PRODUCTION MANAGEMENT

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Our programme 32 hours – 4 credits

Module 1 – Operations Management, from Design to Production

Module 2 - Supply Chain Management

Module 3 – Lean Manufacturing – Six Sigma and TQM

Module 4 – Industry 4.0 AND Lean 4.0

Marking of the assessment

Written Examination with closed questions

20 questions plus a project work with Dr Giovanni Gerardo Muscolo

Keynotes

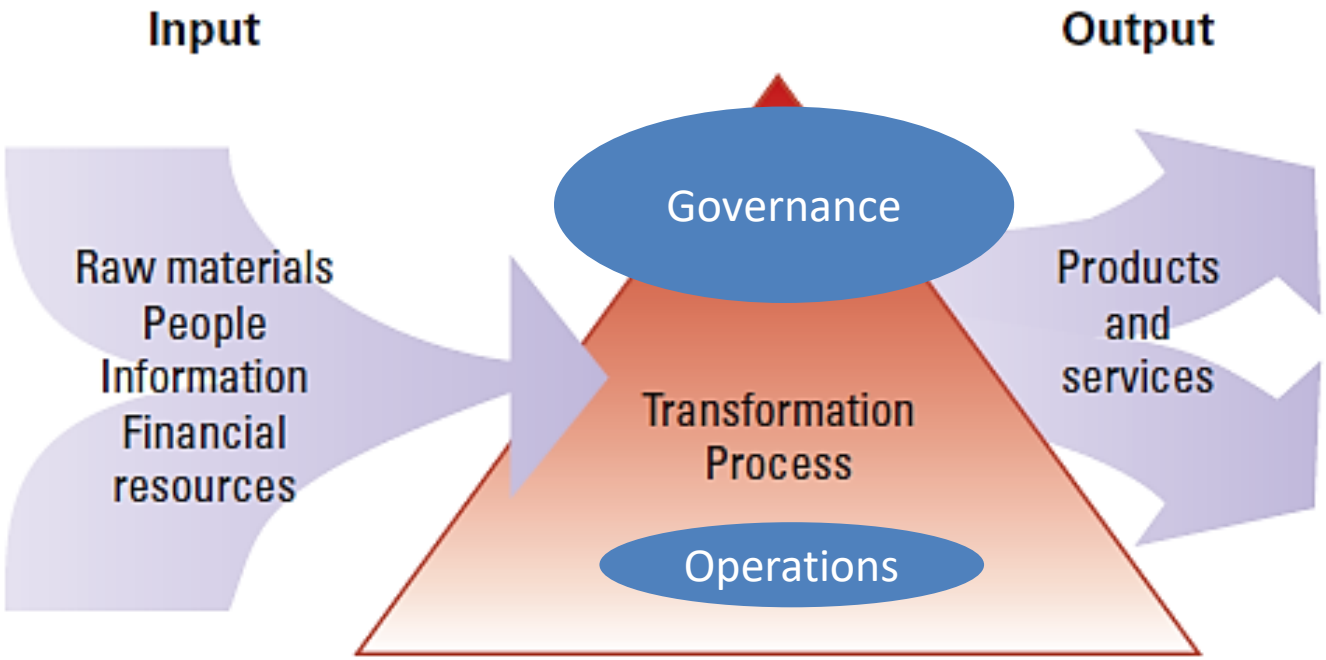
Definitions and relevant concepts are **highlighted in orange** **or in red**. That means you are supposed to study these concepts and definitions, even if I do not want you to learn them by heart !!

Instead, try to really understand the meaning and the context

When you come across this icon  it represents a fundamental part of our programme

MODULE 1
Operations Management, from Design to Production

How does an organisation work?



What is Operations Management?

Operations Management is the set of **processes** and **activities** that creates **value** in the form of goods and services by transforming inputs into outputs

Operations are sometimes considered as a single **function or department** (usually for SMEs) or more often as a group of functions

What is Operations Management?

In simple terms, **Operations Management** is just a matter of transforming, creating **value for customers**

Operations convert inputs such as raw materials into finished goods and services. However, Operations are not just manufacturing processes and activities

For doing that, we have to manage human resources, such as workers, staff and managers, facilities and equipment, data and information

Some important definitions for our course

Function or Functional Area is:
A grouping of staff on the basis of the function each performs in the organisation, such as accounting, marketing, production, logistics, etc.

A Function can contain one or more **processes**:

Sequence of interdependent and linked activities which use resources (people, materials, machines, money) to convert inputs (data, material, parts, etc.) into outputs

A process contains **activities**:
Activity is a unit of work within a process
Activities can be either elementary tasks or sub-processes. To qualify as an Activity, it must exist for a period of time that can be measured

Organisational chart – the major functions

Board of Directors

Design and Development

Product design and development
Process design and development

Production

Production planning & control
Assembling
Machining

Quality Management
Environmental, Health &Safety Management

Warehousing
Logistics
Maintenance

Purchasing

Supplier evaluation
Supplier development
Procurement

Finance/ accounting

Disbursements/ credits
Receivables
Payables
General ledger
Funds Management
Capital requirements
Management Accounting
Budgeting
Performance Measur.
Reporting
Balance sheet

Marketing

Sales promotion
Advertising
Sales
Market research

Human Resources

Recruitment

Job evaluation

Performance evaluation

Wage and Salary Adm.

Personnel records

Some important definitions for our course

For instance, **process design and development** could be a process across (involving) two functions, design and production

Within process design and development, to write production instructions could be considered an activity

Operations Management

The most important functions within operations typically are:

- **Design and development**
- **Production/Manufacturing**
- **Purchasing**
- **Logistics and Warehousing**
- **Quality Control and Management**
- **Environmental, Health and Safety Management**
- **Facilities management and maintenance**

For instance, Finance function does not belong to Operations. It ensures that organisation finance has been properly utilised

Operations Management and the most important Management Systems

Management System: a system (functions, processes and procedures) to establish a strategy and objectives and to achieve those objectives

Operations Management and **Lean Production** (or Manufacturing)

Operations Management and **Total Quality Management**

Operations Management and **Six Sigma**

Operations Management and **Corporate Social Responsibility** (CSR)

Role of Operations Management in Strategic Management

Nowadays the role of OM has been overturned

- Traditional approach:

Firstly, the marketing department lays down product requirements for the design department. Then the production department converts the design to a product within the financial limits imposed by the finance department. Marketing and finance could exert more influence on top/senior managers when they set their strategic goals and objectives

- New approach:

Marketing, Design, Production, Purchasing and Finance are together setting strategies

Operations Management – Manufacturing Vs Services

Every organisation has got its own operations.

For instance, for a Public Hospital usually operations start with the A&E (Emergency) Department and they finish with the hospital discharge

While for a traditional manufacturing SME, operations start with product design or the provision of some raw materials until shipment and after sale service

