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MODULE 2:
Production, scheduling and planning

Learning Unit 1 - Demand management and forecasting

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- Develop different forecasting of the demand for different products in the furniture sector using historical sales.
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- Implement and execute improvement plans related to the theory of restrictions and the layout of the production plant in the furniture sector.

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How to learn?

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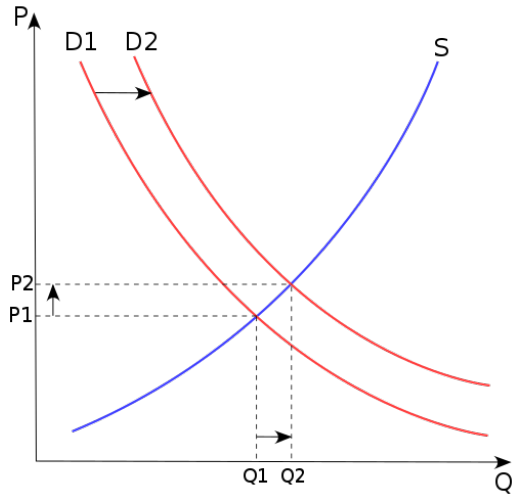
Demand management

Demand= total amount of goods and services requested from a company or organisation to another. They can be acquired for different prices at the market by one or more clients.

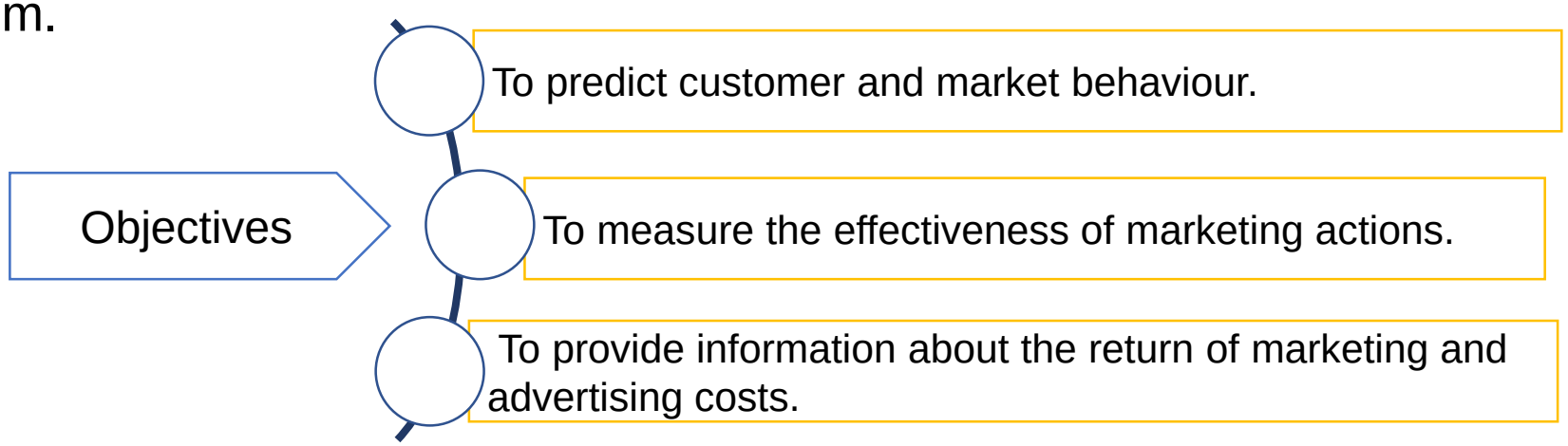
Demand Forecast
It is a forecast for a product's future demand.

Demand History
Amount of an article's units that the market could have bought in the past.

Demand Forecast
It is the amount of a product's units that companies are able to serve and that have been bought by the market in the past.



Demand management= provides essential Information to the production planning subsystem.



The **goal** of **demand management** is to manage all kinds of existing demand. This way, the production system is used efficiently and the final goods can be delivered in time.

Types of demand and forecasts

Types of demand

Independent demand

- ✓ Is random and not related to other products.
- ✓ Demand forecast and total costs optimisation.
- ✓ For final products or spare parts.

Dependent demand

- ✓ It is related to more complex articles.
- ✓ Essential for production and inventory planning (MRP or JIT).
- ✓ Appears in multistage production systems.

Other types of demand

- Unmet demand or shortage
  - Takes place when demand cannot be attended to because of a stockout.
- Static demand
  - Can be predicted.
- Dynamic demand
  - Varies over time.
- Warehouse-based demand
  - Standard product and low variety.
- Make-to-order demand
  - The product is processed before delivery. Non-standard product.

Types of forecasts

- Depending on **time**
  - Long-term
  - Medium-term
  - Short-term
- Depending on **data**
  - Quantitative
  - Subjective
- Depending on the **context**
  - Macro
  - Micro
- Depending on **data**
  - Qualitative
  - Time series analysis
  - Causal
  - Simulation models

Demand components

Main components

- Average demand for the period
- Tendency
- Seasonality
- Cyclical elements
- Random variation
- Autocorrelation

Characteristics

- **Seasonality:** Shows the stages in which demand changes.
- **Tendency:** Defines which type of products to use when predicting demand behaviour.
- **Random variation:** Affects the market by changing demand.
- **Cyclical variation:** Long periods of time.

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Time analysis and forecast techniques

- **Demand forecast** determines the amount of finished products to manufacture, the amount of raw materials to buy, the amount of goods to carry, etc.

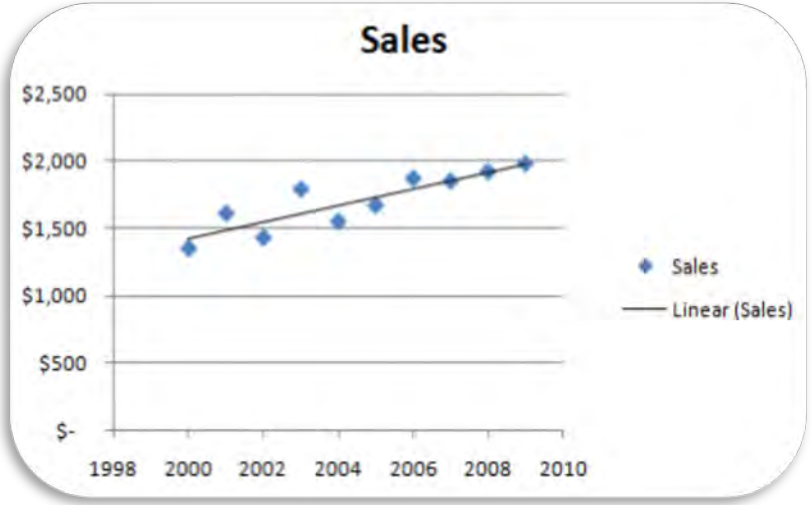
- The duration of each period of time:
  - *Short-term:* Less than three months
  - *Medium-term*: Between three months and two years
  - *Long-term:* Over two years

- The type of forecast to choose depends on:
  - The time horizon
  - The available data
  - The required accuracy
  - The budget size for forecasting
  - Available skilled staff

METHODS FOR TIME SERIES ANALYSIS

Trends forecasting methods

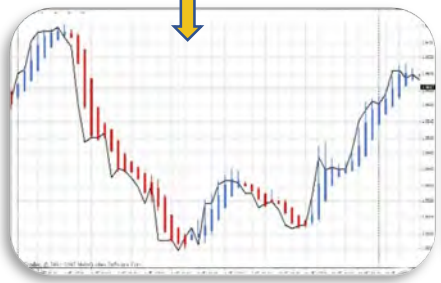
Trends adjustment: Calculating regressions, minimising RMS errors, to obtain linear or exponential trends.



METHODS FOR TIME SERIES ANALYSIS

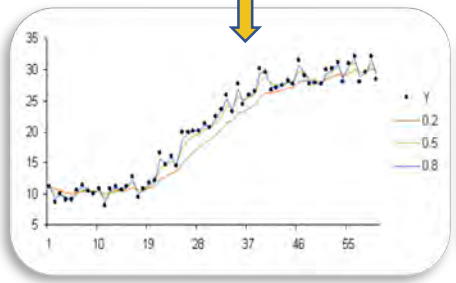
Smoothing method

Smoothing by moving averages: This method smooths historic values in order to cancel random fluctuations. *This is useful for historic values without tendency or seasonality.*

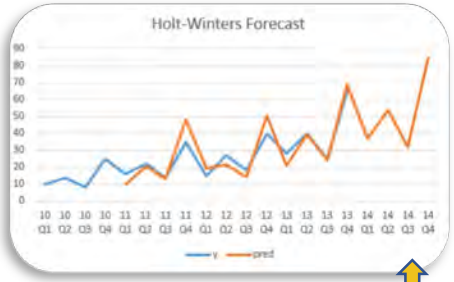


Holt's method: Exponentially smooths values and calculates tendency. This is useful for historic values *with tendency and no seasonality*.

Exponential smoothing: This method smooths exponential historic values in order to cancel random fluctuations. *This is useful for historic values without tendency or seasonality.*



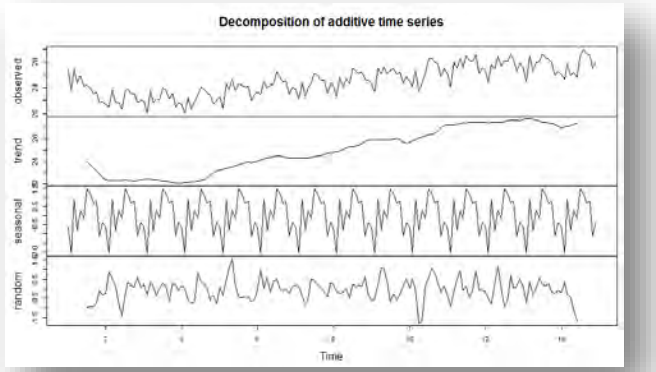
Holt-Winters method: Exponentially smooths values with *tendency* and *seasonality.*



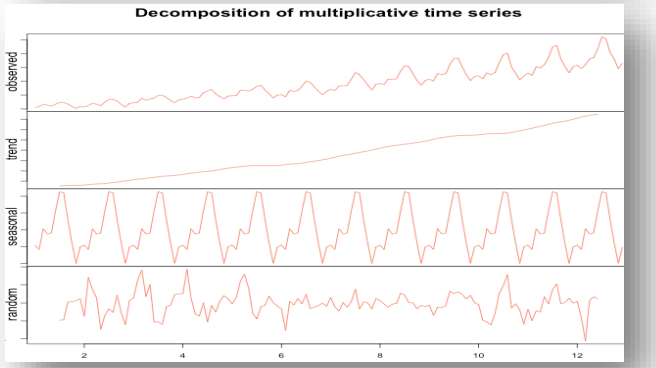
METHODS FOR TIME SERIES ANALYSIS

Time series decomposition methods.

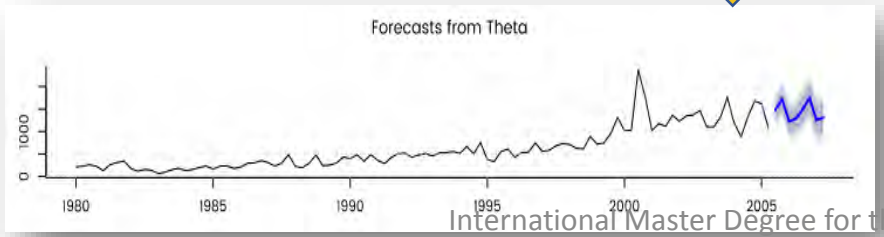
Additive decomposition: Decomposition method for tendency, seasonality and cyclicality patterns. This is useful for historic values with tendency, seasonality and cyclicality.



Multiplicative decomposition: Decomposition method for tendency, seasonality and cyclicality patterns. This is useful for historic values with tendency, seasonality and cyclicality.



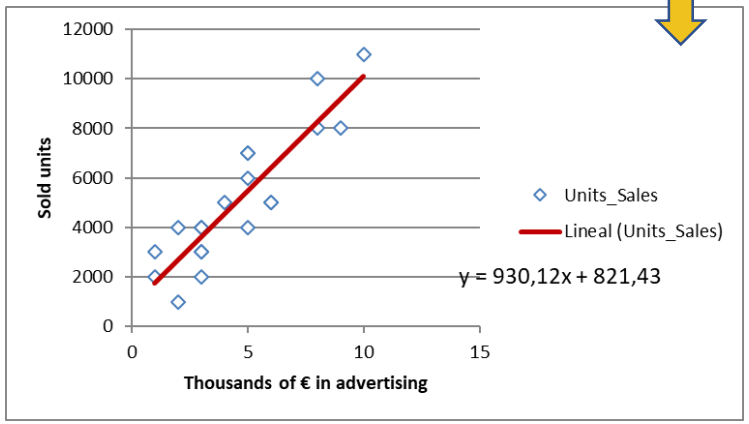
Theta method: If focuses on determining several θ lines which add up to form the forecast.



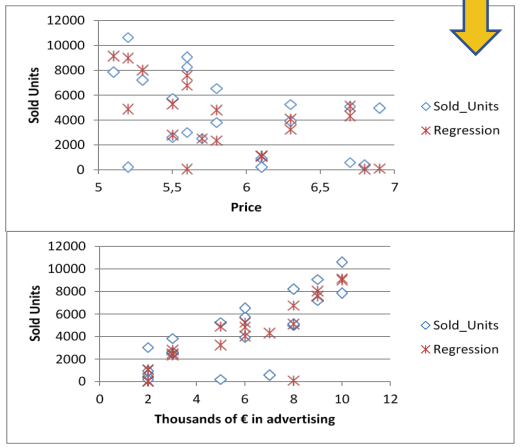
METHODS FOR CAUSAL RELATIONAL FORECAST ANALYSIS

Regression methods.

Simple regression
Linear regression of a Y variable (dependent) in relation to a X variable (independent).



Multiple regression
Linear regression of a Y variable (dependent) in relation to several X variables (independent).



METHODS FOR CAUSAL RELATIONAL FORECAST ANALYSIS

ARIMA method.

ARIMA models (Box Jenkins)

Can be split up in: AR (Auto Regressive). In which p is the order. It is a regression in relation to the previous p forecast values. I (Integrated). In which d is the order of differencing. MA (Moving average). In which q is the order. It is a regression in relation to the previous q forecast errors.

