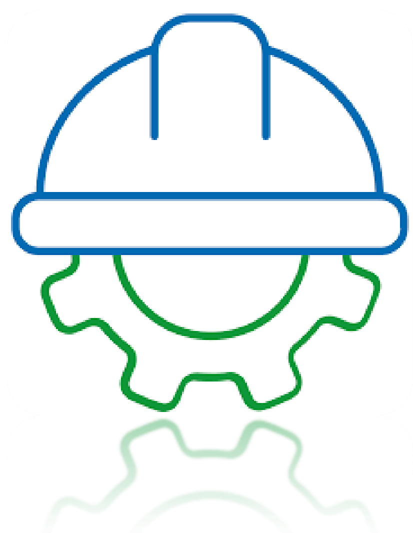
# Methods and Tools for Quality Engineering



Lecturer Eng. Sabina Potra, PhD

# Introduction to Quality Engineering

- Quality = excellence in a product/service that fulfils or exceeds the expectations of the customer

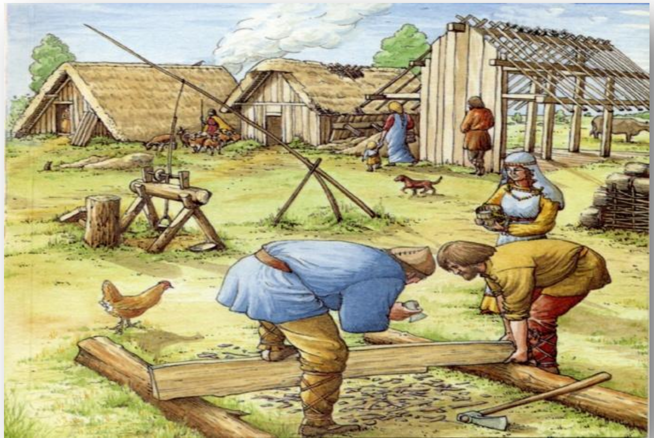
- The quality policy starts from top management and should be a guide to everyone in the company

# Introduction to Quality Engineering

Pre-industrial age:

- Craftsmen sold directly to end users – the workman could control the quality of his own product

- In middle ages (1200-1800) – guilds which took the responsibility of quality control (punishments for members who turned out shaddy products)

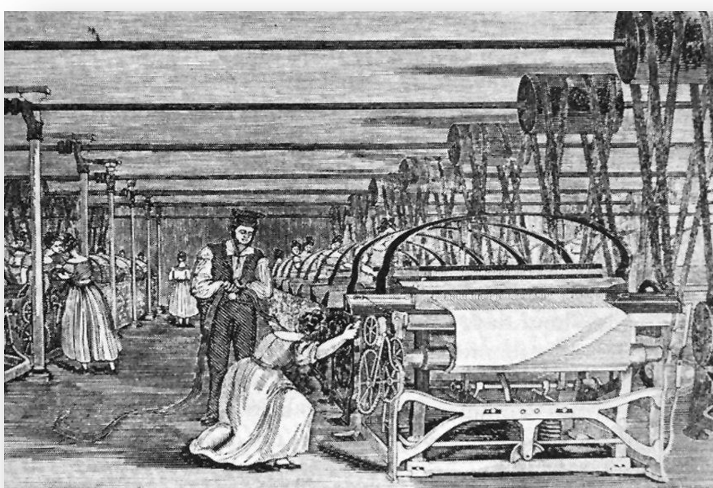


# Introduction to Quality Engineering

Industrial Revolution:

- Manufacture of interchangeable parts required at least a rudimentary inspection activity to endure that the parts fit together

- Large groups of men performing a similar type of work were grouped together under the **supervision** of a foreman (responsibility of quality control)



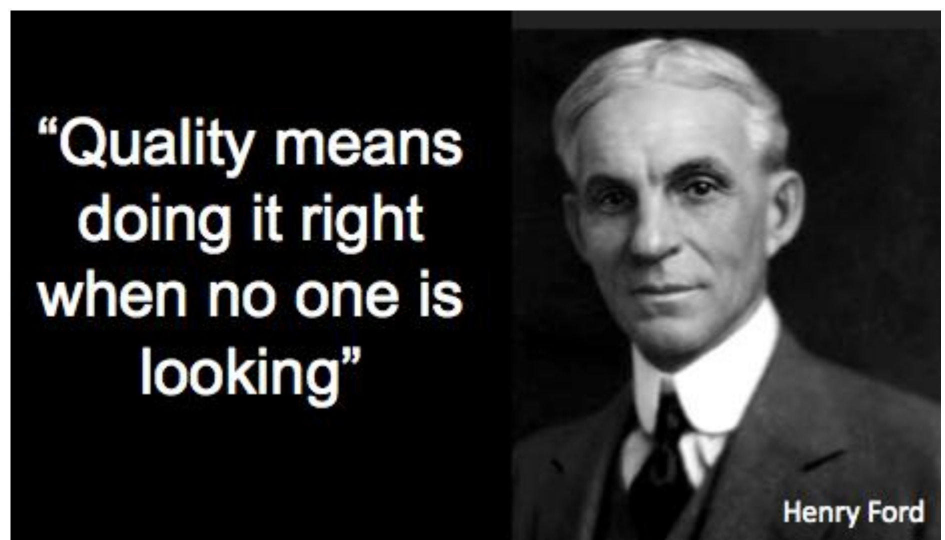
Power Weaving 1836

# Introduction to Quality Engineering

Industrial revolution:

- In the early 1900s, mass production methods were pioneered by Henry Ford and the management system adjusted accordingly (task specialisation, assembly lines, standardised parts, high level of control)

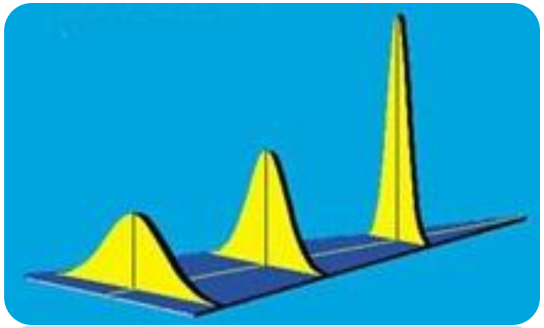
- Inspector title appeared (the last person on the assembly line) – the **inspection-oriented** quality organisation (between WWI and WWII)



