

MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 1: Business
Strategy and Supply Chain

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Funding

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Learning outcomes

This module will enable you to:

- Manage the warehouses from furniture and woodworking industries.
- Carry out the most suitable plant layout at a furniture/wood products manufacturing plant.
- Implement a WMS tool in a Furniture company.
- Implement and assess a valuation of inventory of a furniture company.
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- Develop and implement a plan of occupational safety and health in a furniture company.

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- Read the additional text available where information is more detailed.
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Introduction

Strategy = create value with a controlled network of connected suppliers, in the most efficient way; all parties involved increase their value.



Good strategy = benefit for both parties (client and supplier)

Logistics Supply

A Supply Chain **distinguishes between purchases and supply:**

- **Purchases:** defines the need for materials to identify and compare possibilities to later negotiate with suppliers.
- **Supply:** function in charge of forecasting, planning, purchases, storage, receiving, inspecting, managing and tracking the flow of materials

Purchases and supplies are previous to storage and manufacture:

- **Purchases and supply**

**Operations on
Purchases and Supply**

- Forecast and detect the necessary materials
- Materials Requirement Planning MRP
- Search and appointment of supply companies
- Purchase of ordered materials
- Control of purchases
- Payment of the received order

Material costs range from 40% to 60% out of the total costs

Key factors on the "purchases" sector



Quality

Determines the definition
of materials

Not responsible for →
the quality of materials

Delivery date

Delivery dates are fixed
with the supplier
→ Uncertainty leads to
inventory build-ups

Price

Inversely proportional to
quality and delivery time.
→ Balance between
quality and price so that
products are appealing
to customers.

The importance of the geographic location

Geographic location =
strategic decision

Factors that influence on a "relocation"

- Client and supplier proximity
- Market and customers
- Workforce
- Geographic location
- Price of the land

Direct impact on

- ⑩ Fixed costs
- ⑩ Variable costs
- ⑩ Opportunity costs

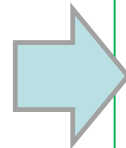
Methods to solve a suitable location

- Factor-rating method
- Break-even analysis
- Centre-of-gravity method
- Transportation method
- ELECTRE method
- P-median method

Supply chain

Supply chain = set of companies correlated that collaborate to **distribute, manufacture and receive** goods and services

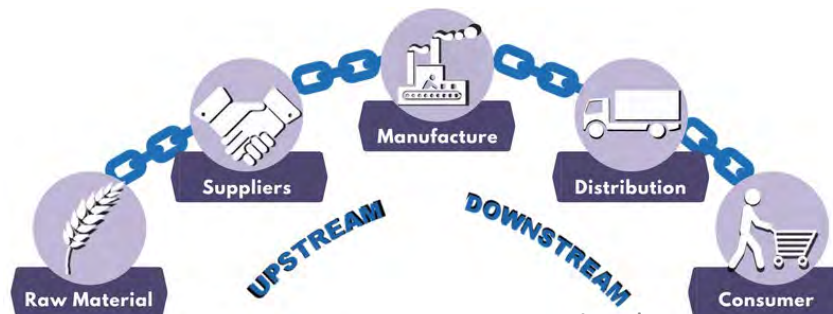
Chain
agents



1. Raw materials suppliers
2. Storage
3. Manufacture
4. Distribution
5. Delivery

SUPPLY CHAIN MANAGEMENT

⑩ Control and management of operations shared among agents.



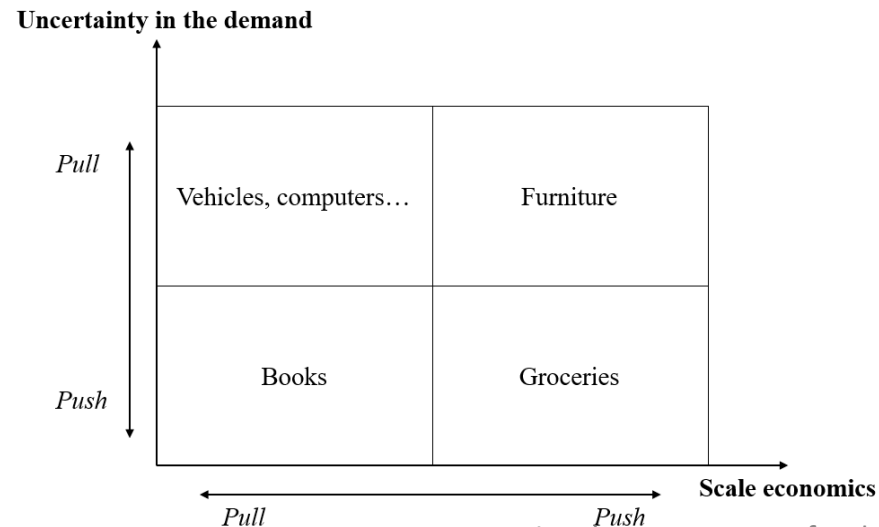
The Supply Chain Management is focused on managing information and materials flows

Information and materials traceability



**Information Flow and Materials Flow
Flow Management methods**

- PULL system (information flow previous to materials flow)
- PUSH system (materials flow previous to information flow)
- PUSH-PULL systems: a mix of the latter



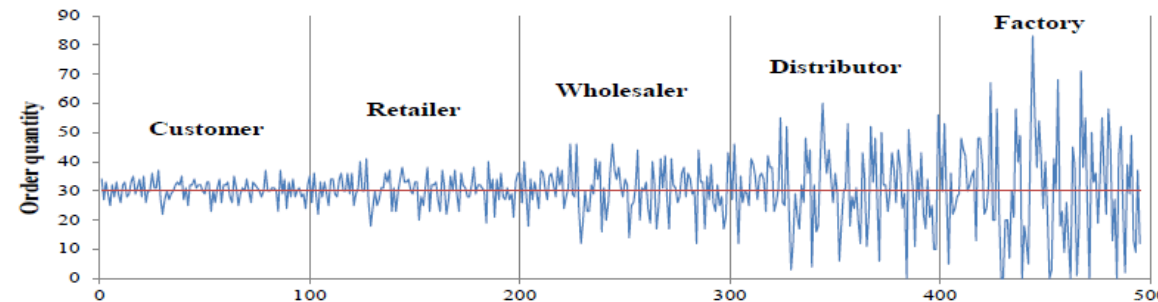
Bullwhip demand effect = differences between real client demand and the demand set by the chain agents

Information and materials traceability

Progressive increase in variations from bottom (clients) to top (last suppliers)

Caused by an increase in demand for a certain product

- direct retailer orders larger quantities to supplier
- the rest of the agents proceed similarly
- product quantities are larger from bottom to top chain agents



Communication and supplier involvement

- Communication and cooperation among companies in a supply chain has notably improved several key aspects in the logistics operations.
- The main noticeable changes in the logistics supply are





MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 2: Storage

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Introduction

Storage is a key element in logistics.

Companies **must design their storage system** before starting their activity

Basic decisions must be taken before other difficult ones

- | | |
|--------------|--------------|
| ➤ Units | ➤ Warehouses |
| ➤ Packages | ➤ Machinery |
| ➤ Boxes | ➤ Personnel |
| ➤ Pallets | ➤ Facilities |
| ➤ Unit loads | ➤ ... |
| ➤ Shelves | |

Unit load

Unit load = the basic unit of storage and transport that is arranged on a support or packaging (box, pallet, container...)

It can be divided into smaller elements

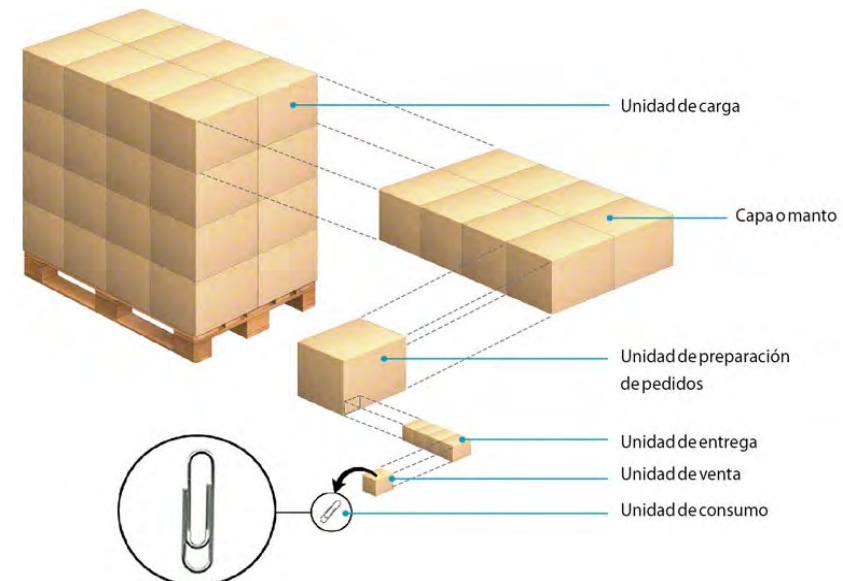
First division = **picking** units

Second division = **delivery** units

Third division = **sales** units

Reasons why companies need to group products:

- To reduce movements
- Standardisation of maintenance equipment
- To reduce load and unload periods
- Consolidation of the unit loads
- Security and maintenance
- To improve transportation
- To use more space



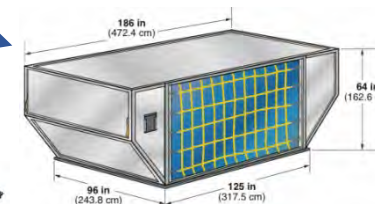
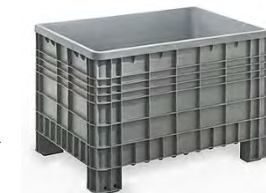
How to prepare unit loads CRITERIA

- Total volume of the load
- Weight of the grouped products
- Articles' shape
- Quantity to be grouped
- Fragility
- Expiration
- The compatibility of the different products that will be grouped
- The production flow of each product
- Picking
- Destination and client
- Special characteristics
- Other economic criteria



Maintenance elements:

- ✓ Pallets
- ✓ Box pallets
- ✓ Racks and containers
- ✓ Boxes and small containers
- ✓ ISO containers
- ✓ Air containers
- ✓ Tanks and hoppers
- ✓ Non-conventional containers



Picker and picking

Picking = collecting and grouping units to prepare an order

Picker = worker in charge of preparing the orders

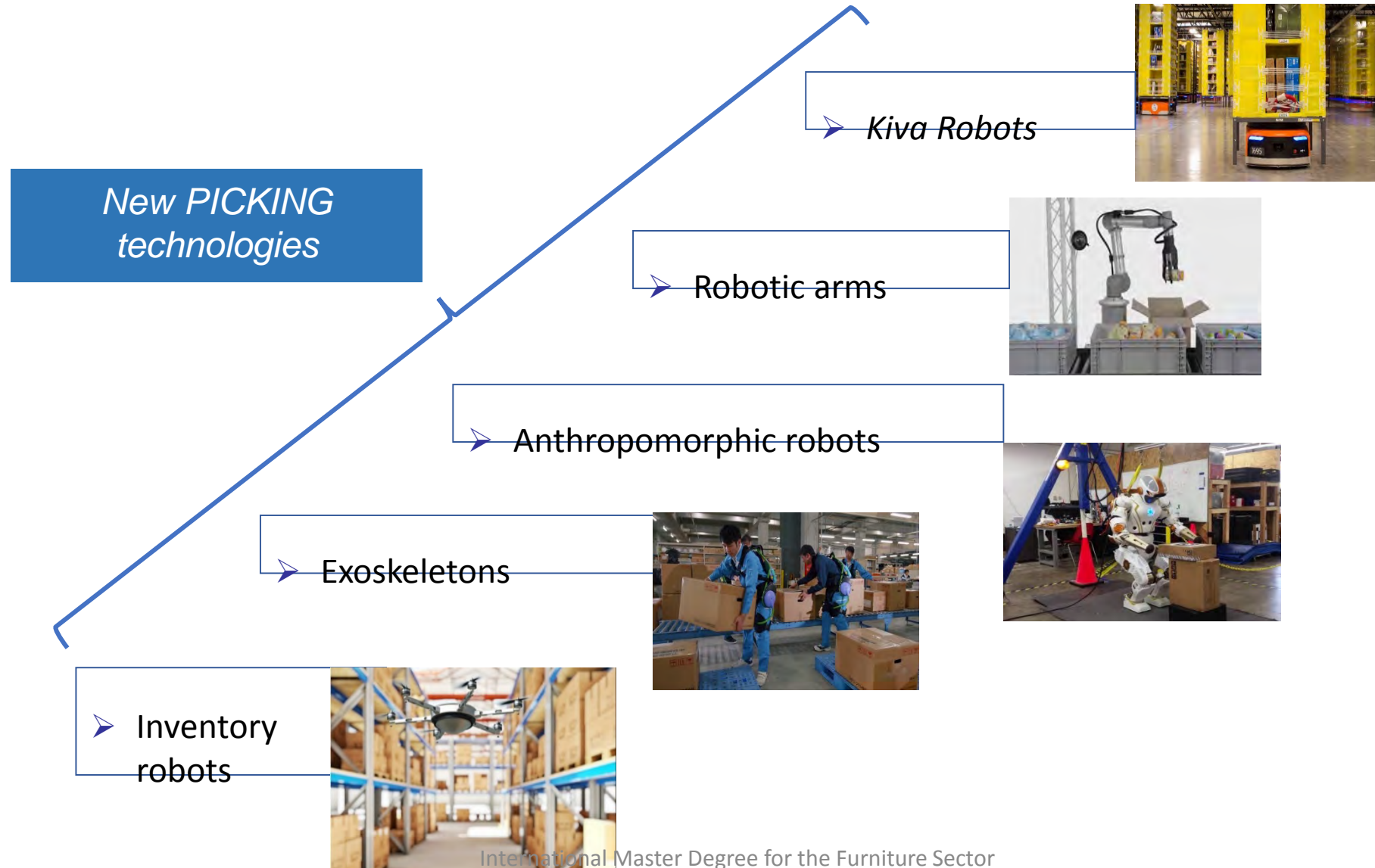
Picking: KEY ELEMENTS:

- Products (number, reference, characteristics...)
- Amount of orders
- Number of lines of each order
- Storage and transportation resources
- The degree of automation
- Zoning
- Rotation of products
- Routes
- Time distribution
- Costs
- Information flows

Picking operations can be carried out in different ways

PICKING strategies

- Single order/piece picking
- Batch picking
- Cluster picking
- Wave picking
- Automatic sorting system
- Picking to box
- Zone picking method
- Pick to light
- Put to light
- Voice picking
- Picking with wearable computers
- Vision picking
- Picking by barcodes
- Radio Frequency picking



Warehouse functions

Warehouse = an establishment that **regulates the differences** between the inflows and the outflows.

