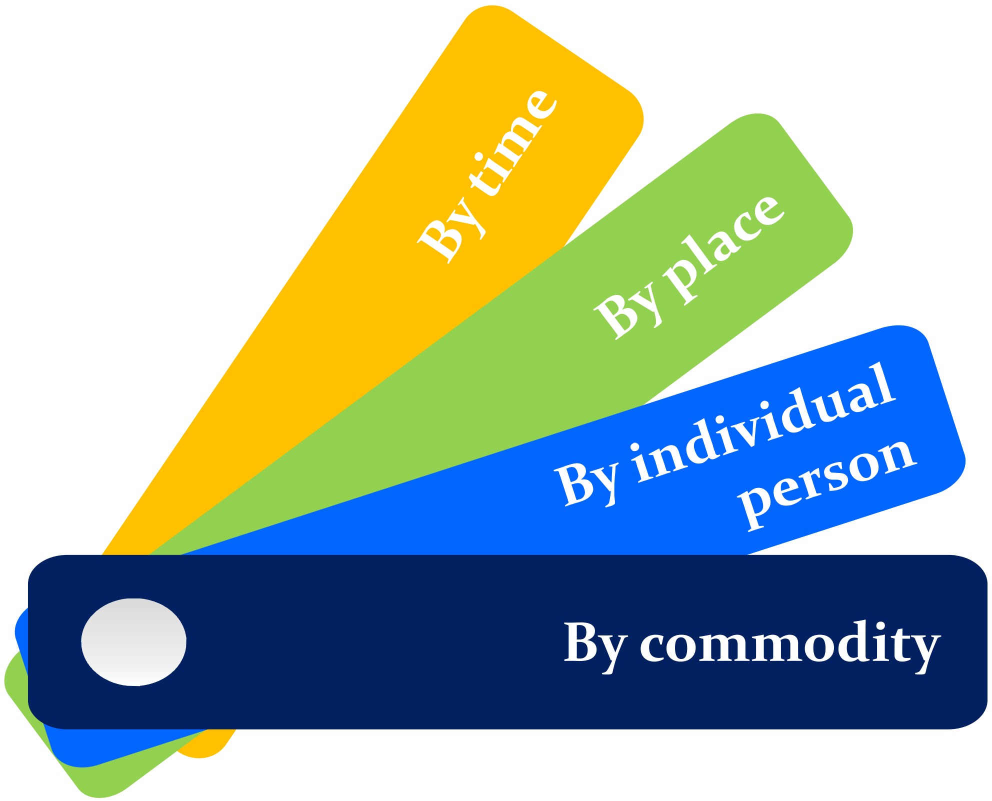
Two alternative concepts

- Average-cost approach
  - Rates are based on average or fully allocated costs.
- Marginal-cost / Variable-cost approach
  - Rates are based on the cost of producing one more unit of an output.

Images courtesy of PT Compliance Group

Value-of-service Pricing

Differential Pricing



Differential pricing can be done based on several methods of segregating the buyers into distinct groups.

Rate Making in Practice

Rate Structure Systems

- Class Rates
- Exception Rates
- Commodity Rates
- Special Rates

Risk Management Process

* Determine the potential transportation disruptions

* Evaluate the likelihood and impact of each disruption

* Monitor and update the plan, identify new risks

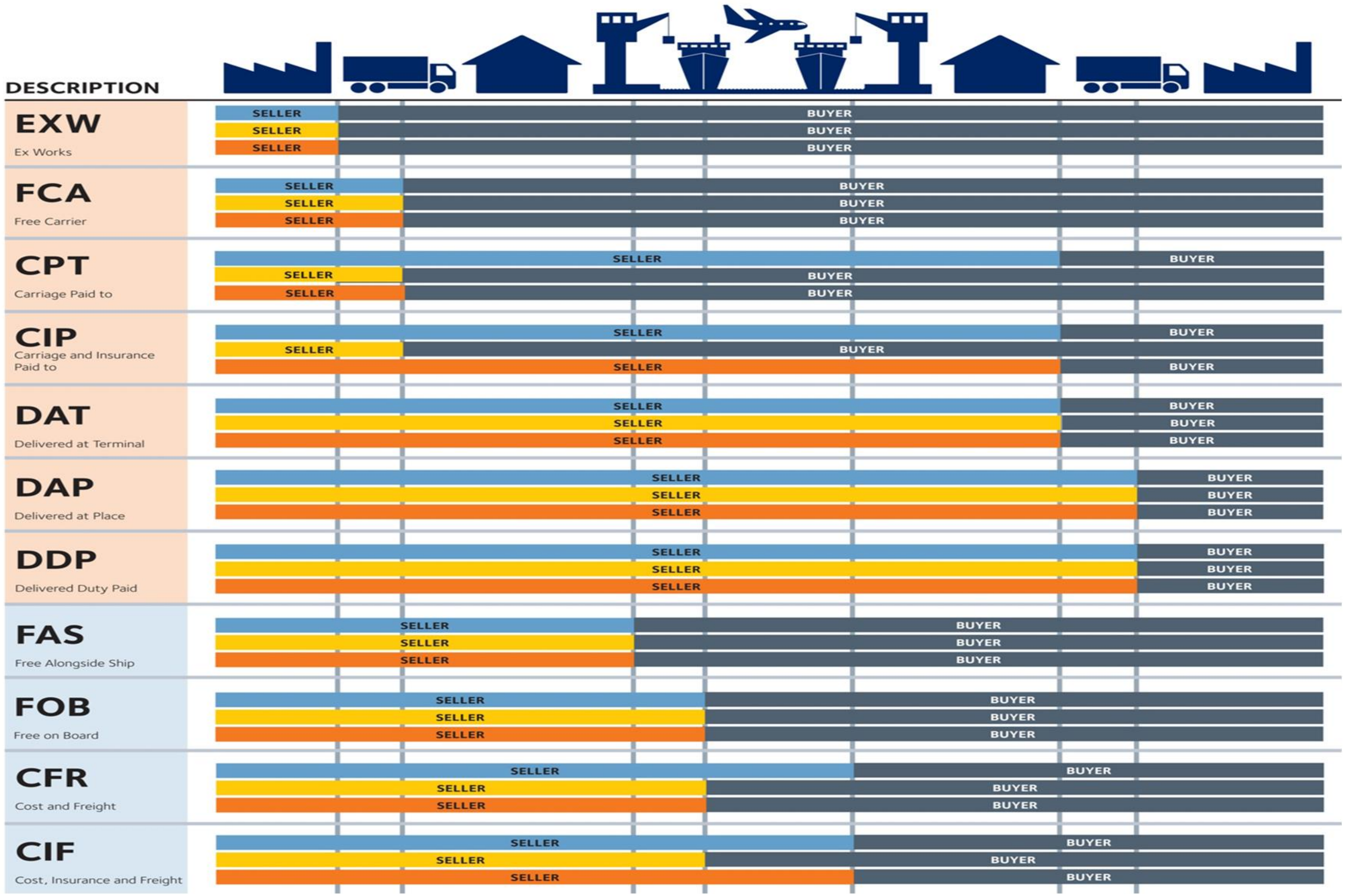
* Apply risk management and mitigation strategies

Incoterm

COSTS RISK INSURANCE

All modes of transport

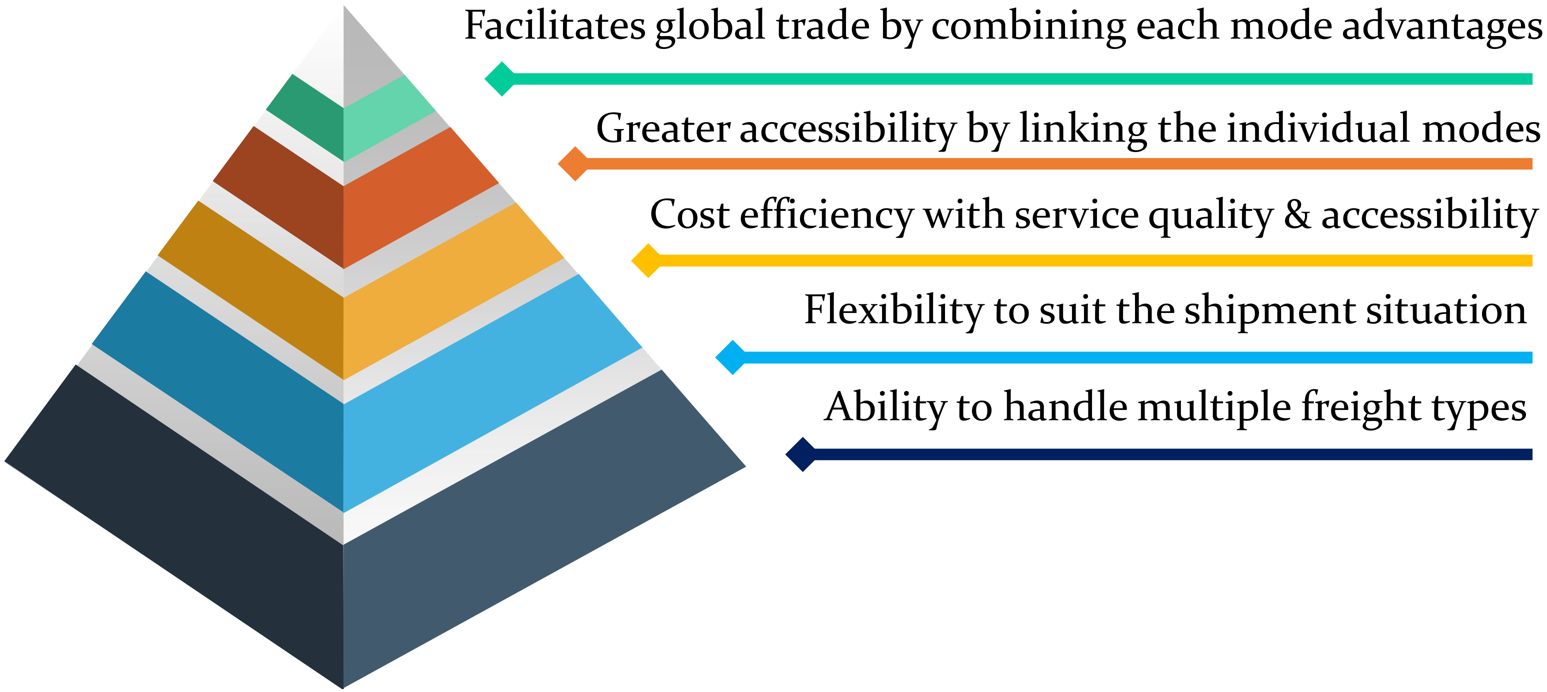
Sea and inland waterways



Images courtesy of NDF Freight Forwarding Ltd

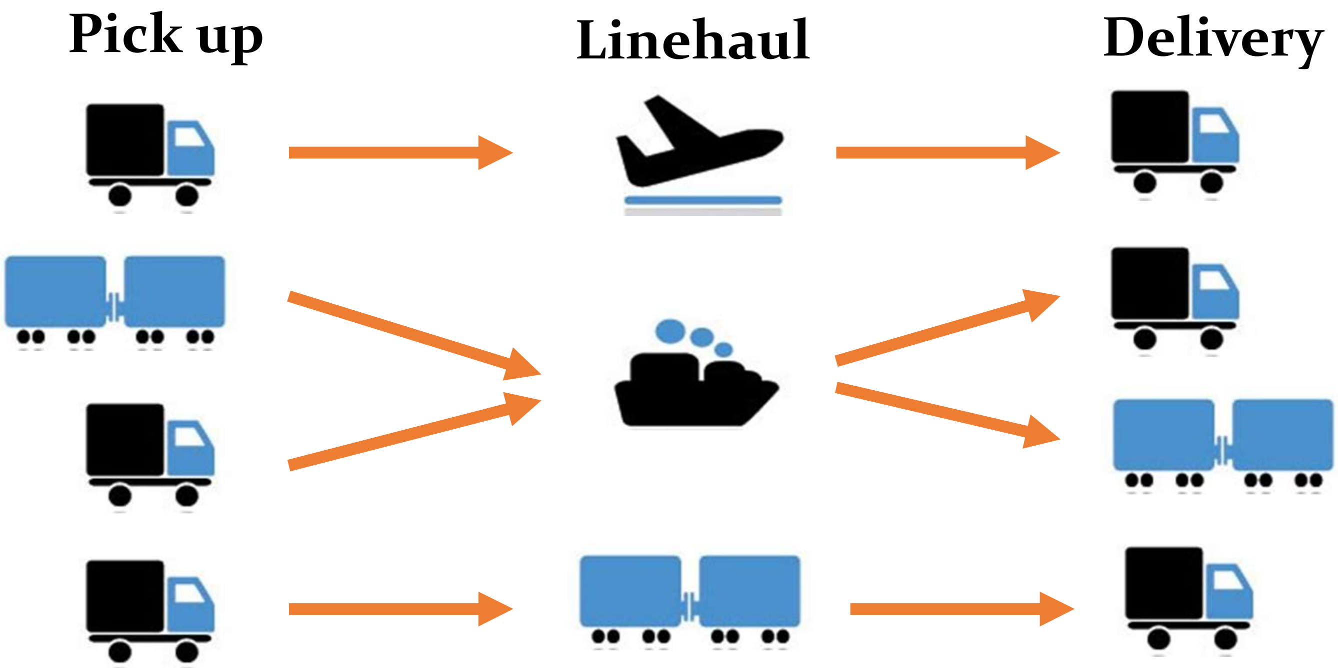
Intermodal Transportation

Intermodal transportation involves the use of two or more modes of transport in moving a shipment from origin to destination.