Manufacturing VS Service Operations

Refinery

Automatic machine

Electric Installation

Restaurant

Logistics company

Health care

Investment management

Education/teaching

Consulting

100% 75 50 25 0 25 50 75 100%

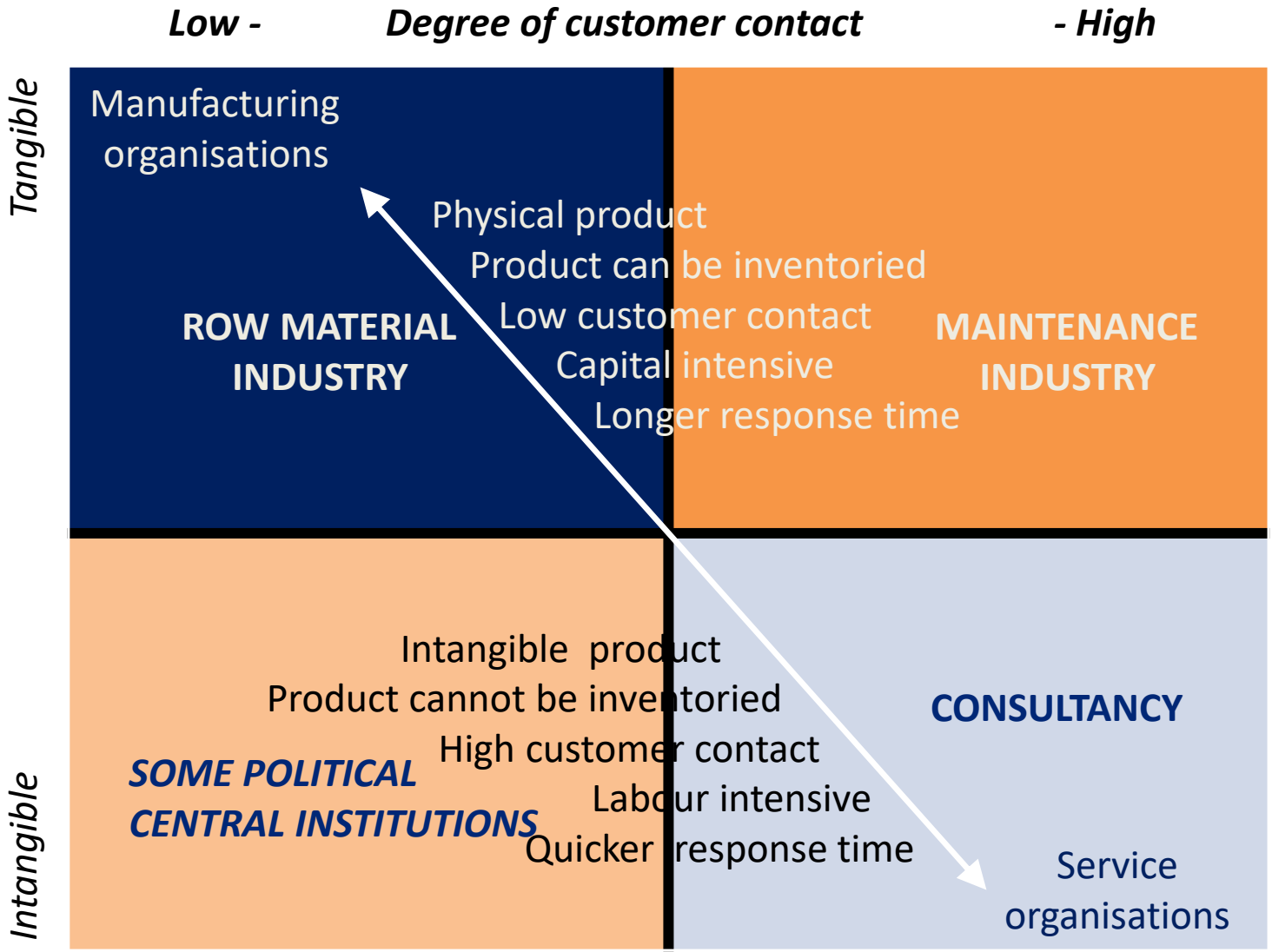
Percent of physical product

Percent of service

Manufacturing Vs Services Operations

100% Product (e.g. refinery)	100% Service (accountant)
Physical product	Intangible product
Product can be inventoried	Product cannot be inventoried
Low customer contact	High customer contact
Capital intensive	Labour intensive
Longer response time	Quicker response time

Operations Management - Manufacturing and Service Organ.



Industrial Plant for Manufacturing

An industrial plant is the place (the **factory**), made up of offices, warehouses, production spaces, etc. engaged in the business of manufacturing

Plant sometimes could be referred to a big machine

Within an industrial plant we can find the **shop floor** , the part of a factory where production as distinct from offices is carried out

Industrial Plant for Manufacturing

- ✓ Industrial plant **capital intensive** versus **labour intensive**

- ✓ Labour intensive = $C_{fi}/C_{vL} < 1$
- ✓ Capital intensive = $C_{fi}/C_{vL} > 1$

Where C_{fi} is the fixed cost of the machines/plants
C_{vL} is the variable cost of labour

Operations Management and Production

Different kinds of production managed in the shop floor

Two main categories of production:

- ✓ **Intermittent** processing systems – medium-low volume of many different products

- ✓ **Continuous** processing systems – high volume of a few and standardised products

Operations Management and Production

Classification based on the type of production processes

- ✓ **Mono or single line**
- ✓ **Convergent processes**
- ✓ **Divergent processes**

Operations Management and Production

Classification based on the type of production processes

- ✓ **Mono or single line** – the output of one process goes directly through the following process. It can be intermittent or continuous

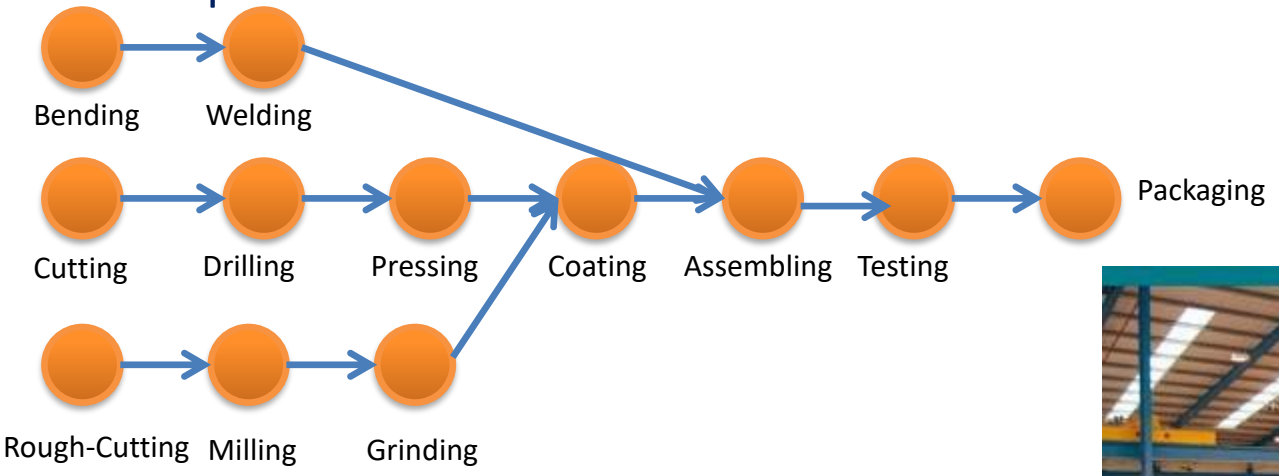
Continuous furnace for ceramics
(**intermittent** - different products)

Continuous flow for milk
(**continuous** - same product)

Operations Management and Production

Classification based on the type of production processes

- ✓ **Convergent processes** – products from different processes (raw materials or semi-finished products) converge into a final process in order to make the finished product



Intermittent convergent processes
(**job-shop**)