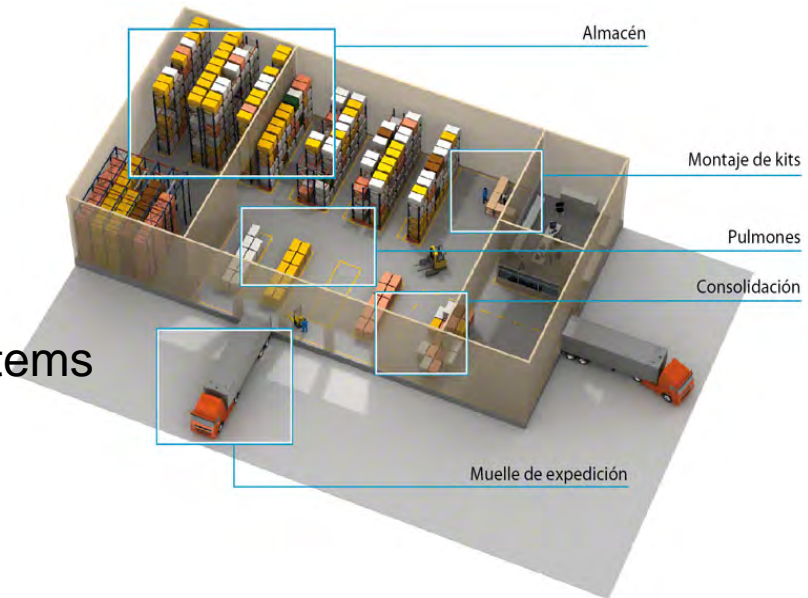
Flows **are not coordinated**. This is the main reason why companies need to **define optimal storage logistics**.

A warehouse contributes to have an adequate balance between the internal production (in series) and the external demand (independent and irregular).

- Balance between production and demand
- The accumulation of products for periods of high and unexpected demand
- Constant production
- Correct development of the processes of the value chain
- Protection against any unexpected event

+ benefits

- Reception of the products
- Quality control
- Management and inventory of stored items
- Optimal storage of products
- Shipment of products
 - Picking
 - Consolidation of products
 - Load of items



Warehouse functions

Types of warehouse

There are several types

Block stacking

Stacking unit loads in blocks
separated by corridors



- + Perfect for unit loads (palletised units)
- + Suitable for buildings of limited height
- + High demand products
- Difficult to access
- There cannot be products of different dimensions
- Products can fall or be crushed by each other
- Height limited

There are several types

Conventional storage

Stacking unit loads in blocks
separated by corridors



- + The most common
- + Direct access to each location
- + Perfect for stock control
- + Adaptation to different unit loads
- + Good use of space
- ⊖ Fragile
- ⊖ Very useful for the storage of wood and furniture

There are several types

Compact storage

Shelving system that allows the access of conventional trucks



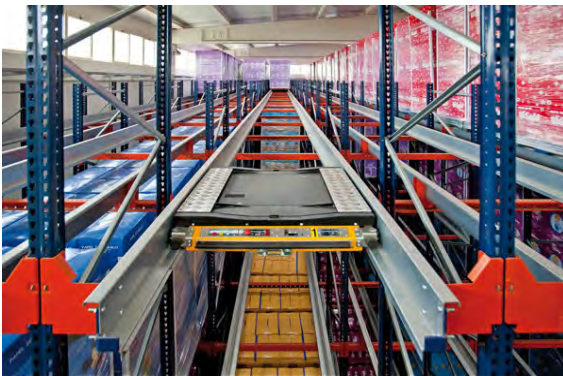
- + They use surface and volume better than the two previous types
- + Corridors do not need to be big Space saving of at least 94%
- + Increase of 40% in the use of the warehouse
- + Storage costs saving of 40%
- ⊖ Limitation of classifications
- ⊖ Useful for those storages whose products do not expire
- ⊖ Not very flexible because its products cannot be varied
- ⊖ Possibility of damaging loads and machinery when manoeuvring

There are several types

Shuttle system

Automated compact storage

- + Reduction of the working time thanks to its full automation
- + The operator is informed by the control software where the pallet is located
- + The system sends the shuttles to the worker's location and carries the load to the exit



There are several types

Dynamic shelving

Pallets or unit loads are stored on rollers which slide by gravity



- + Follows a FIFO (First In First Out) flow
 - + Takes advantage of the available space
 - + Perfect product rotation
 - + Decrease in the use of pallets
 - + Encourages variety and stock control
-
- ⊖ Possibility of crushing
 - ⊖ Not suitable for heavy unit loads

There are several types

Mobile shelving

Shelves that slide on rails

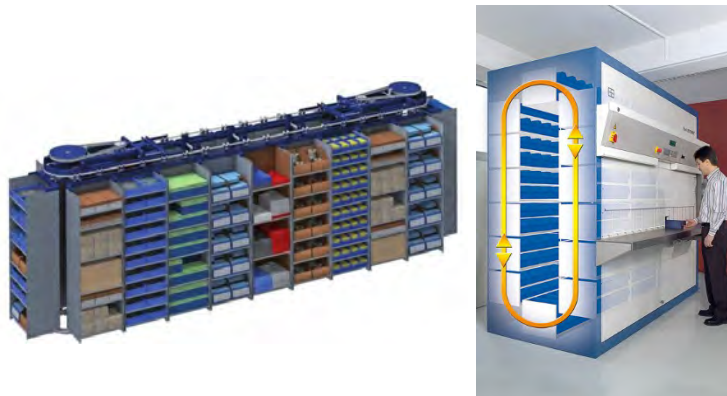


- + Mobile shelves can be opened by RFID
- + Uses more space than other systems
- + Facilitates the communication with information systems
- Great financial investment
- Complex management
- Designed for low frequencies of loading and unloading products
- Workers can only access to a single corridor

There are several types

Carousel storage systems

Products can be set one by one or in groups to be picked by the picker
These systems can be horizontal or vertical



- An horizontal carousel storage system will be chosen in large places whose height is limited
 - Companies whose length is limited but not its height will choose vertical carousel storage systems.
-
- ✚ Use the space properly thanks to its adaptation to different lengths and heights
 - ✚ Easy to integrate with other systems that have already been implemented
 - ✚ Great flexibility

There are several types

Self-supporting warehouse

**It is completely integrated into
the building**



+ Guarantees 25% of savings for those places whose height is higher than 15 meters

⊖ Shelves must be large and strong

⊖ Shelves must be designed with attention because they are usually found in automated warehouses

⊖ It can be damaged by extreme weather

There are several types

Automated storage

These systems work through automated storage and retrieval systems (AS/RS)



- + No human labour
- + Managed through management software
- + Fully automated
- + Easy to relocate the products
- + 90% of the warehouse is used
- + Mistakes are uncommon
- + Full integration with the management systems of the company
- ⊖ Large investment

There are several types

Cantilever racks system

This type of shelving is designed to store large unit loads, such as steel profiles or plates, pipes, mouldings, wooden boards or sheets, plastic profiles, etc.



- + Designed to store any type unit loads
 - + Can be placed on mobile bases
 - + Control of the inventory
 - + Versatile
 - + Together with block stacking, this system is the most common in terms of wood storage (beams, mouldings, slats, boards, plates...).
- ⊖ It requires large plants or warehouses

MODULE 8

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 3 -Warehouse management systems

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Introduction

A Warehouse Management System (**WMS**) = computer tool used to **control**, **coordinate** and **optimise** the movements, processes and operations of a warehouse.

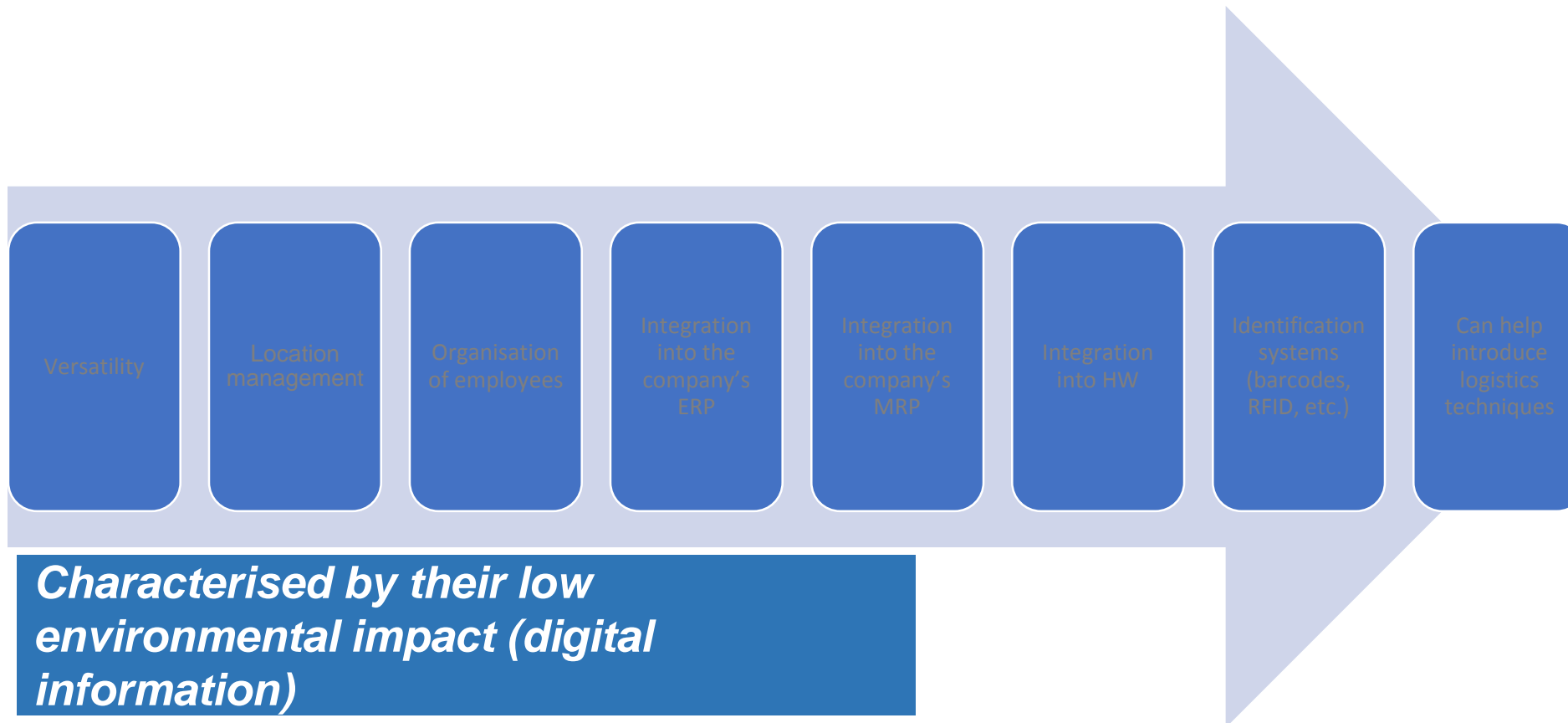
WMS objectives

- ✓ To manage the stock values of products
- ✓ To manage the location of products
- ✓ To manage all the information of their movements