# Introduction to Quality Engineering

Shewhart Walter A. at Bell Labs provided a scientific means of preventing defects through **process control**: the statistical quality control chart (1925)

Shewhart's methods of statistical process control supplimented by other statistical methods developed during the 1930s and 1940s became known as **Statistical Quality Control (SQC)** methods



# Introduction to Quality Engineering

- Process control with engineers (job title: **quality control engineer**) + separate department: the quality engineering department

- Quality engineering reported to **quality control manager**

- The complexity of products and systems increased – failures have been determined unrelated to manufacturing but in the design (reliability engineering)

- As consumers gained political strenght, legislation was passed making effective **quality control a requirement**

# Introduction to Quality Engineering

- Regulatory bodies imposed standard requirements for quality control + the creation of the Consumer Product Safety Commission (advocates for consumers)

- Recalls of defective products vecame common place, costing manufacturers billions of dollars + suits agains them

**VISIBILITY OF QUALITY**


# Introduction to Quality Engineering

The Japanese approach to quality management:

- WW 2 – Japanese plagued with quality problems – they translated works on Statistical Quality Control methods into Japanese
- A series of seminars conducted in 1950 by Dr. W. Edwards Deming, an American statistician and quality expert – the real push for implementing modern quality control methods (the philosophy was assured to top management)
- The Japanese have honored Deming by naming their most prestigious industrial award in his honor, the Deming Prize

**+ free exchange of ideas**

# Introduction to Quality Engineering

**Deming's 14 Obligations of Top Management**

1. Create Consistency of Purpose
2. Adopt a New Philosophy
3. Cease Dependence on Inspection
4. Stop Awarding Business based on $$ Alone.
5. Continuous Improvement of Production Processes
6. Modernize On The Job Training
7. Institute Leadership
8. Drive out Fear
9. Break Down Department Barriers (Silos)
10. Eliminate Slogans that do not provide a Method
11. Eliminate Quotas & Work Standards
12. Remove Barriers that rob Pride from the Individual
13. Institute Programs for Education & Training
14. Structure Management to focus on 1 - 13

# Introduction to Quality Engineering

## American versus Japanese contribution to Quality Control

| American contributions | Japanese contributions |
|---|---|
| Statistical quality control methods (pre WW2) | New techniques: quality circles, fishbone diagrams, Taguchi methods |
| Deming's philosophy (1950) | Long-term orientation to management |
| Juran's approach to quality management (1954) | Externally focused management (customers, competition, government, society) |
| Feigenbaum's total quality control approach | Companywide involvement in Quality control |

# Introduction to Quality Engineering

Both American and Japanese companies were using the same techniques and technology.

What was different? Why Japanese products were considered more efficient, more qualitative?


# Introduction to Quality Engineering

According to Kaoru Ishikawa (1985), the Japanese approach to quality was different :

- Companywide quality control: participation by all members of the organisation in quality control (QC)
- Education and training in QC
- QC circle activities
- QC audits (Deming prize audits and presidential audits)
- Utilization of statistical methods
- Nationwide QC promotion activities

# Introduction to Quality Engineering

## QUALITY FOR ....

| AMERICANS | JAPANESE |
|---|---|
| Defined by the producer (if the product conforms to engineering requirements) | Defined by the customer (the organisation has the responsibility to society) |
| Quality – negative viewpoint (the absence of undesirable attributes) | Quality – positive viewpoint (the presence of desirable attributes) |
| Backward-looking | Forward-looking |
| AQL – acceptable quality level | Perfection |

# Introduction to Quality Engineering

- With the Japanese extension of statistical tools, in 1960-1970 a new concept emerged, that of Quality Assurance

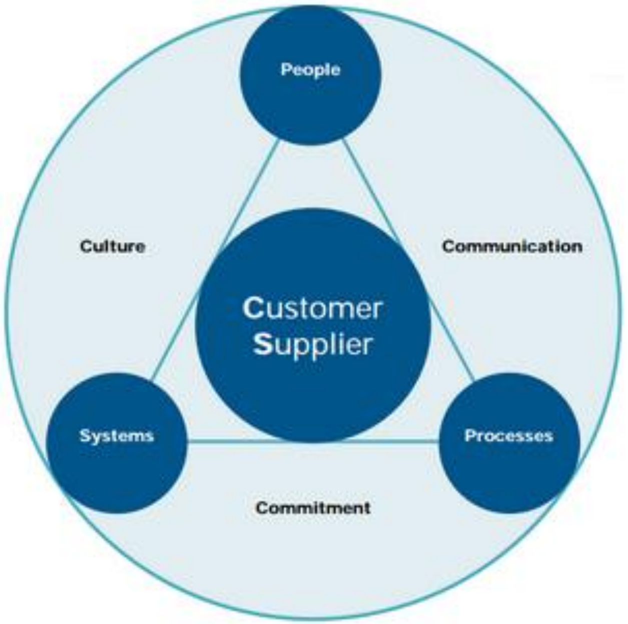
- **Quality Assurance** = control integration in production and product design for an integrated control (emphasis on **prevention** with a wide range of **controled activities** and many persons/departments involved)

# Introduction to Quality Engineering

- With the 1990s European but mainly American companies started reexamining the techniques of quality control in an attempt to outclass Japanese quality products – The **Total Quality Management** (TQM) term appeared.

- TQM = methods and approaches at an organisational level, based on participatory management in which employees continuously improve processes, abilities and systems in order to provide value to customers.

# Introduction to Quality Engineering




Applying TQM means:

- a mentality shift (own work optimisation, **client orientation** and error prevention)

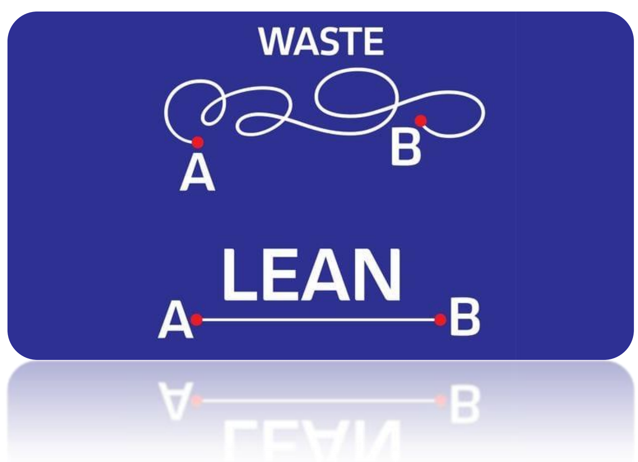
- a work environment shift (work relationships based on communication, trust, collaboration, discipline and attachment to the company)