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MODULE 2:
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Learning Unit 2 - Scheduling techniques and control

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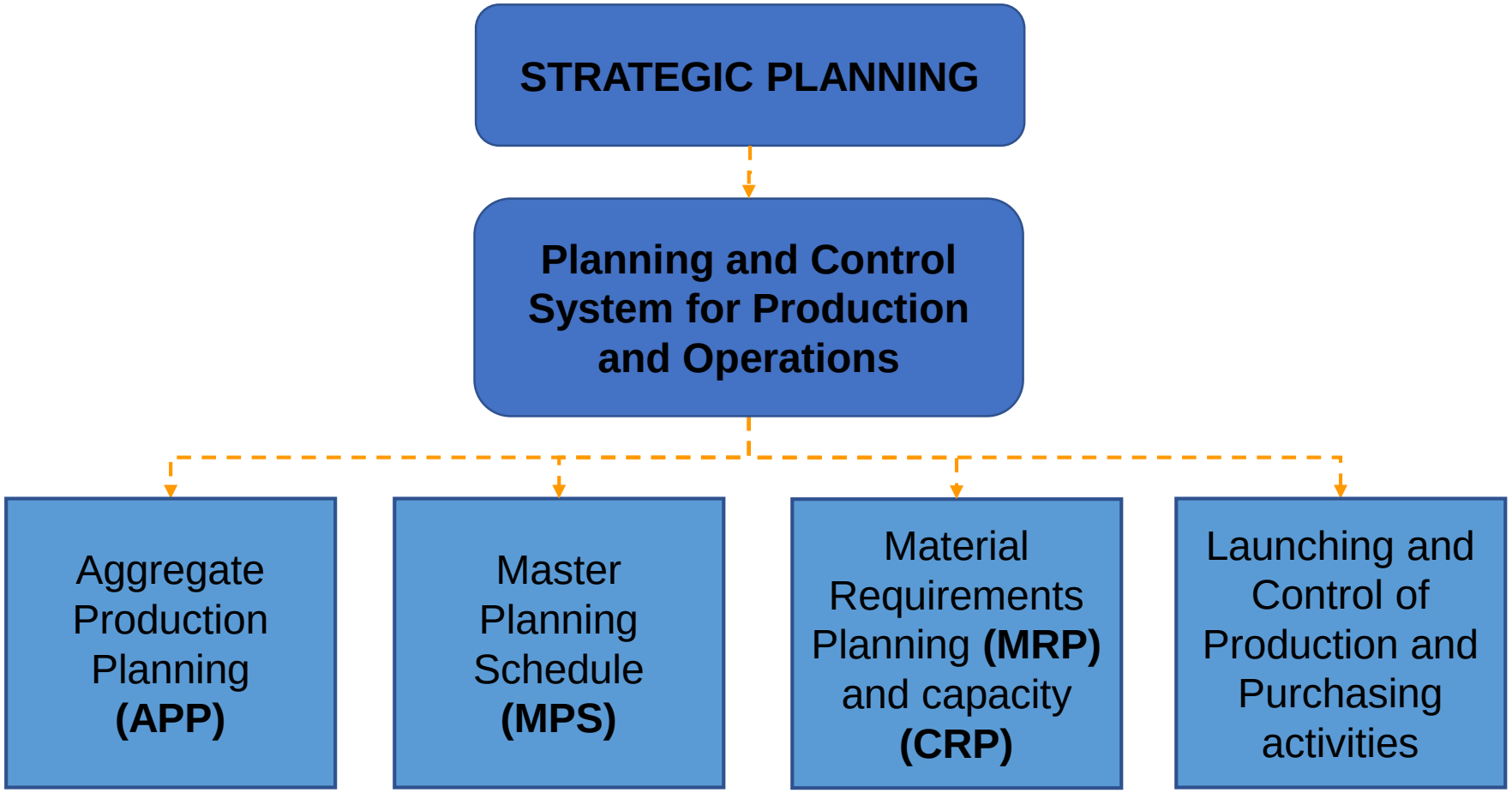
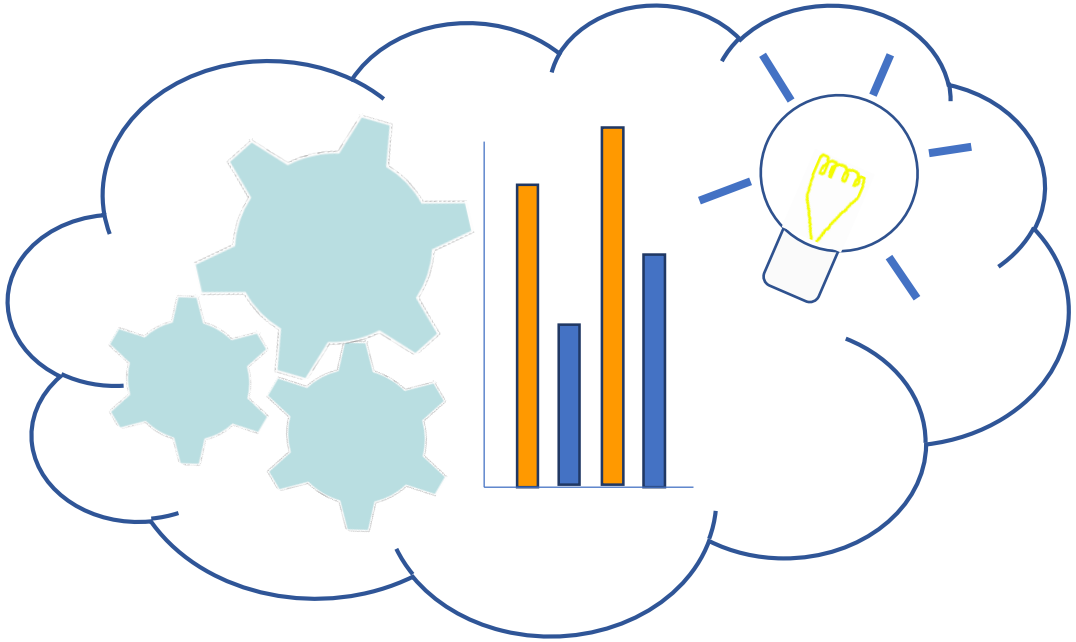
Production planning and control systems



Methods used to transform information from different industrial processes for future strategic operations.



BIG DATA

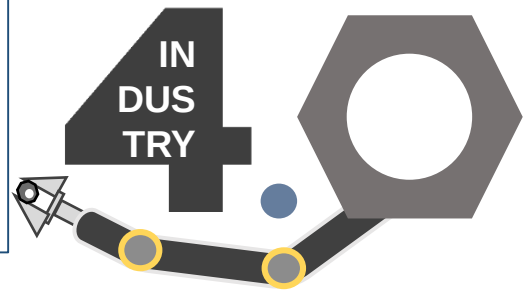
Business Intelligence

Decisions related to the **design** of production and logistic methods for industry 4.0.

- Realisation of goods and services
- Forecasting and capacity planning
- Choosing the resources and the operating process
- Localising logistics units
- Layout of staff and resources in plant
- Successfully choosing suppliers
- Developing and controlling distribution networks
- Determining quality procedures
- Implementing ICT
- Implementing studies about work measurement

Decisions related with the **management and control** of logistic and productive methods.

- Demand forecast
- Capacity and manufacture programming
- Stock management
- Load management
- Manufacture planning and management
- Purchases and supply planning



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Planning and control system for operations

- **Definition:** A set of ordered processes and means useful to manage decision-making related to tasks, control and purchase of supplies needed to meet customer demand.

Essential operations

- To program the capacity and availability needed to meet market demand
- To verify that goods are received in the adequate amount and timing for the production process
- To guarantee the adequate use of resources, staff and facilities
- To manage all kinds of inventories
- To control staff and goods' traceability in the plant
- To keep a good relationship with providers and customers in order to have long-term relations.

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Aggregate production planning (APP)

- **Objective:** To specify the available degree of production, labour force, and inventory in order to minimise manufacturing costs.

- **Function**: To determine the most adequate combination of amount of products finished per time unit, number of workers and available stock.

Main units:
- Products
- Resources
- Time

Calculation techniques:
- Linear programming
- Trial and error techniques
- RMS programming
- Heuristic techniques
- Simulation

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Master production schedule (MPS)

- **Function:** To determine the manufacturing of individual products in each programmed time period, always complying with Aggregate Planning.

- ❑ Unlike APP, MPS **disaggregates products** and **periods**.
- ❑ To carry out an **optimal** MPS, the product group to be produced must be evaluated and the starting and finishing date of production must be set.

Materials resource planning (MRP)

- **Function:** Determines the net requirements of materials and manages production and supplying orders during a period of time.

Plans all manufacturing and materials and components purchase

Allows to change the batch and launching period

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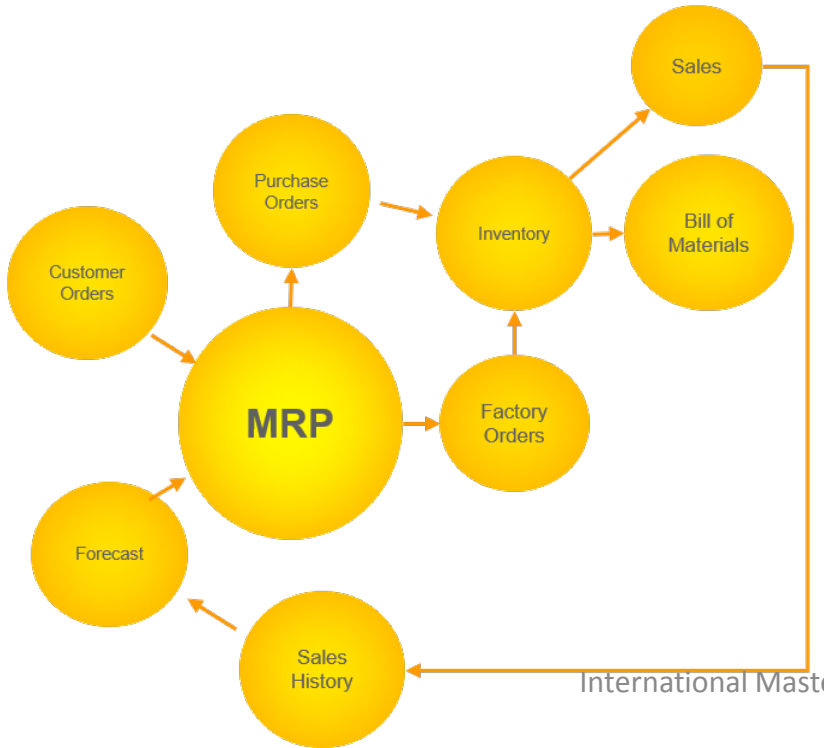

Calculation techniques

- *EOQ*
- *Fixed period*
- *POQ*
- *Heuristic*
- *Optimising*

Capacity requirements planning (CRP)

- **Function:** It calculates the load of all resources when producing the necessary components to assemble product units according to the MPS.

- **It checks if there is enough capacity to produce during the specified planning horizon.**
- **It is calculated in order to verify if the MRP is feasible.**

Feasible	The components production plan and the purchase plan can be carried out.
Not feasible	Reformulating and modifying the MRP

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Distribution requirements planning (DRP)

- **Definition:** Is a method used to deliver goods and services and implies knowing the exact amount of products, its location, and the time needed to meet demand.

- **Objective:** To maximise product availability and to reduce sorting, distribution and maintenance costs in the warehouse.

Elements

- Forecast
- Distribution list
- Inventory
- Inventory policy
- Supply time

⟺

For each type of product, the level of service, the amount of inventory to maintain and the sales forecast are detailed.

A DRP has its own set of functions in order to rationally plan inventory distribution.

- **Supply orders planning and issuing**
- **Supply orders tracking**
- **Supplies allocation**
- **Delivery capacity planning**

When the DRP is used together with the MRP II demand forecast module, it also fulfils these functions:

- Generating a future demand forecast.
- Calculating the safety stock levels in each centre.

The objectives of using a DRP are:

✓*Reducing stock levels to a minimum*
✓*Reducing ownership costs*
✓*Reducing supplying times to a minimum*
✓*Greatest quality available by using as little means as possible*
✓*Accurrate demand forecasts*

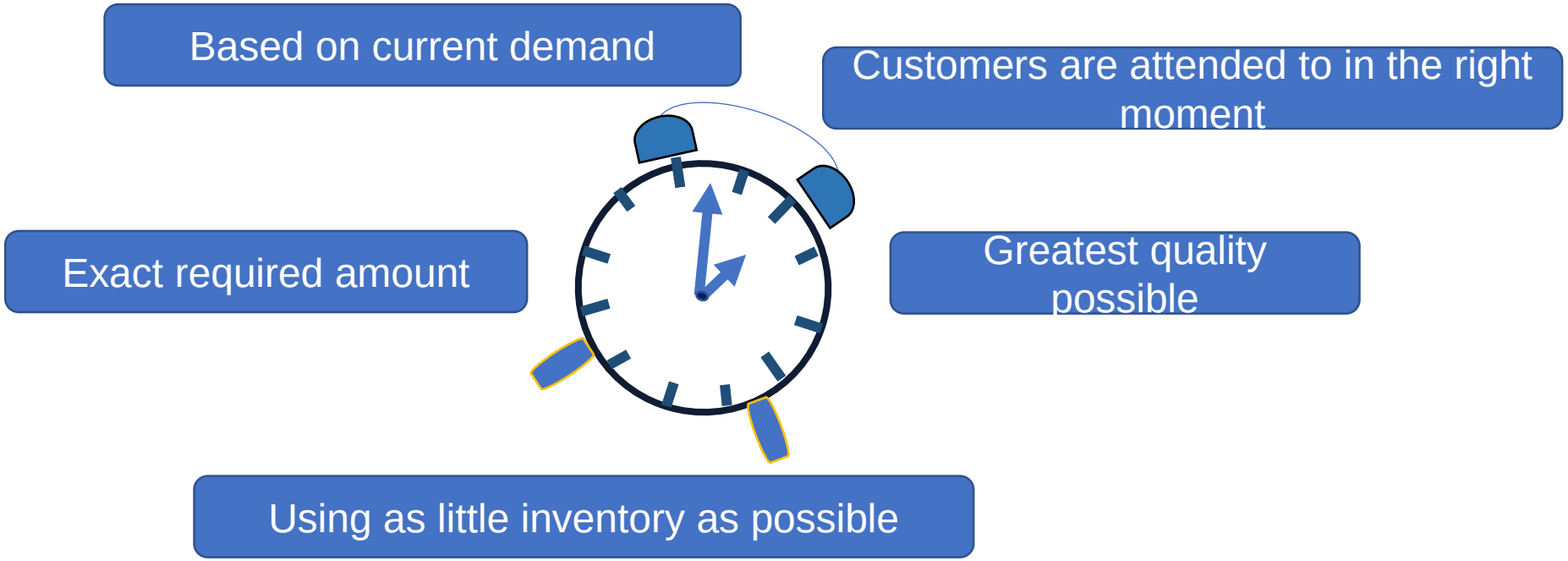
FINAL STAGE Distributing the products in the market

- Deciding how much stock to store and determining the necessary stock replenishment policies according to the Production Planning during the specified periods.

To manage an inventory we have statistical demand analysis and replenishment patterns, classic methods, heuristic techniques and optimising techniques.	They entail some problems: ▪Irregular demand = excessive inventory ▪Lack of integration with the marketing plan ▪Changes in supply contracts ▪Changes in product design

Just in time

Definition: Is a method used for organising production and allows to reduce storing costs almost completely by trying to stay as close as possible to “zero stock”. This way, only those products that are needed at all times are stored in order to avoid the production system from having to stop.



Competitive advantage

Stems from the company's ability to supply the requested product to the market in a short time and in the adequate amount.

OBJECTIVES

- ***Solving major problems.***
- ***Avoiding unnecessary costs***: Removing tasks that add no value to the product.
- ***To have a process as simple as possible:*** Removing complex routes and having a more direct flow of materials.
- ***To design systems to identify problems.***

Just in time advantages

- *Reduces stock levels.*
- *Less warehouses for finished and semi-finished products are needed.*
- *Increase of productivity and decrease of production costs.*
- *Less unnecessary costs.*
- *Identification of “bottleneck” areas.*
- *Identification of quality issues.*
- *Ability to attend to urgent orders.*
- *Allows and requires optimal relations with providers.*
- *The system is more flexible and allows for rapid and more comfortable changes.*

Just in time disadvantages

- *The purchasing costs are higher, since a greater number of orders are issued in smaller batches.*
- *There can be issues or delays during manufacturing.*
- *Delays cannot be allowed.*
- *The cost of changing providers increases.*

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MODULE 2:
Production, scheduling and planning

Learning Unit 3 - Aggregate Planning (AP)

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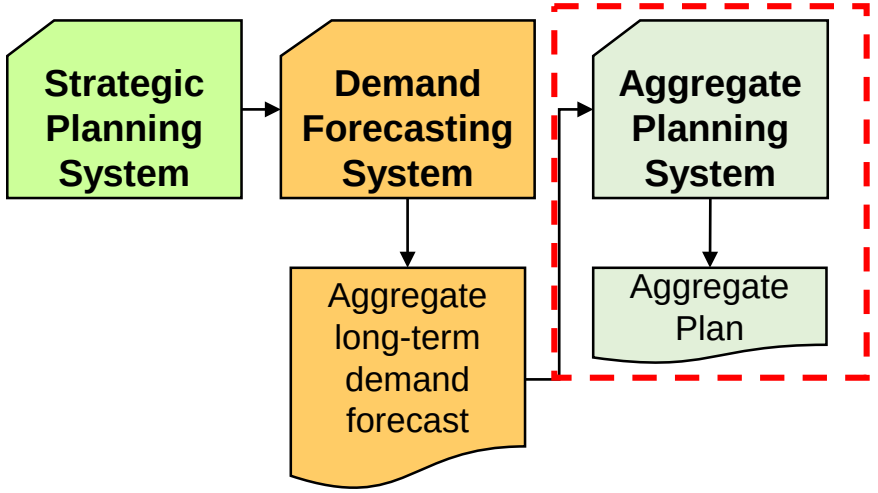
Introduction

❑Aggregate planning (AP) focuses in the production of **units from a product family** and the **production capacities** needed for each type of resource during a planned time horizon.