Intermodal Transportation Options

Carrier, rather than shipper, typically makes decisions of which combination to use.



Standard Dry Cargo Containers

DRY CARGO CONTAINERS

• DIMENSIONS

Type	Container Weight			Interior Measurement				Door Open	
	Gross (kg)	Tare (kg)	Net (kg)	Length (m)	Width (m)	Height (m)	Capacity (m^3)	Width (m)	Height (m)
20 ft	24,000	2,370	21,630	5.898	2.352	2.394	33.20	2.343	2.280
40 ft	30,480	4,000	26,480	12.031	2.352	2.394	67.74	2.343	2.280

HIGH CUBE CONTAINERS

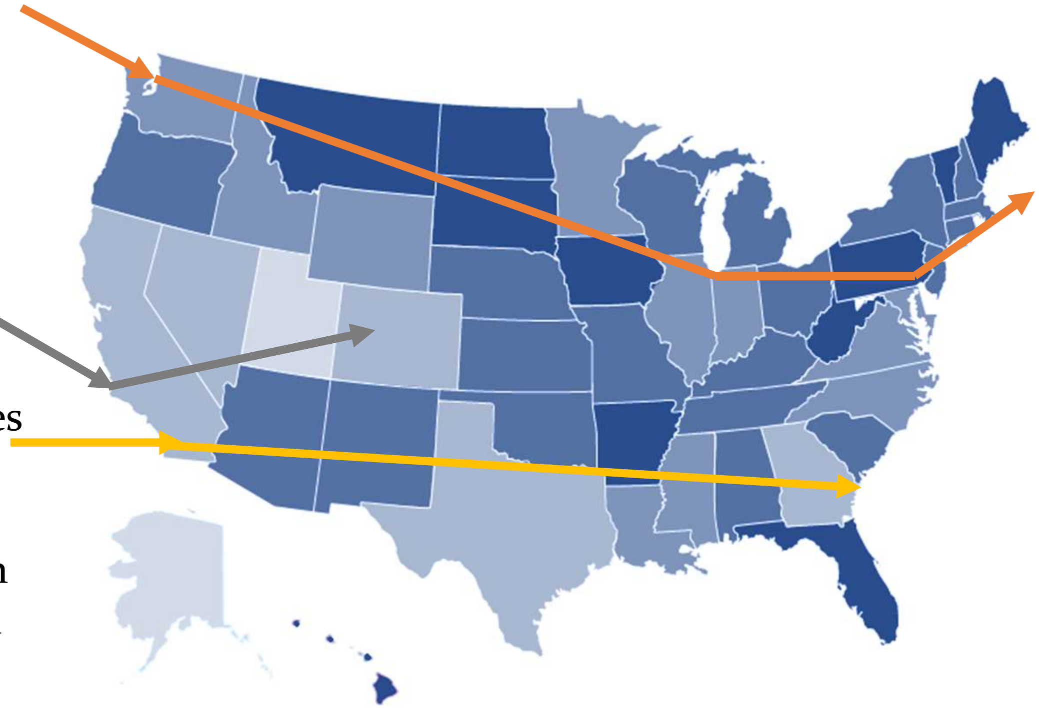
• DIMENSIONS

Type	Container Weight			Interior Measurement				Door Open	
	Gross (kg)	Tare (kg)	Net (kg)	Length (m)	Width (m)	Height (m)	Capacity (m^3)	Width (m)	Height (m)
40 ft	30,480	3,980	26,500	12.031	2.352	2.698	76.30	2.340	2.585
45 ft	30,480	4,800	25,680	13.544	2.352	2.698	86.00	2.340	2.585

Images courtesy of campus.hesge.ch

Intermodal Routing

Land Bridge involves a combination of ocean-rail-ocean intermodal transport



Mini Bridge involves a combination of ocean and rail transport to a location across the destination country

Micro Bridge involves a combination of ocean and rail transport to an inland location.

Intercontinental Transportation

Ocean Shipping

Service Options

Liner

- Serve a particular trade area, such as the trans-Pacific lanes, trans-Atlantic lanes, or Asia-Europe lanes.
- Some liner ships travel on “round the world” schedules.

Charter

- Operate in geographic regions defined by the individual customer
- Charter types include voyage charter, time charter, demise charter (including bareboat charter)

Private

- Private ships are owned or leased on a long-term basis by the company moving the goods.

Intercontinental Transportation

Ocean Shipping – Equipment Types

There were 47,547 cargo ships in the world fleet (2013). Most ships fly a flag of convenience.

- Containerships (box ships)
- Break-bulk ships
- Roll-on/roll-off (RORO)
- Bulk carriers
- Combination ships

Images courtesy of Beach Area

Intercontinental Transportation

Ocean Shipping – Current Issues

Ultra-large containerships (ULCS)

* **Limits of potential routes.** Few ports can handle ships of this length & draught.
* **Port congestion.** Added amount of time required to load/offload containers.
* **Load factors.** High load factors required.

Ocean carrier alliance

* Originally conceived as a competitive tool to provide more frequent service & better reliability.
* Today, used as a defensive response to prolonged overcapacity & faltering freight rates

E-shipping-enabled processes

* Shifts from inefficient, error-prone manual processes to process automation

Images courtesy of Maritime Connector, Sea News, Xpat

Intercontinental Transportation

International Air

Service Options

Combination Carriers

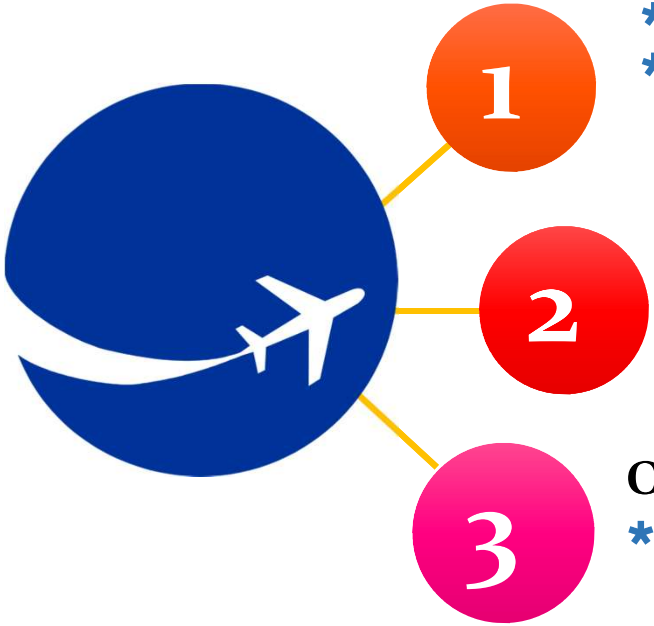
- Move freight and passengers, with cargo loaded in the belly of the aircraft.

Air Cargo Carriers

- Focus exclusively on the movement of freight, packages, letters, and envelopes.
- Provide scheduled service (majority) or on-demand charter service
- Integrated carriers offer door-to-door service e.g. FedEx and UPS
- Nonintegrated carriers offer airport-to-airport service e.g. Cargolux and AirBridgeCargo

Intercontinental Transportation

International Air – Equipment Types



Images courtesy of Galleryhip

Air freighters

- Aircrafts dedicated solely to freight movement
- Carry palletized or containerized cargo called unit load devices (ULDs).

Passenger airplanes

- Passengers travel on main deck/cabin, luggage and some cargo loaded into lower deck/belly
- Commonly restricted to smaller individual shipments of cargo

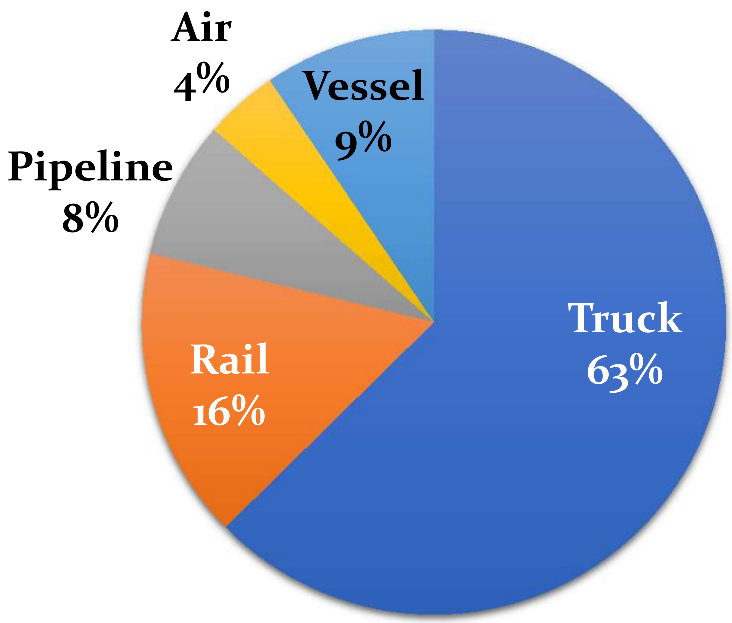
Ombi airplane

- Aircrafts with the flexibility to change the passenger/cargo mix on the main deck of the aircraft

Intracontinental Transportation

Trucking

US-NAFTA Merchandise Trade Value by Mode: 2013



Trucking is the major player for intracontinental freight flows in North America (same in Europe).

Source: US Bureau of Transportation Statistics

Intracontinental Transportation

Trucking – Current Issues

A patchwork of domestic rules and regulations impede international freight flows.

Images courtesy of Forbes

- Few global standards for trucking or roadway infrastructure. Different regulations regarding equipment length, width, and carrying capacity.
- Inconsistent safety regulations regarding driver hours of service, speed limits, and inspections.
- Driving bans during certain times of the day and/or days of the week in some countries.

Intracontinental Transportation

Railroads

Images courtesy of pixgood.com

- International rail service benefits from a standardized infrastructure and equipment.
- Still, North American rail traffic accounts for only 15 percent of the total regional freight volume.
- Rail activity mainly focuses on the movement of bulk raw materials and intermodal containers.

International Gateways

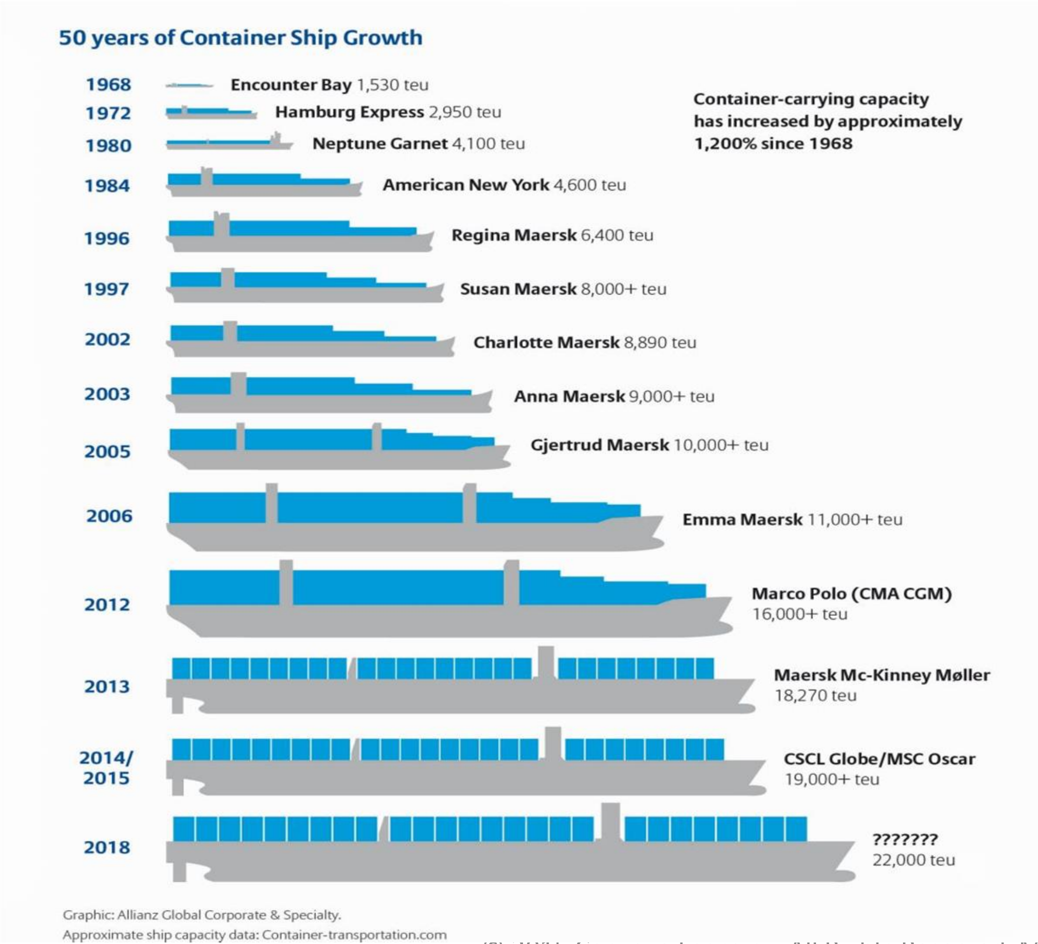
Seaports

A vast majority of international trade flows through a small group of major, deep draft commercial seaports

Images courtesy of Freightos

International Gateways

Seaports – Current Issues



- Increasing size of containerships
  - Deeper waterways
  - Larger cranes
  - Sailing schedules to accommodate the longer unloading and processing times
- Congestion at major seaports
- Periodic labor disputes and protracted labor contract negotiations

Images courtesy of Allianz

Custom Clearance

Customs Broker

Customs brokers are private individuals or firms licensed by the CBP to act as agents for importers, providing expertise in the entry process for a fee.