- a **continuous improvement** shift ( periodic performance indicators establishment, improvement ideas from employees, continuously improved quality requirements)

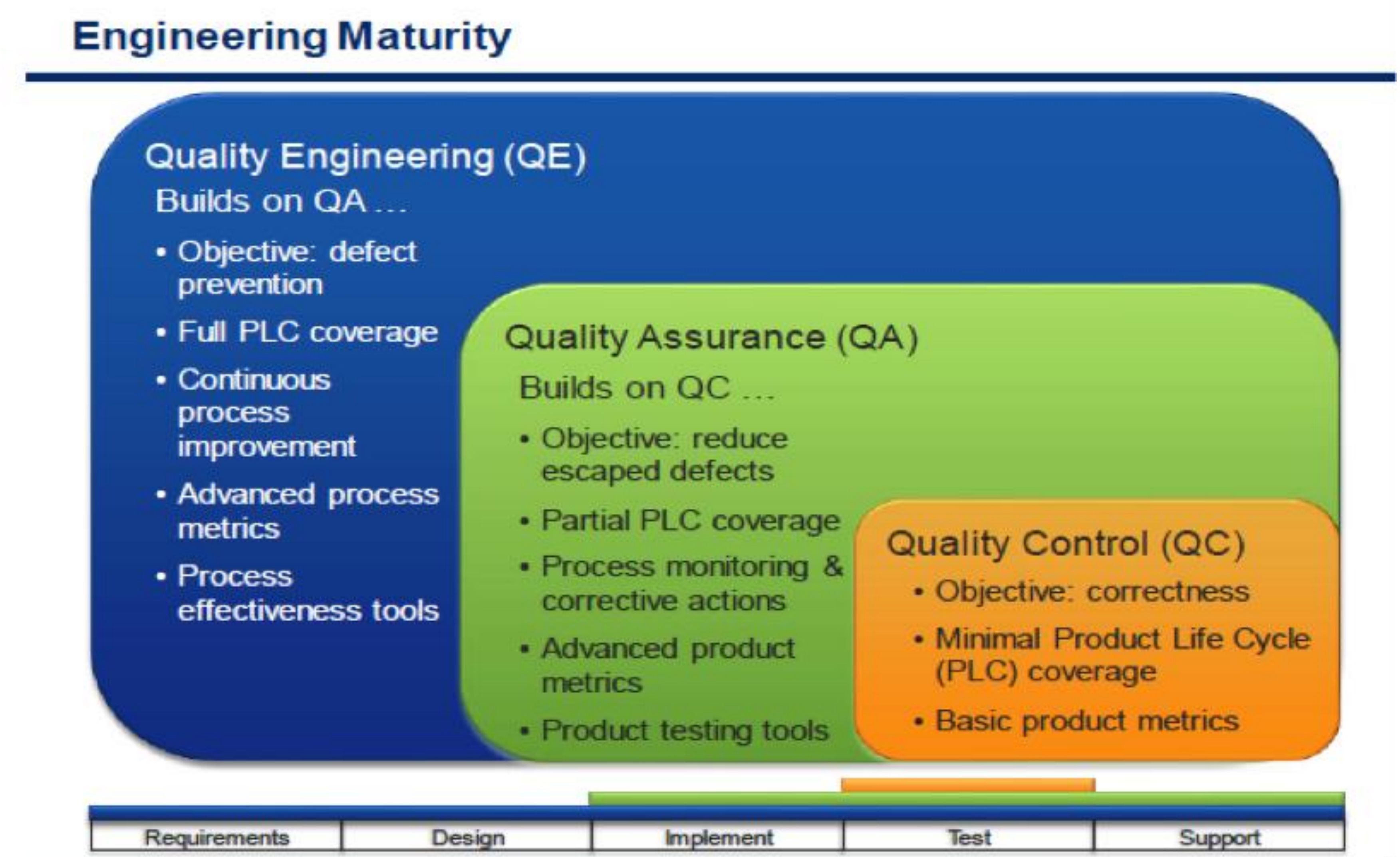
# Introduction to Quality Engineering

Total Quality Management has been overshadowed in time by:

- ISO 9000 (a family of quality management system standards)
- Lean Manufacturing (minimization of waste method)
- Six Sigma methodology (a set of techniques and tools for process improvement)


# Introduction to Quality Engineering



# Introduction to Quality Engineering

- quality concepts -


Quality circles (a Japanese contribution):

- a participatory management technique that enlists the help of employees in solving problems related to their own jobs
- a small group of people (6 - 12) that meets periodically to perform QC and improvement activities
- a voluntary and permanent group comprised of people from the same work space area based on the people-building philosophy (self-motivation and hapiness in improving corporate environment without any compulsion or monetary benefits)
- based on the assumption that workers place their loyalty to the firm above their family

# Introduction to Quality Engineering

- quality concepts -


Quality circles (a Japanese contribution):

- Nippon Wireless and Telegraph – the first company to introduce quality circles in Japan 1962
- By 1978 Japan had more than 1 million circles involving approximately 10 million workers (JUSE – Japanese Union of Scientists and Engineers coordinated the QC movement)
- China adopted this technique and has today more than 20 million quality circles
- USA first adopted quality circles in 1974 through Lockheed Martin, a global aerospace, defense, security and advanced technologies organisation (which first saw them in a visit to Japan). After them, other US companies used the technique BUT some did not understand the function of quality circles and used them only for fault-finding exercises

# Introduction to Quality Engineering

- quality concepts -


Quality circles objectives:

- Change in attitude (from I don't care to I do care) – continuous improvement in quality of work life through humanisation of work
- Self-development – bringind out the hidden potential of people (learning additional skills)
- Team work – development of team spirit for eliminating inter departmental conflicts
- Improved organisational culture – total involvement of employees, higher degree of motivation, positive work environment
- Increased productivity and improved quality

# Introduction to Quality Engineering

- quality concepts -

## Just in Time:

- Definition: a production management methodology which consists of producing only those quantities of each item requested in a short period of time

- A "pull" system related to quality control, a production goal

- Objective: to operate without safety stock ( a narcotic drug that hides symptoms indicating something is wrong)