❑Its goals are to specify the available degree of **production** (aggregate units), **labour force** and **inventory** in order to minimise manufacturing costs in a specific time period.

❑These goals allow for a better cooperation between the operations and management departments.



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Aggregate plan attainment

Some possibilities need to be taken into account while carrying out the aggregate plan and supplying the requested orders to customers:

- **Affecting demand:** Done through accurate forecasts so it increases during periods in which it is under total capacity and it decreases otherwise.
- **Affecting capacity:** By modifying it to adapt to demand forecasts through transitional adjustment methods.

Options regarding a production company's capacity

- *Changing the labour force. Hire and fire costs.*
- *Overtime.*
- *Idle time.*
- *Production outsourcing.*
- *Holidays scheduling.*

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Aggregate planning units

- **PRODUCTS**

  They can be grouped into families, which are a set of goods or services with similar production, operational and material requirements, and similar demand. Data: sales histories. Aggregate data per families are needed.

- **RESOURCES**

  They are a set of resources with similar manufacturing capacities and costs of use. The most common resources in AP are *materials* and *workers*. Data: the way each product uses each resource.

- **TIME**

  It can be grouped in periods (months, weeks, quarters, etc.) depending on the foreseen demand and the production process.

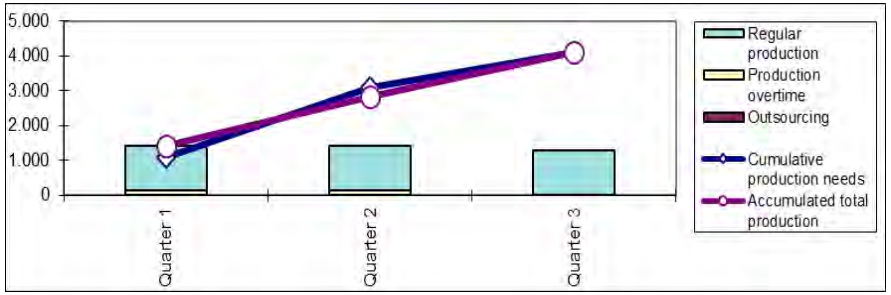
In order to develop an adequate aggregate plan, the best possible combination between the main units and the **following variables** must be found:

Overtime production	Production outside work hours. Higher costs.
Outsourcing	Hiring a different company to manufacture products.
Delayed demand	When customer orders arrive but there is no stock, so they are delayed.
Costs	They can be: production costs, changes in the production rate costs, inventory costs, and delayed demand costs.
Total budget	The objective of AP is to minimise the total production costs during the established planning horizon.

Aggregate planning example

	Quarter 1	Quarter 2	Quarter 3	Total
Demand forecast	1.100	2.000	1.000	4.100
Committed and pending orders				0
Production needs plan	1.100	2.000	1.000	**4100**
Cumulative production needs	1.100	3.100	4.100	
Productive days	80	80	80	240
Workforce per day	8	8	8	8
Workforce variation	0	0	0	0
Regular production	1.280	1.280	1.280	3.840
Production overtime	128	128	0	256
Outsourcing	0	4	0	4
Accumulated total production	1.408	2.820	4.100	**4100**
Final inventory	308	0	0	308
Deferred demand	0	-280	0	-280
Hours of regular labor	5.120	5.120	5.120	15.360
Hours of extra labor	512	512	0	1.024
Cost of regular labor	€ 25.600,00	€ 25.600,00	€ 25.600,00	€ 76.800,00
Extra labor cost	€ 3.072,00	€ 3.072,00	€ -	€ 6.144,00
Cost of idle labor	€ -	€ -	€ -	€ -
Outsourcing cost	€ -	€ 100,00	€ -	€ 100,00
Cost of labor variation	€ -	€ -	€ -	€ -
Possession cost	€ 308,00	€ -	€ -	€ 308,00
Deferred demand cost	€ -	€ 2.800,00	€ -	€ 2.800,00
Total Incremental Cost	€ 28.980,00	€ 31.572,00	€ 25.600,00	€ 86.152,00

From the optimal combination of labour, regular production, extra hours and outsourcing the accumulated total production value, equal to the production needs plan, can be obtained.



Information aggregation

Main problem

Aggregating the existing information to the aggregate planning.

Aggregating product information.

The existing data are **sales histories**, but aggregate data per families are also needed.

Aggregating resources information.

The existing data are the way each product uses each resource. The information needed for aggregating them are costs related to workers.

Aggregating time information.

It is usually daily, so it needs to be aggregated in longer periods.

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Aggregate planning techniques

There are simple trial and error methods for drawing aggregate production plan charts and graphs, but also other more complex plans.

Trial and error techniques

The most common and simple. It does not always obtain the optimum, but it is feasible and can be calculated with only a spreadsheet.

Two types of strategies.

Pure: They focus on one of the three aspects that affect aggregate planning: workforce, inventory and production rates.

Mixed: Based in trial and error solutions, they affect the workforce, the inventory and the production rates.

Linear programming

The goal is to **reduce** an objective function that relates production to associated costs.

Its restrictions are availability, resources capacity, demand to be met, etc.

Disadvantages.

- The model optimum is obtained, but not the real one.
- In the real system, non-linear functions may appear (costs, workers' productivity...).
- Hard to introduce qualitative restrictions.
- The problem may be too big.

RMS programming

- Closer to reality, but more **complex**.
- Its objective function has linear and square summands.
- Restrictions are similar to linear programming.

Heuristic techniques

- Uses acting rules based on **previous** performances.
- The idea is to **minimise** deviation from the average performance.

Simulation

- A model that shows random demand behaviour and the planning response to it.
- The optimal decision variables are obtained from simulations.

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MODULE 2:
Production, scheduling and planning

Learning Unit 4 - Master Production Schedule (MPS)

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Learning outcomes

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- Implement different production planning system in a company of the furniture sector such as: Production Aggregate Plan, Production Master Plan, Materials Requirement Planning and Capacity Requirements Planning.
- Manage and optimize the different resources of a company to meet the sales deadline of the production of any product in the furniture sector.
- Implement and execute improvement plans related to the theory of restrictions and the layout of the production plant in the furniture sector.

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How to learn?

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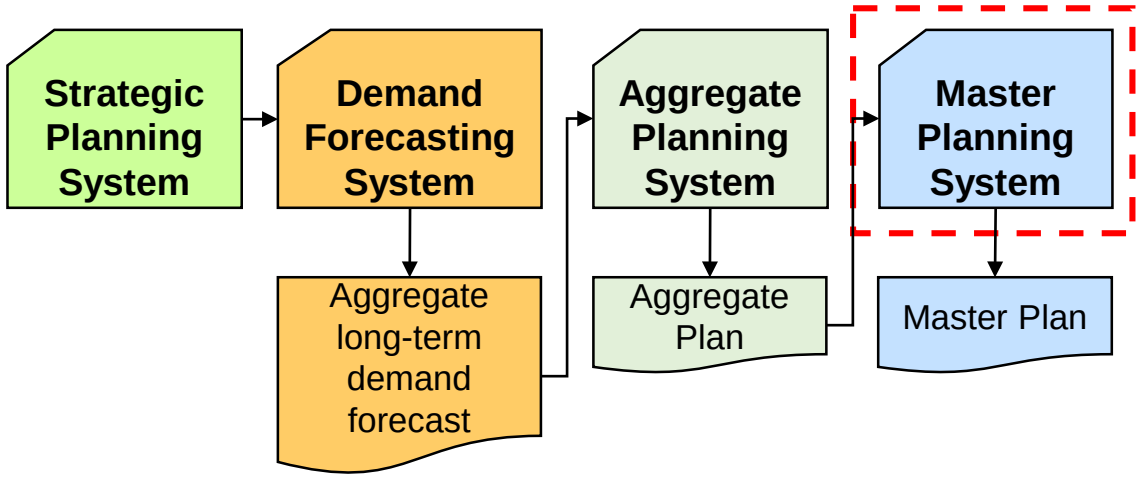
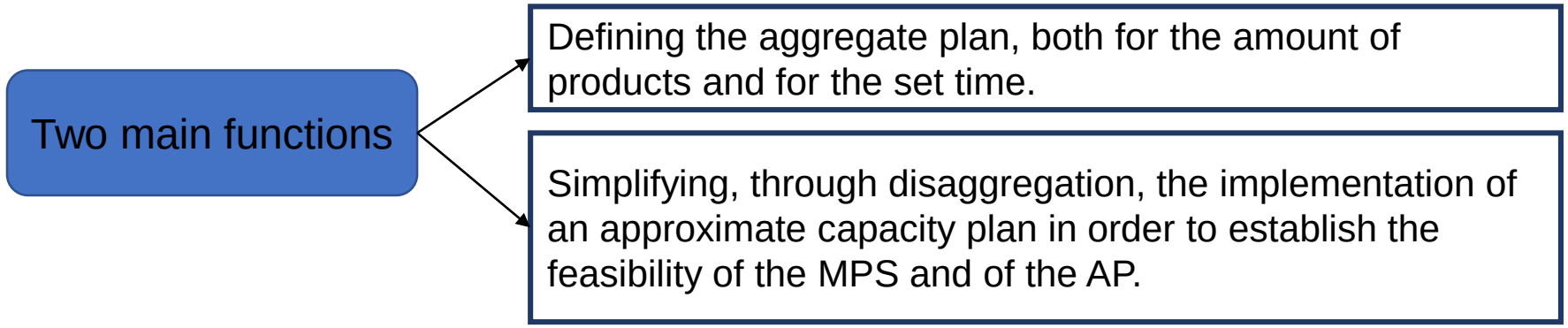
Introduction

Master production schedule (MPS) determines the manufacturing of product units in each period of the planning horizon.

- Aggregate Production Planning must be complied with.
- The modifiable variables are the manufactured product units and the stock levels in each time period.
- It plans when and how much to produce.
- It intends to meet the forecast demand.





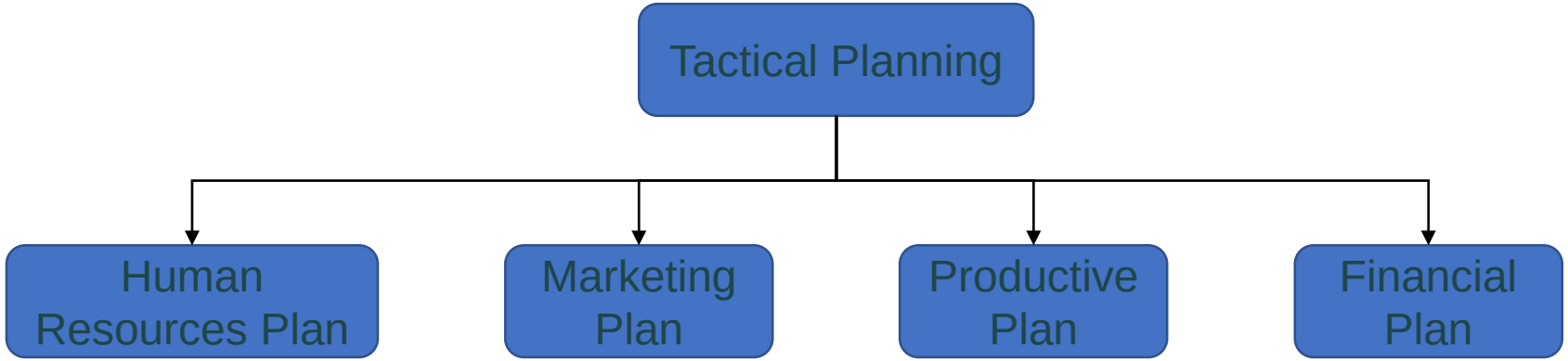
Main differences between MPS and APP

- ***Aggregate level:*** The aggregate plan shows the amount of units to produce for each family in each month during a 1-year horizon. The master schedule shows the amount of units of each article to produce in each week during a 3-month horizon.

- ***Calculation methods:*** The APP takes into account the resources' capacities (aggregate) and tries to obtain the cheapest plan. The MPS disaggregates the decisions made in the APP.

Tactical planning

- **Tactical planning** is an extension of **strategic planning** developed for all the departments of a company.
- The **tactical plan** is carried out medium and short-term. It dictates the steps needed to carry out operations with the resources available.



ADVANTAGES

- The measures taken during the management plan help to find operational inefficiencies.
- Operational deficiencies' detection.
- Once detected, they can be corrected.
- This planning benefits from the contributions of each one of the companies' operators.

DISADVANTAGES

- It takes a **long time** to be developed.
- If the plan is long, it can slow down operations, which means less benefits.

MPS planning horizon

- ***The planning horizon*** can go from a week to more than a year. For MRP environments, a year is recommended. In other cases, from three to six months.

It is not fixed, since the MPS is usually updated monthly in order to adjust it to the deviations that may occur.

- The ***time stages*** are usually one week. They are shorter periods which generate excessive calculations that involve accumulated large deviations.

Time periods in which the customer may have the opportunity to modify the product or the time periods previously agreed upon.

		January				February			
Aggregate Plan (Family units)	Family 1	10.000				12.000			
Aggregate Plan (units/month)	Product 1	6.000				7.200			
		Sem 1	**Sem 2**	**Sem 3**	**Sem 4**	**Sem 5**	**Sem 6**	**Sem 7**	**Sem 8**
Gross Needs	Product 1	1.500	1.500	1.500	1.500	1.800	1.800	1.800	1.800
Master Plan	Product 1	?	?	?	?	?	?	?	?

Planning periods

Time frame planning

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Aggregate planning disaggregation

The **disaggregation** process tries to turn the amounts existing in the aggregate planning into **family units per month**, or into particular **products per week**, in such a way that:

- The manufacturing needs contained in the aggregate planning are covered.
- Service delays are avoided.
- All can be done with as little cost as possible.

Disaggregated from the aggregate planning

- ✓ **PRODUCTS:** The amounts to produce per family are disaggregated into amounts to produce per unit.
- ✓ **RESOURCES:** Disaggregation is not necessary if the method is consistent with the aggregation method.
- ✓ **TIME:** The APP time periods are disaggregated into shorter ones in the MPS.

- Aggregate planning families' breakdown.
- Periodisation of product units in time stages.
- Dimensioning of lots and determining their acquisition date (initial MPS).
- Setting the initial MPS depending on demand (proposed MPS and final inventories per period).
- Agreeing on availability with the clients.

Disaggregation of family units to produce:

- Each family from the aggregate production planning can be disaggregated into product units.

Temporal disaggregation of family units to produce:

- The time periods of the planning horizon are divided into shorter ones.