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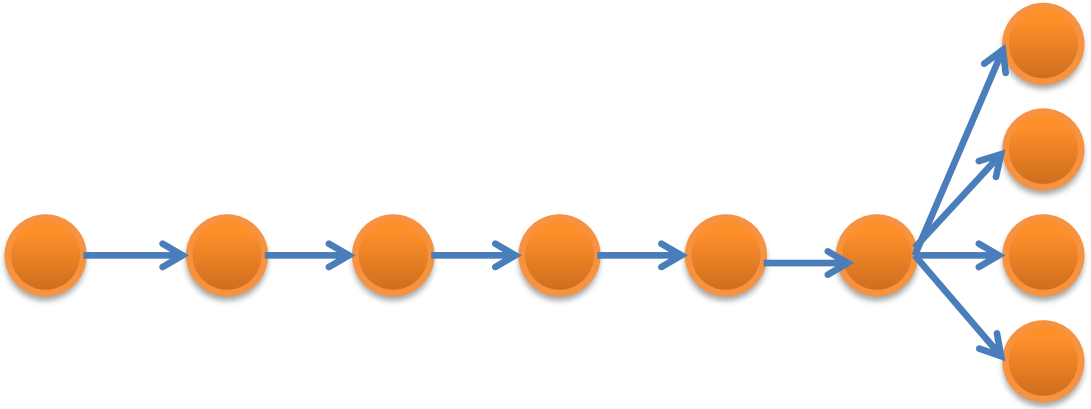
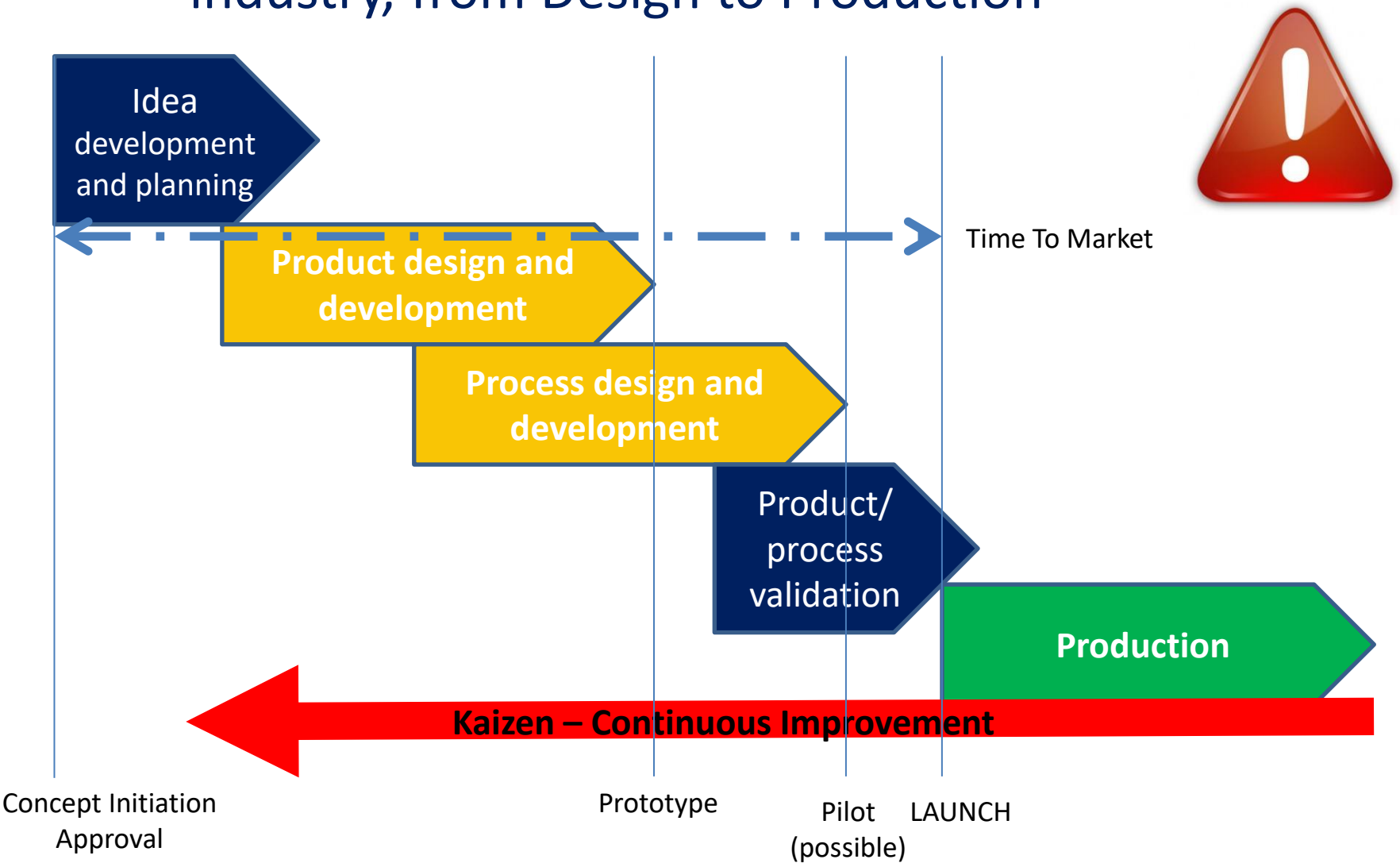
Operations Management and Production

Classification based on the type of production processes

- ✓ **Divergent processes** – from the same raw-materials or semi-finished products we get different products in the last production processes. For example, same kind of drug but with different package size, weight and format



Operations Management for a typical Manufacturing industry, from Design to Production



Operations Management – Idea Development and Planning

Idea development and planning

- ✓ Design Goals (e.g. Kano Analysis and QFD)
- ✓ Break-even analysis
- ✓ Planning (e.g. Project Management)

Concept Initiation
Approval

Design Goals – Kano Model and QFD Analysis

- ✓ Identifying the quality characteristics (VOC, Voice Of the Customer) that are typically fuzzy and not precise
- ✓ Translating the VOC into quantitative terms known as Critical To Quality (CTQ) characteristics. WHAT customers really want
- ✓ Prioritising the CTQs (using Kano and QFD and involving customers)
- ✓ Evaluating HOW well we can satisfy each CTQ and HOW we can improve it (by means of QFD)

Design Goals – Kano Model and QFD Analysis

Example, let's suppose your company has to introduce a new mechanical roller into the market

- ✓ For the customer the new roller has mainly to last longer than the previous model (VOC)
- ✓ The CTQs are lifetime (in hours), oil leaking (quantity), appearance (paint integrity and no rust before a certain working period), etc.
- ✓ Lifetime is the most important one
- ✓ We can improve lifetime changing one furnace in the production process (HOW)

Design Goals – The QFD methodology

How do we capture the quality characteristics from the VOC? We can use the QFD methodology for capturing the VOC transforming it into CTQs (WHATs) and then into HOWs

VOC → CTQs → HOWs

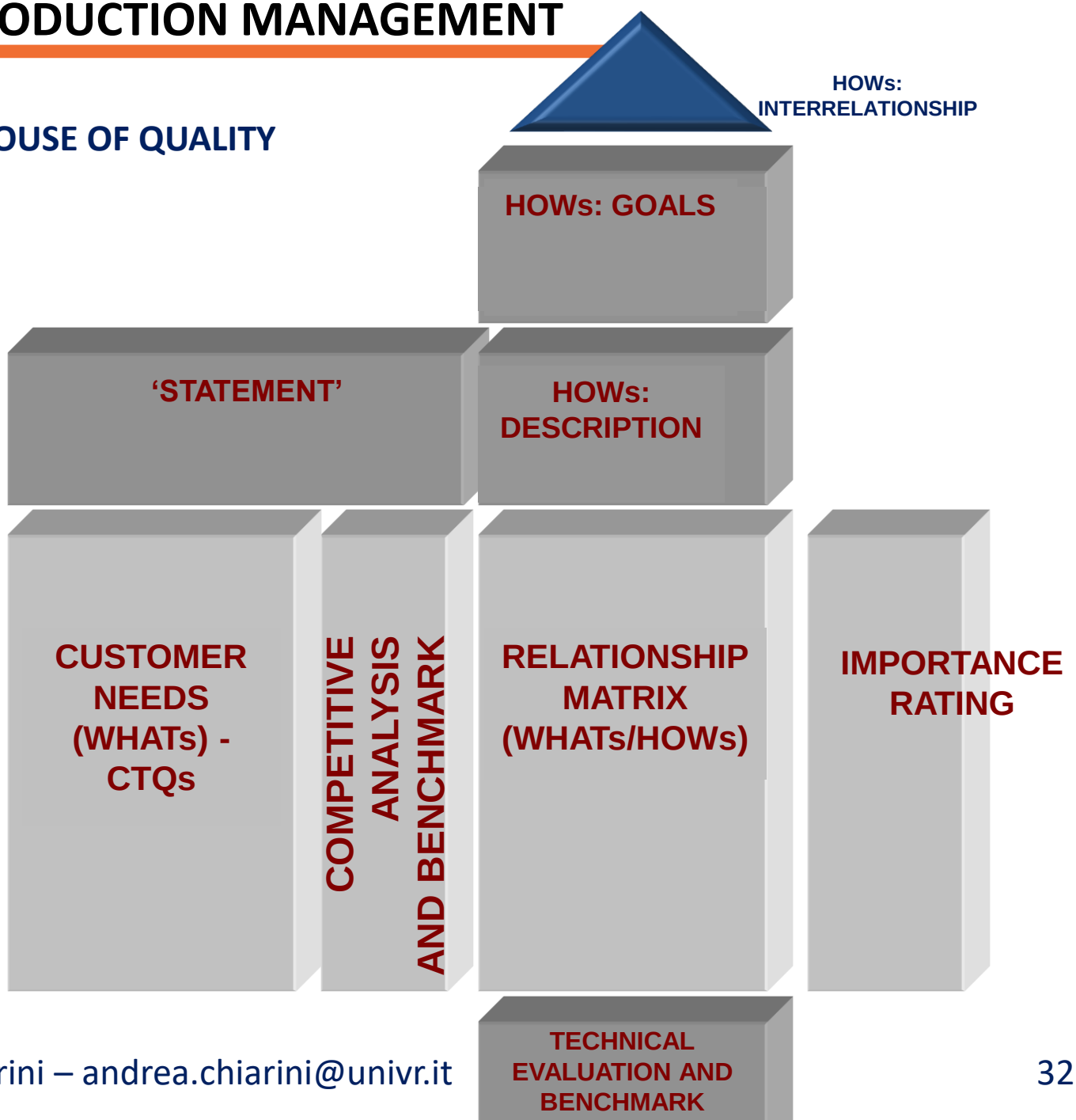
Design Goals – Capturing the VOC - QFD

How do we capture the VOC and transforming it into CTQs (or WHATs)?