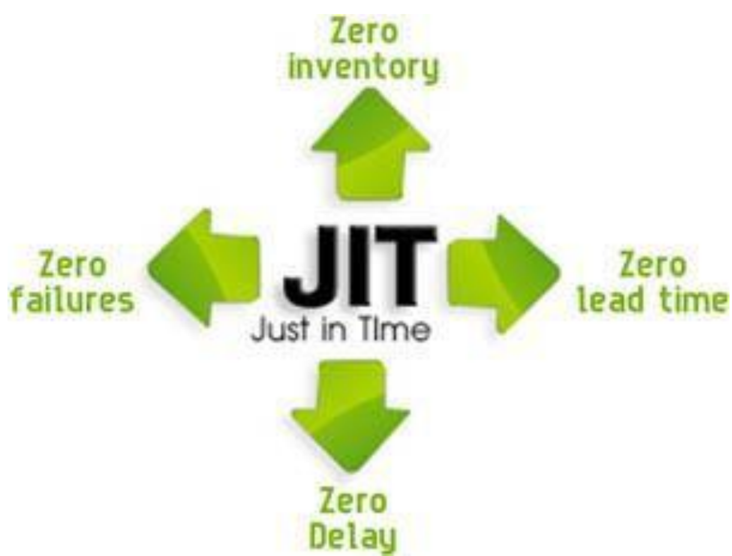
- Basic elements: cutting lot sizes, reducing setup times cutting purchase order costs

# Introduction to Quality Engineering

- quality concepts -

## Just in Time:

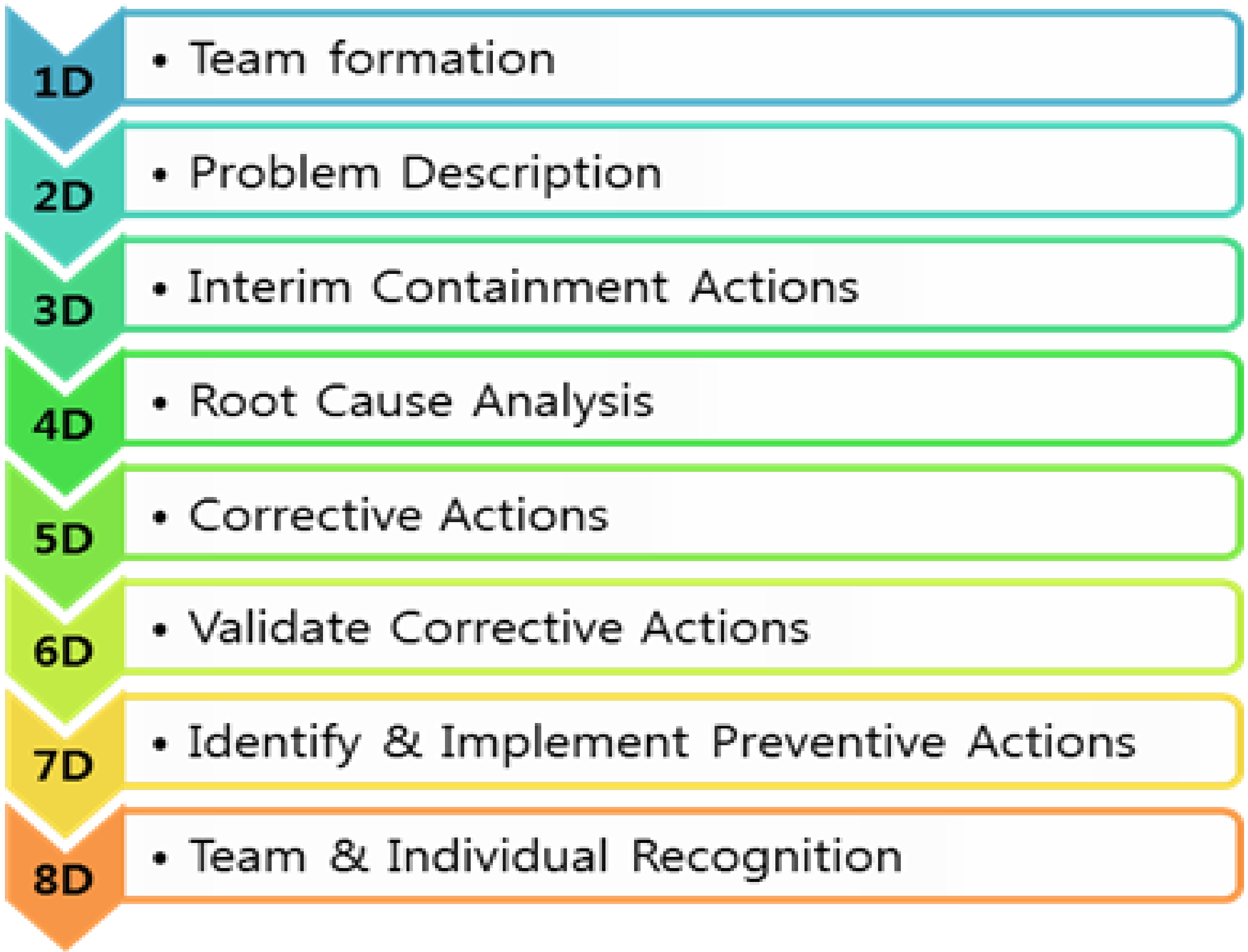
- Is part of a broader company wide effort which includes Total Quality Control (TQC), employee involvement and vendor involvement (close working relationships with a small number of suppliers)