		Units	Units	Units
Aggregate Plan (Family Units)		**10000**	**12000**	**14000**
	Products	**January**	**February**	**March**
Aggregate Plan (units/month)	A	1250	1500	1750
Aggregate Plan (units/month)	B	167	200	233
Aggregate Plan (units/month)	C	2083	2500	2917
Aggregate Plan (units/month)	D	1000	1200	1400
Aggregate Plan (units/month)	E	83	100	117
Aggregate Plan (units/month)	F	250	300	350
Aggregate Plan (units/month)	G	333	400	467
Aggregate Plan (units/month)	H	2500	3000	3500
Aggregate Plan (units/month)	I	1667	2000	2333
Aggregate Plan (units/month)	J	667	800	933

		January			
		Week 1	**Week 3**	**Week 3**	**Week 4**
Master Plan	A	313	313	313	313
Master Plan	B	42	42	42	42
Master Plan	C	521	521	521	521
Master Plan	D	250	250	250	250
Master Plan	E	21	21	21	21
Master Plan	F	63	63	63	63
Master Plan	G	83	83	83	83
Master Plan	H	625	625	625	625
Master Plan	I	417	417	417	417
Master Plan	J	167	167	167	167

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Master production schedule execution

Initial master schedule:

- Lots are *dimensioned* and the production date is established.
- Production must take place when in an MPS period there are *net requirements*.
- In this situation, one must decide if *only the requirements* are produced or if different economical or technical criteria are followed to produce a particular batch.

Proposed master schedule:

- The adjustment depends on the existing demand for the established periods.
- *Medium and short-term* demand *forecasts* for each product are included.
- Each unit's inventory are considered at the end of the week. The *safety stock* for each type of article is also verified.

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MODULE 2:
Production, scheduling and planning

Learning Unit 5 - Capacity Requirements Planning (CRP)

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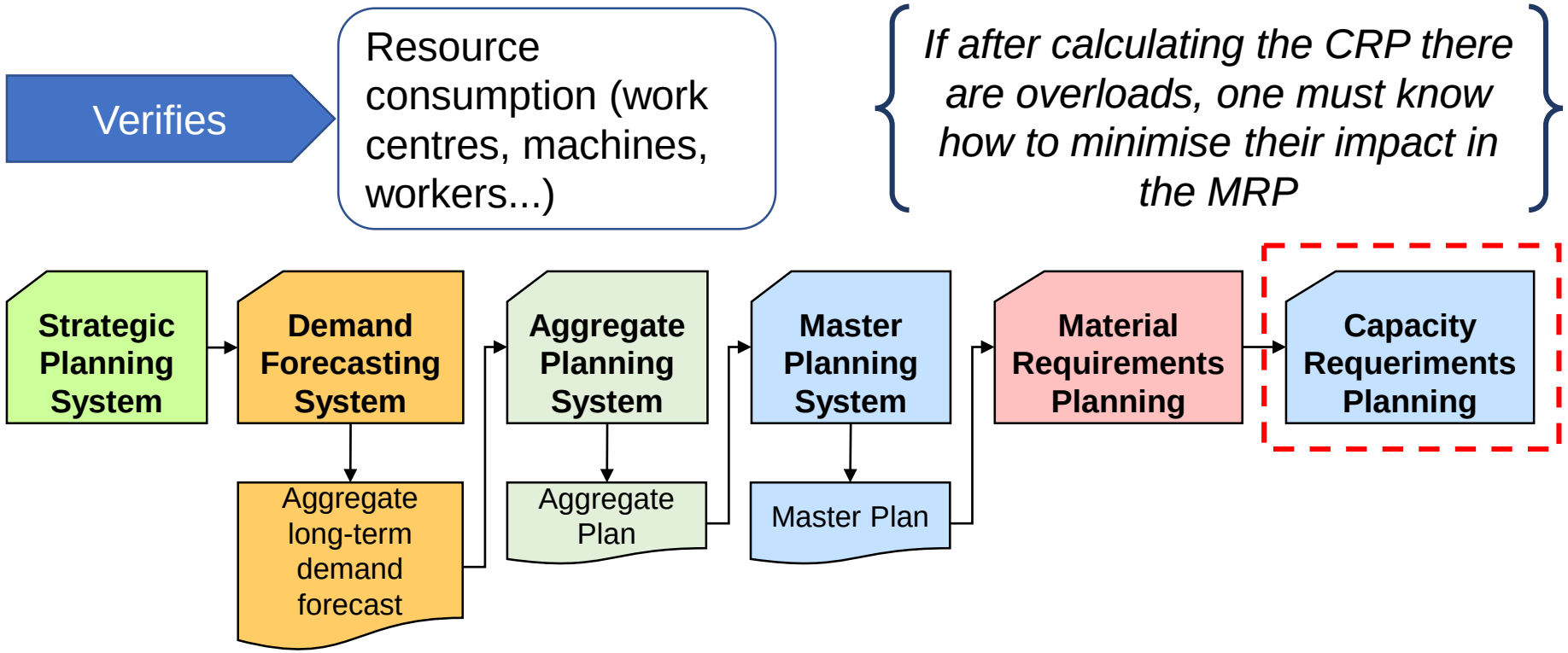
Introduction

Capacity requirements planning (CRP)= calculates the load of all resources when producing the necessary components to assemble product units according to the MPS. Checks if there is enough capacity for the planning horizon.



CRP Feasibility

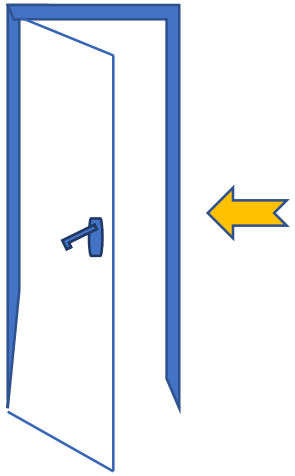
Non-feasible CRP:

- Work centre overloads at some point of the planning horizon
- Need to reconsider and change the MRP

Feasible CRP:

- The launching and control of production and the purchasing plan can be carried out

CRP inputs



INPUTS

The inputs are the MRP planned order releases

Planning periods

ITEMS	Lead time		1	2	3	4	5
1	1	Planned Order Release					
2	1	Planned Order Release					
3	2	Planned Order Release					
Workloads	**Capacity**		1	2	3	4	5
Workload 1	30	load					
Workload 2	20	load					
Workload 3	26	load					
Workload 1	30	margin					
Workload 2	20	margin					
Workload 3	26	margin					

Time frame planning

CRP calculations

CRP

It considers the planned periods of all articles, not only finished ones

Uses the same planning horizon and periods than the MRP

Calculation dynamic

1. Determining the loads generated by the planned orders in each work centre.
2. Load periodisation throughout the supply time.
3. Including loads generated by scheduled receptions.
4. Determining the available capacity per period in each work centre.
5. Comparing the available capacity to the calculation of cumulative variances.

CONCEPTS

- *Roadmap:* The succession of necessary operations in the different work centres to produce an article or a component.

- *Effective capacity of a work centre (Ck):* The amount of time in which operations are carried out in a work centre during a period.

  - *Actual hours of a work centre (Hk):* Working hours.

  - *Utilisation factor of a work centre (Uk):* The ratio between the number of production hours and the number of actual hours during the period.

  - *Efficiency factor of a work centre (Ek):* The ratio between the amount of items that a work centre can produce in theory in practice.

$$Ck = Hk \cdot Uk \cdot Ek$$

CONCEPTS

The following criteria should be considered when calculating the CRP:

Item	Preparation Time (h)	0,5
A	Wait Time (h)	0,16
	Deffects	2,00%
	Use	1,0204

- *i: It is the operation subscript.*
- *j: It is the item subscript.*
- *k: It is the work centre subscript.*
- *PTijk: It is the preparation time of the operation i of the j item in the k work centre. It is measured in hours.*
- *WTijk: It is the preparation time of 1 unit of the j item in the k work centre during the i operation. It is measured in hours.*
- *Dijk: It is the ratio of defective j items that appear during the i operation in the k work centre.*

Lead time: Time that goes from the release of an order until its receipt.

Item	Preparation Time (h)	0,5
A	Wait Time (h)	0,16
	Deffects	2,00%
	Use	1,0204

$$Use = \frac{1}{1 - \frac{\%\ Deffects}{100}}$$

Periods: The different time periods (days, weeks, etc.).

Manufacture Items			Periods	1	2	3	4	5	6
A	Lead Time (min)								
0	3	Planned Orders Releases		230	62	0	0	0	0

Items: Those products whose capacity is calculated.

Planned Order Releases: The main entry of the MRP into the CRP.

$$Load = Preparation\ Time + (Wait\ Time \cdot Planned\ Orders\ Releases)$$

$$Permanent\ Load = \frac{Load}{Lead\ time}$$

Código		1	2	3	4	5	6
A	Planned Orders Releases	230	62				
Workplace	Load	37,3	10,42				
	Permanent Load	12,43	15,9	15,9	3,47	0	0

Effective hours per period in each work centre.

Periods with negative deviations show that there is not enough capacity.

Código		1	2	3	4	5	6
A	Load Planned Orders Releases	12,43	15,9	15,9	3,47	0	0
Workplace	Load Scheduled Receptions	0	0	0	0	0	0
	Total Load	12,43	15,9	15,9	3,47	0	0
	Capacity	15	15	15	15	15	15
	Deviation	2,57	-0,9	-0,9	11,53	15	15
	Accumulated Deviation	2,57	1,67	0,77	12,3	27,3	42,3

$$Load\ Schedules\ Receptions = \frac{[(Scheduled\ Receptions \cdot Use) \cdot Wait\ Time] + Planned\ Orders\ Releases}{Lead\ time}$$

Item		
A	Preparation Time (h)	0,5
	Wait Time (h)	0,16
	Deffects	2,00%
	Use	1,0204

Manufacture Items								
A	Lead Time (min)	Periods	1	2	3	4	5	6
0	3	Planned Orders Releases	230	62	0	0	0	0

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	Permanent Load	12,43	15,9	15,9	3,47	0	0

Código		1	2	3	4	5	6
A	Load Planned Orders Releases	12,43	15,9	15,9	3,47	0	0
Workplace	Load Scheduled Receptions	0	0	0	0	0	0
	Total Load	12,43	15,9	15,9	3,47	0	0
	Capacity	15	15	15	15	15	15
	Deviation	2,57	-0,9	-0,9	11,53	15	15
	Accumulated Deviation	2,57	1,67	0,77	12,3	27,3	42,3

Possible irregularities in capacity

- Overloaded production system
- Unoccupied production system

Adjusting needs to availability

- Production orders' temporary readjustment
- Batch size readjustment
- Changes in staff
- Resource overuse
- Alternative routes and procedures
- Changes in stock volume
- Delivery delay
- Staff flexibility

Use of the CRP

ADVANTAGES

- ✓ Planning the resources needed (workforce, equipment, facilities).
- ✓ Maximising the use of facilities and minimising delays.
- ✓ Changing capacity to avoid bottlenecks.

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MODULE 2:
Production, scheduling and planning

Learning Unit 6 - Materials Requirements Planning (MRQ)

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Learning outcomes

This module will enable you to:

- Develop different forecasting of the demand for different products in the furniture sector using historical sales.
- Implement different production planning system in a company of the furniture sector such as: Production Aggregate Plan, Production Master Plan, Materials Requirement Planning and Capacity Requirements Planning.
- Manage and optimize the different resources of a company to meet the sales deadline of the production of any product in the furniture sector.
- Implement and execute improvement plans related to the theory of restrictions and the layout of the production plant in the furniture sector.

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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:

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How to learn? Self directed approach

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- Read the slides, watch the videos and reflect on the content.
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How to learn? Mixed approach

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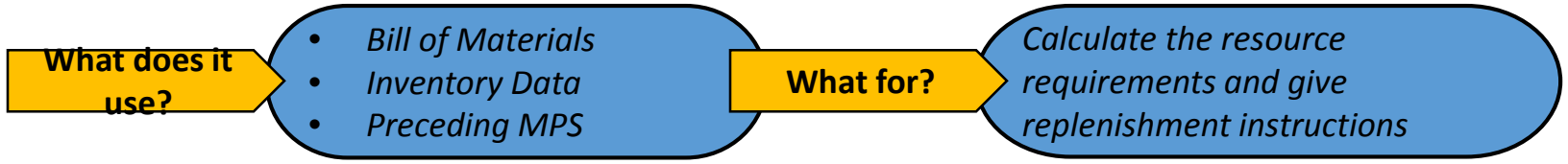
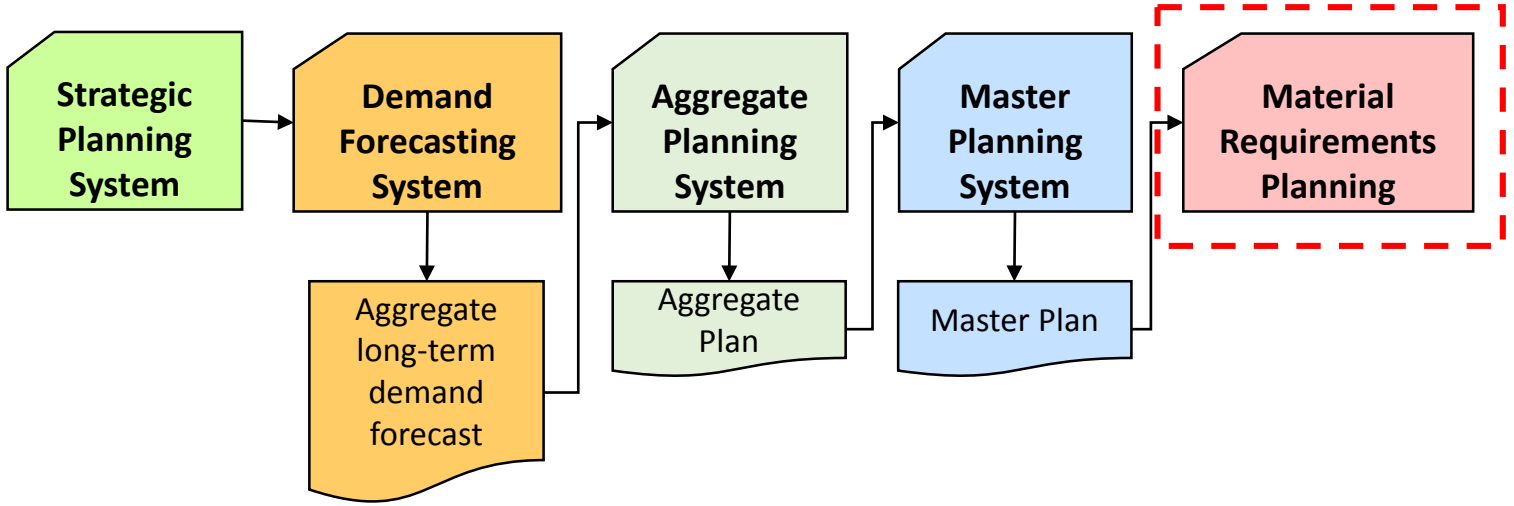
Why study Production, Scheduling & Planning

- The Production-Scheduling and Planning module is a basic material for the management and direction activities in companies that work in the furniture sector, and therefore its knowledge is fundamental for the training of the students that take this course.
- The main objective of the subject is to transmit the knowledge of the production area, which is the heart of the company, and that if it can be handled properly; it can achieve great competitive advantages.
- The Production Scheduling and Planning module aims to be a subject that shows the main types of Production Programming problems at an operational level both for a long time horizon (year or year and a half), and for a relatively short time (weeks or days) and that gives the student tools and capabilities to solve them.

Introduction

Materials Requirements Planning (MRP) = This planning defines the net requirements on elements and materials and organises the manufacturing order or purchase for a specific period of time and a set date.