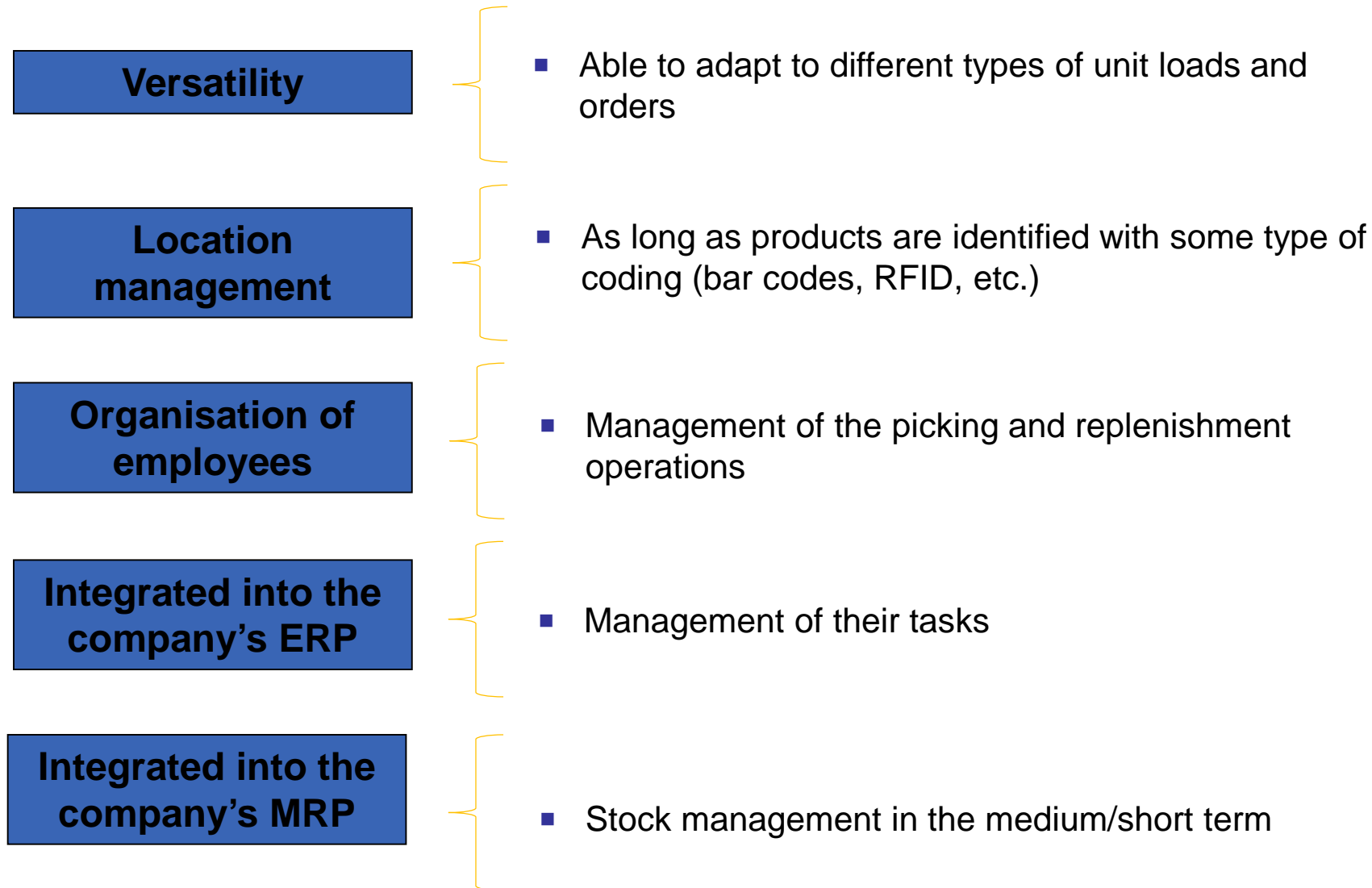
Features of WMS

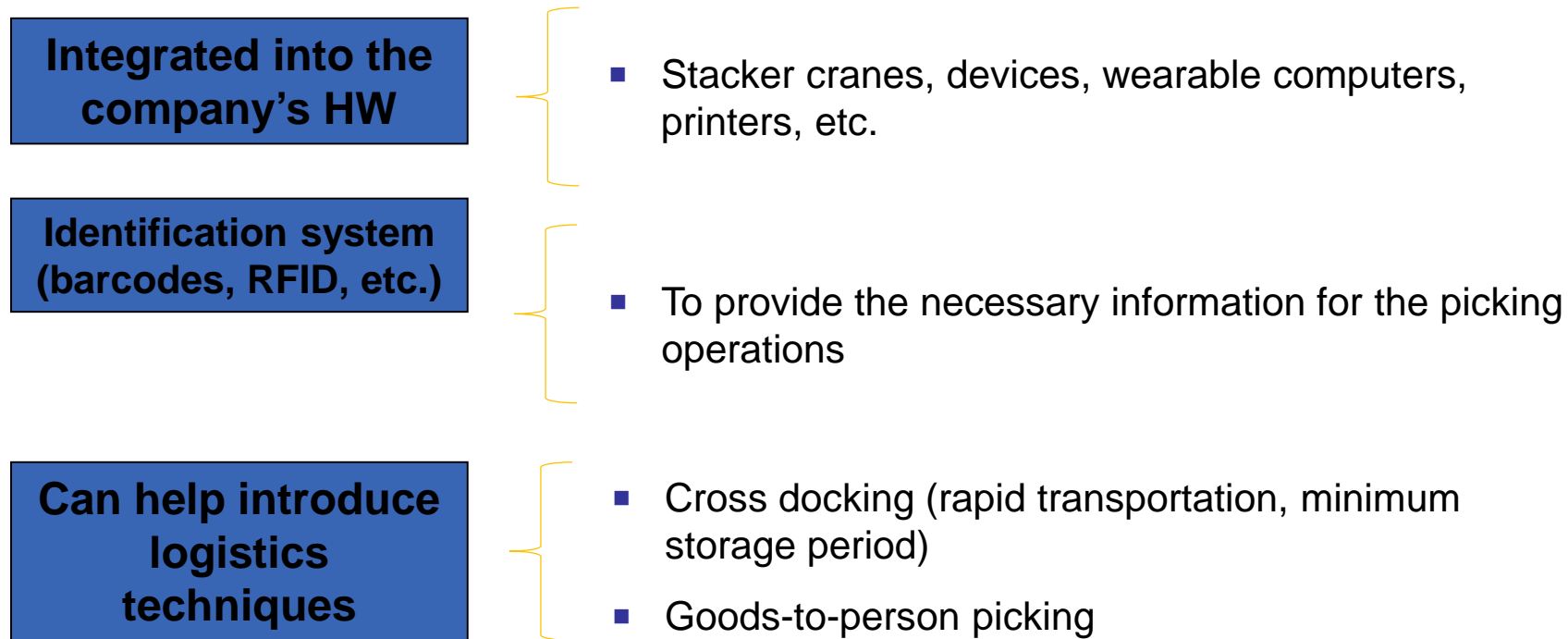
WMS: Main features



Characterised by their low environmental impact (digital information)

Must show the traceability of products, (manufacturing and storage processes)





WMS functions

WMS functions

- **Reception of products**

- ✓ To save information about the reception of products

- **Data capture systems**

- ✓ To store and manage the information of each unit load, each batch, etc.

- **Selection of the perfect location**

- ✓ for each unit.

- **Reduction in the movements of products**

- ✓ Fewer movements. This operations can be correctly executed once all the picking operations have been defined.

- **WMS provide companies with useful information about their stock**

- ✓ To watch the facilities
- ✓ Location management
- ✓ Inventory management
- ✓ Stock management
- ✓ Inventory count

Besides managing the input of products, WMS are in charge of the output of products.

WMS functions

- **Management of the preparation of the units**
 - ✓ These operations include groups of orders and their assignments
- **To facilitate the picking operations**
 - ✓ They also define and guide the traceability of each worker.
- **They provide companies with documentation of shipments**
 - ✓ List of orders, documentation for transport, reports, delivery notes or invoices, etc.
- **Management of the shipment process**
 - ✓ To ensure that products have been shipped without problems
- **Each operation phase can be managed**
 - ✓ WMS can communicate the ERP that shipments have been successfully carried out
 - ✓ The company's resource manager is informed of all the expeditions

WMS are also responsible for the management of merchandise flows (inputs and outputs of products) to the production lines; able to manage several stores or companies simultaneously.

WMS advantages

WMS can bring lots of benefits

Benefits

- They help design a plan to satisfy the company's needs
- They foster workers' productivity
- Productivity rates are higher
- They help companies in the management and control of purchasing and supplies operations
- They contribute to reducing company's costs of emission and possession
- They avoid overproduction
- Pickers are informed of the situation of the stock
- Information about stock is clear and detailed
- They also help design a plan based on forecasts
- They can cause an increase in the service ratio
- They make the decision-making process easier
- They collaborate in the reduction of administrative tasks
- Reduction of stockout events
- They reduce the returns of orders
- They help strengthen a relationship of trust with clients and suppliers
- Medium/long-term profitability

MODULE 8

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 4 - Transportation, distribution and logistics

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Why study Logistics, warehouse, distribution & supply chain management?

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Introduction

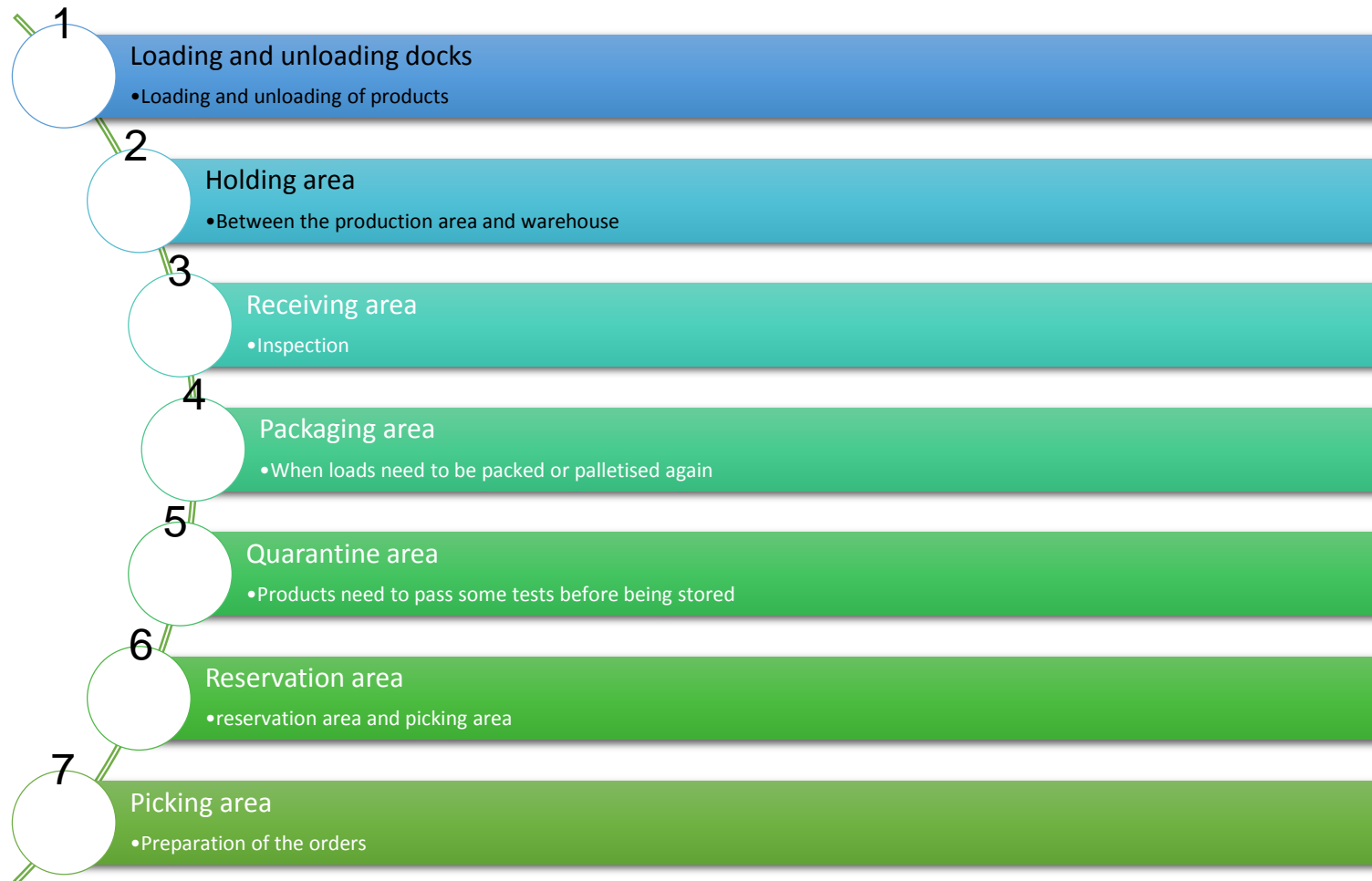
Companies have problems when designing their **layout**.

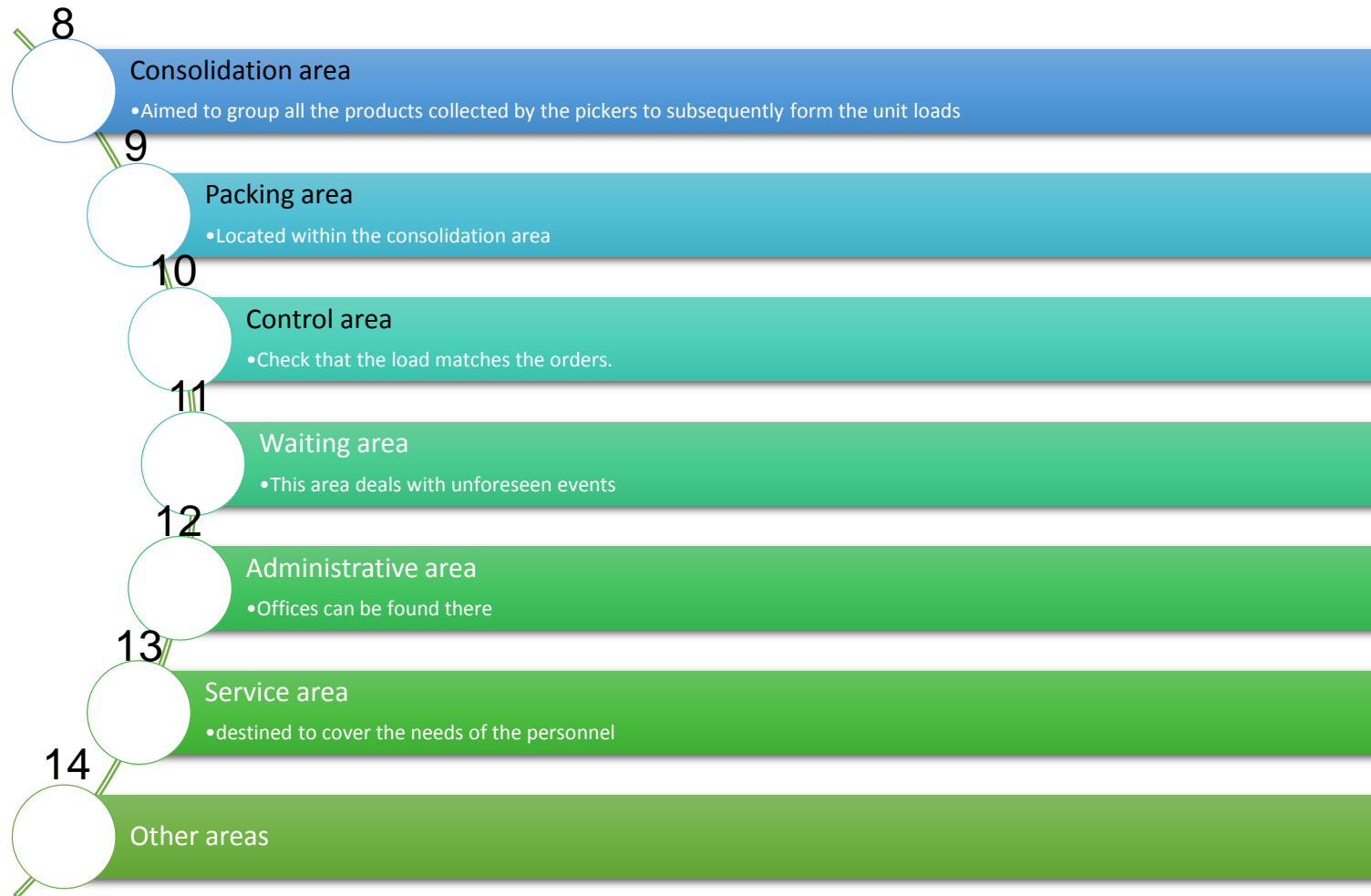
There are several factors to take into account when planning the layout of a warehouse

- ✓ Type of warehouse
- ✓ The material flow
- ✓ Number of workers
- ✓ Products
- ✓ Number of products
- ✓ Production system
- ✓ Tools and the machinery
- ✓ Etc.