# Introduction to Quality Engineering

- quality concepts -

## 8D

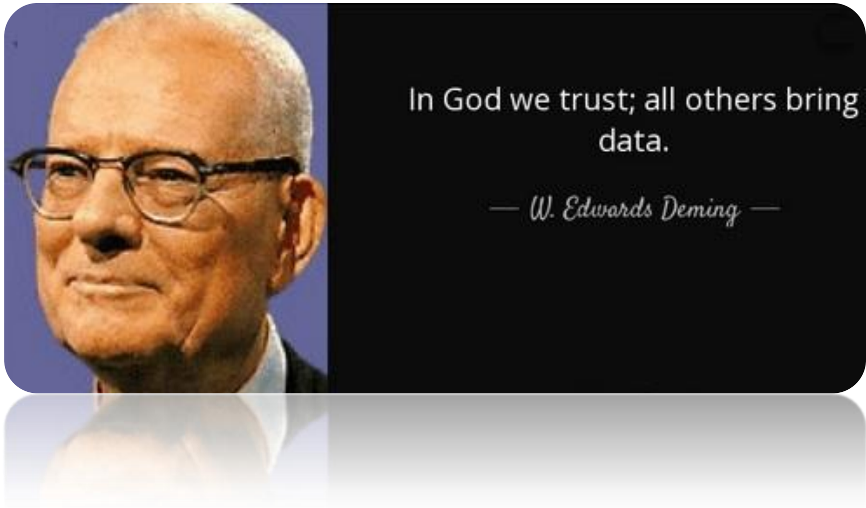


# Introduction to Quality Engineering

- pioneers -

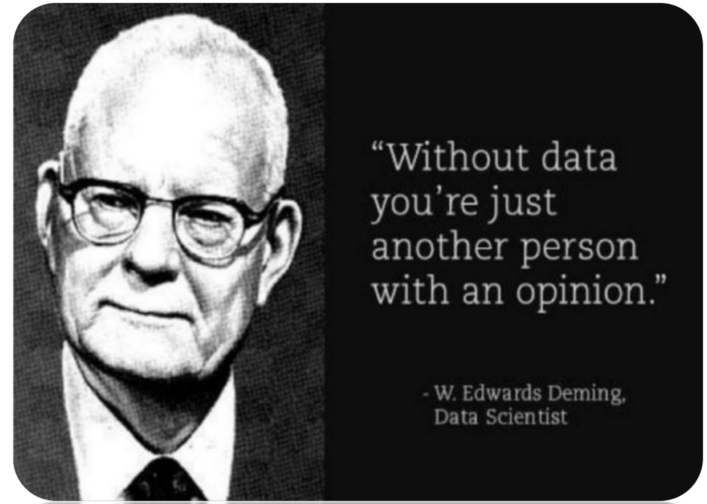
- W.E. Deming
- J.M. Juran
- A.V. Feigenbaum
- P.B. Crosby

# W.E. DEMING (1900-1993)



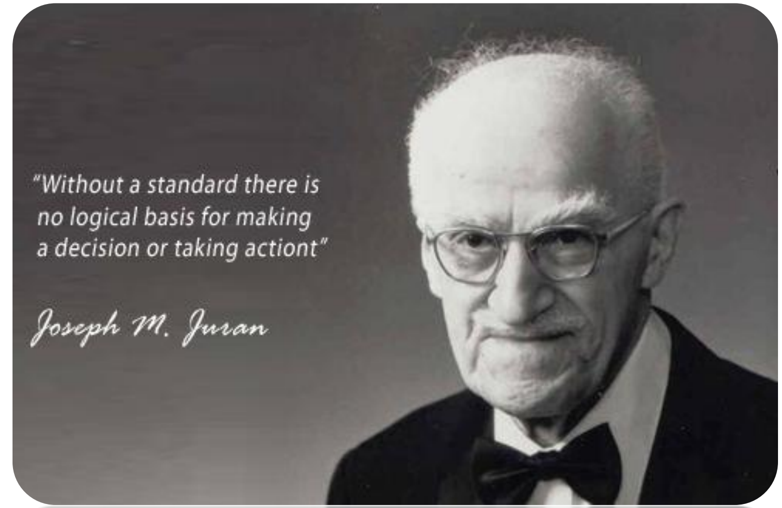

- He was a student of W.A. Shewhart and developed the ideas of his professor in his book “The Statistical Theory of Errors” (1934)
- In the 50s together with J-M. Juran develops several courses in Japan (in 1951 for his merits the national prize for quality receives his name)
- His 14 points program is his reference work (1982)
- He publishes in his book “ Out of the crisis” the Shewhart Cycle which evolved in the Plan-Do-Check-Act (PDSA) approach

# W.E. DEMING (1900-1993)



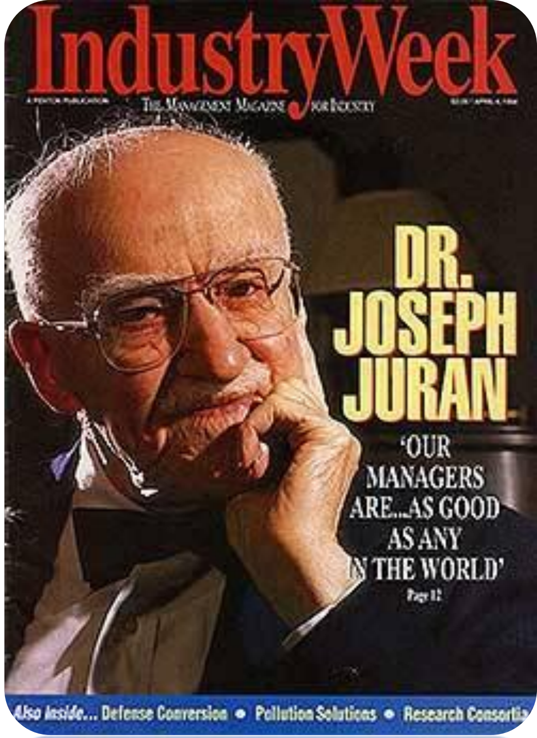

- The key to quality is in management's hands – 85% of problems are due to the system, 15% due to employees
- The heart of his quality strategy is the use of statistical quality control to identify special causes (erratic, unpredictable) and common causes (systematic) of variation
- Statistical tools provide common language for employees throughout a firm and permit quality control efforts to be widely diffused

# J.M. Juran (1904-2008)




- the "father of modern day quality management"
- Born in Braila, Romania, emigrated in the US in 1912 and became an American engineer and management consultant
- 1925 Juran took part of the Bell Labs statistical sampling and control charts techniques and was appointed to apply statistical quality control innovations
- Started courses in quality management for Japanese in 1954