Prepare and file the necessary Customs entry documents

Arrange for the payment of duties

Speed the release of the goods in CBP custody

Coordinate inland and ocean transport

Dockside-inspect cargo

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Chapter 5
DEMAND FORECASTING

Prepared by Cynthia Wisner, MBA

Forecasting Techniques

- **Qualitative forecasting** is based on opinion & intuition.
- **Quantitative forecasting** uses mathematical models & historical data to make forecasts.
- **Time series** models are the most frequently used among all the forecasting models.

Forecasting Techniques *(Continued)*

Qualitative Forecasting Methods

Generally used when data are limited, unavailable, or not currently relevant. Forecast depends on skill & experience of forecaster(s) & available information

Four qualitative models used are –

1. **Jury of executive opinion**
2. **Delphi method**
3. **Sales force composite**
4. **Consumer survey**

Forecasting Techniques *(Continued)*

Quantitative Methods

- **Time series forecasting –** based on the assumption that the future is an extension of the past. Historical data is used to predict future demand

- **Cause & Effect forecasting –** assumes that one or more factors (independent variables) predict future demand

It is generally recommended to use a combination of quantitative & qualitative techniques

Forecasting Techniques *(Continued)*

Components of Time Series

Data should be plotted to detect for the following components –

- Trend variations: increasing or decreasing over many years
- Cyclical variations: wavelike movements that are longer than a year (e.g., business cycle)
- Seasonal variations: show peaks & valleys that repeat over a consistent interval such as hours, days, weeks, months, seasons, or years
- Random variations: due to unexpected or unpredictable events

Forecasting Techniques *(Continued)*

Time Series Forecasting Models

Naïve Forecast – the estimate of the next period is equal to the demand in the past period.

$$F_{t+1} = A_t$$

Where F_{t+1} = forecast for period $t+1$

A_t = actual demand for period t

Forecasting Techniques *(Continued)*

Time Series Forecasting Models

Simple Moving Average Forecast – uses historical data to generate a forecast. Works well when demand is stable over time.

$$F_{t+1} = \frac{\sum_{i=t-n+1}^{t} A_i}{n}$$

Where F_{t+1} = forecast for period $t+1$

A_t = actual demand for period t

n = number of periods to calculate moving average

Forecasting Techniques *(Continued)*

Time Series Forecasting Models

Weighted Moving Average Forecast – is based on an n-period weighted moving average

$$F_{t=1} = \sum_{i=t-n+1}^{t} w_i A_i$$

Where
F_{t+1} = forecast for period *t+1*
A_i = actual demand for period *i*
n = number of periods to calculate moving average
w_i = weight assigned to period i ($\Sigma w_i = 1$)

Forecasting Techniques (*Continued*)

Time Series Forecasting Models

Exponential Smoothing Forecast – a type of weighted moving average where only two data points are needed

$$F_{t+1} = F_t + \alpha(A_t - F_t) \text{ or } F_{t+1} = \alpha A_t + (1 - \alpha) F_t$$

Where F_{t+1} = forecast for Period $t + 1$

F_t = forecast for Period t

A_t = actual demand for Period t

α = smoothing constant ($0 \leq \alpha \leq 1$)

Forecasting Techniques (Continued)

Time Series Forecasting Models

Linear Trend Forecast – trend can be estimated using simple linear regression to fit a line to a time series

$$\hat{Y} = b_0 + b_1 x$$

Where $\hat{Y}$ = forecast or dependent variable

x = time variable

b_0 = intercept of the line

b_1 = slope of the line

Forecast Accuracy *(Continued)*

Several measures of forecasting accuracy follow –

- **Mean absolute deviation (MAD)-** a MAD of 0 indicates the forecast exactly predicted demand
- **Mean absolute percentage error (MAPE)-** provides a perspective of the true magnitude of the forecast error
- **Mean squared error (MSE)-** analogous to variance, large forecast errors are heavily penalized

Forecast Accuracy (Continued)

Mean absolute deviation (MAD)-

MAD of 0 indicates the forecast exactly predicted demand.

$$\text{Mean absolute deviation (MAD)} = \frac{\sum_{i=1}^{n} |e_t|}{n}$$

Where e_t = forecast error for period t
A_t = actual demand for period *t*
n = number of periods of evaluation

Forecast Accuracy *(Continued)*

Mean absolute percentage error (MAPE) –

provides a perspective of the true magnitude of the forecast error.

$$\text{Mean absolute percentage error (MAPE)} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{e_t}{A_t}\right|(100)$$

Where e_t = forecast error for period t
A_t = actual demand for period *t*
n = number of periods of evaluation

Forecast Accuracy *(Continued)*

Mean squared error (MSE) –

analogous to variance, large forecast errors are heavily penalized

$$\text{Mean squared error (MSE)} = \frac{\sum_{t=1}^{n} e_t^2}{n}$$

Where e_t = forecast error for period t
n = number of periods of evaluation

Collaborative Planning, Forecasting, & Replenishment (CPFR)

<u>What is CPFR?</u>

It is a business practice that combines the intelligence of multiple trading partners in the planning & fulfillment of customer demands.

It links sales & marketing best practices, such as category management, to supply chain planning processes to increase availability while reducing inventory, transportation & logistics costs.

Collaborative Planning, Forecasting, & Replenishment *(Continued)*

Real value of CPFR comes from sharing of forecasts among firms rather than sophisticated algorithms from only one firm.

Does away with the shifting of inventories among trading partners that suboptimizes the supply chain.

CPFR provides the supply chain with a plethora of benefits but requires a fundamental change in the way that buyers & sellers work together.

Collaborative Planning, Forecasting, & Replenishment *(Continued)*

CPFR Benefits

- Strengthens partner relationships
- Provides analysis of sales and order forecasts
- Uses point-of-sale data, seasonal activity, promotions, to improve forecast accuracy
- Manages the demand chain and proactively eliminates problems before they appear
- Allows collaboration on future requirements and plans

Collaborative Planning, Forecasting, & Replenishment *(Continued)*

CPFR Benefits (continued)

- Allows collaboration on future requirements and plans
- Uses joint planning and promotions management
- Integrates planning, forecasting and logistics activities
- Provides efficient category management and understanding of consumer purchasing patterns

Collaborative Planning, Forecasting, & Replenishment *(Continued)*

CPFR Benefits (continued)

- Provides analysis of key performance metrics (e.g., forecast accuracy, forecast exceptions, product lead times, inventory turnover, percentage stockouts) to reduce supply chain inefficiencies, improve customer service, and increase revenues and profitability.

Useful Forecasting Websites

- Institute for Business Forecasting & Planning
  https://ibf.org/
- International Institute of Forecasters
  www.forecasters.org
- Forecasting Principles
  www.forecastingprinciples.com
- Stata (Data analysis & statistical software)
  www.stata.com/links/stat_software.html

Software Solutions

Forecasting Software simplifies the calculation processes and saves a great deal of time

▪ Business Forecast Systems	www.forecastpro.com
▪ John Galt	www.johngalt.com
▪ Just Enough	www.justenough.com
▪ SAS	www.sas.com
▪ Avercast, LLC	www.avercast.com

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Chapter 6

RESOURCE PLANNING SYSTEMS

Prepared by Cynthia Wisner, MBA

Operations Planning

Operations planning is usually hierarchical & can be divided into three broad categories:

- **Long-range – Aggregate Production Plan (APP)** usually covers a year or more, involves the construction of facilities & major equipment purchase
- **Intermediate –** plan spans six to eighteen months. Shows the quantity & timing of end items (i.e., master production schedule – MPS)
- **Short-range –** plan covers a few days to a few weeks. Detailed planning process for components & parts to support the master production schedule (i.e., materials requirement planning – MRP)

Operations Planning (*Continued*)

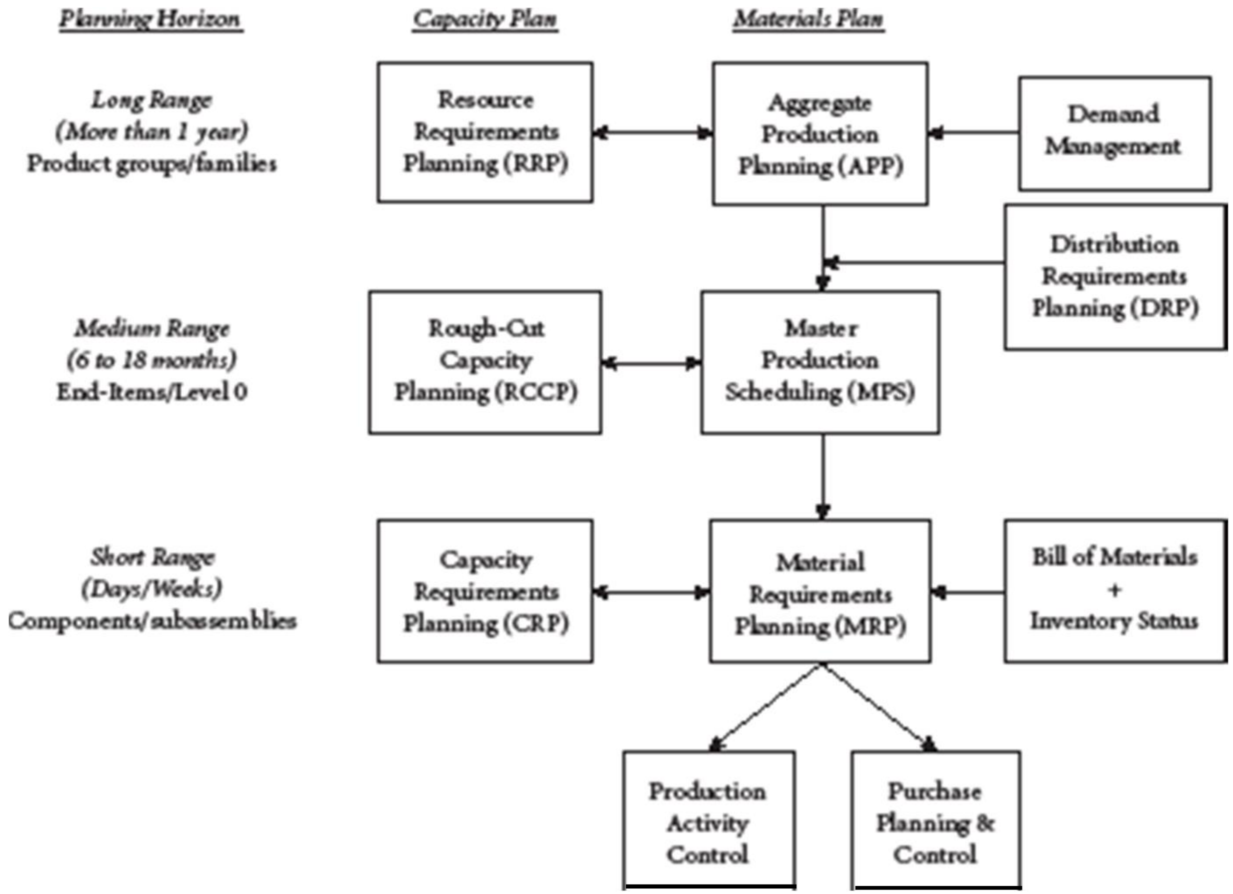


Figure 6.1

Operations Planning *(Continued)*

- **Material Requirements Plan** (MRP) is a system of converting the end items from the master production schedule into a set of time-phased component part requirements
- **Manufacturing resource planning (MRP II) –** combined MRP with master production scheduling, rough-cut capacity planning, capacity requirement planning, and other operations planning software modules
- **Enterprise requirements planning (ERP) -** is an extension of MRP-II
- **Distribution requirement planning (DRP) -** describes the time-phased net requirements from warehouses & distribution centers. Links production with distribution planning

Aggregate Production Plan

Hierarchical planning - process that translates annual business plans & demand forecasts into a production plan for a product family (products that share similar characteristics) in a plant or facility leading to the Aggregate Production Plan (APP)