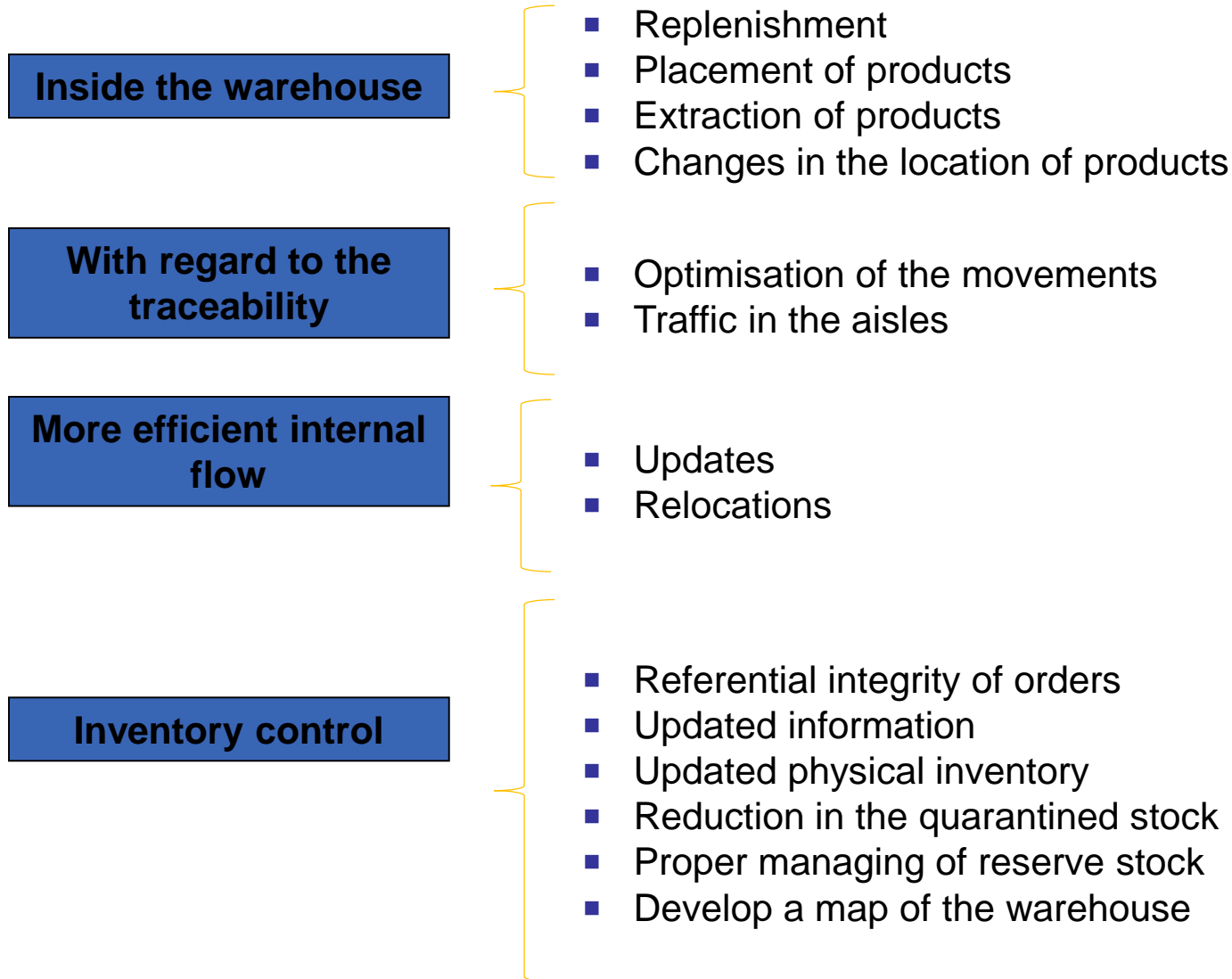
Factors to take into account

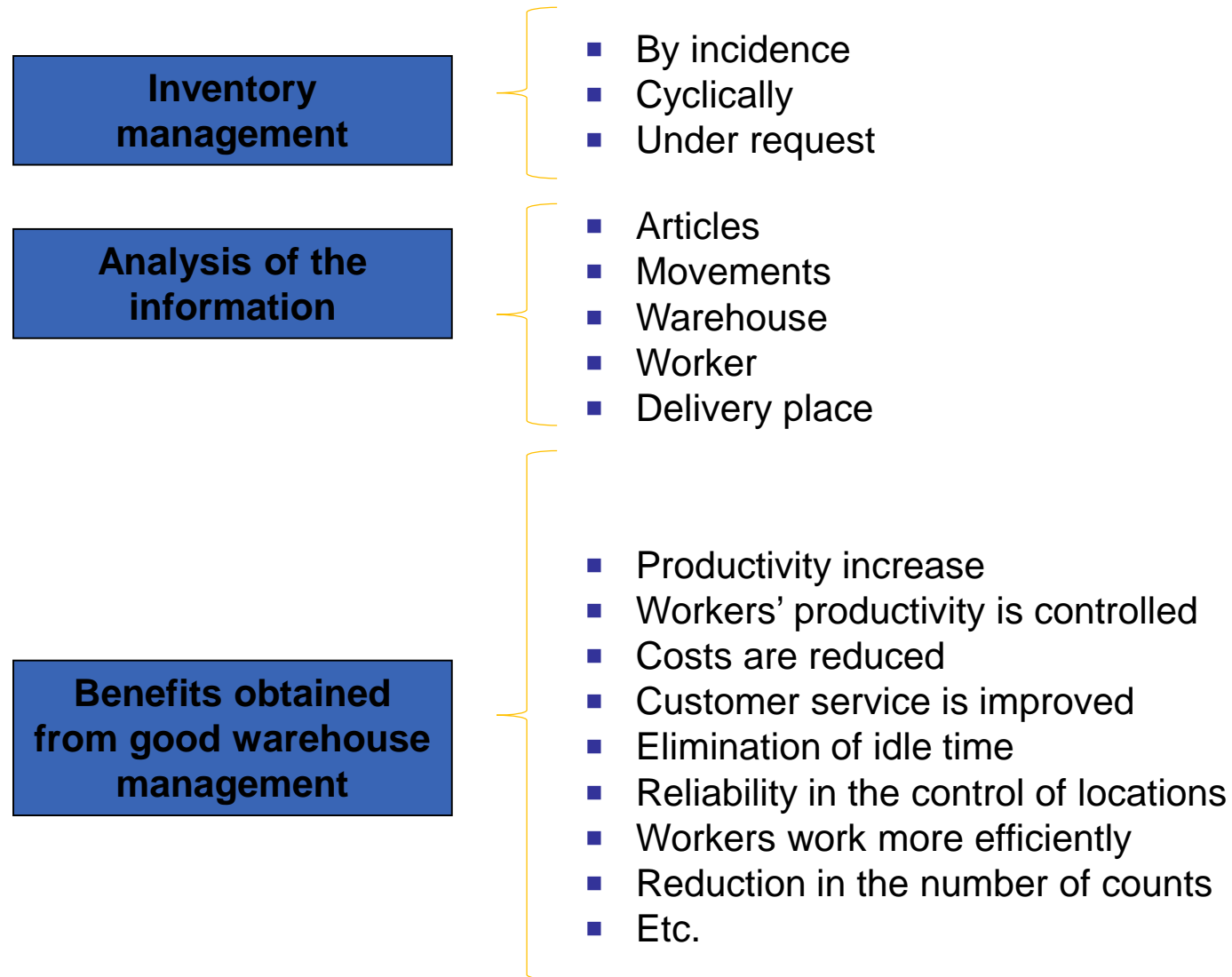
Warehouse areas



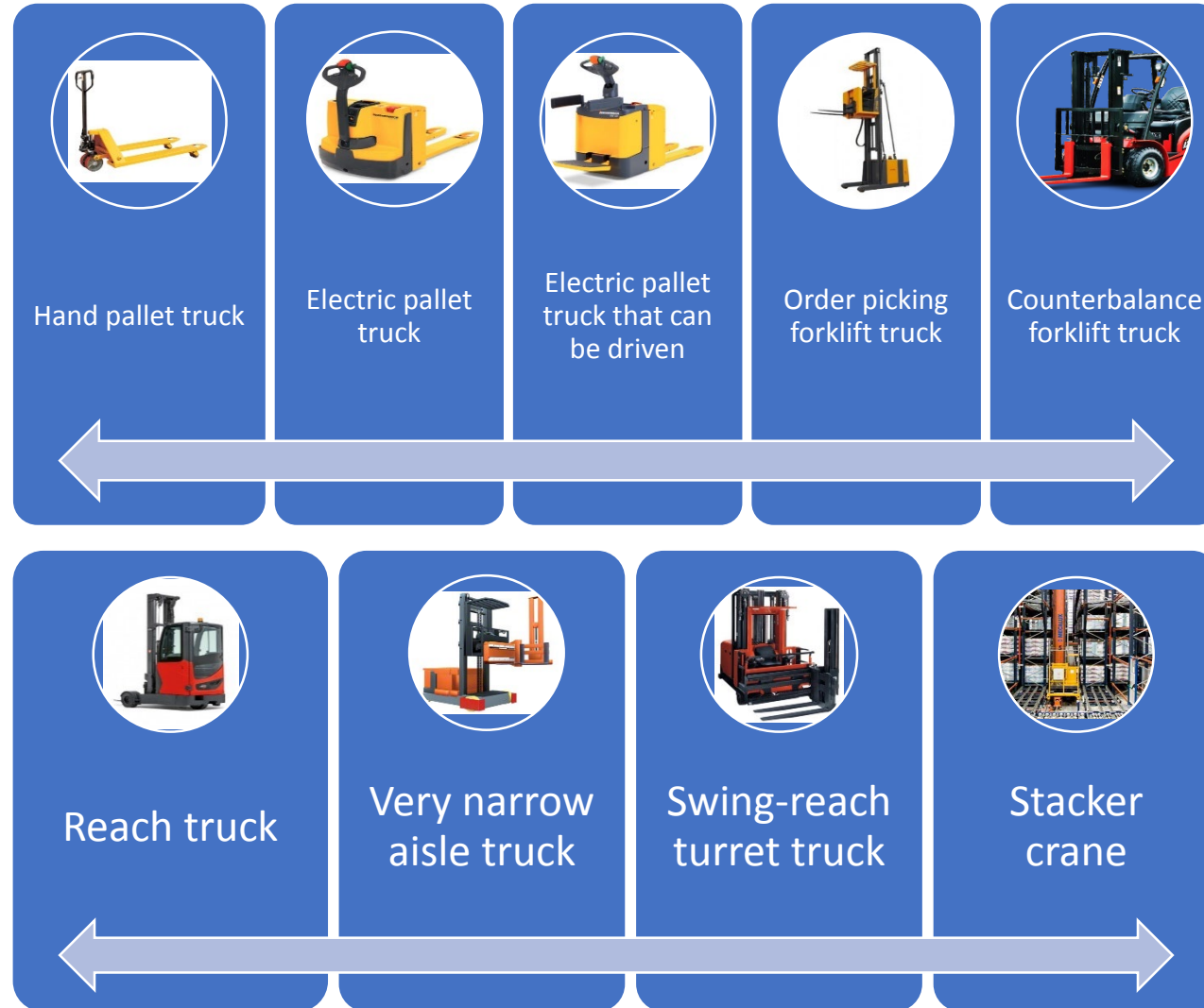


Internal movements and inventory management





Internal tools and transports

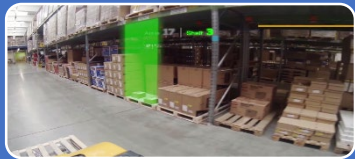


Coding articles



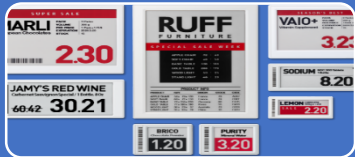
Artificial vision systems

- read objects by video cameras and/or by a set of photoelectric cells connected to computers
- Their main use is to automate quality control processes



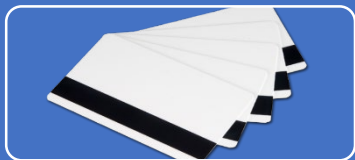
Augmented reality

- Define digital views that are integrated in a real physical environment
- Very useful for the picking operations



Electronic tags

- Radio transmitters that can be active or passive



Magnetic strips

- Usually found in cards that have the electromagnetic information signals recorded on tape segment



Magnetic character recognition

- Generally, they are numeric characters
- They can be recognised mechanically or magnetically.



Optical character recognition (OCR)

- Characters that are printed
- Read by a beam



Voice recognition system (VRS)

- Computer system programmed to recognise and interpret words
- Commonly used in pick-to-voice systems



Barcodes

- Used in many sectors



Matrix codes

- QR-Code; Maxicode, EZ-Code, ddTag



RFID

- Simultaneous transmission
- Active or passive access to the data bank

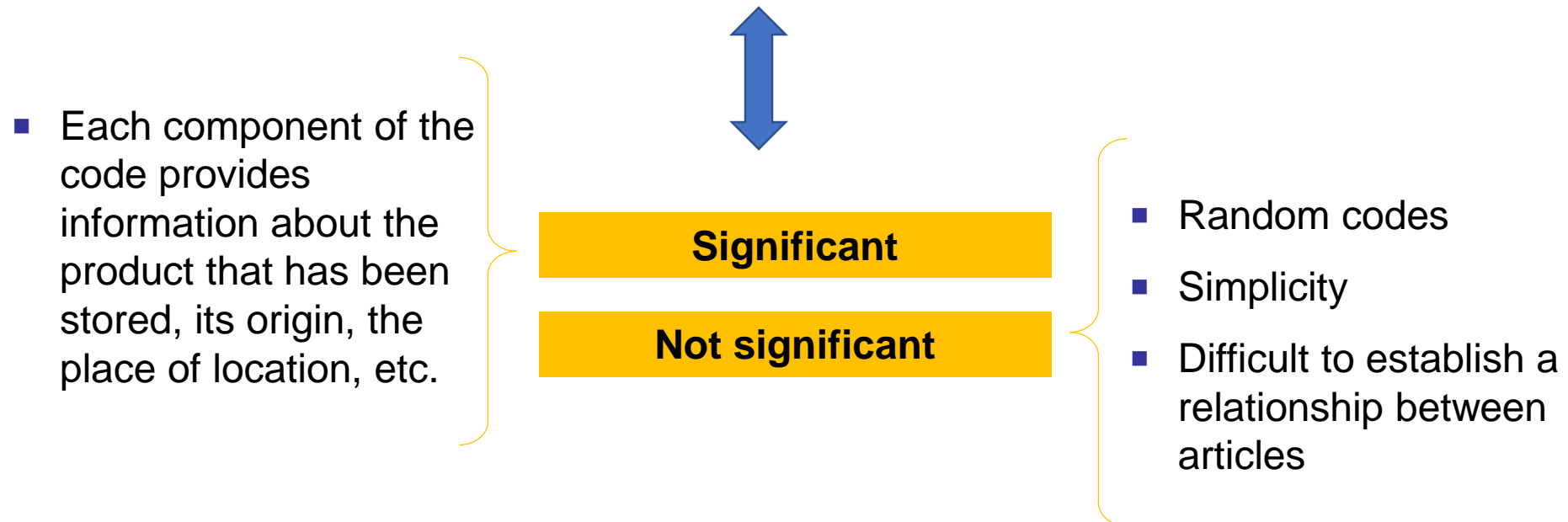
Coding systems help develop the activities of the logistics chain. They **make several warehouse tasks easier**