Bill of Materials

Description of the level-ordered structure of each product

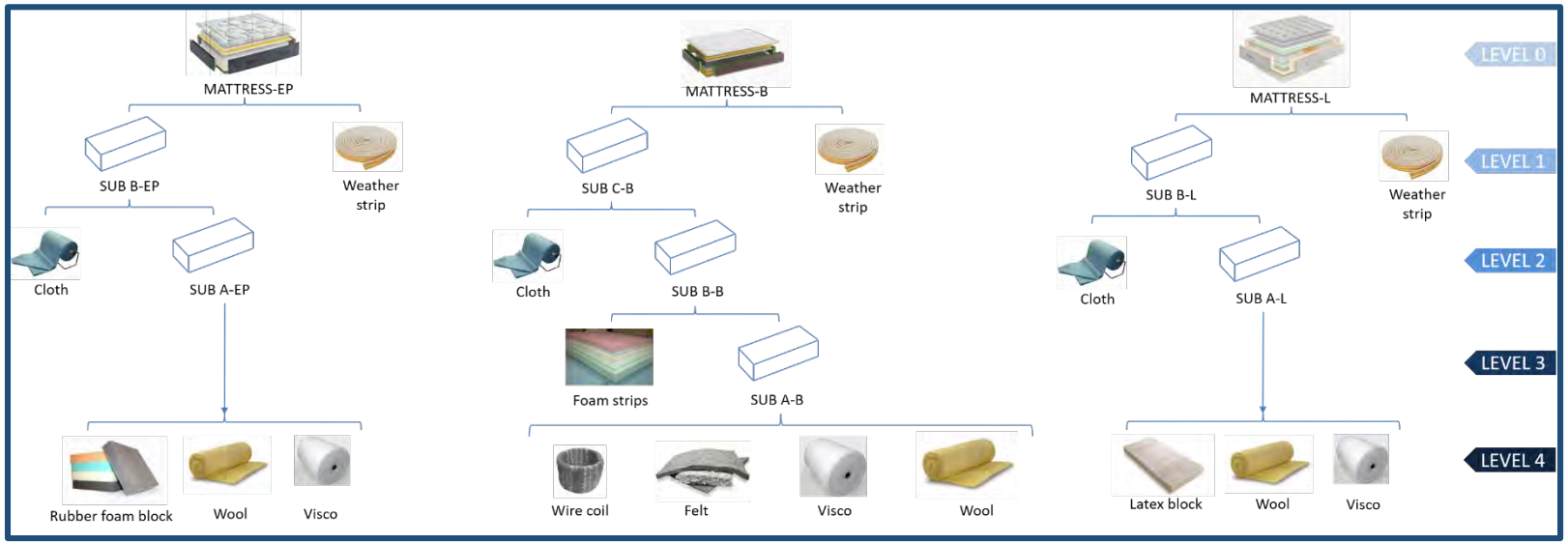
- Integrating components
- Quantities of each components
- Components assembly sequence to manufacture the end product

IdItem	Description	Level MRP	LT	SS	CurrentStock	MinBatch	Batch	FactorUse	UnitCost	EmissionCost	WarehouseCost
MATTRESS-B	Bonnell Mattress	0	1	150	410	1	1	1	65	40	0,65
MATTRESS-L	Latex Mattress	0	1	5	55	5	1	1	160	50	1,6
MATTRESS-EP	Polyurethane Foam Mattress	0	1	75	220	1	1	1	105	45	1,05
SUB C-B	Bonnell Mattress without Weather Strip	1	1	0	150	0	0	1	65	40	0,65
SUB B-B	Bonnell Mattress without Weather Strip, Cloth	2	1	0	385	0	0	1	40	20	0,4
SUB A-B	Bonnell Mattress without Weather Strip, Cloth, Foam Strips	3	1	0	370	0	0	1	30	20	0,3
SUB B-L	Latex Mattress without Weather Strip	1	1	0	35	0	0	1	140	20	1,4
SUB A-L	Latex Mattress without Weather Strip, Cloth	2	1	0	20	0	0	1	130	20	1,3
SUB B-EP	Polyurethane Foam Mattress without Weather Strip	1	1	0	75	0	0	1	60	20	0,6
SUB A-EP	Polyurethane Foam Mattress without Weather Strip, Cloth	2	1	0	80	0	0	1	45	20	0,45
WEATHER STRIP	Weather Strip	1	1	0	2200	50	50	1	6	15	0,6
CLOTH	Cloth	2	1	0	1200	30	30	1	25	20	0,25
FOAM STRIPS	Foam Strips	3	1	0	1200	5	5	1	7	20	0,07
WIRE COIL	Wire Coil	4	1	0	2500	900	900	1	130	30	1,3
FELT	Felt	4	1	0	550	100	50	1	4	15	0,04
VISCO	Visco	4	1	0	1500	10	10	1	70	20	0,7
WOOL	Wool	4	1	0	1500	15	15	1	35	20	0,35
LATEX BLOCK	Latex block	4	1	0	70	10	1	1	25	25	0,25
RUBBER FOAM BLOCK	Rubber foam block	4	1	0	170	20	1	1	7	20	0,07

Bill of Materials

It can be represented by:

- ***Tree Diagram***
- ***Ranked Bill of Materials***
- ***Database***



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Inventory management and control

Likewise, adequately controlling and managing inventories is a key factor in business management, since ownership or product-delay costs are a big part of the total costs of a company.

*The main **goals** of managing and controlling inventories are:*

- **Minimise** as much as possible the **investments** on inventory.
- **Minimise storage costs**(Stocks=essential products)
- Keep **enough stock** to **properly fulfill** demand. To do such thing, **demand must be forecasted** for a certain period of time.
- Achieve **efficient transport** of the stored goods.
- Draft an efficient inventory information system to connect the WMS in real time.
- **Provide information** about the inventory value to accountancy.
- Outline the **best sales strategy** in order to obtain the best offers.
- **Forecast** future stock requirements.

Stock level is necessary in order to comply with the current demand on products during a certain period of time, even though maintaining stock implies a set of storing costs and it could be either defective or faulty, which means it cannot be modified nor corrected after being stored.

To be able **to control the current stock levels**, there are **two parametres**, among others.

Rotation is a parametre that defines the number of times that an inventory has been replenished for a certain perdio of time. This formula is found by establishing the relationship of total outupts with the average stock.

$$Rotation = \frac{Total\ Outputs}{Average\ inventory}$$

The replenishment **coverage** is a parametre that defines the number of days the stock takes to be replenished by establishing the the relation between the transit period days.

$$Coverage = \frac{Period\ days}{Rotation}$$

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MRP Execution

Main Inputs

- Master Production Schedule (MPS)
- Bill of Materials
- Inventory registry information.

- A MPS does not cover resource capacity.
- After executing a MRP, the CRP system checks that the company does not reach an state of overcapacity.

Planning period: **weekly or monthly**

Planning Horizon: **3 and 12 months**

Master Production Schedule							
Code	Period	1	2	3	4	5	6
A			30		20	30	50
B				40		10	40

A	Weeks					
	1	2	3	4	5	6
Gross Requirements		30		20	30	50
On Hand	10	10	20	20	20	10
Scheduled Receptions						
Net Requirements		30		10	20	50
Planned Order Receipts		40		20	20	60
Planned Order Release	40		20	20	60	

B	Weeks					
	1	2	3	4	5	6
Gross Requirements			40		10	40
On Hand	24	24	24	34	34	24
Scheduled Receptions						
Net Requirements			36			36
Planned Order Receipts			50			50
Planned Order Release		50			50	

Inventory: Stock availability, which depends on the company requirements (can be equal or different than zero).

Demand: Obtained on the Master Production Schedule

Planned Order Releases: Main CRP input, which are orders already calculated.

A

	Weeks					
	1	2	3	4	5	6
Gross Requirements		30		20	30	50
On Hand	10	10	20	20	20	10
Scheduled Receptions						
Net Requirements		30		10	20	50
Planned Order Receipts	LT	40		20	20	60
Planned Order Release	40		20	20	60	

Net Requirements: These net requirements are the result of deducting stock availability and planned receipts to gross requirements plus safety stock.

Lead time: Planning orders received are delayed in time, as much as lead time specifies.

MRP outputs

Outputs in a MRP system

Main outputs:

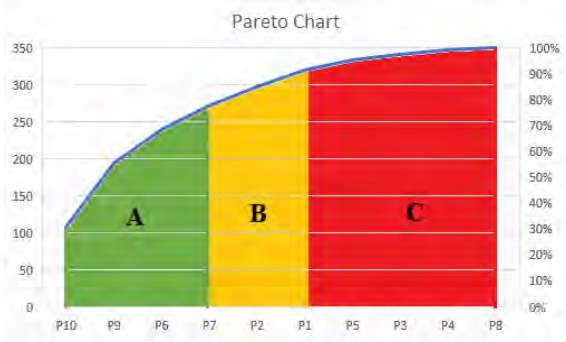
- *Order and purchase planning*
- *Action reports*

Secondary outputs:

- Providing very important information on logistics:
  - *Individual exception messages*
  - *ABC product analysis or Pareto Chart or ABC method*
  - *Reports*

MRP interaction among departments

- *Sales*
- *Engineering*
- *Finances*
- *Information systems*



Batch sizing techniques

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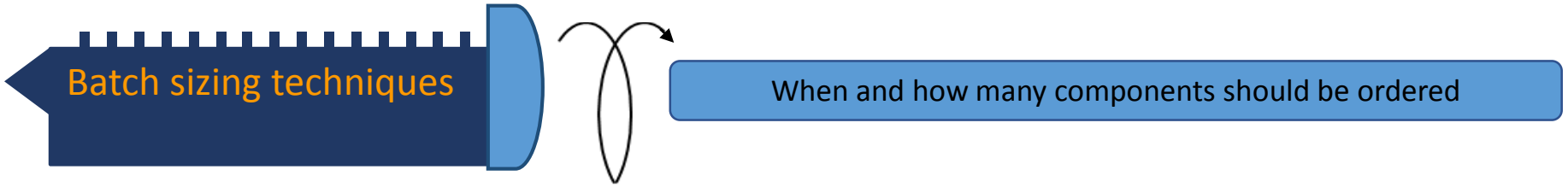
This tool allows to **change** the **batch** and its **release period**, both on production and purchase orders in every period on the planning horizon.

MRP calculation techniques	More common techniques
➢ **Classic**(batch to batch, EOQ, fixed order period, POQ) ➢ **Heuristic** (minimum unit cost, minimum total cost, Silver-Meal) ➢ **Optimising techniques**	*Batch to Batch* *Minimum Unit Cost* *Minimum Total Cost* *Silver-Meal*



Classic

When there is a **fixed order quantity** or a **fixed lead time**

Simple and proper techniques for independent demand

TYPES

Batch to Batch

- Easiest technique
- Orders adjust to only what is needed
- Minimises ownership costs

Fixed order period

- Fixes the lead time between orders
- Batch size= MRP Net Requirements

Economic Order Quantity (EOQ)

- Common for independent demand difficulties

Production Order Quantity (POQ)

- Similar to EOQ
- The value of a period is calculated by using the Economic Order Quantity (EOQ)

Heuristic

Appropriate for discrete demand since their calculate solutions are good quality

Simple technique that requires few computing time

TYPES

Minimum Unit Cost

- Unit cost calculation of ordering the net requirements on the first period.
- First and second periods are continously added up until reaching a relative minimum.

Minimum Total Cost

- Similar to the previous one, but adding *issuing and storage total costs*.

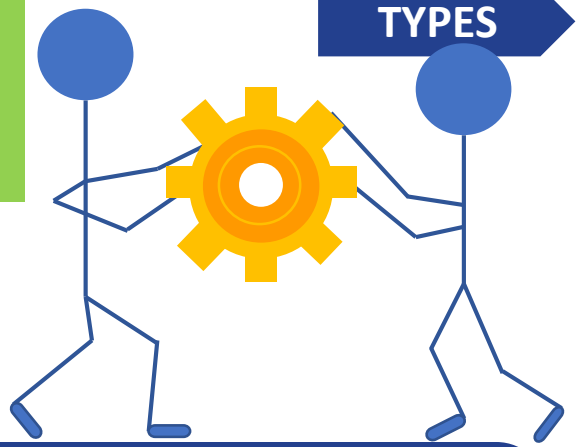
Silver-Meal Method

- Selection of the minimal total cost batch (*Issuing Cost + Total Cost)* for the supply covered time interval.

Optimising techniques

Proper for discrete demand. Optimal batch sizing.

Complex technique and time-consuming computing calculations.



TYPES

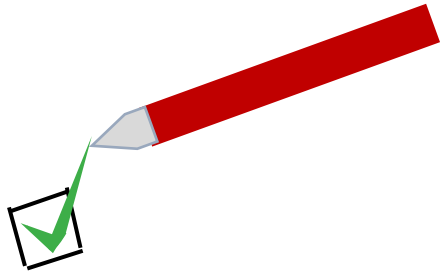
Minimum Total Cost

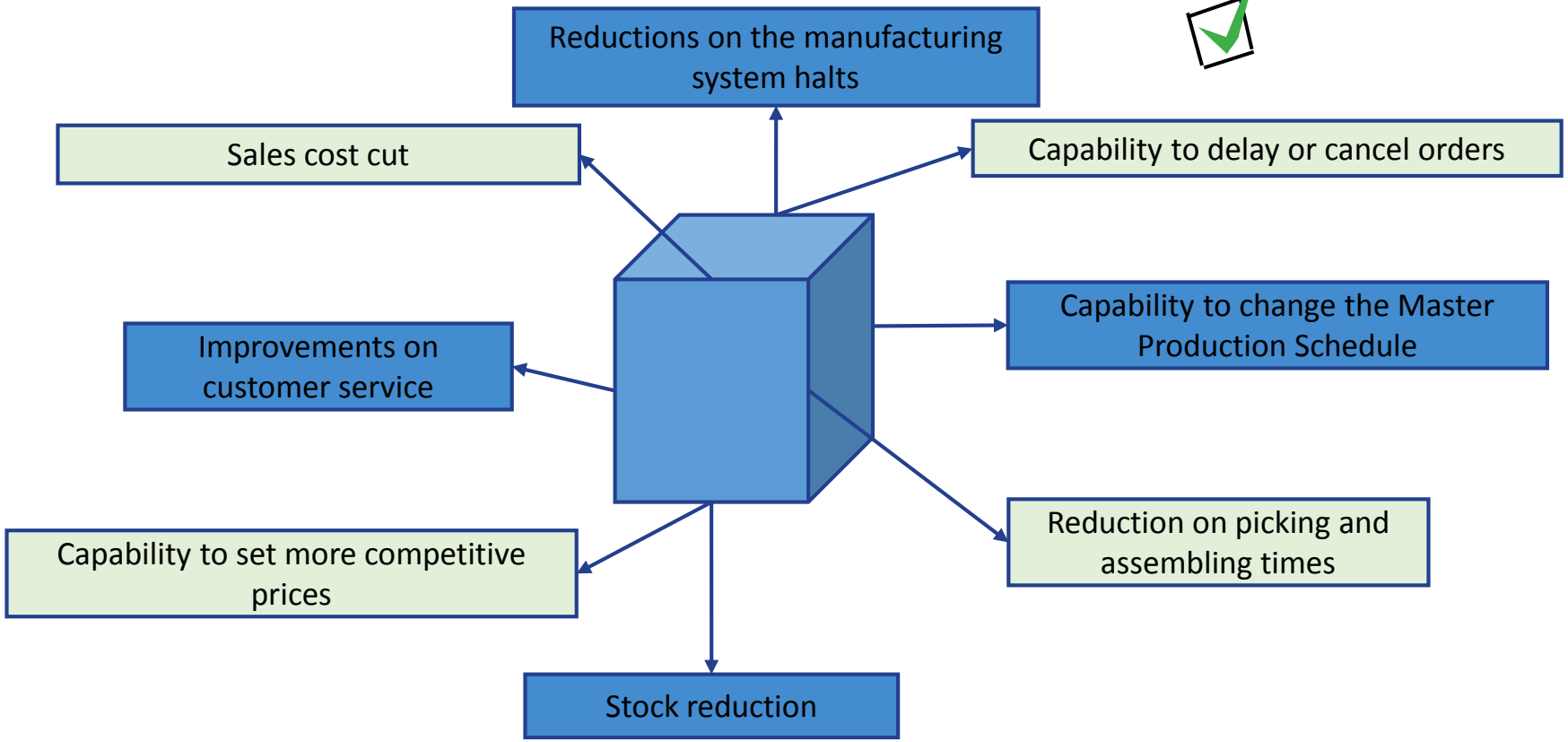
- Based on a determining a dynamic model for batch sizing.
- EOQ model variation.
- Product demand changes over time.
- Based on dynamic programming with an optimising character.