# J.M. Juran (1904-2008)

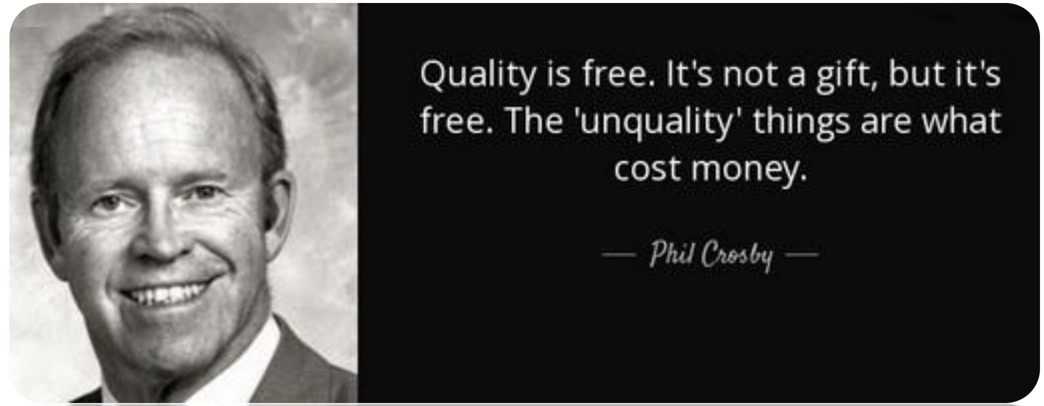



- defines quality as "fitness for use by the customer"
- Fitness is based on a product's availability, reliability and maintainability
- His " universal process for quality improvement" requires studying symptoms, diagnosing causes, and applying remedies
- He recommends project-by-project improvement and project selection based on their projected return on investment

For solving problems in a systematic way, Juran considered necessary to:

1) **Analyse the problem** – find the cause for the symptom
2) **Eliminate the cause** – determine the best therapy for solving the problem

| Juran's 10 steps to quality improvement | |
|---|---|
| 1 | Build awareness of opportunity to improve |
| 2 | Set-goals for improvement |
| 3 | Organize to reach goals |
| 4 | Provide training |
| 5 | Carryout projects to solve problems |
| 6 | Report progress |
| 7 | Give recognition |
| 8 | Communicate results |
| 9 | Keep score |
| 10 | Maintain momentum |




# P.B. Crosby (1926-2001)

- Argues that quality reduces costs because "doing it right the first time" is less expensive than the cost of detecting and correcting defects
- Careful tracking the cost of quality will pinpoint where the greatest improvement in quality is likely

| STEP NUMBERS | STEPS OF QUALITY IMPROVEMENT |
| --- | --- |
| 1 | Management Commitment |
| 2 | Quality Improvement Teams |
| 3 | Quality Measurement |
| 4 | Cost of Quality Evaluation |
| 5 | Quality Awareness |
| 6 | Corrective Action |
| 7 | Zero-Defects Planning |
| 8 | Supervisory Training |
| 9 | Zero Defects |
| 10 | Goal Setting |
| 11 | Error Cause Removal |
| 12 | Recognition |
| 13 | Quality Councils |
| 14 | Do It All Over Again |

# Comparison

| | Deming | Juran | Crosby |
|---|---|---|---|
| **Definition of quality** | Continuous improvement | Fitness for use | Conformance to requirements |
| **Emphasis** | Tools/system | Measurement | Motivation (behaviour) |
| **Types of tools** | Statistical process control | Analytical, cost-of-quality | Minimal use |
| **Use of goals and targets** | Not used | Significant emphasis | Posted goals for workers |

# Armand V. Feigenbaum (1921-2014)

- the "father of Total Quality Control" (known today as Total Quality Management), he first coined the term in 1956 in Harvard Business
- An American quality control expert (worked for General Electric) and businessman, his main contribution to quality thinking was his assertion that the entire organization should be involved in improving quality

# Armand V. Feigenbaum (1921-2014)

- He has a list of 9M's that directly influence the quality of products and services

- Markets
- Money
- Management
- Men
- Motivation
- Materials
- Machines and Mechanization
- Modern information methods
- Mounting product requirements

# Armand V. Feigenbaum (1921-2014)

– Quality is a company-wide process;

– Quality is what the customer says it is;

– Quality and cost are a sum, not a difference;

– Quality requires both individual and team zealotry;

– Quality is a way of managing;

– Quality and innovation are mutually dependent;

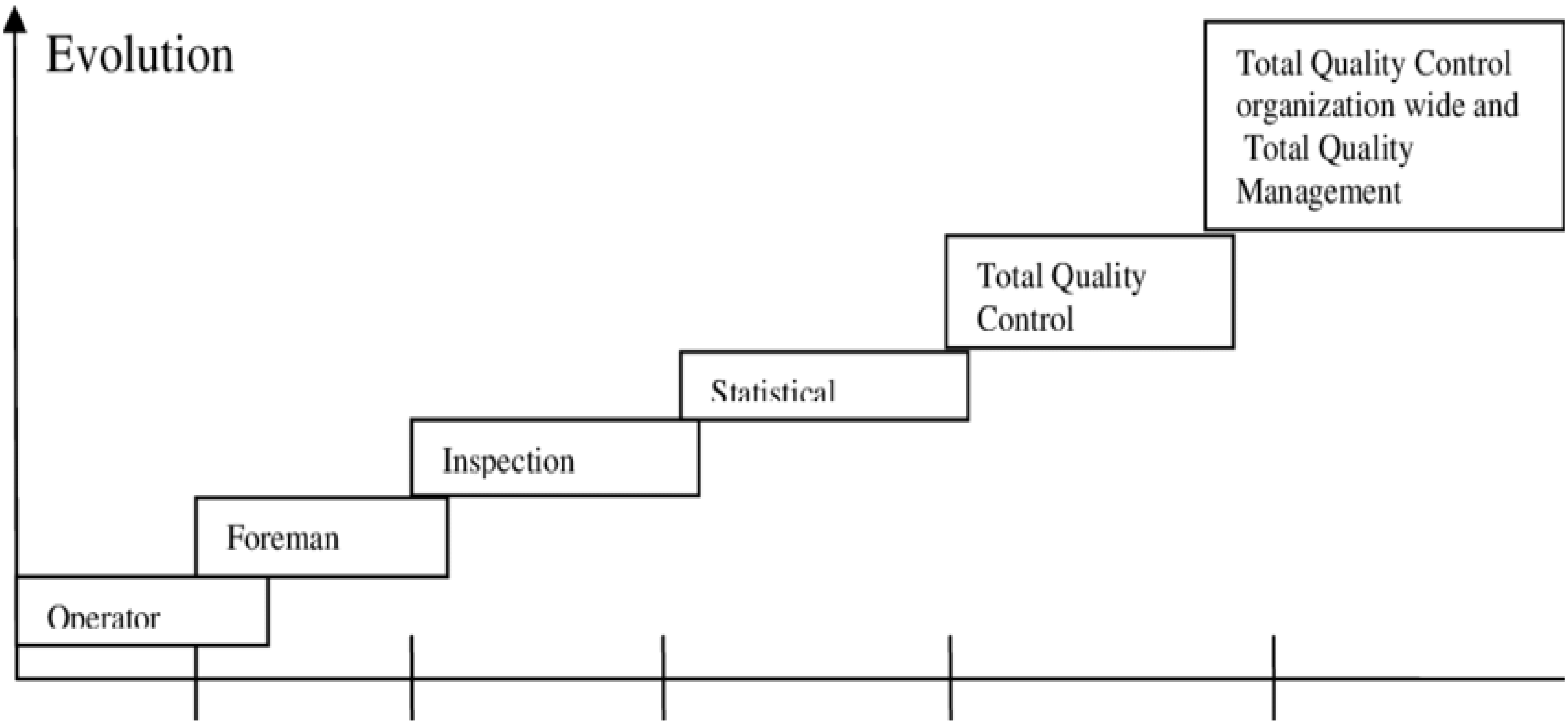
– Quality is an ethic;