- ✓ Execution of demanded orders
- ✓ Reception of the products
- ✓ Identification and location of products
- ✓ Verification and inspection
- ✓ Classification and grouping
- ✓ Picking operations
- ✓ Expedition of products
- ✓ Invoicing

Benefits of coding:

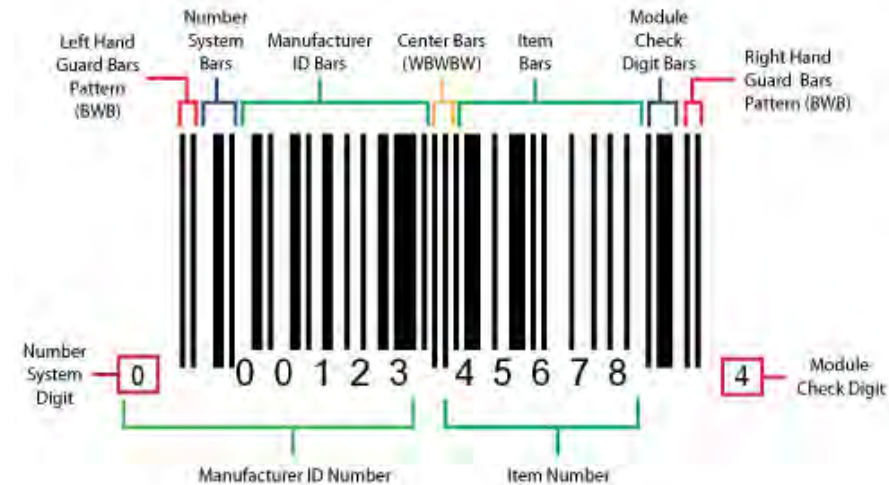
The coding of the articles can be numeric, alphabetical or alphanumeric

It also can be significant or not significant



Barcodes

- ✓ Store information with different orders
- ✓ Can identify any article in the logistics chain
- ✓ inventory control or consult the characteristics of a product
- ✓ These codes can be recorded, glued or attached on the items, containers, packages or unit loads
- ✓ These bars follow certain coding standards (EAN-13 and EAN-128).



Barcodes

- + Every barcode is different
- + EAN numbers are the access code to the database,
- + They do not cause any problem to the products they go with
- + They are multi-industry and international
- + They are safe
- + Very cheap
- Very difficult to modify information
- Reader must be located close to the code
- Limited identification capacity
- Staff is needed
- Require good visibility
- Surfaces must be flat
- Affected by external conditions or by friction with other materials

RFID

- ✚ They do not require a direct vision
- ✚ Faster and efficient
- ✚ They reduce the inventory
- ✚ Paper is not required
- ✚ They can read different products at the same time
- ✚ They can be integrated into other types of technologies
- ✚ They cannot be faked
- ⊖ There can be numerous tags in the same area and the reader can activate different tags simultaneously
- ⊖ They can have problems with metals
- ⊖ Requires maintenance
- ⊖ The active labels are the most expensive ones and they also need a battery power supply

RFID vs Barcodes

	Barcodes	RFID
Vision over the tag	Direct vision, the tag must be near	No direct vision (between 10 and 100 m)
Identification	Only one article can be identified at the same time	Can identified several articles at the same time
Reading efficiency	Limited reading speed (one at a time)	Greater reading speed (several simultaneously)
Location of the tag	The tag must be in a flat surface	Depends on the product
Material	Do not cause any problem to the products they are attached with	Problems with metals or liquids
External conditions	Affected by external conditions or by friction with other materials	Not affected by external conditions or by friction with other materials
Safety	Medium-low	High (access code)
Costs	Low	High (financial investment and maintenance)
Profitability	Medium-high	High
Price	Low, since only the tag needs to be paid	High, these labels have a much higher cost than barcodes

MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 5 - Distribution requirements planning. Inventory management

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- Manage the warehouses from furniture and woodworking industries.
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- Implement a WMS tool in a Furniture company.
- Implement and assess a valuation of inventory of a furniture company.
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Inventory management

A **fundamental aspect** of business management

There are several costs related to them, like **the ownership or waiting costs**.

Tasks related to inventory management

- Determination of the registration methods
- Products turnover
- Classification forms determined by the control methods
- Input and output flows
- Different methods of calculation of the inventory

The storage and waiting costs can be reduced by carrying out an adequate stock management that allows companies to deliver the items to the customer

Inventory management: MAIN OBJECTIVES

- To minimise the investment in the inventory as much as possible
 - the greater the inventory is, the greater the costs are
- To minimise storage costs
 - Keeping in stock only those products that are essential, and in the minimum amount needed
- Enough inventory to satisfy the demand
 - Essential to forecast the demand
- Achieve an efficient transportation system
 - Maximum value and reduce costs
- Efficient inventory information system
 - Locations, quantities, etc.
- To calculate the inventory value
 - To have an adequate estimation of the production and logistics costs
- To follow the best purchasing strategy
 - to take the best offers.
- To make forecasts of future needs of inventory
 - Associated with demand forecast

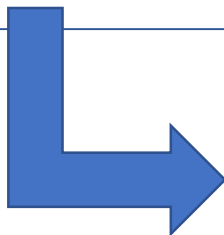
A determined level of stock is necessary in order to meet the existing demand.
However, maintaining an inventory means having to deal with a wide range of costs.

It also helps avoid interruptions in the productive process

The main objective of inventory management is **to reduce costs related to the maintenance and possession** of stock

Why do companies need to have stock?

- To avoid interruptions in the productive process
- To level the production flow
- To obtain economic advantages
- To compensate the lack of balance between the production and consumption



Companies must answer this question:
When and how much do we need to produce?

Two parameters must be taken into account when controlling inventory

Number of times the inventory
is renewed in a period of time

Calculated dividing the total
outputs into the average stock

**Products
turnover**

$$Rotación = \frac{Total\ salidas}{Inventario\ medio}$$

Number of days it takes to
renew the stock

Calculated by dividing the
days of the period into the
turnover of the same period

Coverage

$$Cobertura = \frac{Días\ periodo}{Rotación}$$

**There are key
inventory
management
methods and
concepts that are
relevant**

ABC classification

A (most important products); B-C (less important products)
→ The category is decided according to some criteria

Key concepts according to input and output flows

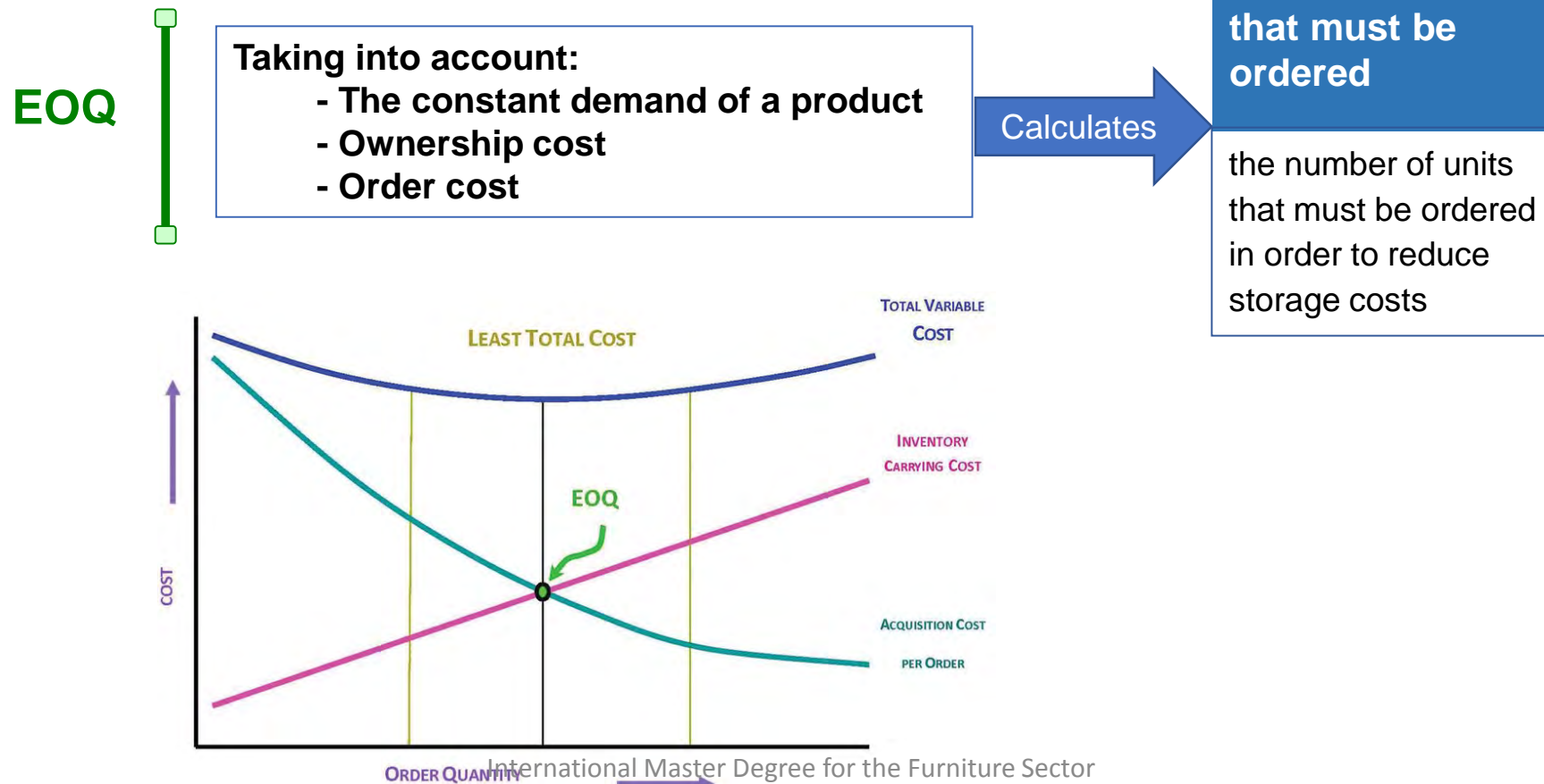
FIFO: First In – First Out
LIFO: Last In – First Out
VWAP: Volume-weighted average price

JIT method

JIT: Just In Time
→ Stock equals to 0
→ It stores only those products that are needed to guarantee that there are no stops during the production phase.

Economic Order Quantity (EOQ)

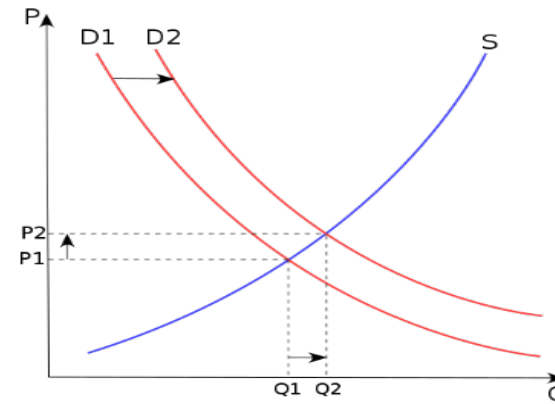
Another **common inventory management system**



Characteristics of the demand

Demand = total amount of goods requested by one company to another

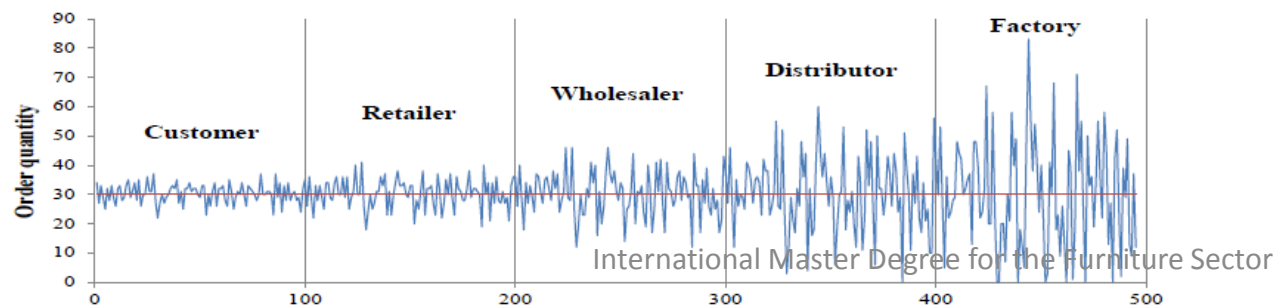
The demand curve is the
graphic representation of
the demand



DEMAND

Bullwhip effect

- This phenomenon refers to the great imbalance that can occur between the real demand requested by customers and the demand made by the companies in the supply network



- Seasonality

it indicates when the demand is higher or lower, since it is not constant

- Trend

it states which products should be taken into account to forecast the demand

- Random variable

Unexpected revolution in demand. It revolutionises the market in several stages of different periods of time

- Cyclic variation

It occurs over long periods of time. The demand undergoes cyclical increases and decreases.

Characteristics of the demand

Dependent demand

- ✓ Random and depends on market conditions
- ✓ Not related to other products
- ✓ A demand forecast is carried out
- ✓ This demand is found in finished products (cupboards, tables, chairs...)