- ✓ **Heuristic and classic techniques are used to solve batch sizing problems in a MRP.**
- ✓ **No batch sizing technique is better than another, since it depends on each product, production procedure and type of demand.**

MRP Benefits

Essential to deal with large quantities of materials, products, works in progress, components, etc.





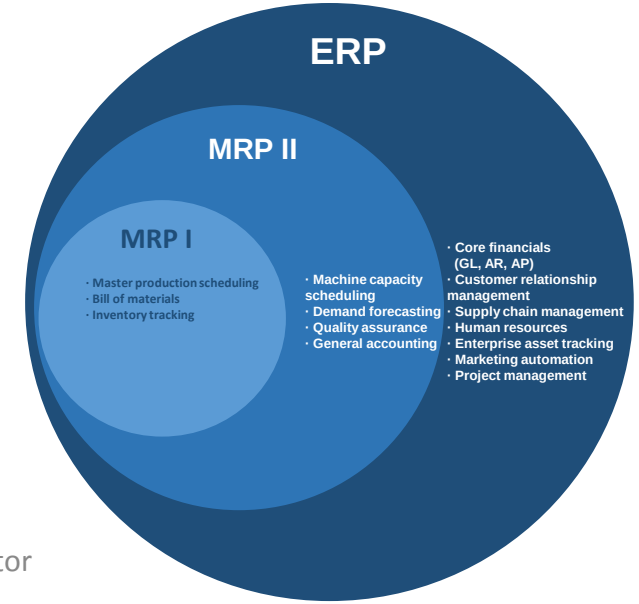
Manufacturing Resource Planning (MRP II)

A **Manufacturing Resource Planning (MRP II)** is a method to **efficiently plan** a company's resources for **production**. It is an **improved MRP version**, since MRP II is a direct evolution and an extension to a closed-circuit MRP.

Composed of different modules grouped for the Production Schedule (*MPS, MRP, CRP*)

Main functions

- ✓ Digitalised industrial process
- ✓ Medium, short and very short-term Capacity Planning
- ✓ Medium and long-term planning
- ✓ Work centres management
- ✓ Cost calculation
- ✓ Medium and long-term Aggregate Plan (**AP**)
- ✓ Master Production Schedule (**MPS**)
- ✓ Stock management
- ✓ Materials Requirements Planning (**MRP**)
- ✓ Communication with suppliers (**CRM**, **EDI**)
- ✓ Budgets
- ✓ Business activity simulations



BENEFITS

- Information and precise information about the company management.
- Large databases.
- High efficacy to spot unexpected mistakes.
- Prior and integrated management with great precision during the productive development.
- Operative methodology set appropiately.
- Safety stock elimination and increase of rotation.
- Less halts.
- Improvement on goods supply process.
- Good costs and budgets assessment.
- Adequate supply organisation.
- Guidance for product manufacture and distribution processess.
- Improvement on customer service.
- Better budget quality and certainty.

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MODULE 2:
Production, scheduling and planning

Learning Unit 7 - Risk Management.
Theory of Constraints (TOC)

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How to learn? Mixed approach

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Introduction

The **Theory of Constraints (TOC)** is based on hierarchically structuring a company, because problems may arise when an organisation tries to optimise only one single area, instead of every possible level, starting from those with the most obvious drawbacks during the manufacturing development.

The system fundamentally rests on the balance between product manufacturing workflow and capacity managemenet and control; in other words, it rests on bottleneck and non-bottleneck resources.

Bottleneck

- ✓ When the capacity of any procedure cannot meet the demand when the productive system is working, we understand such procedure as bottleneck. It could be either machinery, worker, workforce, etc.
- ✓ On the other hand, the resources with overcapacity are known as non-bottleneck.

The **Theory of Constraints (TOC)** indicates that any system seeking a continuous improvement process to find its own goals first needs to:

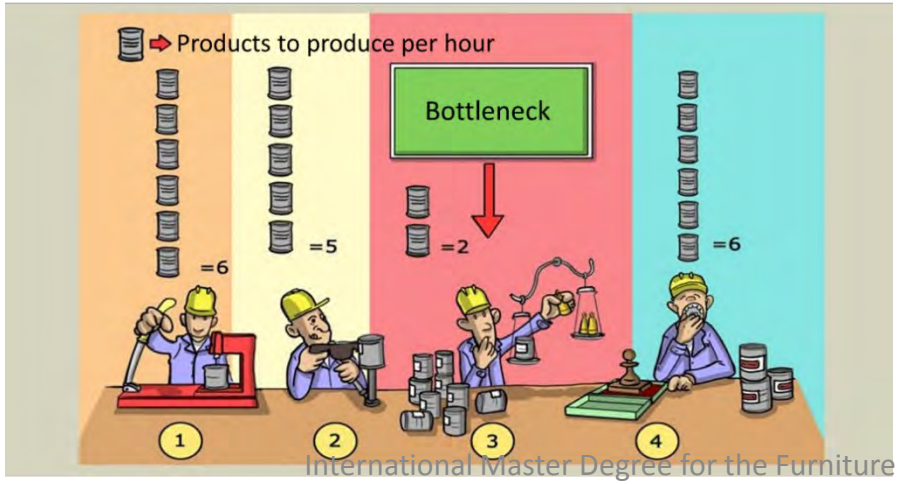
- **Determine the limits of the productive system:** All the resources that limit the system must be traced down.
- **Decide how to benefit from limits:** Every resource must be extremely productive even with its limits.
- **Relegate resources to the previously made decisions:** Benefit as much as possible from the resources requires exploiting the means of a company.
- **Increasing limits:** Limits must be increased due to lack of capacity when needed and when the productive system requires it.
- **If any of the previous stages' limits has been affected, the system needs to be restarted:** Limits have an impact on all the areas. Unoptimised or untreated work areas or centres can be a burden to the other centres and affect the productivity of the whole productive system.

Optimised Production Technology (OPT)

Optimised Production Technology (OPT) is a continuation to the control of materials or products outputs and inputs, based on bottleneck management methods in a work centre.

Basic function: OPT controls the output capacity of a manufacture system with the procedures with less capacity.

Goal: controlling the flow and level of inventory in the system to guarantee that the bottleneck does not stop functioning, considering its output its directly related to the output of the complete system.



9 basic principles

1. *Production flow should be balanced, instead of balancing productive capacity.*
2. *Non-bottleneck resources should not be used in relation to its own capacity, but to another limit of the system.*
3. *Use and activate a resource are not synonyms.*
4. *An hour lost in a bottleneck is an hour lost in the whole system.*
5. *An hour gained in a bottleneck resource is a mirage.*
6. *Bottlenecks control both inventory and billing.*
7. *The transfer batch should not and must not be equal to the process batch.*
8. *The process batch must be variable along the route and also time.*
9. *Priorities can only be set if all the system limits are taken into account simultaneously.*

Capacity

Capacity is defined as the time available for production. Maintenance or failure times are not included.

Resource costs and manufactured products must be considered.

Time horizons to plan capacity

- **Long term** (longer than a year)
- **Midterm** (monthly or quarterly plans that regard the following 6 to 18 months)
- **Short term** (less than a month)

When a company seeks to add capacity to its productive system, there are several aspects that must be taken into account:

- *Keeping the system balanced*
- *Frequency for increasing capacity*
- *External capacity sources*

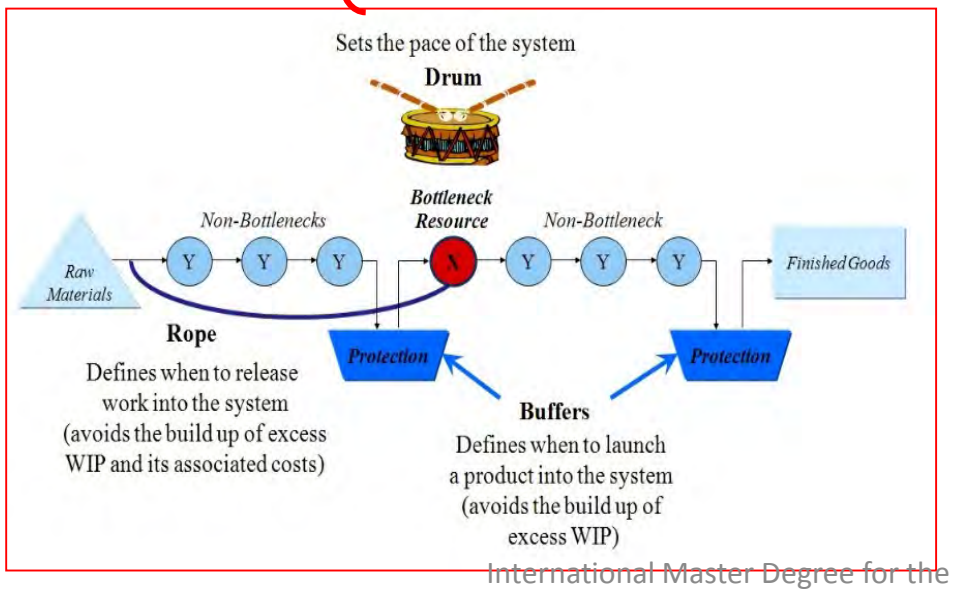
Work is measured so that standard times can be established. Standardised work is a set of operative procedures where operations are fixed and ordered in the best way possible.

DRB method (Drum, Buffer, Rope)

TOC presents certain procedures with **limited capacity** which dictate the time of production.

DBR method acknowledges such limits and proposes a production planning system that seeks to reduce the time needed to control the operations programme and avoid transmitting fluctuations to the process.

Drum: represents the production time dictated by the procedure.
Buffer: Used to avoid small lags that may interfere with the procedure.
Rope: Represents the materials release program.



Every productive system needs one or several control points to check the flow of a product within the system.

If there are no bottleneck resources present in the chain, the best place to settle the drum would be a resource limited by capacity.

If the system presents a bottleneck, such stage is ideal to settle the **control point** (also known as *drum).*

On the whole, there are two possible solutions to a bottleneck:

1. Keep a *buffer inventory* that guarantees that there is always something to work on.

2. Establish *systems with feedback*, so that the first resource on the chain is informed about the productive capacity and/or the inconvenience that the rest of resources may be facing.

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MODULE 2:
Production, scheduling and planning

Learning Unit 8 - Improvement of plant layout

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Funding

- This training material has been developed within the framework of the **International Master for the Furniture Sector (IM-FUTURE)** project.

- The project is implemented within the framework of the **Cooperation for Innovation and the Exchange of Good Practices** Key Action and is funded by the **Erasmus+ Programme** of the **European Union**.

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Learning outcomes

This module will enable you to:

- Develop different forecasting of the demand for different products in the furniture sector using historical sales.
- Implement different production planning system in a company of the furniture sector such as: Production Aggregate Plan, Production Master Plan, Materials Requirement Planning and Capacity Requirements Planning.
- Manage and optimize the different resources of a company to meet the sales deadline of the production of any product in the furniture sector.
- Implement and execute improvement plans related to the theory of restrictions and the layout of the production plant in the furniture sector.

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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:

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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.
- Test your understanding by taking the test at the end of the PowerPoint Presentation. Aim to score at least 70%
- If there are aspects that you find interesting and want to explore further access one of the texts recommended in the Bibliography

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How to learn? Full time approach

- Attend all classes and the lecturer will provide explanations while showing the slides.
- Read the additional text available where information is more detailed.
- The lecturer will organise opportunities for you to discuss the content of the course so that you understand.
- Test your understanding by taking the test at the end of the PowerPoint Presentation. Aim to score at least 70%.
- The lecturer will present a task for you to complete that will enable you to better understand the topic. The nature of the task depends on particular circumstances.
- If there are aspects that you find interesting and want to explore further access one of the texts recommended in the Bibliography.

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How to learn? Mixed approach

- Read the additional text available before attending the face to face classes.
- Attend all classes and the lecturer will provide explanations while showing the slides.
- The lecturer will organise opportunities for you to discuss the content of the course.
- Test your understanding by taking the test at the end of the PowerPoint Presentation. Aim to score at least 70%
- The lecturer will present a task for you to complete that will enable you to better understand the topic. The nature of the task depends on particular circumstances.
- If there are aspects that you find interesting and want to explore further access one of the texts recommended in the Bibliography.

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Why study Production, Scheduling & Planning

- The Production-Scheduling and Planning module is a basic material for the management and direction activities in companies that work in the furniture sector, and therefore its knowledge is fundamental for the training of the students that take this course.
- The main objective of the subject is to transmit the knowledge of the production area, which is the heart of the company, and that if it can be handled properly; it can achieve great competitive advantages.
- The Production Scheduling and Planning module aims to be a subject that shows the main types of Production Programming problems at an operational level both for a long time horizon (year or year and a half), and for a relatively short time (weeks or days) and that gives the student tools and capabilities to solve them.

Introduction

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Plant layout

A layout is the main goal of the architectural industry, since it consist of adjusting the available room to the requirements of a productive system.

Goal

It organises the elements of an industrial manufacturing system by physically ordering the industrial elements.

- It is defined as a process to organise the resources of a plant.
- A previous planning is necessary.
- All the means involved in the manufacturing process are affected.
- Manufacturing means that intervene in the process directly: workforce, materials and machinery.
- Its main goal is to find the right order so that it is as economical as possible.