We can determine directly from the customer what they would like a particular product or service to do, through:

- ✓ One-on-one customer interviews
- ✓ Focus groups
- ✓ In-context customer visits (observation)

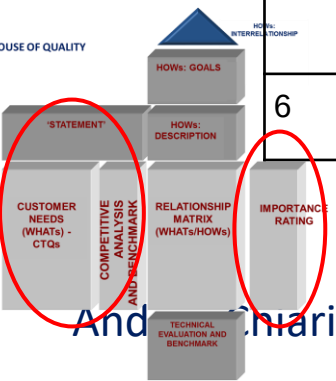
QFD - THE HOUSE OF QUALITY



QFD, Quality Function Deployment

What are the most important characteristics of the new T 102 roller ?

	WHATs - CTQs	COMPETITIVE ANALYSIS (OUR CURRENT STATE)	COMPETITIVE BENCHMARK				I.R.	
			A	B	C	D		
1	Longer lifetime than the average T products	3	3	④	3	2	5	Must be
2	No oil leak	2	3	⑤	4	3	4	Must be
3	Not damaged paint	4	④	④	3	④	2	Performance
4	No rust when shipped	4	1	3	1	④	4	Must be
5	Delivery by 30 days	2	4	⑤	4	3	2	Performance
6	Using customer's pallet	2	2	③	1	1	1	Delighter



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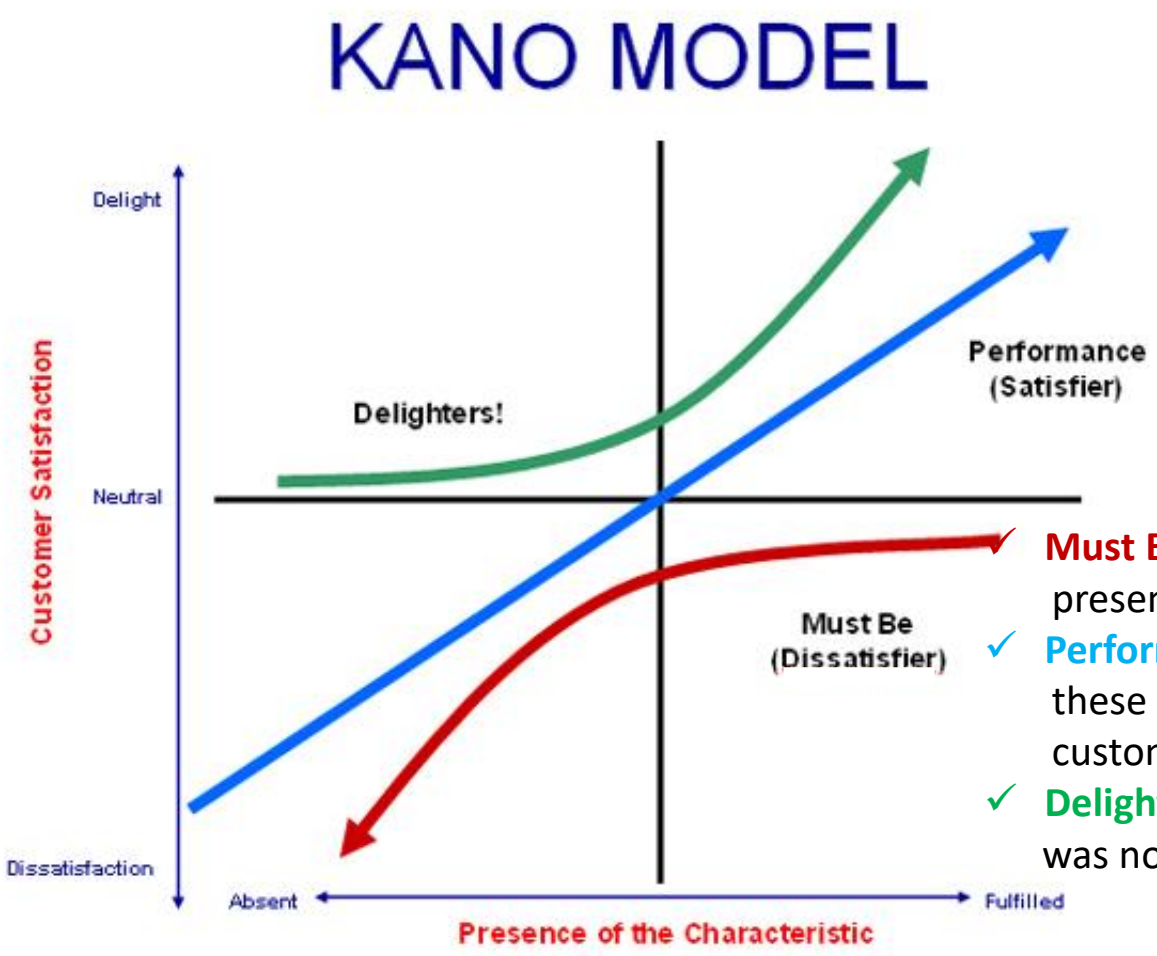
Design Goals – Kano Model and Analysis

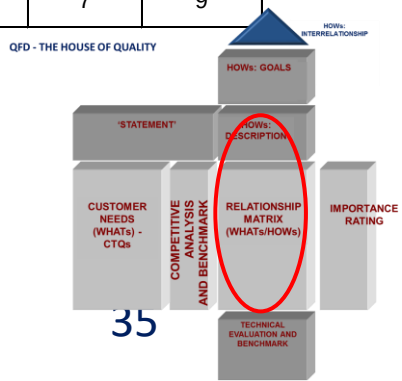


- ✓ **Must Be**: The quality characteristics MUST BE present or we will lose the customer
- ✓ **Performance**: The better we are at meeting these needs, the more satisfied the customer is
- ✓ **Delighter**: Those qualities that the customer was not expecting but received as a plus

RELATIONSHIP MATRIX

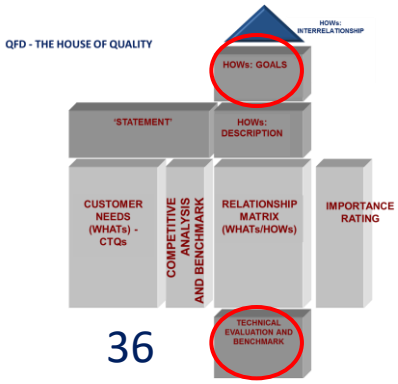
			HOWs									
			1	2	3	4	5	6	7	8	9	10
What are the most important characteristics of the new T 102 roller?			More hardness (change of furnace)	Less axial play (new CNC)	New steel plant	Better grinding	New sealed ring	New ring supplier	New coating plant	New kind of painting	Inventory control	Faster pallet
	WHATs	**I.R.**										
1	Longer lifetime than the average T products	5	5 (25)	3 (15)	5 (25)	3 (15)	3 (15)	1 (5)	0	0	0	0
2	No oil leak	4	3 (12)	5 (20)	1 (4)	3 (12)	5 (20)	0	0	0	0	0
3	Not damaged paint	2	0	0	3 (6)	0	0	0	5 (10)	0	0	0
4	No rust when shipped	4	0	0	3 (12)	0	0	0	5 (20)	5 (20)	3 (12)	1 (4)
5	Delivery by 30 days	2	0	0	1 (2)	0	0	0	0	0	5 (10)	5 (10)
6	Using customer's pallet	1	0	0	0	0	0	0	0	0	0	5 (5)
	ABSOLUTE SCORE		37	35	49	27	35	5	30	20	22	19
	RELATIVE SCORE		2	3	1	6	4	10	5	8	7	9