Independent demand

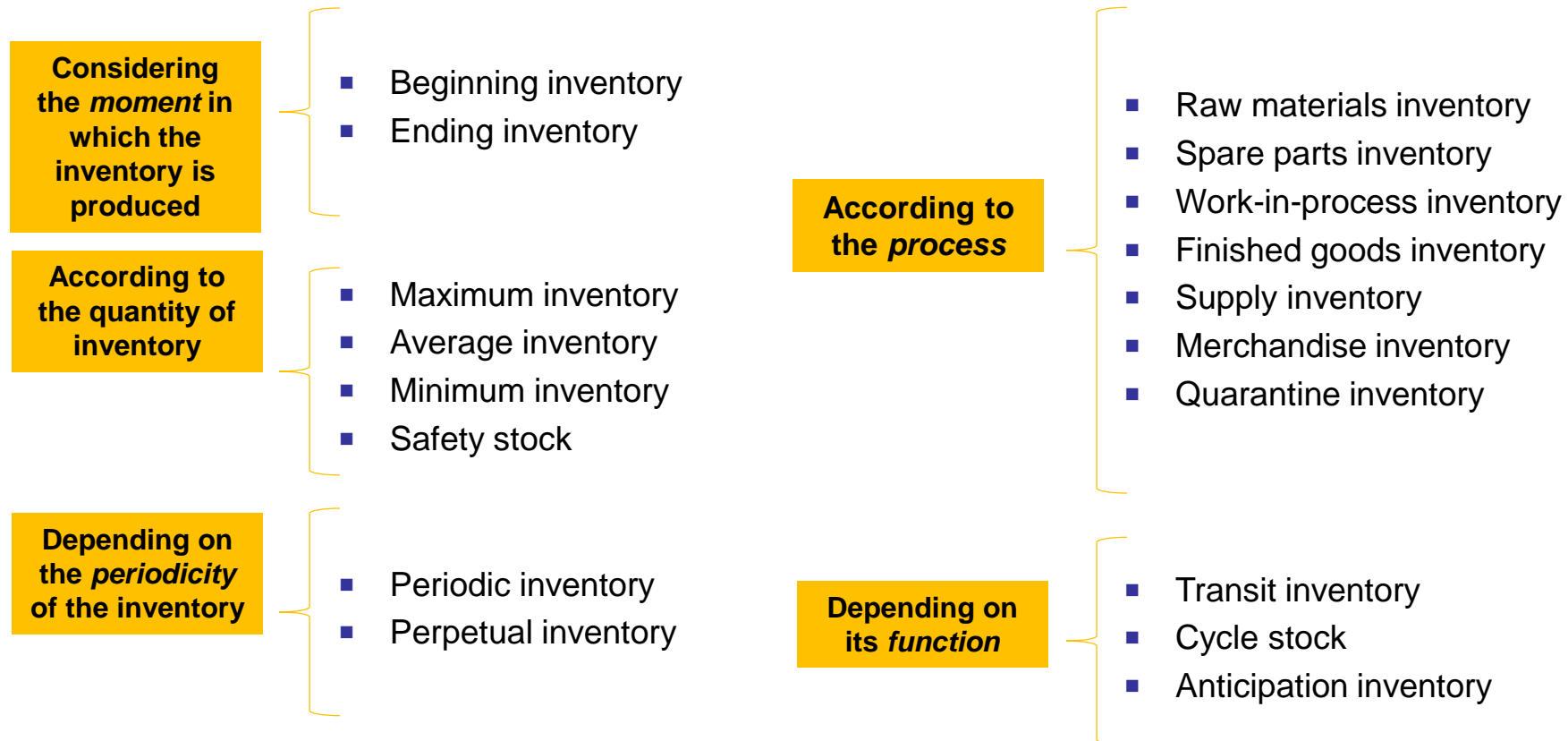
- ✓ Related to more complex articles
- ✓ Coordination between inventory and production management is essential
- ✓ Material requirements planning (MRP) and JIT are popular management methods
- ✓ They occur in multi-stage production systems (furniture)
- ✓ Semi-finished products (shelves, legs, upholstered seats...)



Types of inventory

Inventory = detailed, ordered and valued relationship of the elements that make up the assets of a company in a specific period

They are usually managed and controlled through
centralised databases



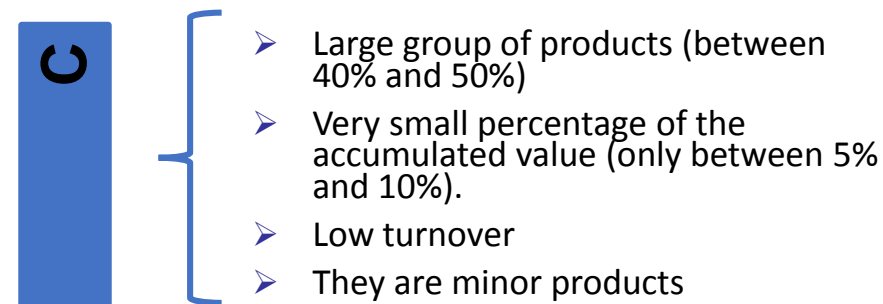
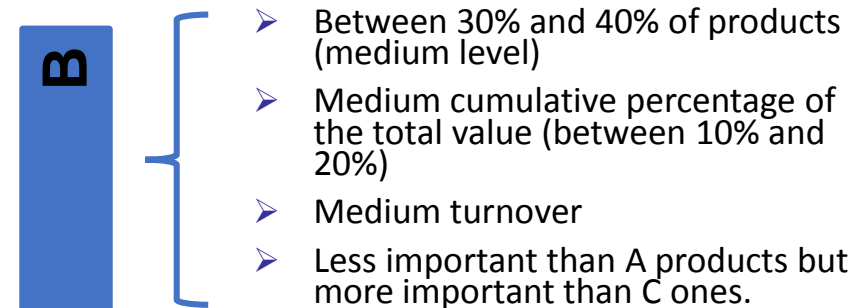
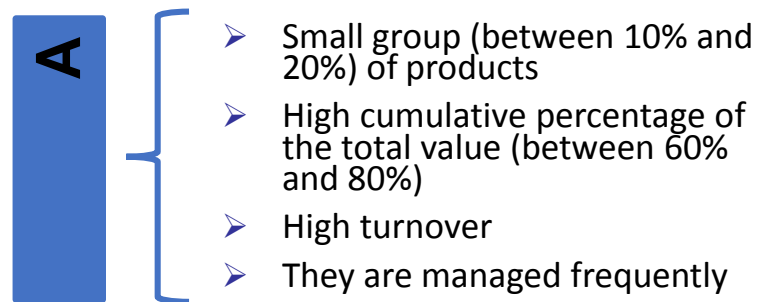
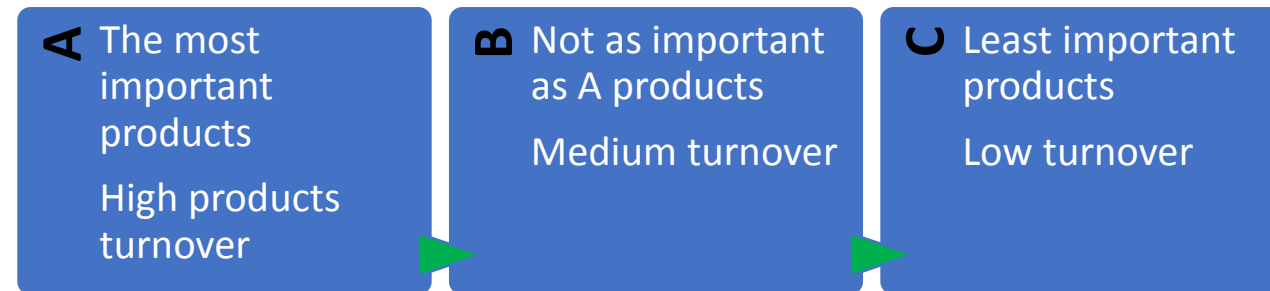
Inventory costs

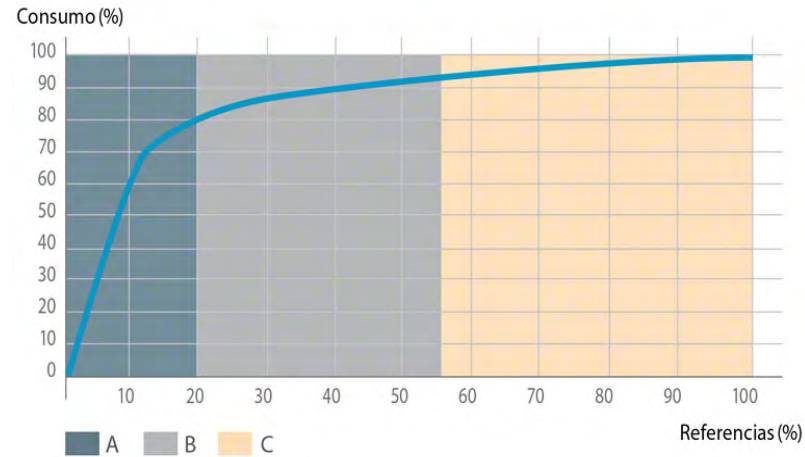
Inventory costs = costs related to storage, handling, production and any industrial operation that has an impact on the goods

- Replenishment costs
 - Order costs
 - Issue costs
- Storage or ownership costs
 - Costs of the storage and maintenance process
 - Between 15% and 50% of the total costs
- Total cost
 - Order cost + storage cost + purchase cost
- Production costs
 - fixed cost of preparing machines + variable cost of manufacturing
- Shipping costs
 - fixed cost of the facilities + the variable cost per transport unit
- Non-quality costs
 - Those that appear when companies have not previously invested in adequate quality processes
- Unmet demand costs
 - Delayed unmet demand; Lost unmet demand (loss of sales)

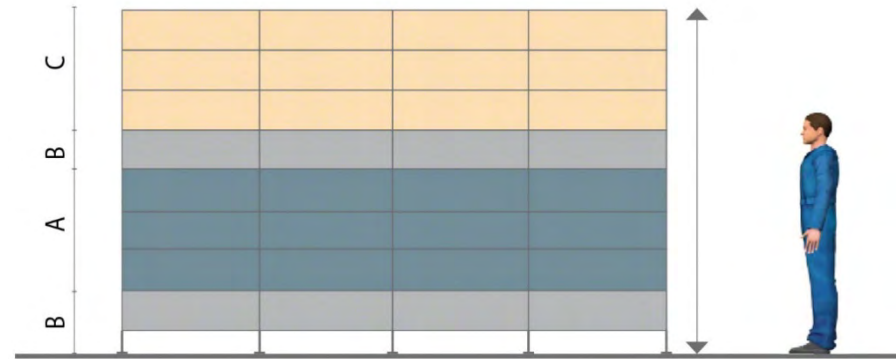
ABC classification

The Pareto chart (or ABC) = classifies products into three main categories

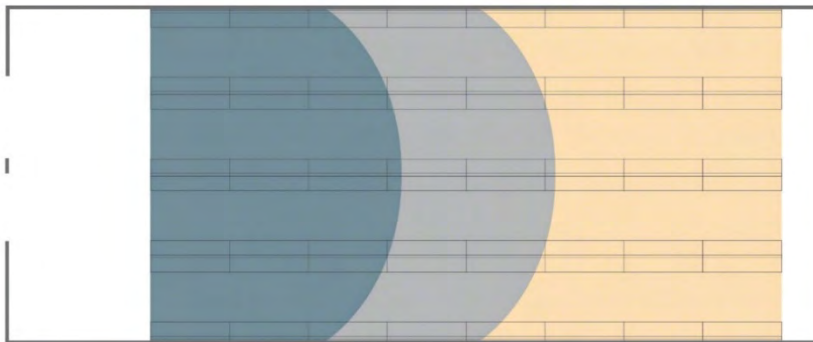




ABC classification



ABC classification for the picking process



Layout of a warehouse following
ABC classification

ABC criteria

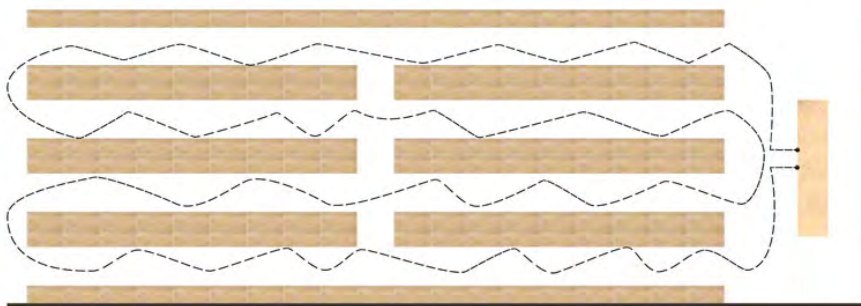


1. Contributes to the decision-making process related to a relatively small number of units
2. Reduces management, administrative costs, etc.
3. It also focuses inventory management on those products that really should be treated individually (financially and use of space)

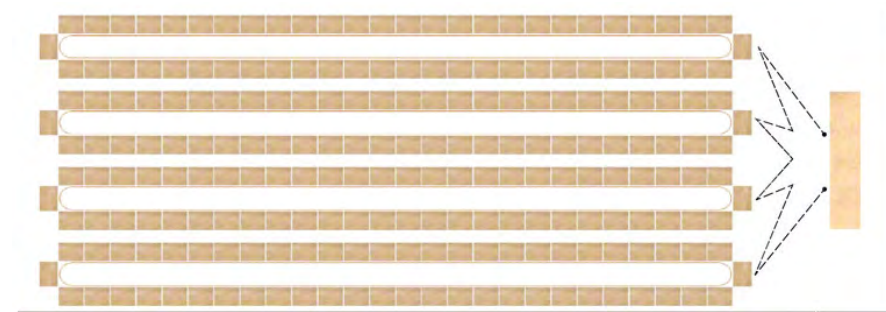
Has a direct effect on the picking operations

Minimises the transports and movements made by the operators and the materials

Type A products are placed close to the entrance and exit, followed by those of type B and, lastly, type C



Route made by the picker (person-to-goods system)

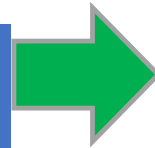


Route made by the picker (goods-to-person system)

Input and output flows

Once the input flow has been valued, it is necessary to do the same with the output flow.

The value given to the outputs



1. The value given to the outputs will be part of the cost of the article
2. It will affect all future decisions

The most used material flow criteria for the management

- FIFO (first in- first out)
- LIFO (last in – last out)
- VWAP (Volume-weighted average price)

The least used

- HIFO (highest In – first out)
- NIFO (next In – first out)
- FEFO (first expired – first out)
- Standard price method

MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 6 - Lot sizing procedure

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Economic order quantity models

EOQ is the most elementary inventory management model

Its main objective is to determine the optimal amount of products to order with the purpose of minimising the costs generated (ownership, order, acquisition costs...)

This technique answers the following basic questions

- What should be the size of the batch?
- When should the orders be issued?

The storage and waiting costs can be reduced by carrying out an adequate stock management that allows companies to deliver the items to the customer

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Hypothesis

Repetitive order
the decision to order is repetitive

Constant demand
Demand occurs at a constant and known speed during a period of time

Constant delivery time
The time that elapses between an order and its arrival

Standing order
Continuous review models: an order can be made at any time
Periodic review models: when the amount of inventory available is reviewed periodically. Therefore, orders are made periodically too.