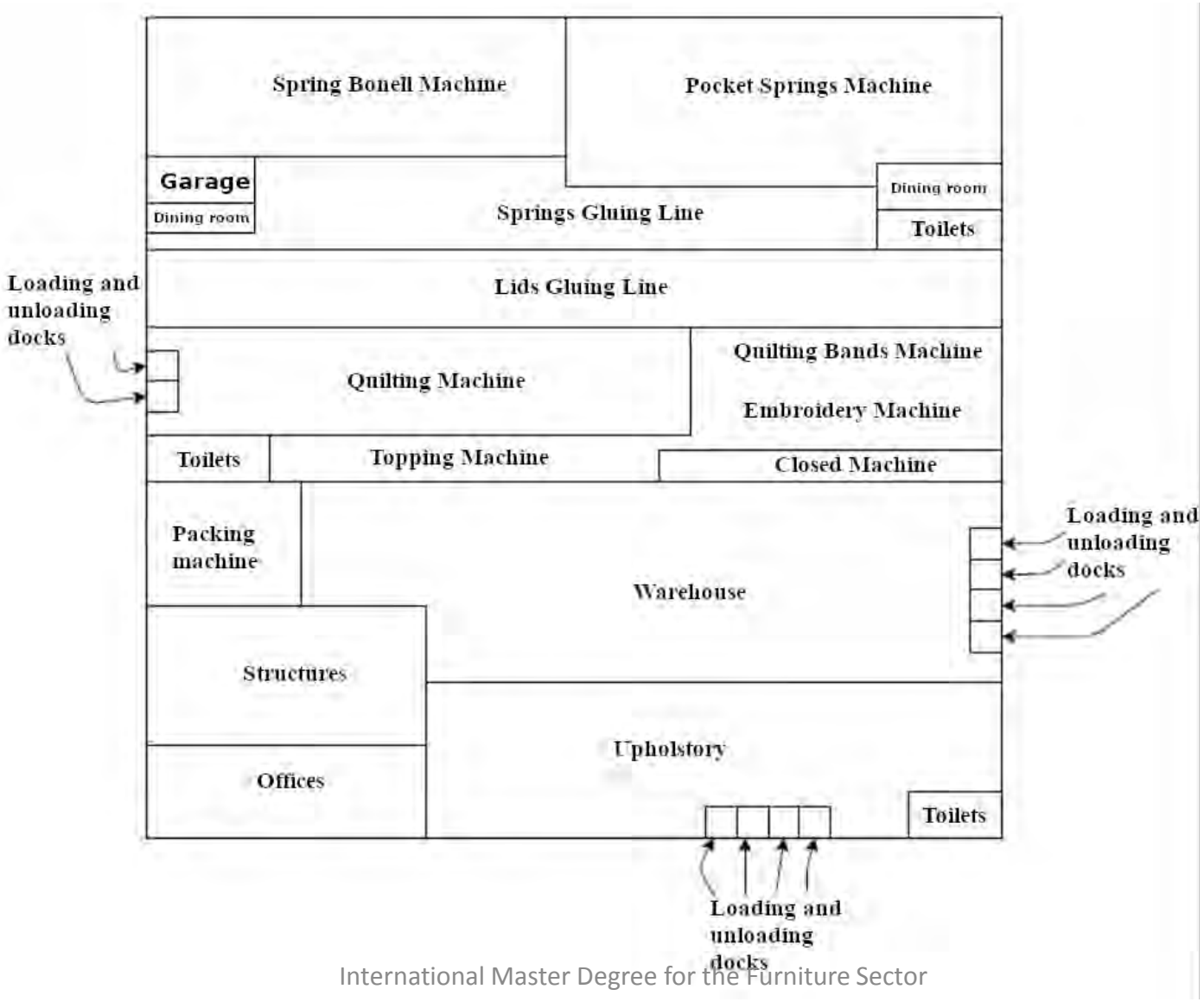
Types of plant layout

By product: Equipments are distributed according to the chain of product operations sequencing.

By process: Means with the same function are grouped together in the same area.

By cells: Equipments are grouped according to their specialty.

By fixed position: Product stays in an invariable location.


Spring Bonell Machine
Pocket Springs Machine
Garage
Dining room
Springs Gluing Line
Dining room
Toilets
Loading and unloading docks
Lids Gluing Line
Quilting Machine
Quilting Bands Machine
Embroidery Machine
Toilets
Topping Machine
Closed Machine
Packing machine
Warehouse
Loading and unloading docks
Structures
Upholstory
Offices
Toilets
Loading and unloading docks

Objectives of plant layout

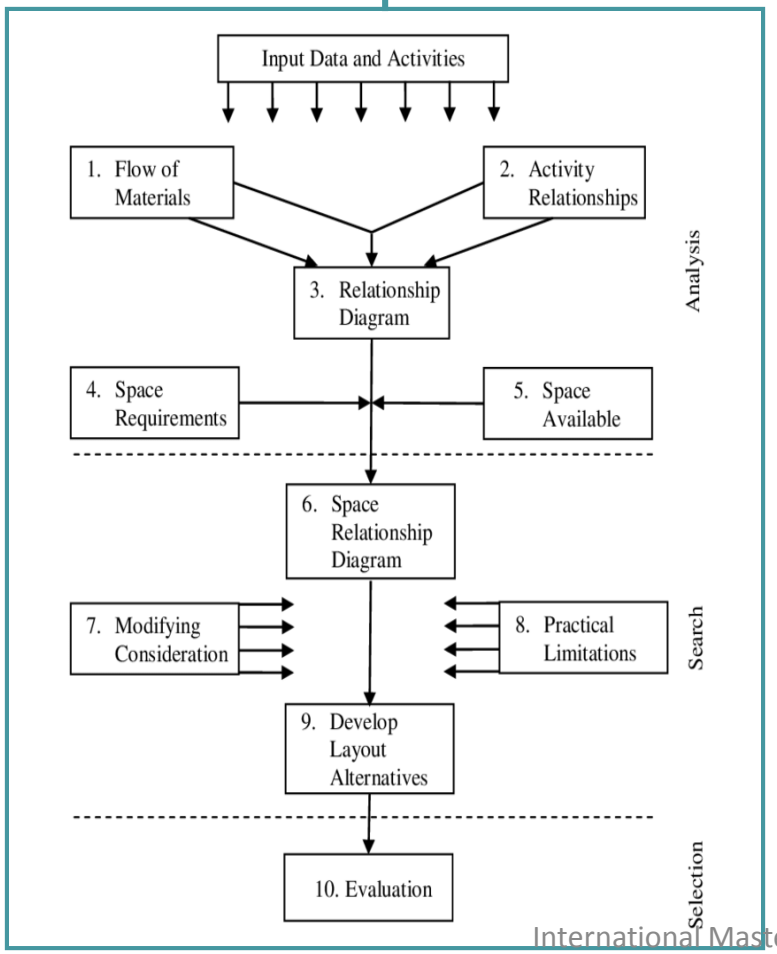
A layout is ideal when meets all the requirements of the parts of a manufacturing and/or logistics system that are involved in the implementing process.

GOALS

- Simplifying the productive process.
- Minimising the costs for handling materials.
- Reducing as much as possible the work in progress.
- Using the room effectively.
- Promoting work safety.
- Avoiding unnecessary investments on capital.
- Estimulating staff to improving their performances.

Flow of materials analysis

Analysing the flow of product materials means determining the sequence for materials moves all throughout the different stages of the productive process, and determining the frequency or distance of such moves.



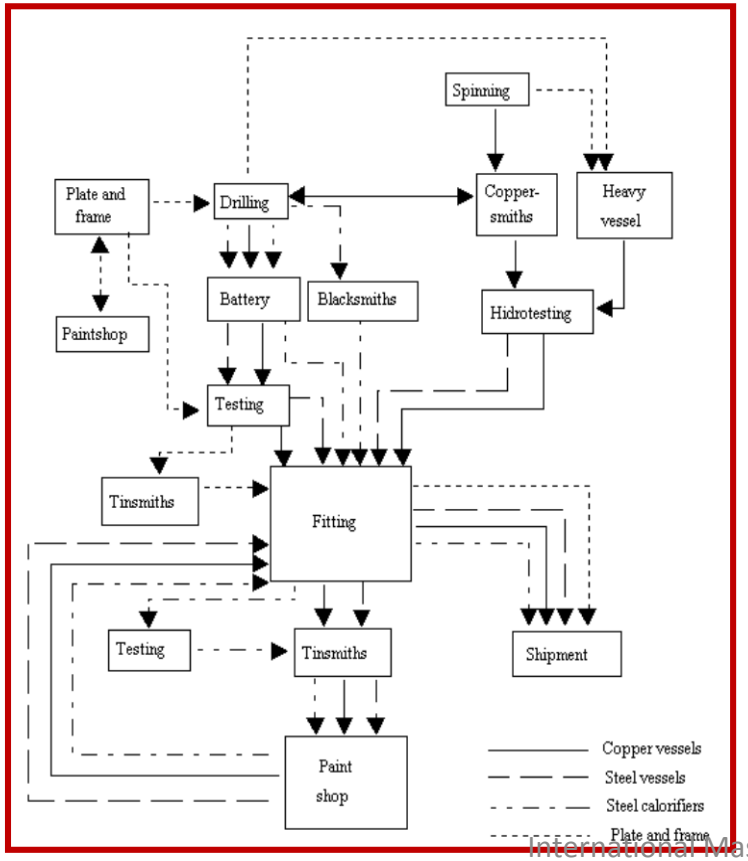
The **flow of materials analysis** is the foundation to a plant layout

1. The flow of materials represents an important part of the process.
2. Volume and materials in progress are multitudinous.
3. Maintenance or transport costs are high compared to operations costs.

There are three ways to analyse the materials flow:

1. **Simple flow diagram:** Few products, large quantities.
2. **Multi-product diagram:** Several products.
3. **Matrix table:** Many different products, small quantity.

1



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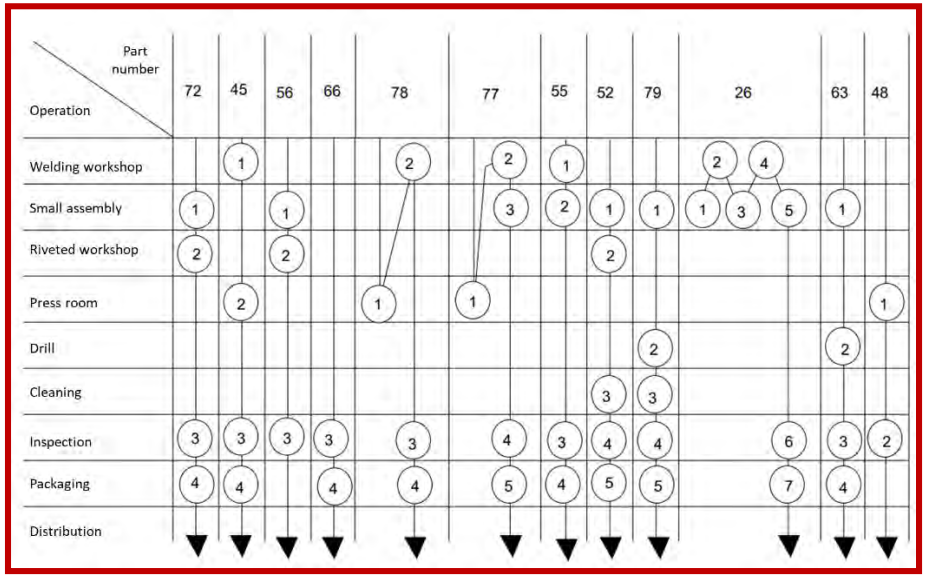


3

From \ To	1	2	3	4	5
1 Quilting Machine		856	242		
2 Glued Fabric			146		
3 Spring Machine				872	
4 Packaging					527
5 Warehouse					

Activities relationship

The **activity relationship or correlation** represents the coordination between the work areas and manufacturing operations in a company. This way:

Processes

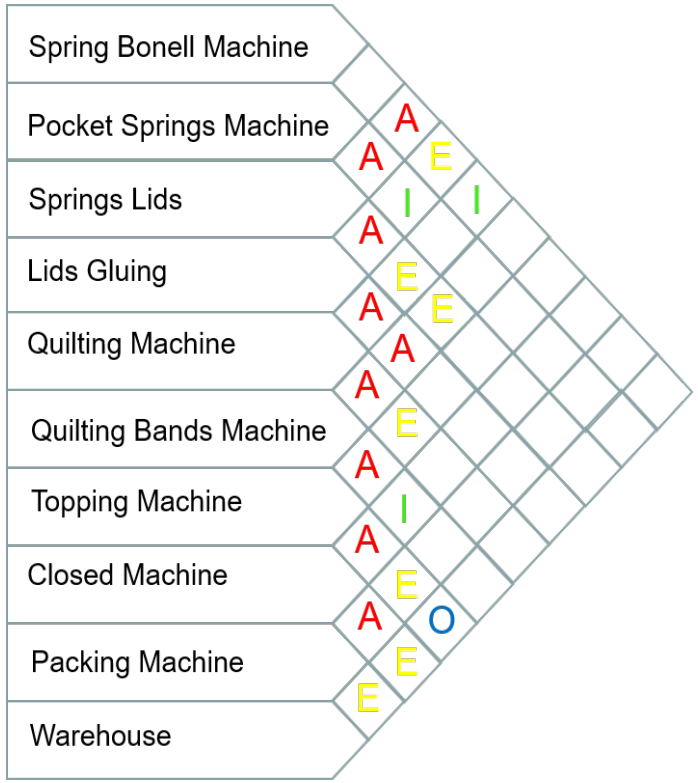
A **systematic procedure** is needed to settle the connection among activities that, at the same time, identifies and categorises the connection while integrating the services that are indirectly productive.

The **activity relationship chart** is a diagonally organised chart in which the relationship among activities is represented. In it, the company assesses if the activities need to be close depending on each variable.

1. List of activities.
2. The combination of criteria or aspects that assess how close each different activity need to be with each other (noise, smell, safety, common staff, etc.)
3. A relation scale that assesses activities closeness; in other words, a system that quantifies with a homogeneous rate on the closeness need depending on different aspects.

Código	Relación	Color
A	Absolutamente necesaria	Rojo
E	Especialmente importante	Amarillo
I	Importante	Verde
O	Ordinaria	Azul
U	Sin importancia (Unimportant)	-
X	Rechazable	Marrón

Values scale



Activity relationship chart

Sequencing of plant operations

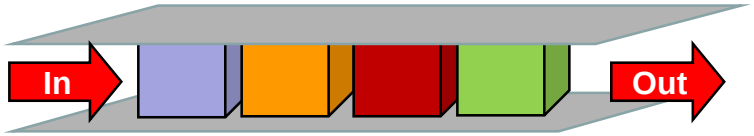
Depending on the **productive system** designed, the **manufacturing process** and the type of product manufactured, there is a chance that the **flow of materials**, the **products in progress** and the **end products** vary during its productive development within the manufacture facilities.

There are **heuristic rules** used in product manufacturing **operation sequencings** to value the product inputs and outputs.

Heuristic rules

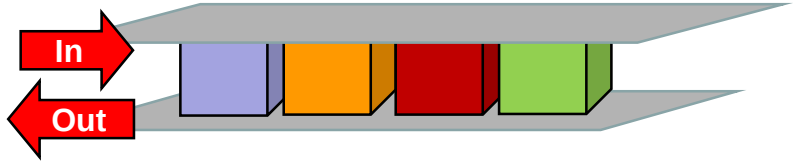
FIFO rule

First In First Out: First product in the warehouse is the first product to get out of the work area.



LIFO rule

Last In First Out: Last product to arrive in the warehouse is the first product to get out of the work area.



Heuristic rules

SOT rule

Shortest Operation Time: The job with the shortest processing time is chosen to increase flow time and usage.

LOT rule

Last In First Out*:* The job with the longest processing time is selected as the most important one to process it first.

DD SOT rule

The job with the shortest operation time is chosen to be processed next, except for those cases where a job has already been delayed for a specific period of time. Then, the rule is not followed and the most delayed job is processed.

SROT rule

Shortest Remaining Operation Time: The prioritised job is the one with the shortest processing time from the operating tasks pending.

LIFO method

Longest Remaining Operation Time: The job prioritised is the one with the largest amount of processing time for all the pending operations.

Heuristic rules

Apart from the mentioned before, other rules are:

- *LRO (Less Remaining Operations)*
- *MRO (Most Remaining Operations)*
- *WINQ (Work In Next Queue)*
- *LSU (Least Set-Up)*
- *DD (Due Date)*
- *SS (Static Slack)*
- *DS (Dynamic Slack)*
- *SS/TPR*
- *DS/TPR*
- *DS/NOR*
- *RDS (Relative Dynamic Slack)*

problems →

- Johnson's Algorithm for n pieces and 2 machines.
- Johnson's Algorithm for n pieces and 3 machines.
- Johnson's Algorithm for n pieces and m machines.
- Lomnicki's Algorithm for n pieces and 3 machines.
- Lomnicki's Algorithm for n pieces and m machines.