- Planning horizon of APP is at least one year & is usually rolled forward by three months every quarter
- Costs relevant to the aggregate planning decision include inventory, setup, machine operation, hiring, firing, training, & overtime costs

Aggregate Production Plan *(Continued)*

Basic Production Strategies :

Chase Strategy - Adjusts capacity to match demand. Firm hires & lays off workers to match demand. Finished goods inventory remains constant. Works well for make-to-order firms

- Generally produce one-of-a-kind, specialty products
- Generally require highly skilled labor
- Can be problematic when highly skilled workers are needed in a tight labor market

Aggregate Production Plan *(Continued)*

Basic Production Strategies :

Level Strategy - Relies on a constant output rate while varying inventory & backlog according to fluctuating demand. Firm relies on fluctuating finished goods & backlogs to meet demand. Works well for make-to-stock firms

- Inventory carrying and stockout costs are major cost concerns

- This strategy works well when highly skilled workers are needed in a tight labor market

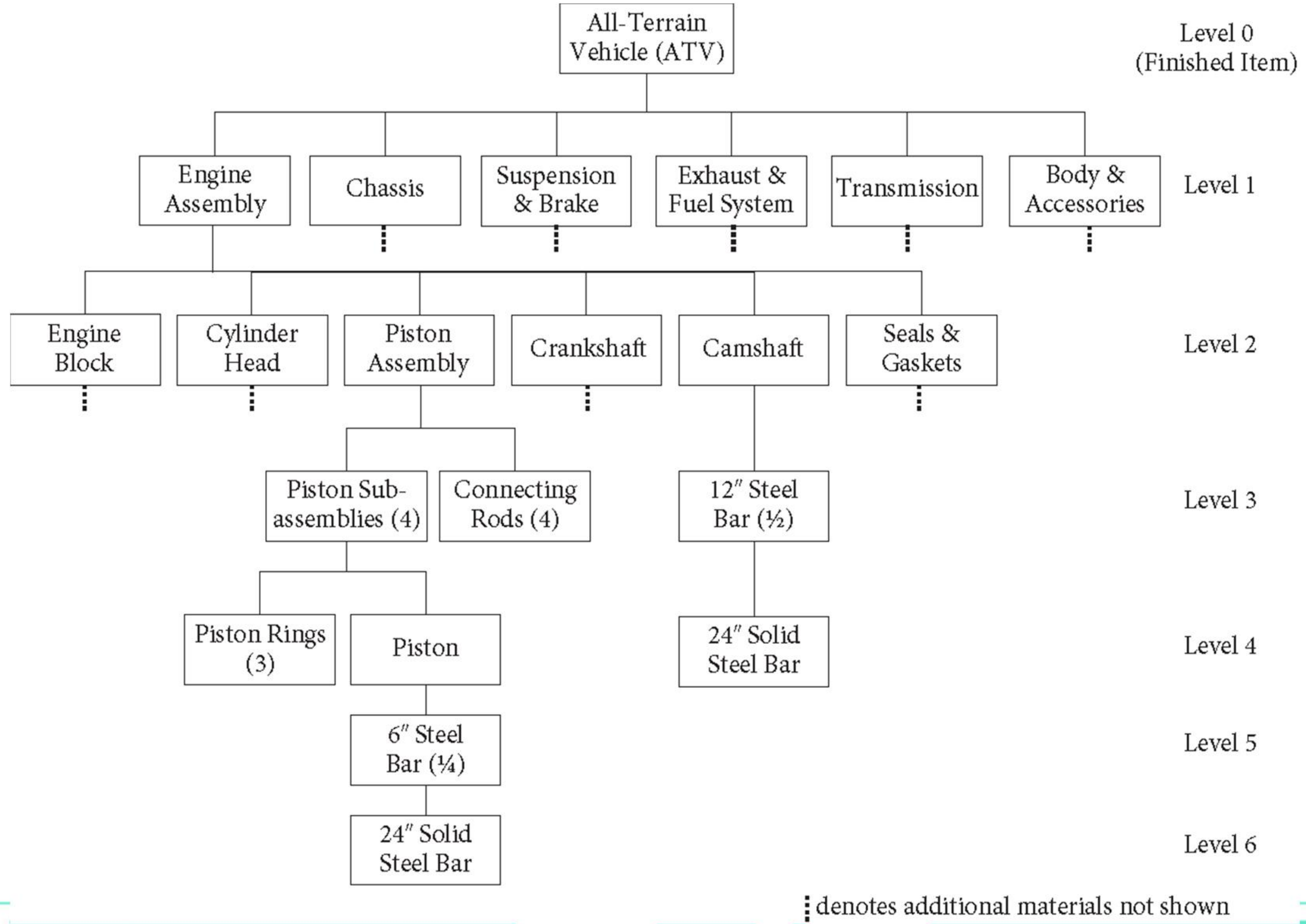
Aggregate Production Plan *(Continued)*

Basic Production Strategies :

Mixed Production Strategy - Maintains stable core workforce while using other short-term means, such as overtime, subcontracting & part time helpers to manage short-term demand

- Complementary products (with different demand cycles) may be produced
- Additional shift may be scheduled
- This strategy works well with firms producing multiple products

The Bill of Materials (Continued)



(Fig. 6.4)

Material Requirements Plan (*Continued*)

Example 6.2

The production schedule for the ATV corporation is obtained from the MPS (table 6.4) and inventory status shows that 30 units of Model A are available at the beginning of the period. The parent-component relationships and planning factors are available in the BOM (figure 6.4). Assuming the following lot sizes (Q), lead times (LT), and safety stocks (SS), the MRP computations follow.

Material Requirements Plan *(Continued)*

Example 6.2

Model A ATV—Level 0		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Requirements		10	10	20	0	20	0	0	20
Scheduled Receipts			10						
Projected On-hand Inventory	30	20	20	20	20	20	20	20	20
Planned Order Releases		20		20			20		
Q = 10; LT = 2; SS = 15									

× 1 × 1 × 1

Engine Assembly—Level 1		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Requirements		20		20			20		
Scheduled Receipts		20							
Projected On-hand Inventory	2	2	2	0	0	0	0	0	0
Planned Order Releases		18			20				
Q = LFL; LT = 2; SS = 0									

× 1 × 1

Piston Assembly—Level 2		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Requirements		18			20				
Scheduled Receipts		20							
Projected On-hand Inventory	10	12	12	12	22	22	22	22	22
Planned Order Releases				30					
Q = 30; LT = 1; SS = 10									

× 4

Connecting Rods—Level 3		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Requirements				120					
Scheduled Receipts									
Projected On-hand Inventory	22	22	22	52	52	52	52	52	52
Planned Order Releases			150						
Q = 50; LT = 1; SS = 20									

Capacity Planning

Capacity – refers to a firm's labor and machine resources

Resource Requirement Planning (RRP) - a long-range capacity planning module, checks whether aggregate resources are capable of satisfying the aggregate production. Resources considered include gross labor hours & machine hours

Medium-range capacity plan, or rough-cut capacity plan (RCCP) - used to check feasibility of MPS. Converts MPS from production needed to capacity required, then compares it to capacity available

Capacity requirement planning (CRP) - a short-range capacity planning technique that is used to check the feasibility of the material requirements plan

Capacity Planning *(Continued)*

Lead capacity strategy – a proactive approach that adds or subtracts capacity in anticipation of future market conditions and demand

Lag capacity strategy – a reactive approach that adjusts its capacity in response to demand

Match or tracking capacity strategy - a moderate strategy that adjusts capacity in small amounts in response to demand and changing market conditions

Distribution Requirements Planning (DRP)

Distribution requirements planning (DRP) - a time-phased finished good inventory replenishment plan in a distribution network

- DRP is a logical extension of the MRP system & ties physical distribution to manufacturing planning and control system
- MRP operates in a dependent demand situation, whereas the DRP operates in an independent demand setting

Development of ERP Systems

Enterprise Resource Planning Systems (ERP) - integrates the internal operations of an enterprise with a common software platform and centralized database system

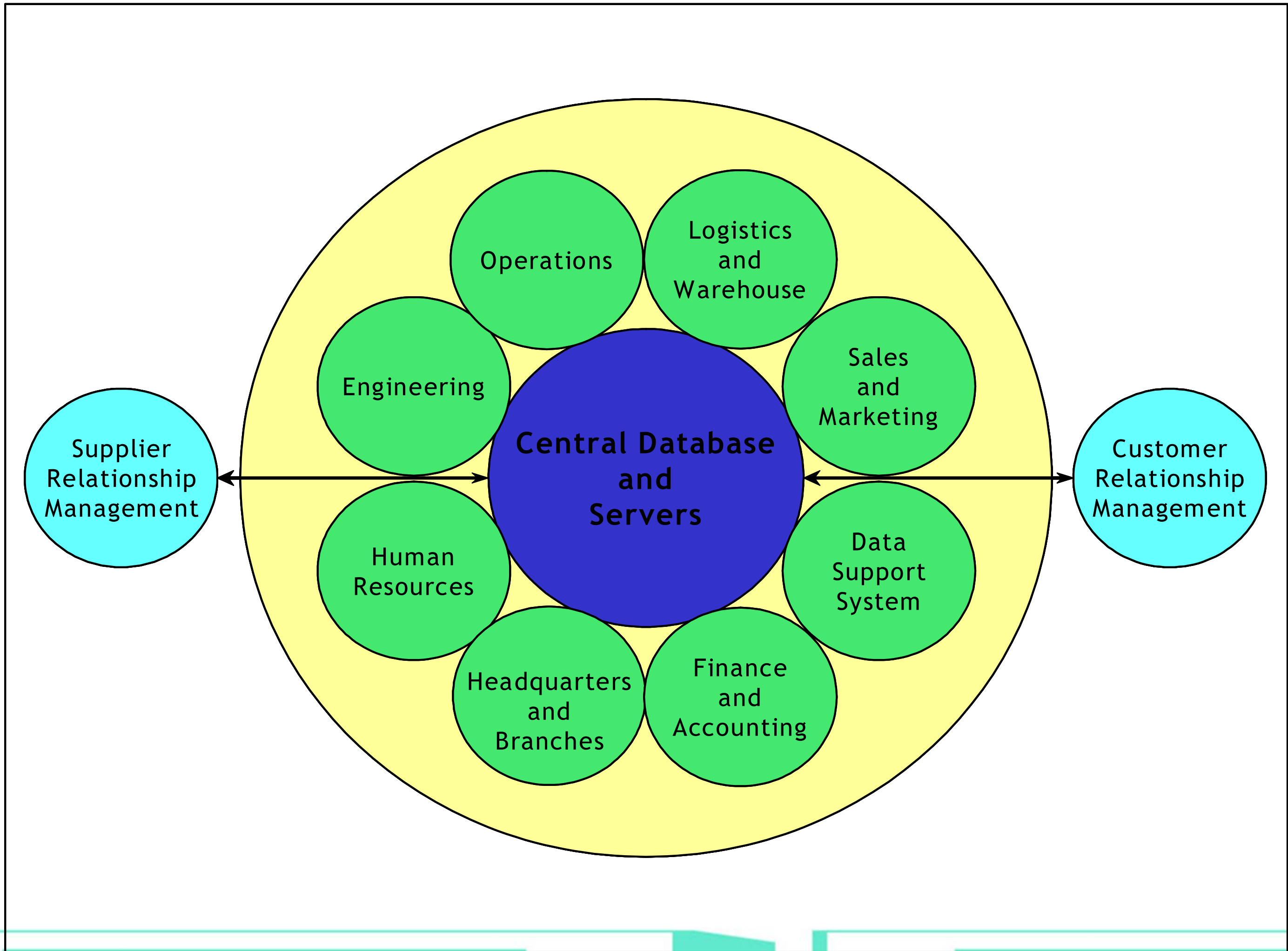
- With a shared, centralized database system, ERP is capable of automating business processes rapidly and accurately

- ERP provides means for supply chain members to share information so that scarce resources can be fully utilized to meet demand, while minimizing supply chain inventories

Development of ERP Systems

(Continued)

Figure 6.6 - Generic ERP System



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Chapter 7

INVENTORY MANAGEMENT

Prepared by Cynthia Wisner, MBA

Introduction

- Inventory can be one of the most expensive assets of an organization
- Inventory may account for more than 10% of total revenue or total assets
- Management must reduce inventory levels yet avoid stockouts and other problems
- Effective inventory management is important to both manufacturers and service organizations
- Excessive inventory is a sign of poor inventory management

Dependent & Independent Demand

Inventory management models –

Generally classified as dependent demand and independent demand models

- **Dependent Demand –**

  Describes the internal demand for parts based on the demand of the final product in which the parts are used. Subassemblies, components, & raw materials are examples of dependent demand items.

- **Independent Demand –**

  The demand for final products & has a demand pattern affected by trends, seasonal patterns, & general market conditions.