– Quality requires continuous improvement;

– Quality is the most cost-effective, least capital-intensive route to productivity, and;

– Quality is implemented with a total system connected with customers and suppliers”.

# Armand V. Feigenbaum (1921-2014)



# Armand V. Feigenbaum (1921-2014)

Feigenbaum argued for training needs – employees need several skills to be effective participants in quality control and quality improvement efforts:

1. **Problem identification** (what are the quality problems?)

2. **Measurement of quality problems** (How serious is the problem?)

3. **Problem selection** (What problems are most urgent, costly, important?)

4. **Problem resolution** (Who can solve the problem? The individual worker, quality team, quality department, purchasing or management?)

# Introduction to Quality Engineering

- Selected problems can be tackled using an appropriate **problem solving techniques**

Employees need sufficient **training in problem solving methods** to effectively solve quality problems in their own work (reworking a defect, adjusting a piece of machinery) and, when appropriate, to participate in group problem solving as members of quality circles or work teams.

# Introduction to Quality Engineering

(quality costs)

The American Society for Quality Control (ASQC) divides quality costs into four separate categories:

A. **Prevention costs** – incurred to prevent the ocurrence of nonconformances in the future

B. **Appraisal costs** – incurred in measuring and controlling current production to assure conformance to requirements

C. **Internal failure costs** – generated before a product is shipped as a result of nonconformities

D. **External failure costs** – generated after a product is shipped as a result of nonconformities

# Introduction to Quality Engineering

(quality costs)

The quality cost system is primarily a management information system and its purpose is to guide management in its efforts to improve quality.

! You should not go to extremes trying to obtain to the penny accuracy, a good aproximation is best

# Introduction to Quality Engineering

(quality costs)

The basic factors of production are : land, labor, capital and management

**BUT** they also consitute the source of all costs !

# Introduction to Quality Engineering

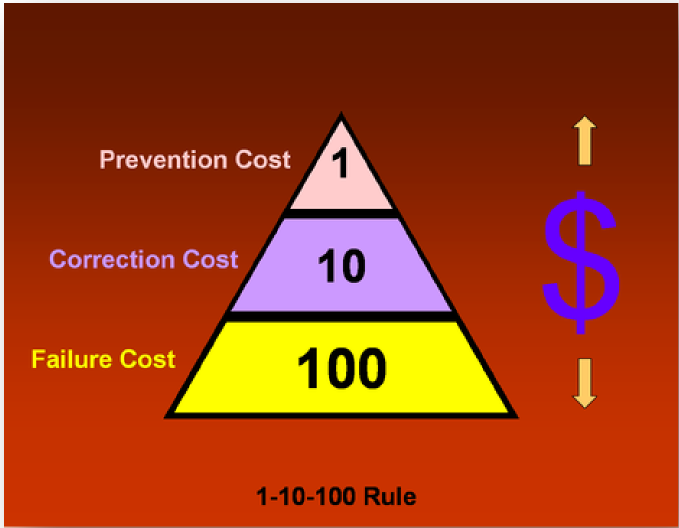
(quality costs)

Old mental models:

Increased input = increased output
(costs) (resulting production)

Increased sales = increased profit

! Failure costs



# Introduction to Quality Engineering

(quality costs)

There are two categories of investment that produce improved profitability:

- Research and development investment
- Investment in the reduction of failure costs

# Introduction to Quality Engineering

(quality costs)

Reduction of failure costs = more output is obtained from the same or less input

Opportunity cost = the dollar amount that would be derived from the employment of a factor of production in the best alternative use

**! Failure costs are opportunity costs**

**The rational way to improve competitiveness**

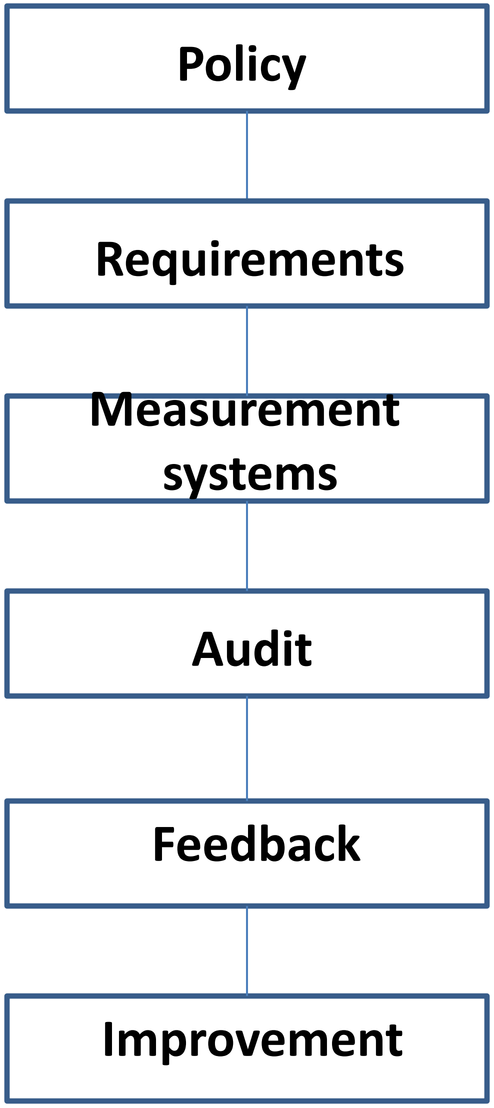
# Introduction to Quality Engineering

(quality costs)

# Quality audit

Total Quality System

(TQS) = a process that assures continual improvement while implementing the policy established by top management



# Quality audit

| | |
|---|---|
| **Policy** | Top management |
| **Requirements** | Processes, products, vendors for minimum variability |
| **Measurement systems** | Designs, quality costs, products, processes, services, customers, vendors, special studies |
| **Audit** | Management, quality control, consultants, vendors |
| **Feedback** | Quality Information Systems (QIS), Management by Wandering Around (MBWA), direct customer input, direct vendor input |
| **Improvement** | Redesign, training, new processes, new management systems |

# Quality audit

TQS Audit – purpose: to seek verification that an adequate system exists and is being adhered to.