5= strong relationship

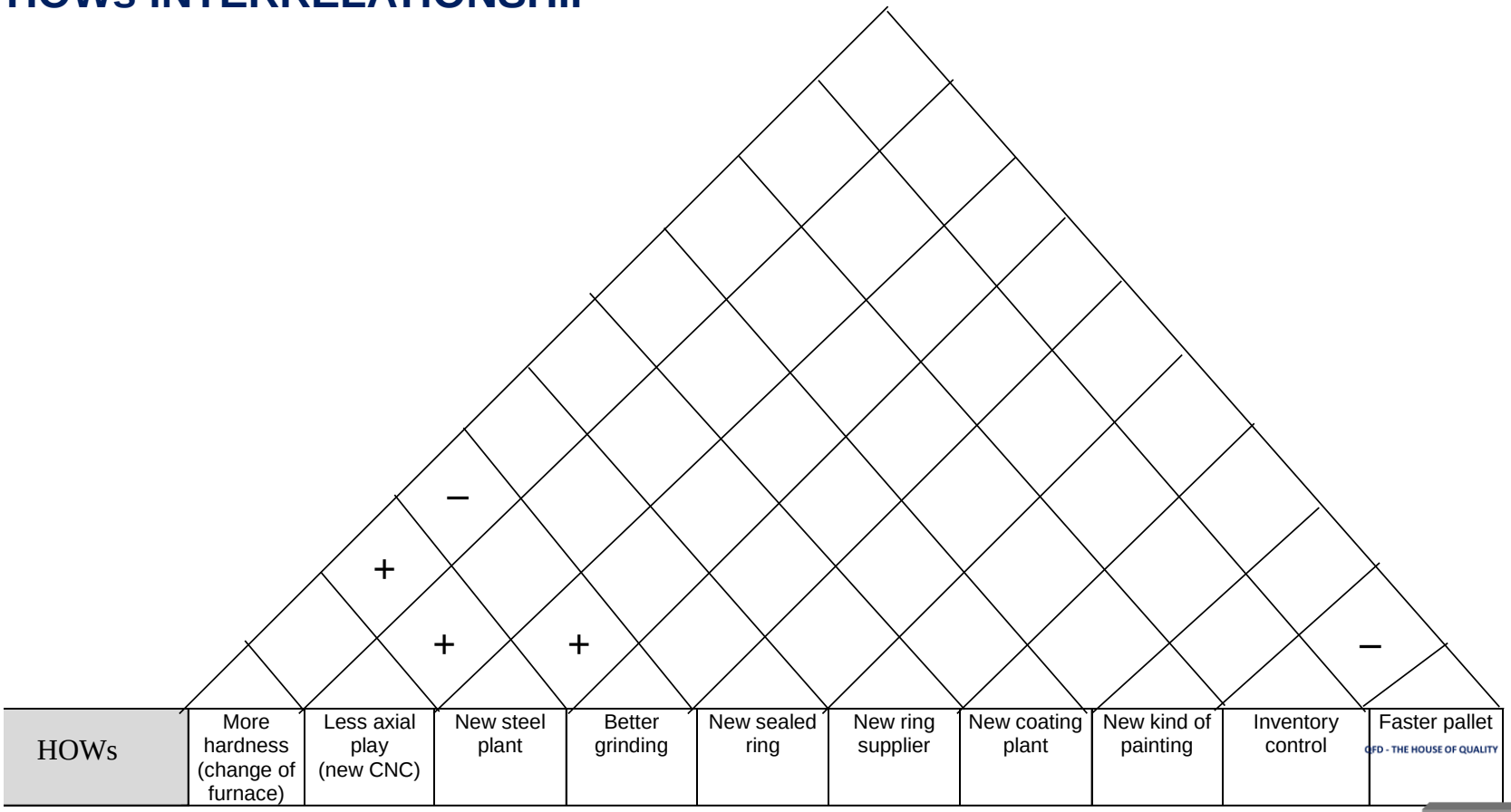


HOWs DESCRIPTION AND GOALS – TECHNICAL EVALUATION AND BENCHMARK

HOWs		More hardness (change of furnace)	Less axial play (new CNC)	New steel plant	Better grinding	New sealed ring	New ring supplier	New coating plant	New kind of painting	Inventory control	Faster pallet
GOALS		↑	⊙	⊙	↑		⊙	⊙		↓	↓
ECHNICAL ALUATION	We	2	3	2	2		3	1		2	3
	Best in class	4	4	5	?		3	?		?	?
HOW MUCH		> 5%	0,02 mm	Vendor Rating = 90	Cpk > 1		Vendor Rating = 80	< 5 microns		< 15 days	< 2 days

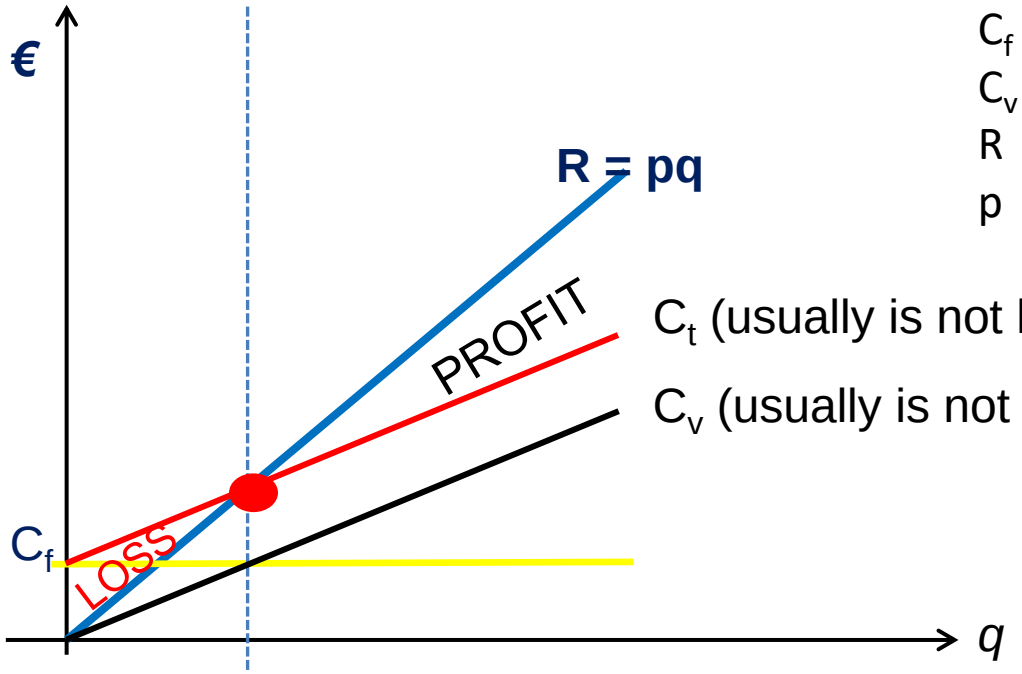


HOWs INTERRELATIONSHIP



Break-Even analysis

Break-Even quantity: quantity of products a company needs to sell to cover its total costs (C_t)



(C_t = R)

C_f = Fixed Costs
C_v = Variable Costs
R = Revenue
p = price per unit

C_t (usually is not linear) = C_f + C_v

C_v (usually is not linear)

Break-Even analysis

Break-Even quantity: quantity of products a company needs to sell to cover its total costs (C)

Assumption, C_v varies linearly with q, where C_v are the **Variable Costs**

$C_t = C_f + C_v$; and $C_v = C_{vu}\, q$ (C_{vu} = variable cost per unit)

$C_t = C_f + C_{vu}\, q$;

$R = pq$ (p = price per unit)

Since revenue R equals total costs C_t at the break-even point q_{be}

$C_t = R$;

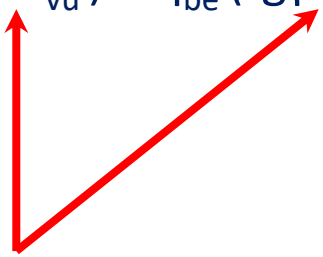
$C_f + C_{vu}\, q = pq$; solving for q:

$$\mathbf{q_{be}} = C_f / (p - C_{vu})$$

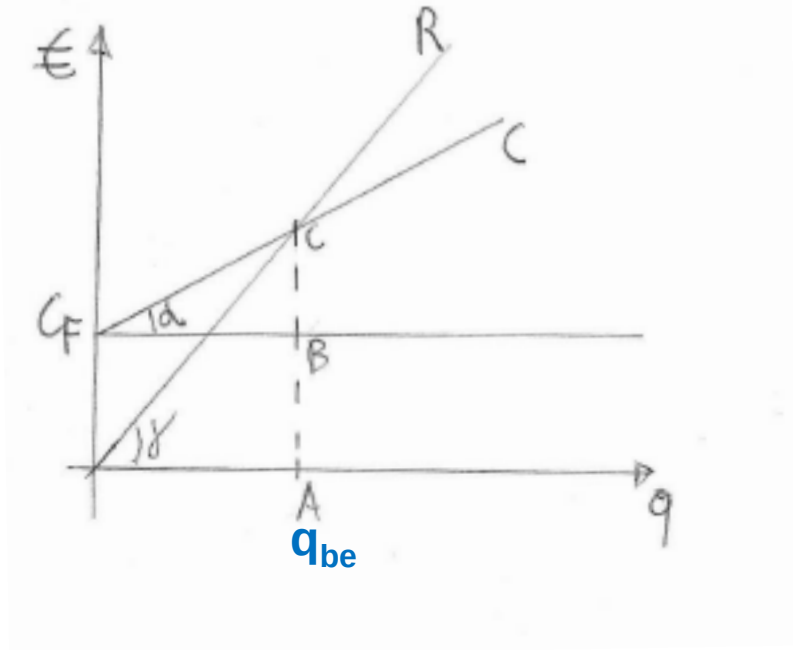
Break-Even analysis

From a geometrical point of view:

$q_{be}\,(p\text{-}C_{vu}) = q_{be}\,(tg\gamma - tg\alpha) = AC - BC = C_f$



These are the slopes of the lines R and C (or C_v)



Break-Even analysis, exercise

ACME Inc after several years of Research & Development (R&D) decides to launch a new glue in the market. The overall R&D cost is about 150,000 € and according to the law the cost can be amortisable in 5 years (30,000 € per year).
According to the Marketing Department for the first year it is expected to sale 20,000 kg of this new glue. The price per unit o per kg is 7€.
For making the glue they have to use two blenders. The machines are on lease for 12,000 € per year. For making 20,000 kg of glue they have to spend over the first year 3,000 € on electricity, 60,000 € on salaries and 14,000 € on raw materials

The company wants to calculate the break-even quantity for the first year of production.