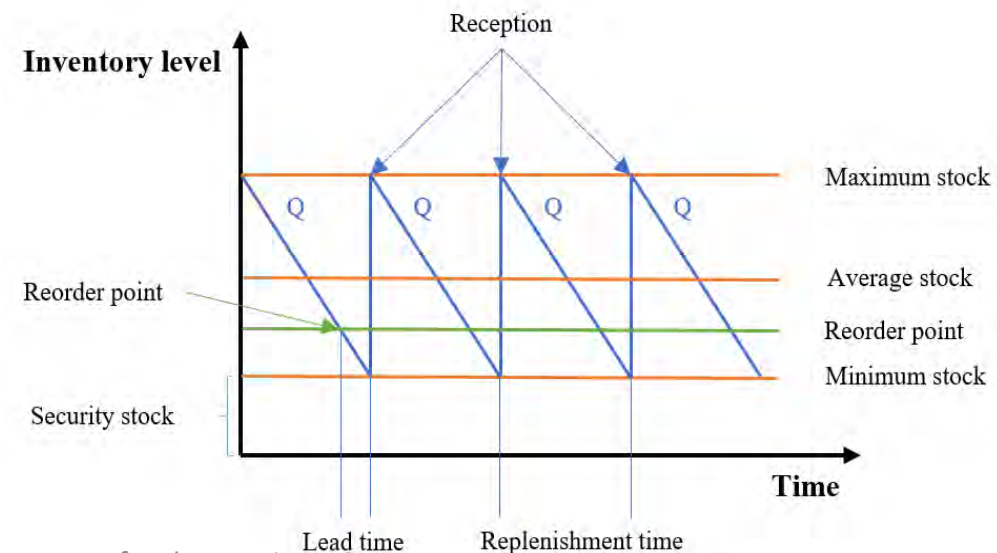
Basic EOQ model

In order to calculate a basic EOQ model we should follow this hypothesis

- The demand is known and constant over time
- If an order of any size (q) is made, an order cost (K) is generated.
- The delivery time for each order is zero
- No shortage of items is allowed
- To maintain an article, the unit cost per period of time is h .
- A single product is considered. Each order is independent

The main characteristics of this model are:

- The quantity ordered is always the same (optimal lot = Q^* .)
- The maximum inventory level matches the quantity ordered $Q_{\max} = Q^*$.
- An action to replenish the inventory stock is executed when the warehouse reaches a certain level of inventory. Reorder point (ROP)



Cost calculation

The optimal lot (Q^*) minimises the costs generated in stock management

En el cálculo de costes, los costes de inventario son:

- Coste de pedido (C_p)
- Coste de almacenaje (C_a)
- Coste de adquisición (C_c)
- Coste de escasez (C_T)

Coste total de pedido o emisión (C_p)

Total order cost: unit cost of each order (K) multiplied by the number of orders to be made, that is, the order frequency (f).

$$C_p = \frac{K \cdot D}{Q}$$

$$f = \left(\frac{D}{Q}\right)$$

Q = quantity that must be ordered
 D = total demand

Coste total de almacenaje (C_a)

Storage costs (h) multiplied by the average stock \hat{I}

$$C_a = h \cdot \hat{I} \cdot t \rightarrow C_a = \frac{h \cdot Q}{2}$$

t = time horizon

Coste total de adquisición o compra (C_c)

the unit cost of purchase (p) multiplied by the demand (D).

$$C_c = p \cdot D$$

t = time horizon

Coste total (C_T)

Suma de (C_p) + (C_a) + (C_c)

$$C_T = \frac{K \cdot D}{Q} + \frac{h \cdot Q}{2} + p \cdot D$$

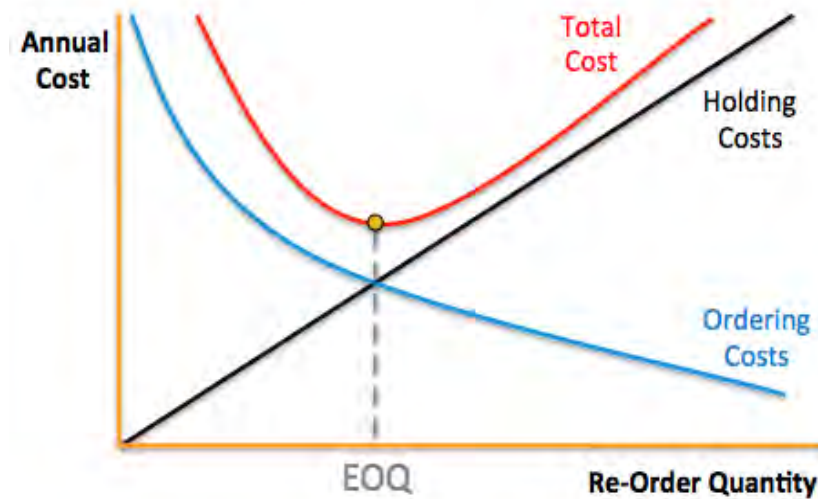
Optimal lot

The minimum value of the total cost corresponds to the minimum of the curve

- Steps:
- The equation is derived and equalled to 0
 - The value of Q obtained is calculated
 - Next step is finding the second derivative of the equation
 - If the second derivative is >0 the curve is convex and the calculated Q value is a minimum.

$$Q^* = \sqrt{\frac{2 \cdot K \cdot D}{h}} \equiv EOQ$$

Q^* = Optimal order quantity
 K = Fixed cost per order
 h = Storage cost
 D = total demand



EOQ model: delivery time different from zero

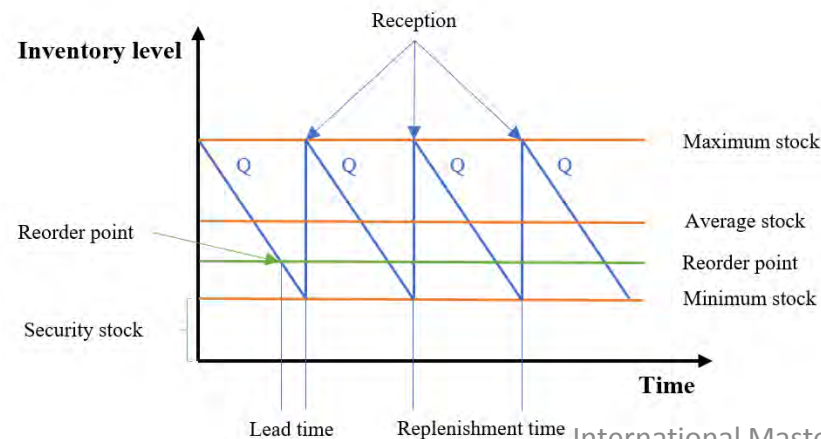
Shipments must arrive exactly when the inventory level is equal to zero. An order must be made when the stock reaches a certain level known as reorder point

R_t = Replenishment time
 S_t = Supply time

If $S_t > R_t$

Reorder point =
supply time multiplied
by daily demand (D/t).

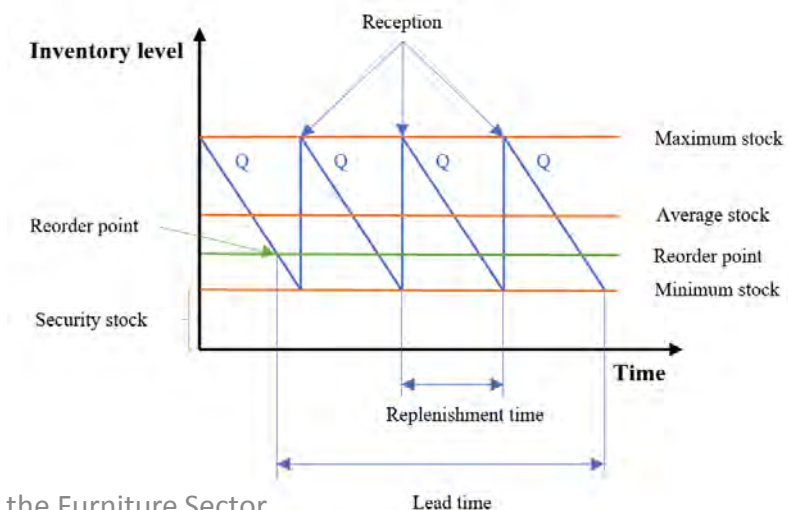
$$P_p = T_s \cdot \left(\frac{D}{t}\right)$$



If $R_t < S_t$

the replenishment time
has to be subtracted from
the supply time,
multiplied by the number
of whole periods covered
by the delivery time.

$$P_p = (T_s - T_r \cdot E) \cdot \left(\frac{D}{t}\right)$$



EOQ model with volume discount

The bigger the orders are, the smaller the unit costs are.

Steps to determine the optimal order quantity:

- Starting with the minimum price, each price has its own EOQ
- When an acceptable EOQ is found, the optimal order quantity is (q) with the minimum value of total cost(q).

Hay que calcular todos los descuentos posibles para cada lotificación ofrecida por el proveedor, hallando el mínimo coste total de cada pedido

$$Q_1^* = \sqrt{\frac{2 \cdot K \cdot D}{h_1}} \quad Q_2^* = \sqrt{\frac{2 \cdot K \cdot D}{h_2}} \quad Q_3^* = \sqrt{\frac{2 \cdot K \cdot D}{h_3}} \quad \dots$$

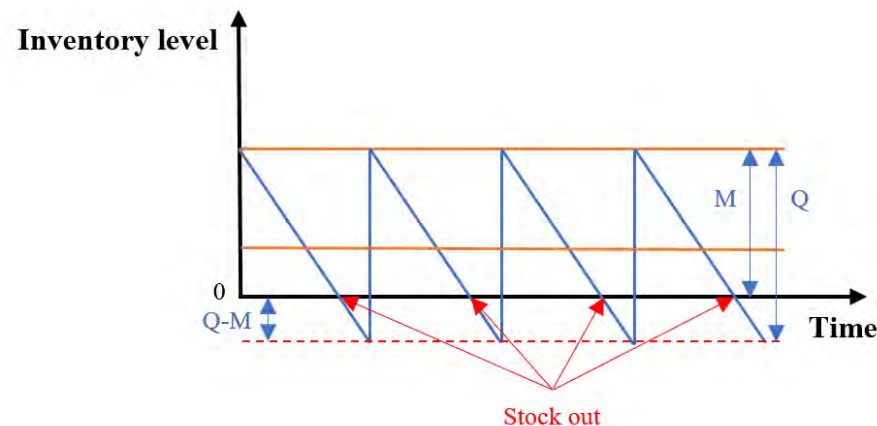
EOQ model: out of stock

The demand is not met on time and there is a shortage of inventory.

Thus, the difference with the basic model is that orders do not arrive when the inventory is zero, they arrive later.

Hypotheses

- It is assumed that the demand accumulates, and that no sales are lost
- At the end of the planning horizon the stock level is zero, so the total demand is satisfied



Q = Lot size that must be ordered.
 M = Maximum level of inventory
 $Q-M$ = Maximum shortage that arises

Associated costs

- ✓ Coste unitario de escasez (s)
- ✓ Coste total de pedido C_p
- ✓ Coste total de adquisición C_c
- ✓ Coste total de almacenamiento C_a

MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 7 - Shipment

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Learning outcomes

This module will enable you to:

- Manage the warehouses from furniture and woodworking industries.
- Carry out the most suitable plant layout at a furniture/wood products manufacturing plant.
- Implement a WMS tool in a Furniture company.
- Implement and assess a valuation of inventory of a furniture company.
- Performance the process of dispatching of goods in a furniture company.
- Develop and implement a plan of occupational safety and health in a furniture company.

How to learn?

- This course could be taken using a “self directed” learning approach.
- For those attending “full time” courses a lecturer will be directing your learning using the learning materials available.
- For those enrolled on a “part time” basis a mixed approach could be employed.
- Please see below recommendations for each of the situations:

How to learn? Self directed approach

We suggest the following sequence:

- Read the slides, watch the videos and reflect on the content.
- Read the additional text available where information is more detailed.
- If possible discuss with a colleague or register for a “Forum” and express your views.
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Why study Logistics, warehouse, distribution & supply chain management?

- The subject of “Logistics, Warehouse, Distribution and Supply Chain Management” is a basic material for the exercise of activities of management and direction of the logistics department in companies that work in the furniture sector.
- After completing this subject, students must achieve an understanding of the essential concepts to organize the storage of goods under the conditions that guarantee their integrity and the optimal use of available media and spaces, according to established procedures.
- Once completed this subject, the student will have full notions of knowledge required for the design, management and control of a warehouse of furniture and related sector.

Transport: networks and means

Goods distribution

- Land: trucks, vans, railways...
- Sea: vessels and ferries
- Air: cargo planes

Land transport is the one most profitable one.

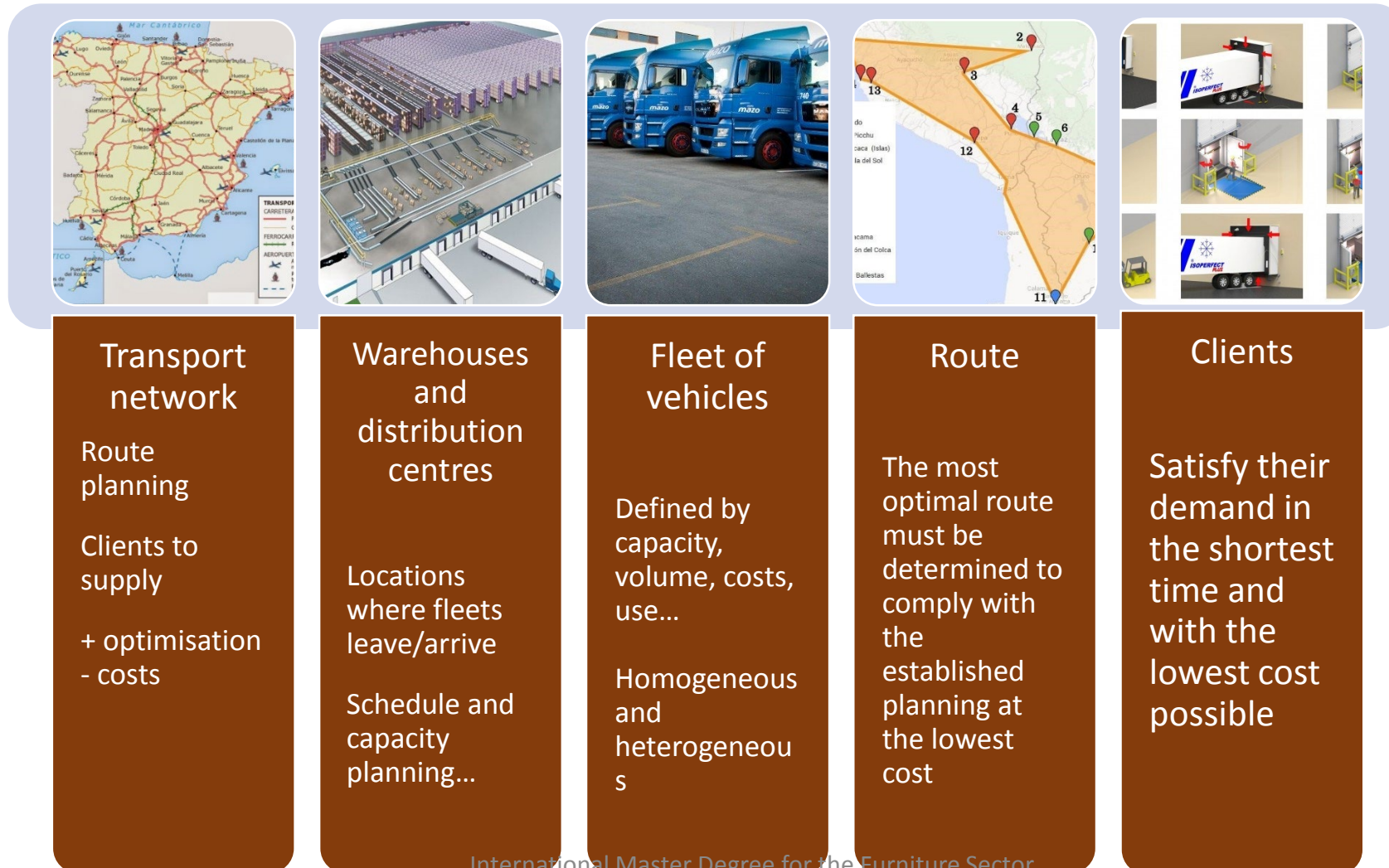
International transport of goods by road has an important weight in exports.