Concepts and Tools of Inventory Management

Functions and Basic Types of Inventory

- The primary functions of inventory are to –
  - **Buffer from uncertainty in the marketplace &**
  - **Decouple dependencies in the supply chain (e.g., safety stock)**
- Four broad categories of inventories
  - **Raw materials- unprocessed purchase inputs.**
  - **Work-in-process (WIP)- partially processed materials not yet ready for sales.**
  - **Finished goods- products ready for shipment.**
  - **Maintenance, repair & operating (MRO)- materials used in production (e.g., cleaners & brooms).**

Concepts and Tools of Inventory Management (*Continued*)

ABC Inventory Control System

Determines which inventories should be counted & managed more closely than others

- Groups inventory as A, B, & C Items
  - **A items** are given the highest priority with larger safety stocks. A items account for approximately 20% of the total items & about 80% of the total inventory cost
  - **B items** account for the other about 40% of total items & 15% of total inventory cost.
  - **C items** have the lowest value and hence lowest priority. They account for the remaining 40% of total items & 5% of total inventory cost.

Inventory Models

Fixed Order Quantity Models

- **Economic Order Quantity Model**
- **Quantity Discount Model**
- **Economic Manufacturing Quantity Model**

These models use fixed parameters to derive the optimum order quantity to minimize total inventory cost

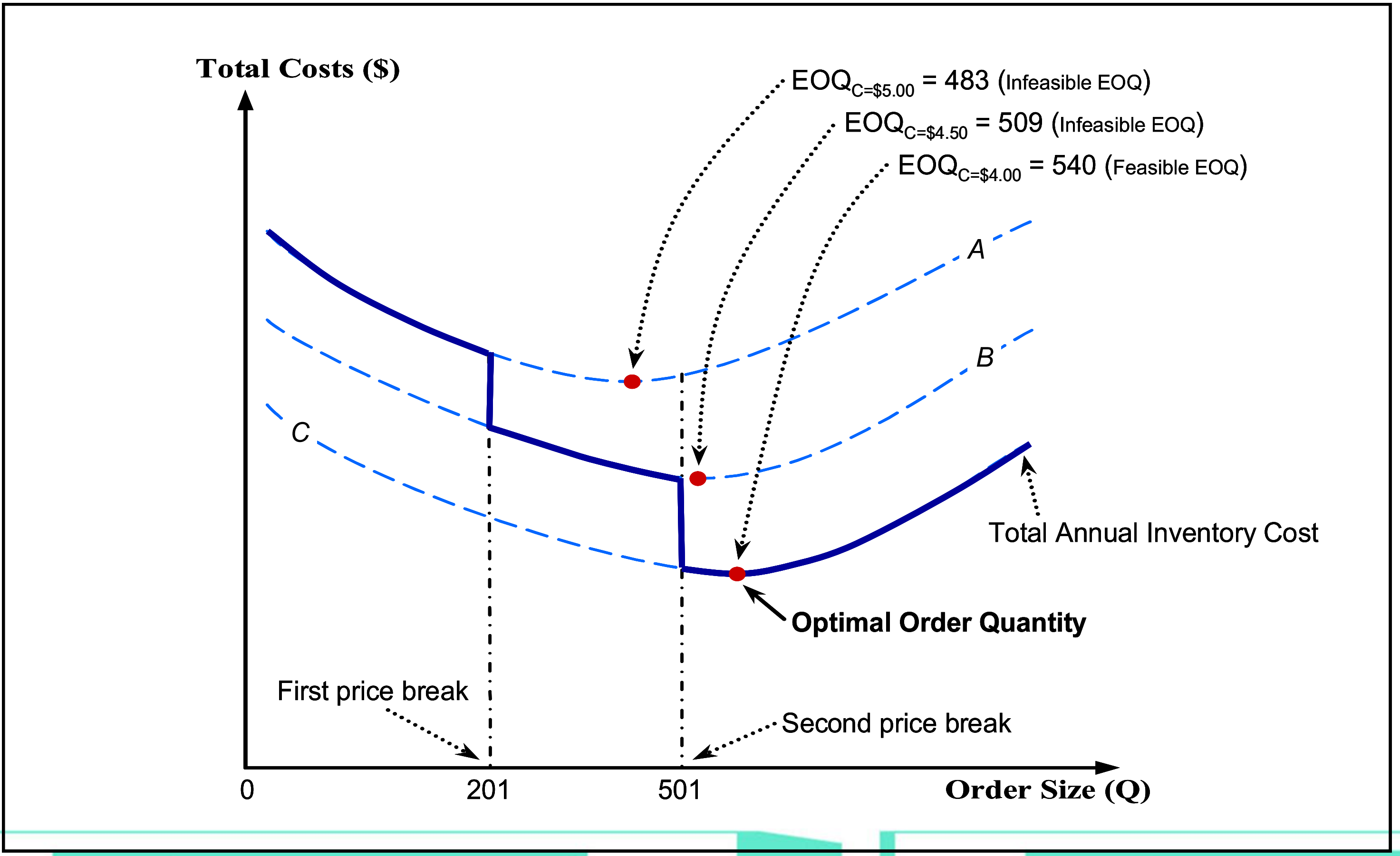
Inventory Models *(Continued)*

- **Economic Order Quantity formula**

$$\text{EOQ} = \sqrt{\frac{2RS}{kC}}$$

Inventory Models (*Continued*)

Quantity Discount Model



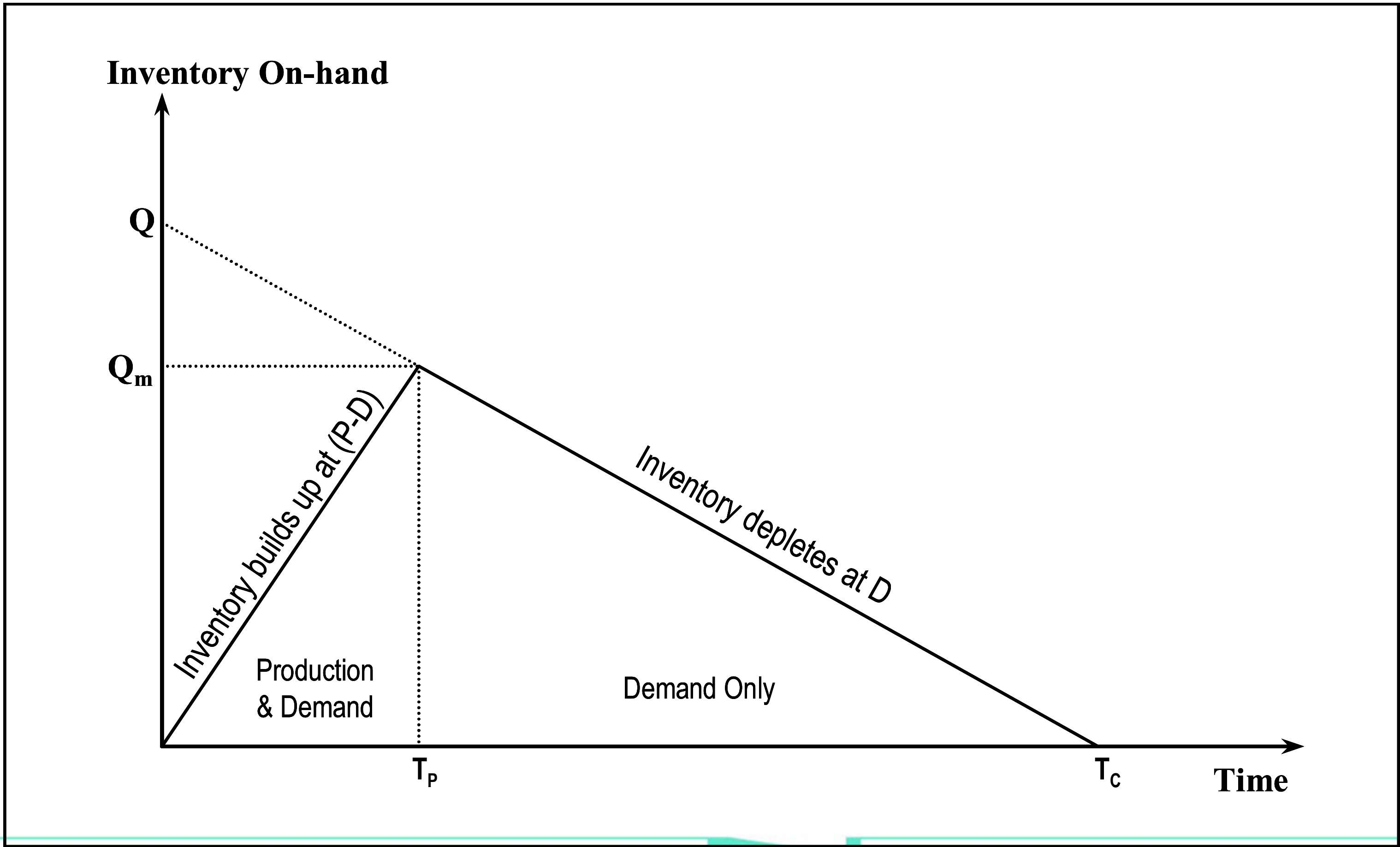
(Fig. 7.5)

Inventory Models *(Continued)*

- The **Economic Manufacturing Quantity Model** or **Production Order Quantity Model**
  - Relaxes the instantaneous replenishment assumption by allowing usage during production or partial delivery.
  - The EMQ model is especially appropriate for a manufacturing environment with simultaneous manufacture and consumption
  - Inventory builds up gradually during the production period rather than at once as in the EOQ model.

Inventory Models *(Continued)*

The EMQ Model



(Fig. 7.9)

Inventory Models (*Continued*)

- The Statistical **Reorder Point (ROP)**
  - The lowest inventory level at which a new order must be placed to avoid a stockout.
  - Demand and delivery lead time are never certain and require safety stock.
- The models used under uncertainty are –
  - Statistical ROP with Probabilistic Demand and Constant Lead Time
  - The Statistical ROP with Constant Demand and Probabilistic Lead Time
  - The Statistical ROP when Demand and Lead Time are both Probabilistic

Inventory Models *(Continued)*

- **The Continuous Review and The Periodic Review Inventory Systems**
  - Order quantity & ROP models assume that the physical inventory is precisely known at every point in time
  - Reality shows that stock records and actual quantity are different & requires continuous review of inventory to determine when to reorder
  - A Continuous Review System is costly to conduct but requires less safety stock than the
  - The Periodic Review System, which reviews physical inventory at specific points in time and requires higher level of safety stock

Inventory Models *(Continued)*

The Continuous Review System

- (s, Q) continuous review policy: orders the same quantity, Q, when physical inventory reaches the reorder point, s
- (s, S) continuous review policy: When current inventory reaches or falls below the reorder point, s, sufficient units are ordered to bring the inventory up to a pre-determined level, S.

Inventory Models *(Continued)*

The Periodic Review System

- *(nQ, s, R) periodic review policy*: If at the time of inventory review, the physical inventory is equal to or less than the reorder point, s, the quantity, nQ, is ordered to bring the inventory up to the level between s and (s + Q).
- *(S, R) periodic review policy*: At each review time, a sufficient quantity is ordered to bring the inventory up to a pre-determined maximum inventory level, S.
- (s, S, R) policy: If at the time of inventory review, the physical inventory is equal to or less than the reorder point, s, a sufficient quantity is ordered to bring the inventory level up to the maximum inventory level, S.

Chapter 8

Principles of Supply Chain Management
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Leong

PROCESS MANAGEMENT: LEAN & SIX SIGMA IN THE SUPPLY CHAIN

Prepared by Cynthia Wisner, MBA

Introduction

In 1990s, supply chain management combined:

- Quick response (QR) - speed & flexibility
- Efficient Consumer Response (ECR) - speed & flexibility
- JIT - Continuous reduction of waste
- Keiretsu Relationships – partnership arrangements

These approaches have emerged as philosophies & practices known as Lean Production (or Lean Manufacturing) & Lean Thinking

Lean Production & the Toyota Production System (*Continued*)

Lean Production

an operating philosophy of waste reduction & value enhancement & was originally created as Toyota Production System (TPS) by key Toyota executives

- Early versions were based on Ford assembly plants & U.S. supermarket distribution systems

Lean Production & the Toyota Production System *(Continued)*

Key concepts incorporated in TPS are –

- Muda - waste in all aspects of production
- Kanban - signal card & part of JIT
- Statistical process control (SPC) as part of TQM efforts
- Poka-Yoke - error or mistake-proofing
- Yokoten – sharing of best practices

The Elements of Lean Production

The Elements of Lean

- Waste Reduction
- Lean Supply Chain Relationships
- Lean Layouts
- Inventory & Setup Time Reduction
- Small Batch Scheduling
- Continuous Improvement
- Workforce Empowerment

The Elements of Lean Production

(*Continued*)

The Seven Wastes

Wastes	Description
Overproducing	Unnecessary production to maintain high utilizations
Waiting	Excess idle machine & operator & inventory wait time
Transportation	Excess movement of materials & multiple handling
Over-processing	Non-value adding manufacturing & other activities
Excess Inventory	Storage of excess inventory
Excess Movement	Unnecessary movements of employees
Scrap & Rework	Scrap materials & rework due to poor quality

(Table 8.2)

The Elements of Lean Production

(*Continued*)