Break-Even analysis, exercise

Machine rental: 12,000
R&D amortisation: 30,000
Overall Fixed Cost C_f = 42,000

Electricity: 3,000
Salaries: 60,000
Raw Material: 14,000
Overall Variable Cost C_v = 77,000
Production quantity for the first year = 20,000 kg
Price per kg = 7

Variable cost per unit C_{vu} = 77000/20000 = 3.85 (per kg)

$q_{be} = C_f / (p - C_{vu}) = 42000/(7-3.85) \approx 13{,}333$

Operations Management – Planning

- ✓ During product/process design stages the company has to organise people and other resources within a determined framework of time (**Time To Market**), money and scope. This is a typical **project**
- ✓ A **project** is a temporary endeavour undertaken to design a product, service, process or to get some particular results
- ✓ A project ends when its objectives have been reached, or the project has been terminated
- ✓ Projects can be large or small and take a short or long time to complete

Operations Management – Project Management

- To manage projects a specific discipline has been established in the 1960's, **Project management**
- **Project Management** is a dynamic process that utilises the appropriate resources of the organisation in a controlled and structured manner, to achieve some clearly defined objectives
- Successful project management means meeting three important objectives: **scope, time and cost**

- For instance, our company has to start the production of a new product for a new customer by the end of June. The product has to be in compliance with all the customer requirements including price per unit

Project Management – The most important processes/ activities

- Define the scope of the project
- Identify the team involved
- Develop a detailed task list (**WBS- Work Breakdown Structures**)
- Estimate time requirements for each task/activity
- Develop the initial time-frame using **GANTT tool**
- Identify interdependencies
- Identify and track **milestones and the critical path**
- Define project phase reviewing
- Identify required resources and budget
- Secure needed resources
- Identify and evaluate risks
- Prepare a contingency plan
- Manage the change control process
- Report project status

Project Management – Define the Scope and the Team

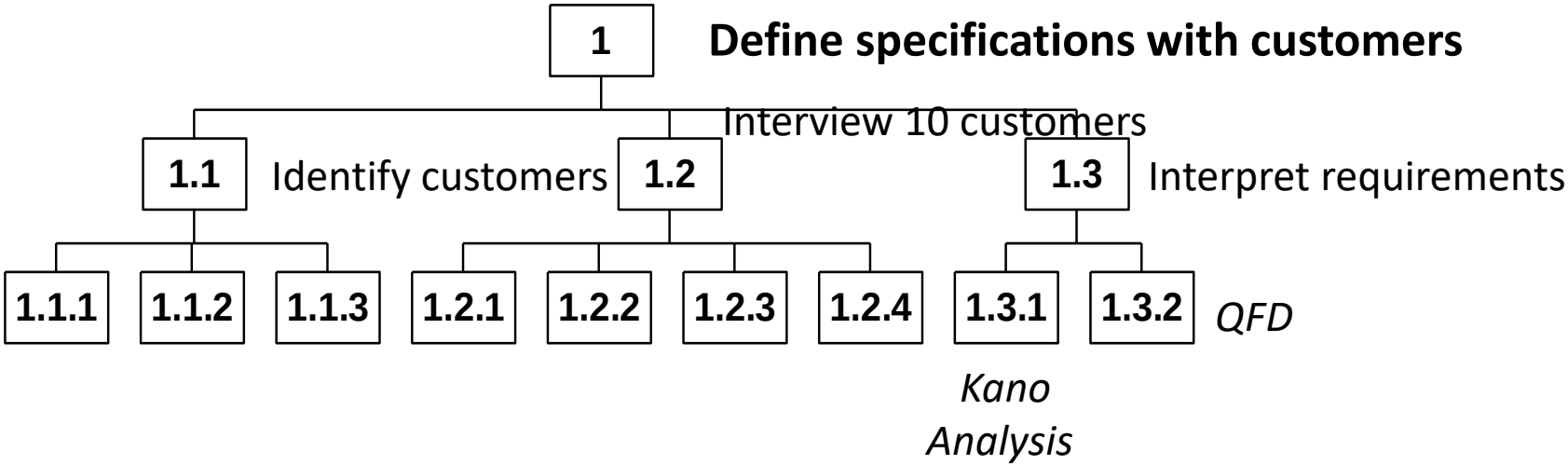
A successful **project scope statement** should be concise and clear
The **project manager** has to state at least:

- A precise time-frame with a precise deadline (Our customers want the new glue ready in the market by the end of June; in March we have to have tested the prototype, etc.)
- The dedicated team (how many employees will be working on the project)
- The expected outcomes (the new glue has to be ready along with its formula, sales catalogues and the right packaging)
- The boundaries of the project (we do not have to choose new dealers for the distribution)

Anyone reading the statement should have a good idea of what the project consists of (and what will not be part of the project)

Project Management – WBS and task list

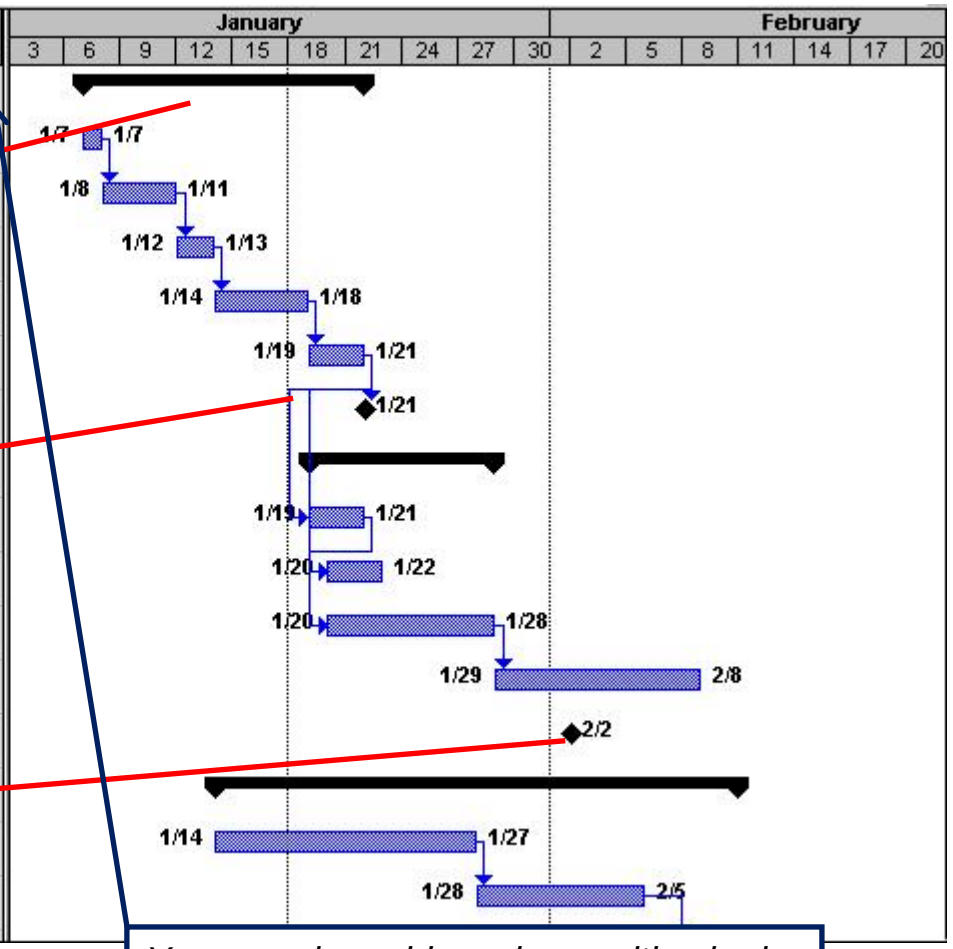
When we have to manage a complex project we can divide project stages into **work-packages** and **tasks (or activities)**. This subdivision process is called **WBS**