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Plant layout based on products

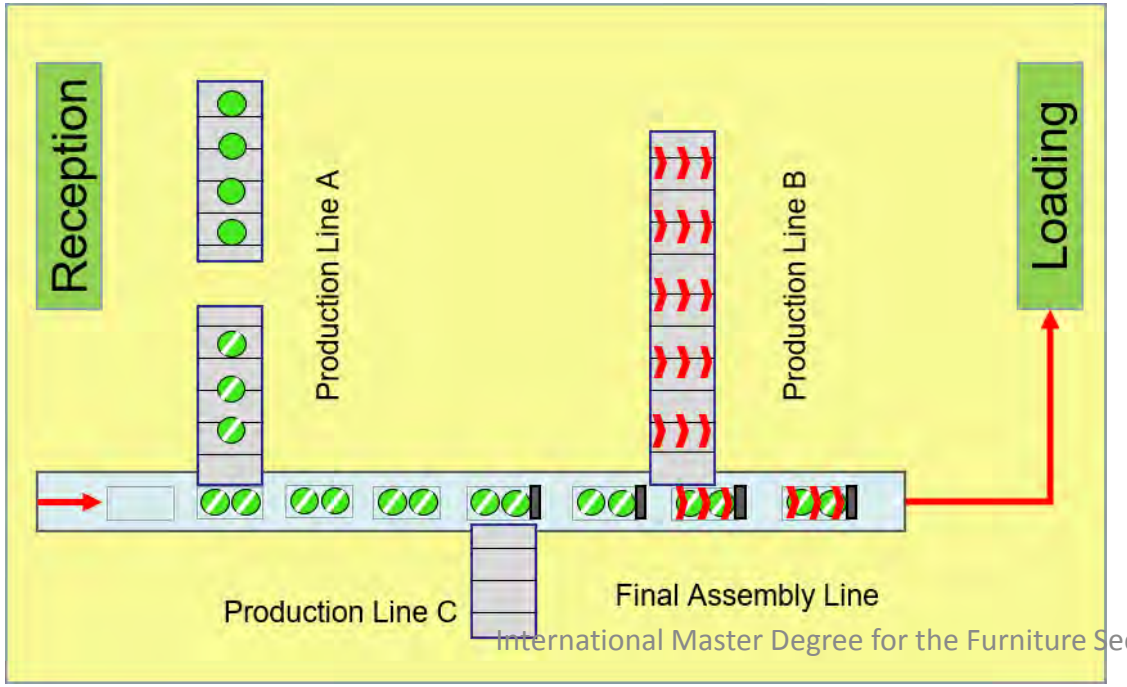
A **product layout** is focused on facilitating the products' traceability inside the manufacturing plant.

High and constant demand

Relocating products is profitable so that they stay close to each other and within the sequence necessary to manufacture a product.

Products

Products are demanded goods that satisfy a certain need or fulfil a consumption desire.



Products can be classified according to:

Type of output

- **Goods:** Physical, storable, with long-term deadlines and their quality is easy to measure.
- **Services:** Intangible, perishable, non-storable, subjective quality.

Product distinction

- **Standard product:** Kept on inventories and with standardised manufacturing processes.
- **Customised product:** Manufactured following a customer's requirements.

Product-component structure

- **A:** Manufacturing a low variety of end products with a large quantity of components.
- **V:** Manufacturing a large quantity of end products with a low quantity of raw materials.
- **I:** A few components create few end products.
- **X:** A great variety of raw materials and components create subassemblies and modules that, when put together, generate a large variety of end products.

Products can be classified according to:

Item demand

- **Static demand:** Foreseable, the capacity implemented with an appropiate adjustment can have better performance.
- **Dynamic demand:** Varies over time. It can have tendencies, seasonality and stages that generate variations that the system must be adjusted to.

Product manufacture volume

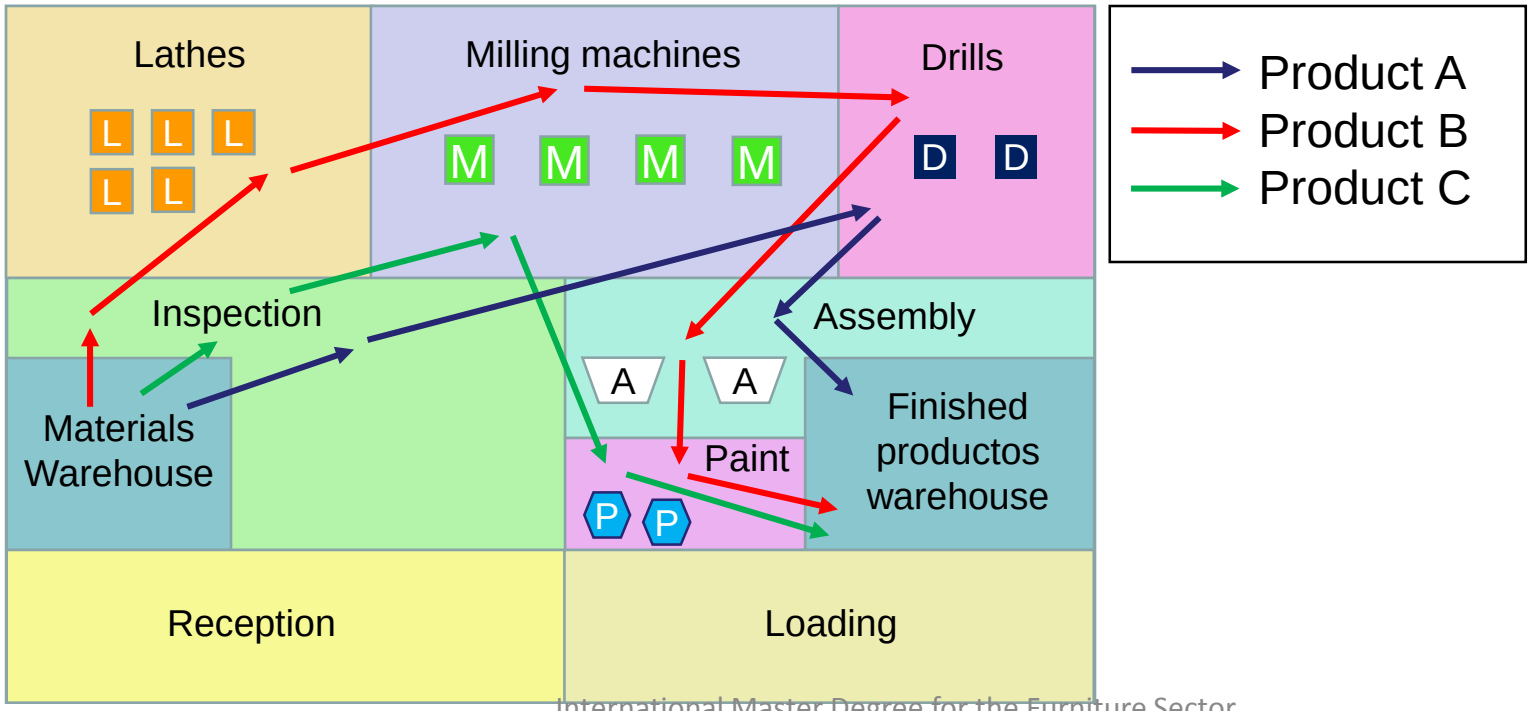
- **Unitary:** Kept on inventories and with standardised manufacturing processes.
- **Reduced volume:** Few standardised products, special manufacturing.
- **High volume**: Resources are ordered in a way that keeps levels efficient enough.

Plant layout based on processes

A **layout based on processes** is focused on locating departments that carry out similar processes close to each other to optimise their centre.

Processes

Set of operations necessary to modify the characteristics of raw materials and turn them into end products.



Products can be classified according to:

Types of processes

- **Manufacture:** Where raw materials are physically changed.
- **Transformation:** Several raw materials are combined, physically or chemically, to create new and different items.
- **Assembly:** Components are assembled to other sub-assemblies to create a new compound product.

Type of flow

- **Projects:** Few products with a long manufacturing period.
- **Batches:** Different products are obtained in the same manufacturing plant.
- **Continuous:** A manufacturing plant always produces the same item.
- **Job-shop method:** Machines are located according to the operations they carry out.
- **Flow-shop:** Machines are located according to the product flow.

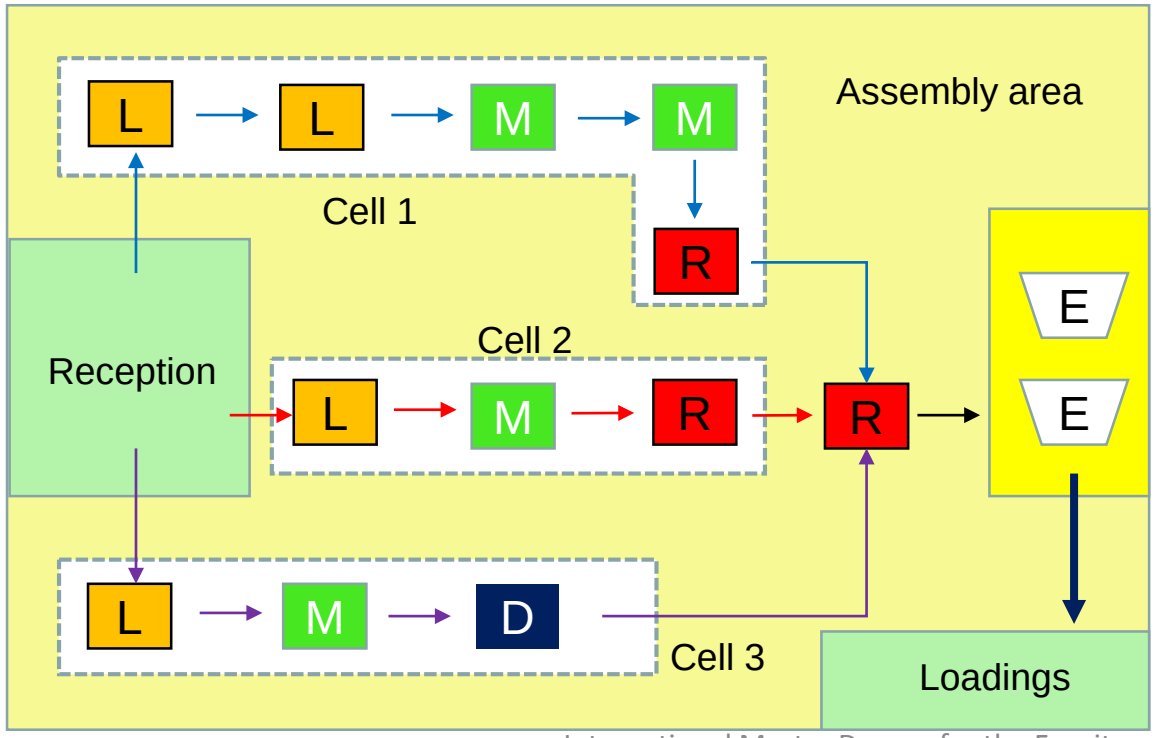
Products can be classified according to:

- **Number of stages:** → **One stage** or **Several alternatives**
- **Type of demand**
  - **Manufacturing inventory:** Productive process and costumers are separated by a warehouse that must be replenished by the manufacturing system.
  - **Customer-Managed Inventory:** The customer orders a product that is not a standard one and, therefore, it must be processed before being delivered.
- **Way of exchanging information**
  - **Push System:** When receiving an order, the system transfers the information to the origin of the productive system and the manufacturing starts from there.
  - **Pull System:** When a customer order is received and transferred to the last stage of a production change in order for it to acknowledge the resources need and places the requirement to the upper stages.
- **Layout** → **By process, by products, by cells** or **by fixed position.**

Plant layout based on cells

The **layout of a group or cell-technology plant** sets different machines in cells to work on goods with similar processing ways and requirements.

This type of layout is common in metal factories, assembly lines and computer-circuit manufacturing companies.



Goal

Obtain benefits from the product layout in the manufacturing similar to workplace.

BENEFITS

- ❑ *Improvement on human relationships.*
- ❑ *Improvement on staff experience.*
- ❑ *Materials and work in progress inventory are less handled.*
- ❑ *Faster manufacturing.*

PROBLEMS

- ❑ *Elaborate a product classifying and encoding system that can compile shapes, sizes, materials, etc. of each product.*
- ❑ *Combine elements according to their families in order to create cell groups.*
- ❑ *Elaborate the physical layout, locating cells interconnected.*

Just In Time plant layout

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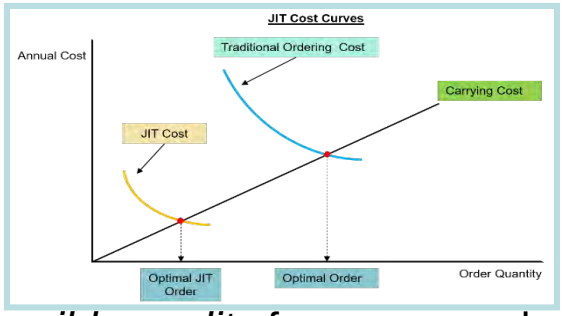
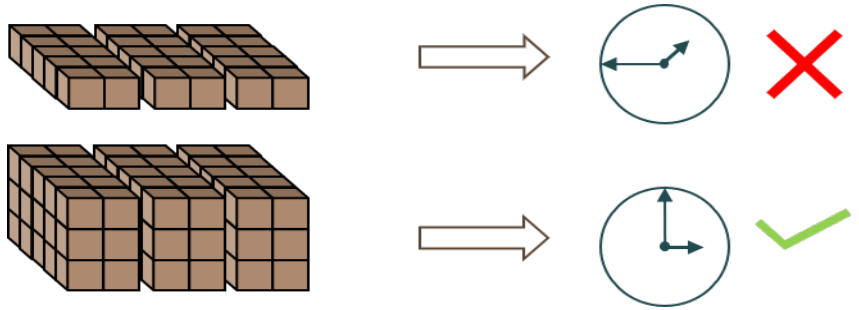
There are four competitive strategic priorities that a plan must have implemented in its productive development in order to function with a Just in Time methodology:

I. **Cost:** Manufacturing products at the *minimum cost possible* while meeting customers' requirements. To do so, processes must be designed and operated efficiently.

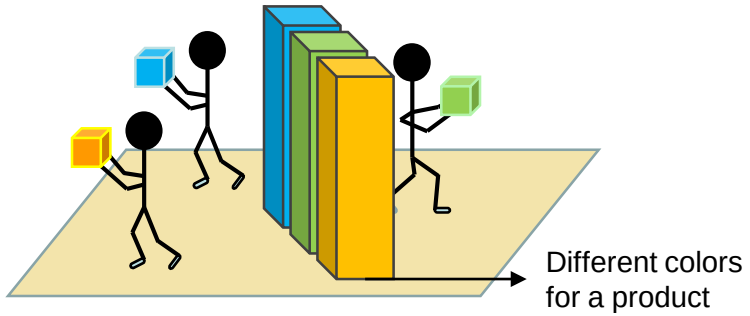


II. **Quality:** It seeks the *maximum possible quality* for every product while meeting customers' requirements.

III. **Time:** A possible method to reduce the *delivery time* is to have a surplus quantity of products or a safety stock in case of unexpected emergencies.



IV. **Flexibility:** Customisation on products show flexibility. With such characteristic, a productive system can create products unique to each customer.



Just In Time is a methodology that involves a Lean Manufacturing ideology.

Lean Manufacturing main tools

KAIZEN

This tool seeks out for constant improvements; improvements are infinite and thus a company should not works towards goals but upgradable processes.

6-σ (Six Sigma)

This tool seeks to define goals, to measure the problem, to analyse what causes the problem, to improve processes and to control that the company keeps improving

5S

It is a Japanese management technique used to maintain an appropriate working environment.

Goals

- *Sort*
- *Set in order*
- *Shine/Sweep*
- *Standardise*
- *Self-discipline*

5 Why

5 Why is an interrogative systematic technique that is used when analysing the problems of a company to narrow down their causes.

SMED	(Single-Minute Exchange of Die) It is a method used to reduce waste in a manufacturing system. It is based on ensuring that changeovers take the shortest time possible.
KANBAN	It is an information system that controls the production of items according to quantity and time in each of its manufacturing processes.
TPM	A methodology focused on reducing wastes related to industrial production halts, quality and costs.
OEE	A percentage that represents the productive effectiveness of industrial machinery in a manufacturing plant.