The Five-S's

Japanese S-Term	English Translation	English S-Term Used
1. Seiri	Organization	Sort
2. Seiton	Tidiness	Set in order
3. Seiso	Purity	Sweep
4. Seiketsu	Cleanliness	Standardize
5. Shitsuke	Discipline	Self-discipline

(Table 8.3)

The Elements of Lean Production

(*Continued*)

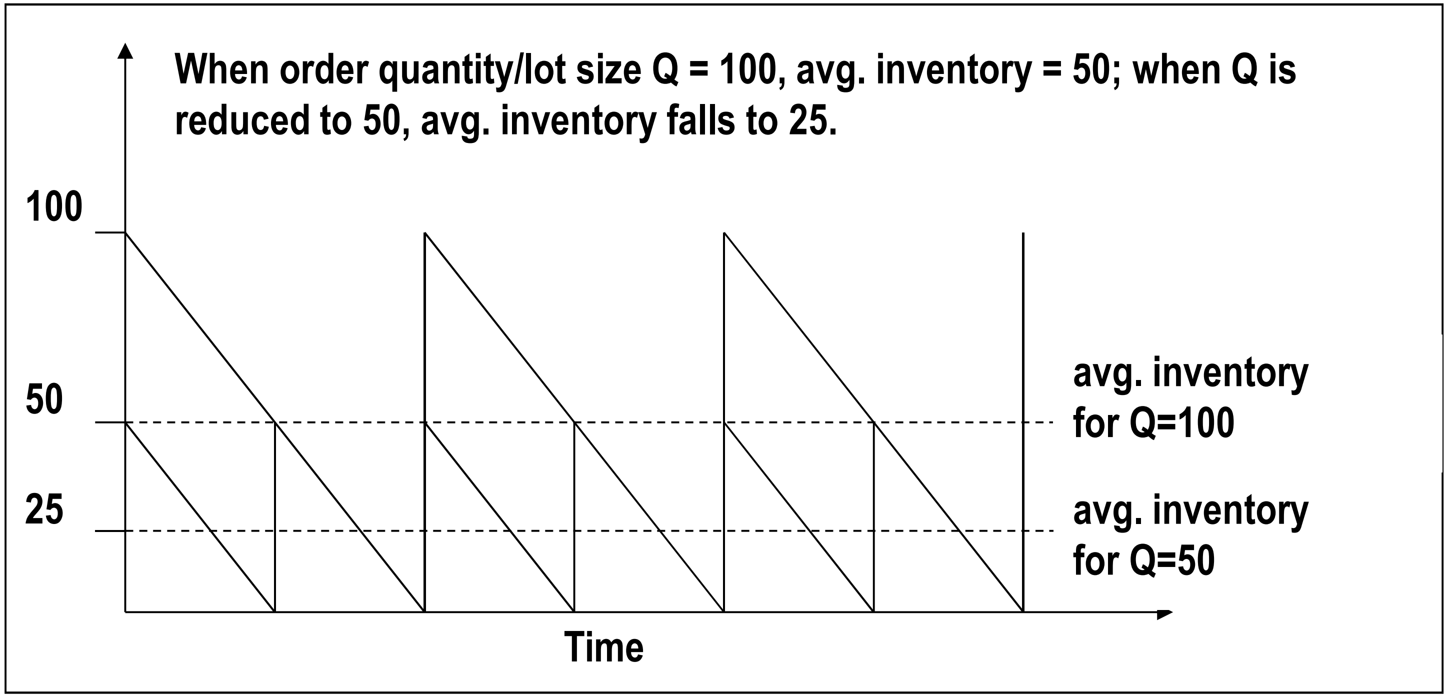
Lean Supply Chain Relationships

- Suppliers & customers work to remove waste, reduce cost, & improve quality & customer service
- Lean Thinking includes delivering smaller quantities, more frequently to point of use
- Firms develop lean supply chain relationships with key customers. Mutual dependency & benefits occur among these partners.
- Locate production or warehousing facilities close to key customers

The Elements of Lean Production

(*Continued*)

Relationship between Order Quantity, Lot Size, and Average Inventory



(Figure 8.2)

The Elements of Lean Production

(Continued)

To determine the number of containers or kanban card sets:

$$\#\text{ of containers} = \frac{DT(1 + S)}{C}$$

Where: D = the demand rate of the assembly line;
T = the time for a container to make an entire circuit through the system, from being filled, moving, being emptied, and returning to be filled again;
C = the container size, in number of parts; and
S = the safety stock factor, from 0 to 100 percent.

The Elements of Lean Production

(*Continued*)

Continuous Improvement (*Kaizen*)

- Continuous approach to reduce process, delivery, & quality problems, such as machine breakdown problems, setup problems, & internal quality problems

Workforce Commitment

- Managers must support Lean Production by providing subordinates with the skills, tools, time, & other necessary resources to identify problems & implement solutions

Lean Systems & the Environment

Lean green practices –

- Reduce the cost of environmental management
- Lead to improved environmental performance.
- Increase the possibility that firms will adopt more advanced environmental management systems

The Origins of Six Sigma Quality

Six Sigma

- Near quality perfection (the statistical likelihood of non-defects 99.99966% of the time)
- Pioneered by Motorola in 1987
- A statistics-based decision-making framework designed to make significant quality improvements in value-adding processes

The Origins of Six Sigma Quality

Six Sigma Metrics

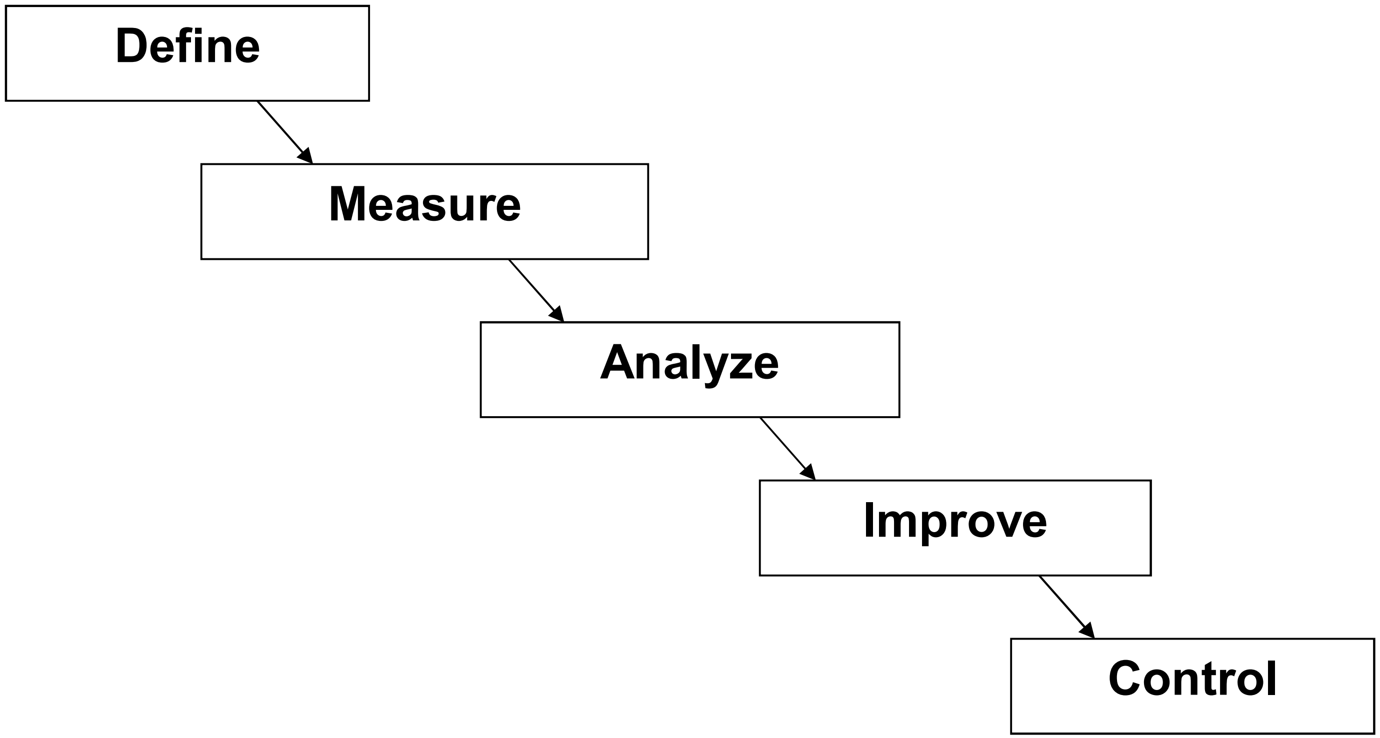
# of std dev above the mean	% of defect-free output	DPMO
2	69.15	308,537
2.5	84.13	158,686
3	93.32	66,807
3.5	97.73	22,750
4	99.38	6,210
4.5	99.865	1,350
5	99.977	233
5.5	99.9968	32
6	99.99966	3.4

Note: standard deviations include 1.5 sigma "drift"

(Table 8.4)

Elements of Six Sigma *(Continued)*

The DMAIC Improvement Cycle



(Fig. 8.5)

Elements of Six Sigma *(Continued)*

Six Sigma Training Levels

Levels	Description
Yellow Belt	Basic understanding of Six Sigma Methodology and tools in the DMAIC problem solving process. Team member on process improvement project.
Green Belt	A trained team member allowed to work on small, carefully defined Six Sigma projects, requiring less than a Black Belt's full-time commitment.
Black Belt	Thorough knowledge of Six Sigma philosophies and principles. Coaches successful project teams. Identifies projects and selects project team members.
Master Black Belt	A proven mastery of process variability reduction, waste reduction and growth principles and can effectively present training at all levels

PERFORMANCE MEASUREMENT ALONG THE SUPPLY CHAIN

Prepared by Cynthia Wisner, MBA

Introduction

“You can’t improve what you don’t measure”

- Designing standards and monitoring them can provide much better information for decision-making purposes.
- Adding several tiers of suppliers & customers complicates performance measurement.
- Achieving adequate performance and then continually improving on those measures are what firms aim toward.
- Performance measures must be visible & communicated to all members of the SC.

Viewing the SC as a Competitive Force

Understanding End Customers

Supply chains need to look at each segment of the market they serve & determine the needs of those customers.

- Variety of products required
- Quantity & delivery frequency needed
- Sustainability level desired
- Product quality desired
- Price of the products

Viewing the SC as a Competitive Weapon *(Continued)*

Understanding SC Partner Requirements

Supply chain strategies must consider the potential trade-offs existing between:

- Cost
- Quality
- Sustainability
- Service

Viewing the SC as a Competitive Weapon (*Continued*)

Adjusting SC Member Capabilities

- SC members audit their capabilities & partners' to determine consistency with needs of end customers & SC
- Firms & their partners must continually reassess performance with respect to requirements
- The best SC performers are more responsive to customer needs, quicker to anticipate changes in the markets, & control costs much better

Traditional Performance Measures

Traditional Performance Measures

- Traditional cost-based information does not reflect the underlying performance of an organization's productive systems; costs & profits can be hidden or manipulated
- Decisions to maximize current stock prices do not necessarily reflect that the firm is performing well
- Financial performance measures, while important, cannot adequately capture a firm's ability to excel in these areas

Traditional Performance Measures (*Continued*)

Use of Organization Costs, Revenue, & Profitability Measures

Problems associated with using costs & profits to gauge performance –

- Uncontrollable environmental forces (e.g., windfall profits that occur when prices rise due to supply interruptions)
- Accurate attribution of cost, revenue, or profit contributions to the various functional or business units

Traditional Performance Measures *(Continued)*

Use of Performance Standards & Variances

Establishing standards for comparison purposes can be troublesome

- Employees & managers do whatever it takes to reach the goal
- Shoddy work & “Cooking” the books

Traditional Performance Measures *(Continued)*

Use of Performance Standards & Variances
(Continued)

Performance variance - the difference between the standard & actual performance

- Managers can be pressured to find ways to make up these variances, resulting in poor decisions
- Standards can reinforce the idea of functional silos (departments only concerned with what is going on in their department)

Traditional Performance Measures (*Continued*)

Productivity & Utilization Measures

Examples

- **Overall total productivity measure**

$$\frac{\text{output}}{\text{costs of (labor + capital + energy + material)}}$$

- **Single-factor productivity measure**

$$\frac{\text{output}}{\text{cost of labor}}$$

Traditional Performance Measures (*Continued*)

Productivity & Utilization Measures

These measures are useful but have the same problems as revenues, costs, & profits

- Productivity decisions may actually increase costs & reduce quality
- Tendency to continue producing & adding to inventory to keep machines & people busy
- Less time is spent doing preventive maintenance & training for greater performance & profits in future
- Traditional measures favor the short-term

Traditional Performance Measures *(Continued)*

Example 14.1 - Productivity Measures at the Ultra Ski Emporium

The Ultra Ski company makes top-of-the-line custom snow skis for high-end ski shops as well as their own small retail shop, and employs fifteen people. The owner has been adamant about finding a way to increase productivity because her sales have been flat for the past two seasons. The table contains her company data.