Project Management – Gantt Chart

The **Gantt chart** shows in a very immediate way what has to be done (the tasks) and when (the schedule)

WBS	Task Name
1	**Define specifications**
1.1	Identify customers
1.2	Interview 10 customers
1.3	Interpret requirements
1.4	Benchmark products
1.5	Define target PDS
1.6	Target PDS Released
2	**Generate concepts**
2.1	Review comp products
2.2	Search patents
2.3	Brainstorm concepts
3	Select top 2 concepts
4	MQ Presented
5	**Profile motor power**
5.1	Design test stand
5.2	Build test stand



Work Package

Critical path

Milestone

You can also add a column with who is in charge of the task

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Project Management – Gantt Chart

- ✓ The Gantt chart is the most popular methodology and useful ways of showing tasks displayed against time
- ✓ On the left of the chart is a list of the tasks and along the top is a suitable time scale
- ✓ Each task is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the task.
- ✓ You can understand at a glance:

  - What the various tasks are
  - When each task begins and ends
  - How long each task is scheduled to last
  - Where tasks overlap with other tasks, and by how long
  - Which **milestones** (zero-day task which can stop the project if not done) you have to go through
  - Relationships among the tasks and the **critical path** (the most important tasks that, if missed, will delay the entire project)
  - The start and end date of the whole project

Project Management – When you can use it

- ✓ Project Management is not just used for designing a product or a service
- ✓ You can use PM every time you have a specific time – frame to respect and you have to organise resources to achieve some clearly defined objectives

- ✓ Examples:
  - You want to implement in six months a complex automated warehouse
  - You want to develop in ten months a new wholesale distribution in Vietnam
  - You want to implement Lean Production achieving an increase of EBIT by 3% in twelve months
  - You want to open a new retail shop in Paris by the end of the next year
  - Etc.

Product/Process Design – Concurrent Engineering (CE)

- ✓ You can also use Project Management for CONCURRENT ENGINEERING
- ✓ **CONCURRENT ENGINEERING (CE)** is a systematic approach to the integrated, concurrent design of products and their related processes, including production, logistics and after-sales support. The different work-packages and activities run simultaneously in parallel, rather than consecutively in series.
- ✓ CE has been mainly used for reducing **Time To Market (TTM)**
- ✓ TTM is the length of time taken from product idea to the launch of production. It is a strategic issue for competition
- ✓ CE is also important for cutting product costs and increasing quality
- ✓ CE is also based on **DFx (Design For X)** methodologies

Operations Management – Product/Process Design/Development

Product design and development

Process design and development

- ✓ Product Design outputs (Drawings, technical specifications, BOM, etc.)
- ✓ Process Design outputs (process flow and layout)
- ✓ Process instructions and Control Plan
- ✓ Packaging specifications and instructions
- ✓ Design Controls - Risk Analysis (DFMEA and PFMEA) and DFx
- ✓ Robust Design
- ✓ Prototyping
- ✓ Etc.

Product/Process Design – Design outputs

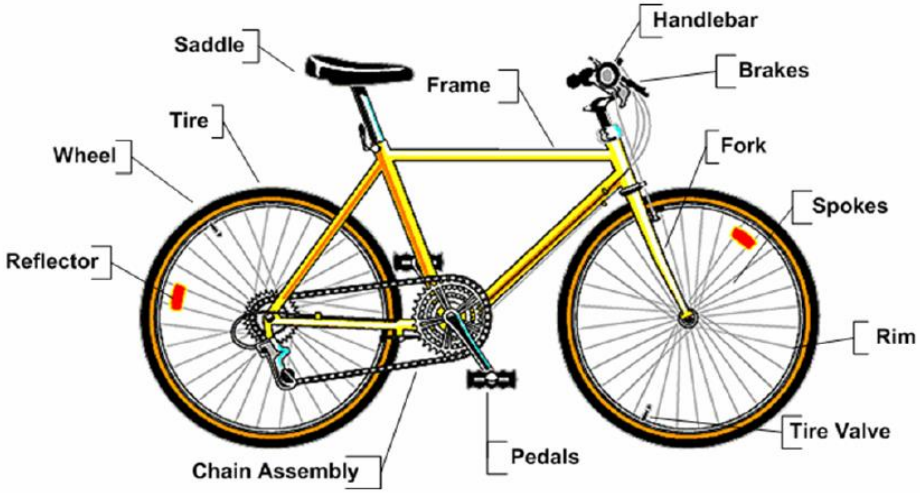
Product and process design generates several output, these usually are, depending on the kind of industry:

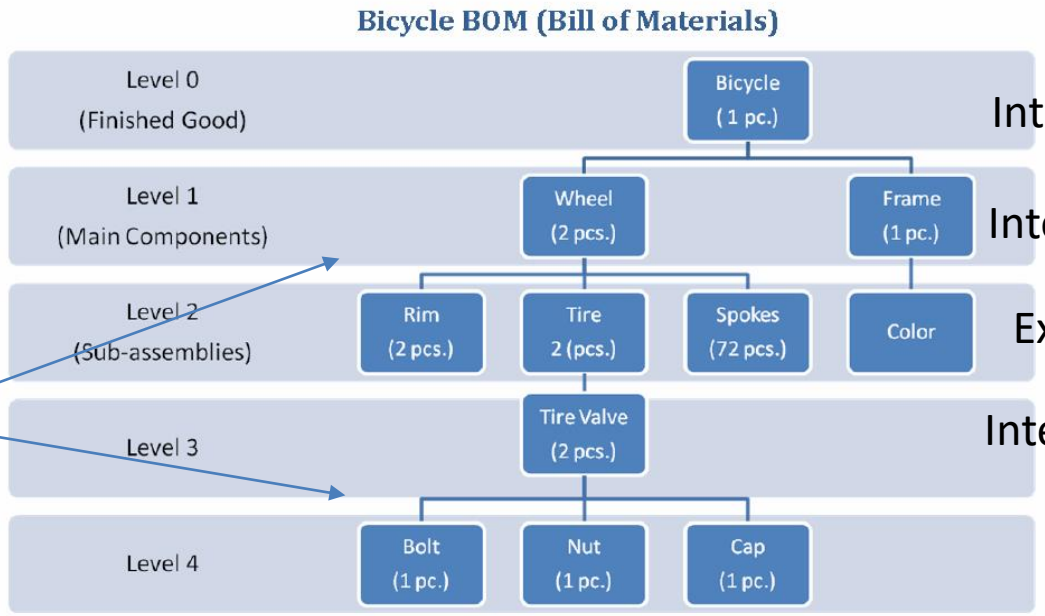
- **Technical drawings** (for instance using CAD software), typical of mechanical industry
- **Bill Of Materials** (BOM), list of the product components and how they are worked
- **Recipes**, list of ingredients or chemicals and their quantities which compose the product (e.g. food, beverage, drug, etc.)
- **Formulae**, list of chemicals with specific chemical formula
- **Specifications** and technical requirements, documents which refer to technical and quality characteristics of a product/component (e.g. steel hardness, electric specifications of a switch, of hardware, etc.)

- **Process flow**, a diagram which lists and links all the production processes needed to make the product (machines and assembly/manual stations)
- **Process layout**, disposal/arrangement of the production processes within the plant
- **Packaging specifications** and instructions, type of packaging used for logistics activities and instructions for handling it

All Design outputs are usually verified an re-examined during the design process (Design controls)

The Bill Of Materials – Design outputs





Internal Assembly

Internal Assembly

External supplier

Internal Assembly

External suppliers

Andrea

Product/Process Design Controls – FMEA (Risk Analysis)

- ✓ Developed by military and aerospace industry in the 1950s to study problems that might arise from malfunctions of military systems. The methodology has been particularly used by NASA (Failure is not an option !)
- ✓ **FMEA (Failure Modes and Effects Analysis)** is a **preventive** and systematic methodology for identifying all possible failures in a complex situation
- ✓ It can be applied for designing a product or a service
- ✓ Failure modes means the way, or modes, in which something might fail.
- ✓ **Failures** are any errors or defects, especially ones that affect the customer and other involved parties. Failures can be potential or actual
- ✓ **Effects analysis** refers to studying the consequences of those failures to the customer and/or the end-user of the product/service (or another party)

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Product/Process Design – FMEA – Case study

A company located nearby Bologna (Italy) manufactures caps for the automotive and truck sector. They are designing a new cap along with its production process and they want to evaluate the potential risks of this product to the end-users (drivers) in case of failures. In particular within the cap there is a spring that in the past gave some problems. Applying FMEA:

1 – Ask yourself: how can the component fail? (One component at a time)

2 - Try to evaluate: what are the effects on the customer/end user ?