Transport network configuration

- It determines the costs of distribution of the articles
- It also determines the planning and organisation of the supply chain
- Direct impact on the final cost of the product (between 10% and 20% of the total price)
- It generates costs
- Transportation is a vital part of companies' operations
- Companies must keep improving transport operations
- Small improvements translate into high cost savings

Operational research techniques related to fleet management and the use of information technologies (ICT, EDI, etc.) can help to improve the capacity, quality and level of service operations.

The main elements within a distribution network are:



Types of transports

The features of the product are relevant to choose the most convenient transport



Road transport

- Cheap, flexible, fast, and versatile
- The type of vehicle depends on the size and weight of the goods
- Delivery time depends on external agents.



Rail transport

- Not very popular, but becoming popular.
- Perfect for long-distance routes.
- It is very reliable and safe. Not as flexible and fast as road transport.



Sea transport

- Commonly used at international level. Becoming popular.
- Prices are adapted to the transported weight: the more load is transported, the more profitable the route will be.
- Great variety of vessels specialised in different types of goods.



Air transport

- Price is determined mainly by the weight, volume and urgency of the delivery. The fastest one.
- It is used mainly for highly valuable freight.
- To transport important and low volume products.

Transportation problems

The main elements within a distribution network are:

Types of problems



- Shortest path problem
- Path problem

Path problem



They are becoming more common and difficult due to the incorporation of new objectives and restrictions

Geolocation



Real location. Used in transportation problems to calculate distances and costs.

Parameters



Latitude, longitude, great-circle distance, real distance, etc.

In order to solve these problems:

- It is fundamental to determine if the matrix formed by the route is symmetric or asymmetric.

Relevant problems:



- Travelling salesman problem (TSP)
- Capacitated Vehicle Routing Problem
- Others

MODULE 8:

Subject 1: Logistics, warehouse and supply chain management

Learning Unit 8 - Safety measures and hazardous materials

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Introduction

Occupational Safety now has a "preventive" approach, rather than a "reactive" one.

It acts before hazards take place.

- ✓ Plan and integrate the set of activities of a company according to its hierarchical
- ✓ First, the company must assess risks
- ✓ If necessary, measures must be adopted to eliminate or at least reduce the risks detected

Preventive action

Occupational Safety and Health

The current OSH laws seek to eliminate safety and health risks
To do so, the main risks need to be acknowledged, assessed and controlled

Basic Principles on Preventive Action

- Avoiding risks
- Assessing unavoidable risks
- Combatting risks at their roots
- Adapting jobs to their staff
- Updating techniques
- Substituting hazards with safety or barely hazardous components
- Planning prevention
- Prioritising collective protection
- Training the staff

Types of Risk

- Linked to safety conditions
- Part of industrial hygiene
- Defined as ergonomics and psychosociology

Work centres

Areas where workers are located

• Structural safety	{ Buildings must be solid and adequate resilience
• Danger zones	{ Dimensions must enable safe work
• Floors, openings, unevennesses, rails	{ Stable, non-slippery, regular, easy-to-clean
• Single-partition walls, windows, roofs, walls	{ Signs, manufactured with safe materials
• Traffic routes	{ Signaled, adequate in number and dimensions
• Doors and gates	{ Signaled and protected against ruptures
• Ramps, ladders	{ Non-slippery materials 8% to 12% elevation
• Escape routes and exits	{ Clean and exiting to the exterior or safety area

General safety conditions on workplaces

Work tools

Risks associated to hand-operated tools

- ✓ Staff accessibility to cutting elements
- ✓ Ejection of particles
- ✓ Falls due to excessive physical efforts

Preventive measures

- ✓ Purchase of safe and good quality tools
- ✓ Designed use and information
- ✓ Instruction
- ✓ Equipments to protect individually
- ✓ Regular maintenances
- ✓ Optimal storage

Risks associated to mechanical tools

- ✓ Electric contact
- ✓ Contact to cutting elements
- ✓ Ejection of particles
- ✓ Falls due to excessive physical efforts

Preventive measures

- ✓ Risks seen in hand-operated tools
- +
- ✓ Risk prevention that arise when using energy (electricity, compressed air, etc.)

Machinery

Risks associated to machinery

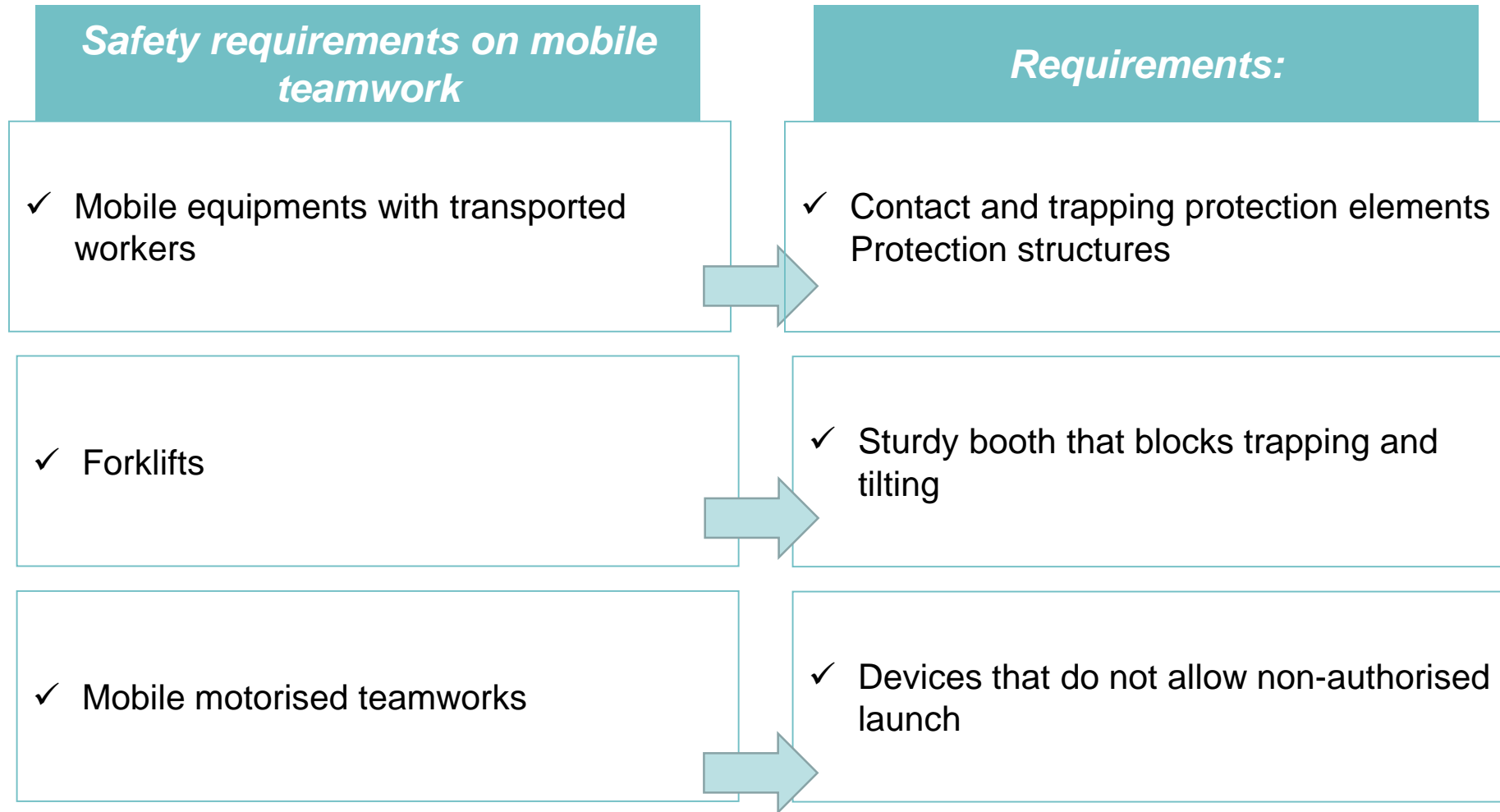
- ✓ Mechanical risk
- ✓ Electric risk
- ✓ Heat risk
- ✓ Noise exposure
- ✓ Vibrations exposure
- ✓ Radation exposure
- ✓ Chemical materials and substances exposure
- ✓ Risks derived from evading ergonomy when designing a machine



Safety measurements

- ✓ Machinery designed and manufactured with enough balance to avoid falls
- ✓ Machinery resilient to the efforts they are ment to do
- ✓ Materials appropriate for manufacture
- ✓ Manufacturer's instructions on inspections and maintenance
- ✓ Elements susceptible to burst or break
- ✓ Liquid-driving elements, calculated and protected against ejections

Teamwork



Storage, handling and transport

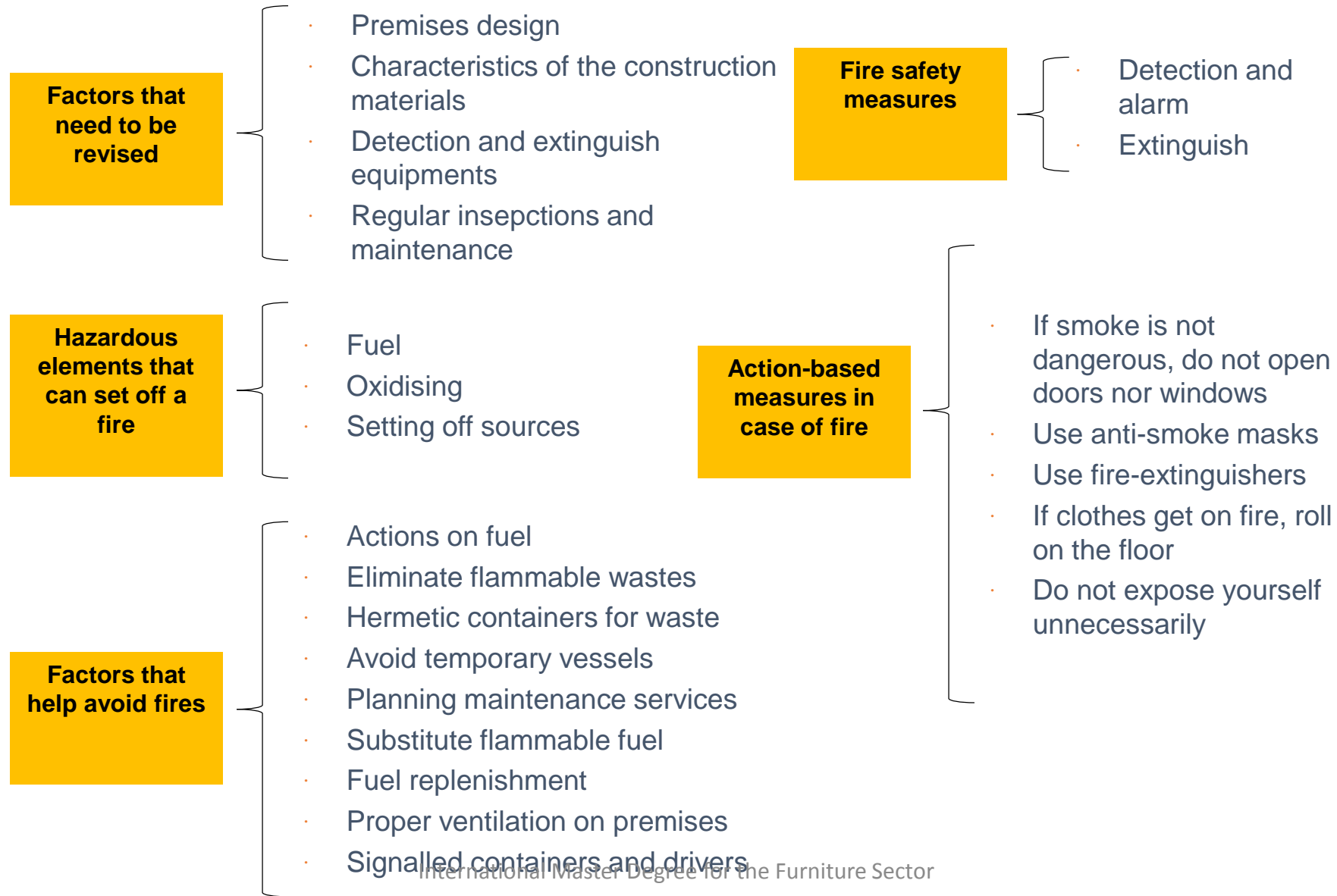
Tips

- ✓ Objects appropriately stored
- ✓ Avoid objects sticking out of piles
- ✓ Use ladders or forklifts
- ✓ Do not lean heavy piles on bearing walls
- ✓ Secure objects that can roll with a wedge
- ✓ Protect materials from humidity and heat
- ✓ Regularly inspections

Factors

- ✓ What will be transported?
- ✓ Where will it be transported?
- ✓ Where will the goods be stored?
- ✓ Who will be transporting it?
- ✓ Which means will be used?

Fire safety



Hazardous materials