Inputs and Outputs	Last Year
Skis produced	1,000
Labor hours	10,800
Materials purchased	$18,000
Lease payments	$24,000

Traditional Performance Measures (*Continued*)

Example 14.1 (*Continued)*

She has calculated the annual single-factor and total productivity values as:

Labor productivity = 1,000 skis/10,800 hours = **0.093 skis/labor hour**

Material productivity = 1,000 skis/$18,000 = **0.056 skis/material $**

Lease productivity = 1,000 skis/$24,000 = **0.042 skis/lease $**

She calculates their total productivity by multiplying the labor hours by their average wage of $17 per hour, and finds:

Total productivity = 1,000 skis/[10,800($17) + $18,000 + $24,000] = **0.0044 skis per dollar**

Traditional Performance Measures (*Continued*)

Example 14.1 (*Continued*)

The owner figures she can get some great improvements in productivity by finding a low-cost supplier, moving to a cheaper location and laying off six workers (reducing her workforce by 40 percent), making the new single-factor productivities:

Labor productivity = 1,000 skis/10,800(.6) hours

= **0.154 (a 66 percent increase)**

Material productivity = 1,000 skis/$12,000

= **0.083 (a 48 percent increase)**

Lease productivity = 1,000/$18,000

= **0.056 (a 33 percent increase)**

Traditional Performance Measures (*Continued*)

Example 14.1 (*Continued*)

The new total productivity:

Total productivity = 1,000 skis/[10,800($17)(.6) + $12,000 + $18,000]

= **0.0071 skis per dollar** (a whopping 61 percent increase!)

Consequently, the owner decided to make the changes for the coming year. Unfortunately, they went out of business in six months due to poor-quality materials, a bad location and overworked, low-morale employees.

World-Class Performance Measurement Systems

Developing World Class Performance Measures

- Identify the firm's strategic objectives.
- Develop an understanding of each functional area's set of requirements for achieving the strategic objectives.
- Design and document performance measures for each functional area that adequately track each required capability.
- Assure the compatibility and strategic focus of the performance measures to be used.

World-Class Performance Measurement Systems (*Continued*)

Developing World Class Performance Measures

(continued)

- Implement the new performance monitoring system.
- Identify internal and external trends likely to affect firm and functional area performance over time.
- Periodically re-evaluate the firm's performance measurement system as these trends and other environmental changes occur

World-Class Performance Measurement Systems (*Continued*)

Table 14.1 World-Class Performance Measures	
Capability Areas	**Performance Measures**
Quality	1. No. of defects per unit produced and per unit purchased 2. No. of product returns per units sold 3. No. of warranty claims per units sold 4. No. of suppliers used 5. Lead time from defect detection to correction 6. No. of workcenters using statistical process control 7. No. of suppliers who are quality certified 8. No. of quality awards applied for; No. awards won

World-Class Performance Measurement Systems *(Continued)*

Table 14.1	World-Class Performance Measures
Capability Areas	**Performance Measures**
Cost	1. Scrap or spoilage losses per workcenter 2. Average inventory turnover 3. Average setup time 4. Employee turnover 5. Avg. safety stock levels 6. No. of rush orders required for meeting delivery dates 7. Downtime due to machine breakdowns

World-Class Performance Measurement Systems (Continued)

Table 14.1 World-Class Performance Measures	
Capability Areas	**Performance Measures**
Customer Service	*Flexibility* 1. Average number of labor skills 2. Average production lot size 3. No. of customized services available 4. No. of days to process special or rush orders *Dependability* 1. Average service response time or product lead time 2. % of delivery promises kept 3. Avg. no. of days late per shipment 4. No. of stockouts per product 5. No. of days to process a warranty claim 6. Avg. number of hours spent with customers by engineers *Innovation* 1. Annual investment in R&D 2. % of automated processes 3. No. of new product or service introductions 4. No. of process steps required per product

SC Performance Measurement Systems

Performance measurement systems must –

- Link SC trading partners to achieve breakthrough performance in satisfying the end users
- Overlay the entire supply chain to assure that all contribute to supply chain strategy

In a successful chain, members jointly agree on a SC performance measurement system

SC Performance Meas. Systems *(Continued)*

Environmental sustainability

- Addressing the need for protecting the environment & reducing greenhouse gas emissions as well business & consumer needs

Green supply chain management (GSCM)

- Sharing of environmental responsibility along the SC such that sound environmental practices predominate, & adverse global environmental effects are minimized.

Carbon footprint

- Supply chains evaluate design configurations and various options for reducing total carbon emissions

SC Performance Meas. Systems (*Continued*)

Supply Chain Performance Measures

- *Total SCM costs* are the costs to process orders; purchase & manage inventories; & information systems
- *SC cash to cash cycle time is the a*vg. # of days between paying for materials & getting paid by SC partners
- *SC production flexibility* is the avg. time required to provide an unplanned 20% increase in production
- *SC delivery performance* is the avg. % of orders filled by requested delivery date

SC Performance Meas. Systems *(Continued)*

Supply Chain Performance Measures *(continued)*

- *SC perfect order fulfillment performance* is the average % of orders that arrive on time, complete, & undamaged.
- *Supply chain e-business performance* is the avg. % of electronic orders received for all SC members.
- *Supply Chain Environmental Performance* is the % of SC w/ISO 14000 partners, avg. % env. goals met, avg. # of policies adopted to reduce greenhouse gas emissions, or avg. % of carbon footprints offset

The Balanced Scorecard

Kaplan & Norton created BSC to align an organization's performance measures with its strategic plan & goals. The BSC framework consists of four perspectives –

- Financial perspective
- Internal business process perspective
- Customer perspective
- Learning & growth perspective

Also referred to as scorecarding

The Balanced Scorecard (*Continued*)

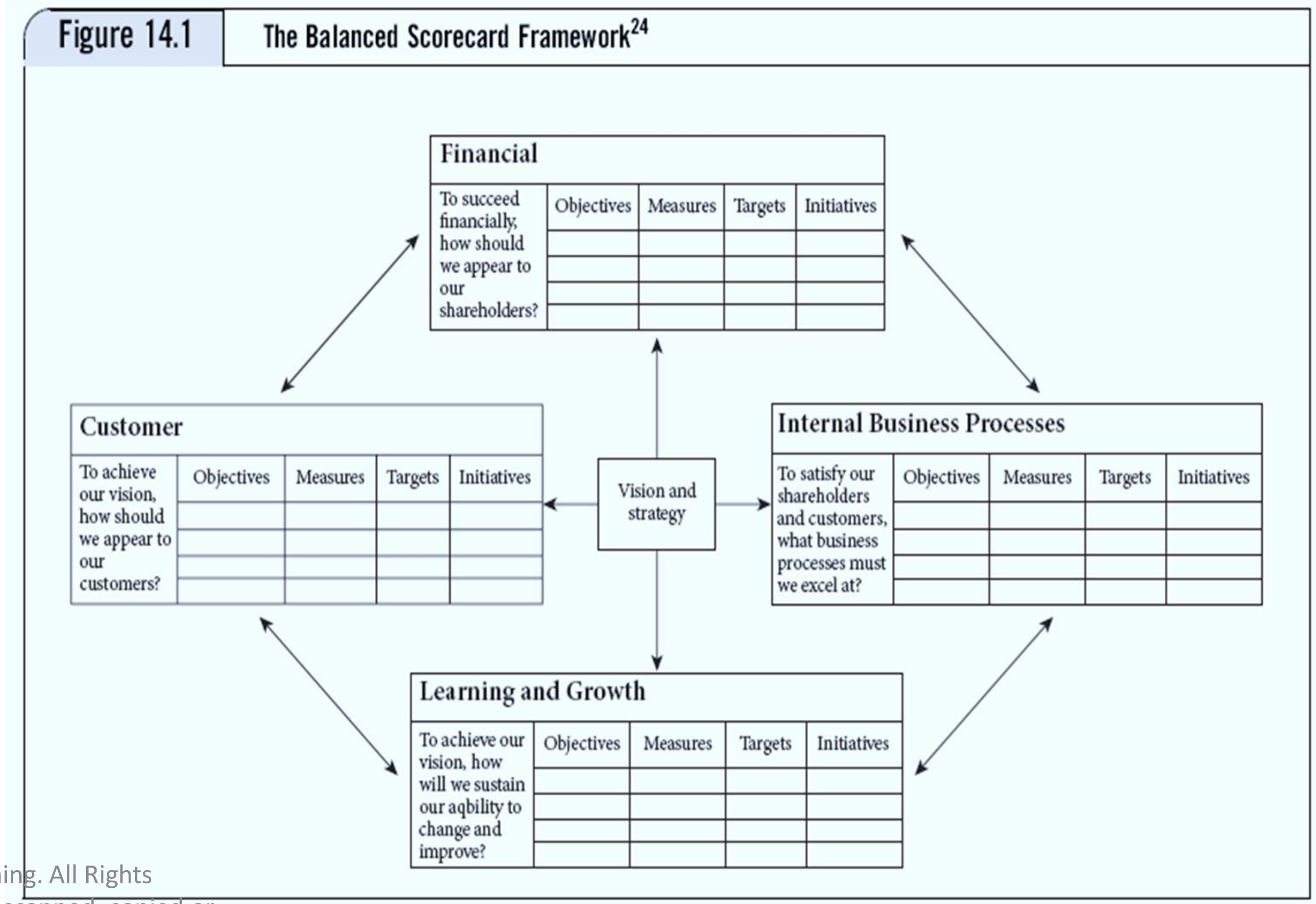


Figure 14.1 The Balanced Scorecard Framework[24]

The Balanced Scorecard (*Continued*)

Web-Based Scorecards & Dashboards

- Web-based software applications used to design scorecards, which also link via the Web to a firm's enterprise software system.
- Provide managers a way to see real-time progress toward organizational milestones & help to ensure that decisions remain in sync with the firm's overall strategies.

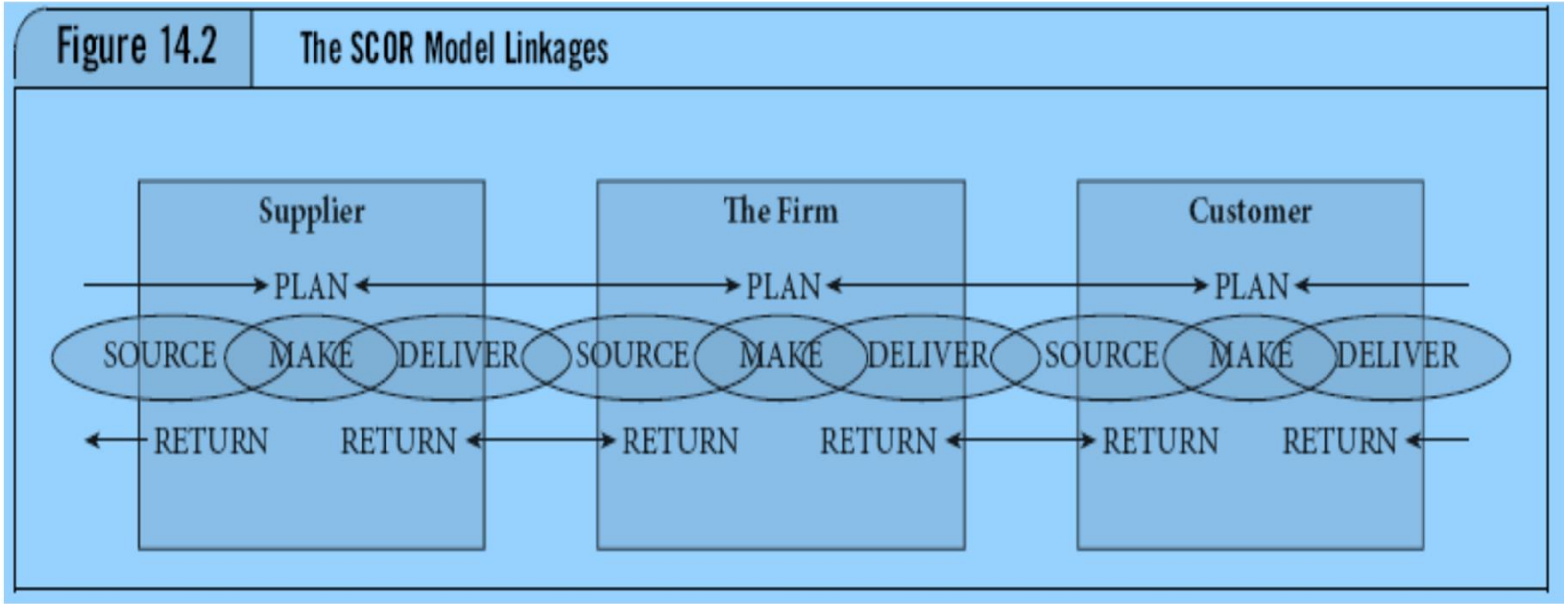
Supply Chain Operations Reference (SCOR) Model

SCOR model developed by the Supply Chain Council (now CSCMP) for SCM diagnostic benchmarking & process improvement

The SCOR model separates supply chain operations into 6 process categories –

- Plan
- Source
- Make
- Deliver
- Return
- Enable

SCOR Model (*Continued*)



SCOR Model (*Continued*)

Table 14.2 SCOR Performance Categories and Attributes	
Performance Category	**Performance Attribute**
Reliability	1. On-time delivery performance 2. Order fill rates 3. Order accuracy rates
Responsiveness	1. Order lead times or speed
Agility	1. Response times for unforeseen events 2. Production flexibility
Cost	1. Supply chain management and logistics costs 2. Cost of goods sold 3. Warranty and returns processing costs
Asset Management	1. Cash-to-cash cycle time 2. Inventory days of supply 3. Asset turns

SCOR Model (*Continued*)

Companies generally use SCOR-based benchmarking to:

- Set reasonable performance goals based on the SCOR model
- Calculate performance gaps against a global database
- Develop company-specific roadmaps for supply chain competitive success

PURCHASING MANAGEMENT

Prepared by Cynthia Wisner, MBA

A Brief History of Purchasing Terms

Purchasing – Obtaining merchandise, capital equipment; raw materials, services, or maintenance, repair, and operating (MRO) supplies in exchange for money or its equivalent

Merchants – Wholesalers and retailers who purchase for resale

Industrial Buyers – Purchase raw materials for conversion, services, capital equipment, & MRO supplies

A Brief History of Purchasing Terms (*Continued*)

Purchasing - key business function for acquiring materials, services, & equipment

Contracting - term often used for the acquisition of services

Supply Management - a newer term to describe the expanded set of responsibilities of purchasing professionals

- Institute of Supply management defined supply management as the "*Identification, acquisition, access, positioning, and management of resources an organization needs or potentially needs in the attainment of its strategic objectives*."