3 – Analyse: what are the root-causes of the failure?

4 – Ask yourself: what are the current controls for avoiding it?

5 – Calculate the RPN indicator

6 – Riduce RPN by means of preventive/corrective actions

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Product/Process Design – DFMEA (Design FMEA) PFMEA (Process FMEA)

Component /Process	Failure Modes	Effects	Failure mode causes	Current controls	O	S	D	RPN
Internal spring	Spring loosened	Fuel could leak from the tank	Wrong calculations of the hardness	No checks at all	2	9 	10	180
Final assembly	Blocked	Cap does not allow air to escape. Tank could blow up	Wrong assembly	Final inspection	2	10 	5	100

Part of the Product or part of the process

Causes of the failure. We have to find what the root-causes are

Kinds of checks and inspections we currently have during the design process or during production

Product/Process Design – Design Controls - FMEA

O – OCCURRENCE: For each cause we have to determine the occurrence rating. This rating estimates the probability of failure occurring for that reason during the lifetime of the product/service. Occurrence is rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable

S – SEVERITY: it determines how serious each effect is. Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic for the end-user or customer (i.e sudden accident, people wounded, death)

D – DETECTION. This rating estimates how well the controls can detect either the cause or its failure mode after they have happened but before anyone or anything could be affected. Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists)

RPN - RISK PRIORITY NUMBER. It is equal to S × O × D and varies from 1 to 1000. Also we can calculate **CRITICALITY** by multiplying Severity by Occurrence, S × O. These numbers provide guidance for ranking potential failures in the order they should be addressed

Product/Process Design – Design Controls FMEA

When Severity is very high (9 or 10) we can talk of **CRITICAL CHARACTERISTICS (CCs)**

So , in our example the hardness of the spring (which can be measured) is considered a Critical Characteristics (It is a particular kind of CTQ)

Critical characteristics are measurements or indicators that reflect **safety or compliance** with government regulations and need special controls

When RPN is equal or more than 18 (2x9x1 or 1x9x2) we must put in place corrective action for reducing RPN value. For instance we can try to reduce O from 2 to 1 redesigning the part of the product or we can try to reduce D (if possible) putting in place more controls

When the effect can lead to a dissatisfaction of the customer (Severity from 2 to 8) we can talk of **Critical To Quality (CTQs)** characteristics. When S is equal to 9 or 10, CTQs are equivalent to CCs

In any case we have to prioritise causes through the RPN value and try to reduce it

FMEA – Risk Analysis methodology for different situations

Nowadays FMEA is one of the most used **Risk Analysis** methodology

FMEA is not just used for product risks. Every time there is risk and we want to evaluate and prioritise this risk we can employ FMEA

Examples, environmental risks:
We want to evaluate the risk of dioxins emission in atmosphere from a certain chimney

Plant Point	Potential Environmental impacts	Effects	Causes	Current controls	O	S	D	RPN
Chimney 4	Dioxins emission in large quantity (more than law limits)	Possible skin lesions Fines and immediate plant closure	Filters not changed	Monthly check	2	10	2	40
			Filter damaged	Monthly check	1	10	2	20

Health and safety risks:
We want to e evaluate the risk of operators' fall from a very high crane

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Product/Process Design – Design Controls - Design For X

- ✓ **Design For X** are a series of methodologies for better integrating marketing, product and process design, production, logistics and other processes that usually do not interact with each other

Marketing idea

Engineers' idea

Real production output !!

- ✓ Manufacturing and production issues are often ignored or omitted in early design steps. In the traditional approach Marketing is only focused on 'saleable' products and Design on sturdy and solid products

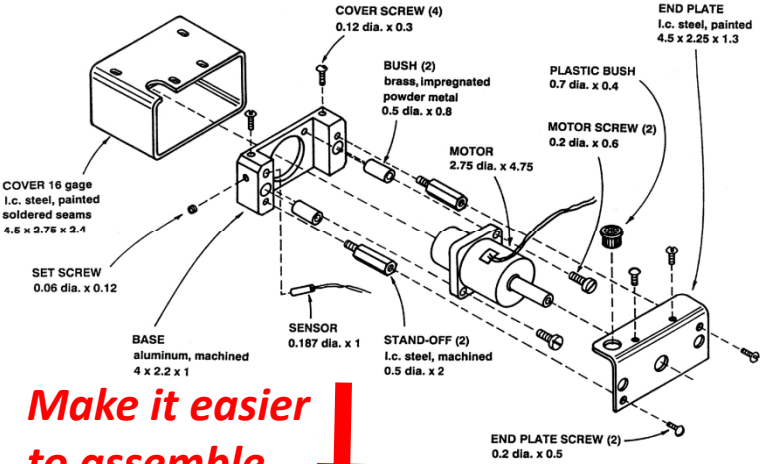
- ✓ DFX methodologies are basically **Team-Working**

Product/Process Design – Design For X

- ✓ The DFX family started with DFA (Design For assembly) but continues to increase in number as fostered by the need for better decision making in particular related to manufacturing. Manufacturing and production issues are often ignored or omitted in early design steps
- ✓ The DFX family is also one of the most effective approaches to implement concurrent engineering (Time-To-Market reduction)

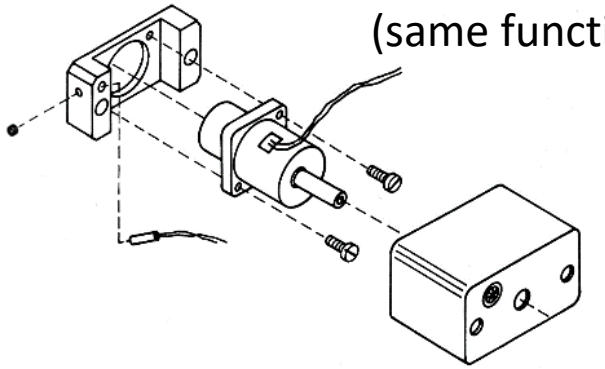
DFX Methodology	Scope
DFA-Design For Assembly	Designing products with **less and more standardised components** in order to reduce assembling times and to ease activities to operators
DFM-Design For Manufacturing	Designing products with more **machinable** components (materials, tolerances, kind of geometry, etc.)
DFL- Design For Logistics	Designing products and packaging easier to move, carry, storage and preserve
DFRM – Design For Reliability and Maintainability	Designing products more reliable during life-cycle and easier to maintain and repair
DFE – Design For the Environment	Design for ease of recycling, reuse, energy and resources consumption, etc.

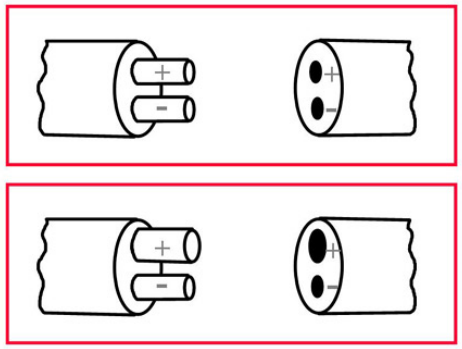
Product/Process Design – Design For X – Examples



Make it easier to assemble

From 19 to 6 components (same function)





Make it easier to assemble

Make it greener

More recyclable parts

Make it easier to repair

The shortest machine time

The longest machine time

Make it easier to machine

Make it easier to transport

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Product/Process Design – Design For X

Every time you make a change, you take a risk !!

Evaluate the potential introduced risk by means of FMEA

EXERCISES (FROM PREVIOUS WRITTEN EXAMS)

1. Project Management is a particular methodology:
1. for planning and scheduling activities related to complex projects
2. that allows managers to identify the so called critical-path
3. for capturing the Voice Of the Customer
4. that transforms the 'whats' into 'hows'

2. The following departments typically belong to operations management:
1. Engineering Department
2. HR Department
3. Finance
4. Warehouse Management

3. Break-even analysis is important because:
1. allows the company to evaluate the total amount of time for producing a product
2. allows the company to calculate the quantity of products to sell to cover its total costs
3. can be calculated as the quantity when total revenues are equal to fixed costs
4. can be calculated as the quantity when variable costs are equal to fixed costs