The Role of Supply Management in an Organization

The primary goals of purchasing are:

- Ensure uninterrupted flows of raw materials at the lowest total cost,
- Improve quality of the finished goods produced, and
- Maximize customer satisfaction.

Purchasing contributes to these objectives by:

- Actively seeking better materials and reliable suppliers,
- Work closely with and exploiting the expertise of strategic suppliers to improve quality and materials
- Involving suppliers and purchasing personnel in new product design and development efforts.

The Role of Supply Management in an Organization (*Continued*)

The Financial Significance of Supply Management

Profit-Leverage Effect

A decrease in purchasing expenditures directly increases profits before taxes (assuming no decrease in quality or purchasing total cost)

Return on Assets (ROA) Effect

A high ROA indicates managerial prowess in generating profits with lower spending (caveat- ROA ratios vary from one industry to another)

Inventory Turnover Effect

Increased inventory turnovers indicate optimal utilization of space and inventory levels, increased sales, avoidance of inventory obsolesce

The Role of Supply Management in an Organization (*Continued*)

The Financial Significance of Supply Management

Profit-Leverage Effect

Profit Leverage Effect			
	Simplified P&L	**Increase Sales 10%**	**Decrease Cost 10%**
Gross Sales	1,000,000	1,100,000	1,000,000
- Cost of Goods Sold (50%)	(500,000)	(550,000)	(450,000)
= Gross Profit	500,000	550,000	550,000
- Sales, General, & Administrative (45%)	(450,000)	(495,000)	(450,000)
= Profit Before Tax	50,000	55,000	100,000
Change in Profit		10%	100%

The Role of Supply Management in an Organization *(Continued)*

The Financial Significance of Supply Management

Return on Assets (ROA) Effect

Return on Assets Effect			
	Simplified P&L	**Increase Sales 10%**	**Decrease Cost 10%**
Gross Sales	1,000,000	1,100,000	1,000,000
- Cost of Goods Sold (50%)	(500,000)	(550,000)	(450,000)
= Gross Profit	500,000	550,000	550,000
- Sales, General, & Administrative (45%)	(450,000)	(495,000)	(450,000)
= Profit Before Tax	50,000	55,000	100,000
Assets	500,000	500,000	500,000
Return on Assets	10%	11%	20%

The Purchasing Process – *Manual Purchasing* (older system)

Step 1- Material Requisition/Purchase Requisition –

Stating product, quantity, and delivery date. May originate as a **planned order release** from the MRP system. **Traveling requisition** used for recurring orders.

Step 2- The Request for Quotation (RFQ) –

Buyer identifies suppliers & issues a request for quotation (RFQ) for routine items or a **Request for Proposal (RFP)** for highly technical products. **Supplier Development** is used to develop supplier capabilities.

Step 3- The Purchase Order (PO) –

Is the buyer's offer & becomes a binding contract when accepted by supplier. When initiated by the supplier on their own terms, the document is a **sales order**. The **Uniform Commercial Code (UCC)** governs transactions in the U.S., except Louisiana.

Sourcing Decisions – *The Make or Buy Decision*

Outsourcing –

Buying materials and components from suppliers instead of making them in-house. The trend has moved toward outsourcing.

Backward vertical integration –

Refers to acquiring sources of supply

Forward vertical integration –

Refers to acquiring customer's operations.

The Make or Buy decision is a <u>strategic</u> decision

Sourcing Decisions – *The Make or Buy Decision* *(Continued)*

Reasons for Buying or Outsourcing

- **Cost advantage** –
  - Especially for components that are non-vital to the organization's operations, suppliers may have economies of scale
- **Insufficient capacity** –
  - A firm may be at or near capacity and subcontracting from a supplier may make better sense
- **Lack of expertise** –
  - Firm may not have the necessary technology and expertise
- **Quality** –
  - Suppliers have better technology, process, skilled labor, and the advantage of economy of scale

Sourcing Decisions – *The Make or Buy Decision* *(Continued)*

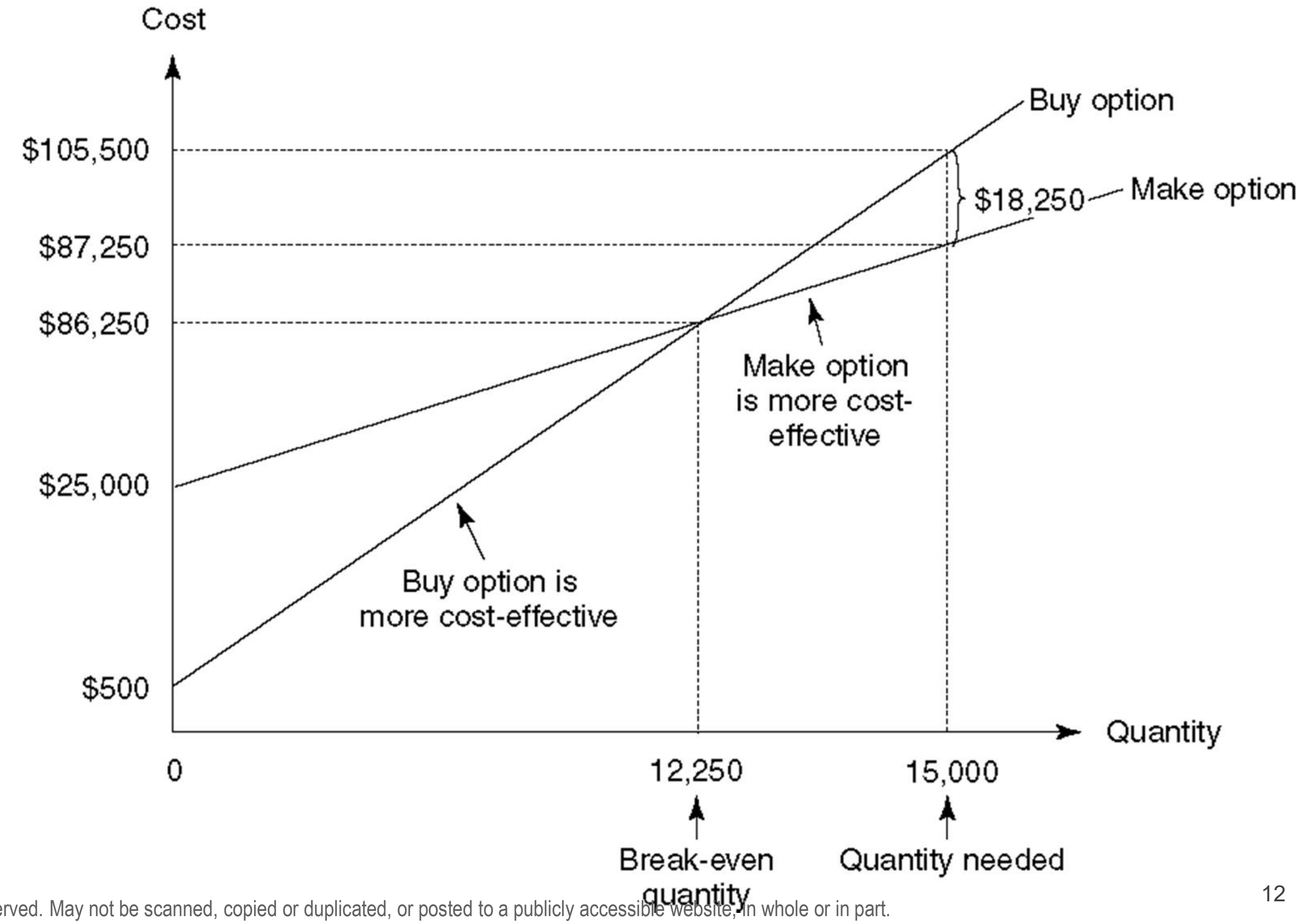
Reasons for Making

- Protect proprietary technology
- No competent supplier
- Better quality control
- Use existing idle capacity
- Control of lead-time transportation, and warehousing cost
- Lower cost

Sourcing Decisions – *The Make or Buy Decision* *(Continued)*

The Make-or-Buy Break-Even Analysis

Costs	Make	Buy
Fixed	$25,000	$500
Variable	$5	$7
Annual Requirements		15,000



Sourcing Decisions – *The Make or Buy Decision* *(Continued)*

The Make-or-Buy Break-Even Analysis

Costs	Make	Buy
Fixed	$25,000	$500
Variable	$5	$7
Annual Requirements		15,000

Find break-even point Q by setting the total cost of the two options equal to one another and solving for Q:

Total Cost to Make = Total Cost to Buy

25,000 + 5Q = 500 + 7Q
7Q − 5Q = 25,000 − 500
2Q = 24,500
Q = 12,250 units = Break-even point

Sourcing Decisions – *The Make or Buy Decision* *(Continued)*

The Make-or-Buy Break-Even Analysis

Costs	Make	Buy
Fixed	$25,000	$500
Variable	$5	$7
Annual Requirements		15,000

Total Cost for both options at the Break-even Point

$$TC_{BE} = 25{,}000 + 5 \times 12{,}250$$
$$= 86{,}250 \text{ dollars}$$

Total Cost for the Make Option at 15,000 units;

$$TC_{Make} = 25{,}000 + 5 \times 15{,}000$$
$$= 100{,}000 \text{ dollars}$$

Total Cost for the Buy Option at 15,000 units;

$$TC_{Buy} = 500 + 7 \times 15{,}000$$
$$= 105{,}500 \text{ dollars}$$

$$\text{Cost Difference} = TC_{Buy} - TC_{Make}$$
$$= 105{,}500 - 100{,}000$$
$$= 5{,}500 \text{ dollars}$$

Roles of Supply Base

Supply Base - list of suppliers that a firm uses to acquire its materials, services, supplies, and equipment

- Firms emphasize long-term strategic supplier alliances consolidating volume into ***one or fewer*** suppliers, resulting in a **smaller supply base**

Preferred suppliers provide:

- Product and process technology and espertise to support buyer's operations, particularly new product development and value analysis
- Information on latest trends in materials, processes, or designs
- Information on the supply market
- Capacity for meeting unexpected demand
- Cost efficiency due to economies of scale

Supplier Selection

The process of selecting suppliers, is complex and should be based on multiple criteria:

- Product and process technologies
- Willingness to share technologies & information
  - **Early supplier involvement (ESI)**
- Quality
- Reliability
- Cost
  - **Total cost of ownership or acquisition**
- Order system & cycle time
- Capacity
- Communication capability
- Location
- Service

How Many Suppliers to Use

Single-source - a risky proposition. Current trends favor fewer sources.

Reasons Favoring a Single Supplier

- To establish a good relationship
- Less quality variability
- Lower cost
- Transportation economies
- Proprietary product or process
- Volume too small to split

Reasons Favoring Multiple Suppliers

- Need capacity
- Spread risk of supply interruption
- Create competition
- Information
- Dealing with special kinds of business

Purchasing – *Centralized vs. Decentralized*

Purchasing Organization is dependent on many factors, such as market conditions & types of materials required

- ***Centralized Purchasing*** - purchasing department located at the firm's corporate office makes all the purchasing decisions
- ***Decentralized Purchasing*** - individual, local purchasing departments, such as plant level, make their own purchasing decisions

Purchasing – *Centralized vs. Decentralized*

(Continued)

Advantages -

Centralization

- Concentrated volume-
- Avoid duplication
- Specialization
- Lower transportation costs
- No competition within units
- Common supply base

Advantages -
Decentralization

- Closer knowledge of requirements
- Local sourcing
- Less bureaucracy

A Map of SCM Systems