1) Primarily responsibility for auditing TQS: **top management**

2) The **manager of each activity** must perform audits within his/her area to assure that the requirements are being met

**3) Third party audits** – by the quality department or auditors from outside the organization (They should not be a primary source of detailed information for management)

# Quality audit

Basic ground rules before audit:

1. Requirement – the existence of an requirement
2. Measurement means – the performance standard writtenn and communicated; the existence of an established means of measuring performance
3. Responsibility – the responsibility for action unambiguous

# Quality audit

**AUDITS** ---→**quantitative**: produce a score that indicates the degree of compliance of a program or quality system (normally conducted by third parties for an objective assessment)

---→**qualitative**: a generalized assessment of the effectiveness of a quality program (less formal, used for internal personnel, including management when auditing own operations)

# Quality audit

Audits serve many **purposes**:

- **Financial level** – they provide a means for evaluating the effectiveness of quality cost expenditures
- **Human resource level** – properly done, they can furnish a means for motivating people to higher level of performance
- **Management and risk assessment** – can be used as an early warning system to indicate potential trouble before it actually leads to a negative customer reaction

# Quality audit

Audits can also be classified according to just what is being audited:

1). **The quality program audit** – at the broadest level, it assesses the appropriateness of the quality program relative to the company policy and mission

2). **The quality system audit** – measures the overall effectiveness of the quality program and provides guidance for improving the effectiveness

3). **Audits of procedures** – determine the extent of compliance to procedures (they can uncover practices that are outdated/ineffective or the need for formal practices where none currently exist

# Quality audit

4). **Product audits** – can be conducted while the product is in-process or on a finished product, in-depth evaluations of small samples to determine the extent of compliance to established product requirements (from the point of viewof the end user)

5). **Process audits** – conducted to evaluate the conformance of materials and processes to established requirements

6). **Special audits** – commissioned by managers to obtain needed facts on their operations

(from opinion surveys to housekeeping checks)

# Quality audit


## The Quality Manual

- is a set of documents used to define an organization's Quality Management System (QMS)

- Needs to be constantly updated

- Has to be well thought out and customized to the company's particular need

**!** The emphasis is on clarity and common sense, not on an effort to document every conceivable eventuality

# Quality audit


Example:

1. A large defense contractor: over 350 pages with 68 ways to identify scrap material (red paint stamped with an “R”, a scrap tag, etc.)

OR

# Quality audit


Example:

1. A large defense contractor: over 350 pages with 68 ways to identify scrap material (red paint stamped with an “R”, a scrap tag, etc.):

- Difficulties because there were always new cases not allowed for in detail

- A government auditor complained about some defective microchips which were not properly identified (they were in a plastic bag with an appropriate tag **BUT** the parts themselves were not stamped with an “R”)

**WHY?**

Few people outside the audit department had ever read the Quality audit

# Quality audit


Example:

2. A medium-size electronics company: 45 pages, the scrap identification problem was handled by a single sentence stated: "Scrap material will be clearly and permanently identified".

OR

# Quality audit

## ISO 9000 ?

- first published in 1987 by International Organisation for Standardization (ISO) adopted as a suitable option for similar quality assurance requirements (The adoption of a single Quality Assurance requirement lead to cost savings throughout the supply chain by reducing the administrative burden of maintaining multiple sets of quality manuals and procedures)

- a family of quality management systems (QMS) standards designed to help organizations ensure that they meet the needs of customers/stakeholders while meeting statutory and regulatory requirements related to a product or service

- deals with the fundamentals of quality management systems

# Quality audit

**ISO 9000** – The 7 quality management principles:

# Quality audit

## ISO 9001

- is a standard that sets out the requirements for a quality management system. It helps businesses and organizations to be more efficient and improve customer satisfaction

- is based on the idea of continual improvement, suited for organisations of all types, sizes and sectors

- a new version of the standard, ISO 9001:2015, has just been launched, replacing the previous version (ISO 9001:2008) - more applicable and accessible to all types of enterprises.

# What benefits will it bring to my business or organization?

Implementing a quality management system will help you:

- Assess the **overall context** of your organization to define who is affected by your work and what they expect from you. This will enable you to clearly **state your objectives and identify new business opportunities**.

- Put your **customers first**, making sure you consistently meet their needs and enhance their satisfaction. This can lead to repeat custom, new clients and increased business for your organization.

# ISO 9001: benefits

- Work in a **more efficient way** as all your processes will be aligned and understood by everyone in the business or organization. This increases productivity and efficiency, bringing internal costs down.
- Meet the necessary **statutory and regulatory requirements**.
- **Expand into new markets**, as some sectors and clients require ISO 9001 before doing business.
- **Identify and address the risks** associated with your organization

# Why was ISO 9001 revised?

- All ISO standards are reviewed and revised regularly to make sure they remain relevant to the marketplace.
- ISO 9001 has been updated to take into account the different challenges that businesses now face.
- For example, increased globalization has changed the way we do business and organizations often operate more complex supply chains, and there are increased expectations from customers.
- ISO 9001 needs to reflect these changes in order to remain relevant.

# Quality audit

Worldwide total of ISO 9001 certificates (end of each year)

| 2000[28] | 2001[28] | 2002[28] | 2003[28] | 2004[29] | 2005[29] | 2006[29] | 2007[29] |
|---|---|---|---|---|---|---|---|
| 409,421 | 510,616 | 561,747 | 567,985 | 660,132 | 773,867 | 896,929 | 951,486 |
| **2008**[30] | **2009**[30] | **2010**[31] | **2011**[31] | **2012**[32] | **2013**[33] | **2014**[33] | |
| 982,832 | 1,064,785 | 1,118,510 | 1,111,698 | 1,096,987 | 1,126,460 | 1,138,155 | |

Top 10 countries for ISO 9001 certificates (2014)[32]

| Rank | Country | No. of certificates |
|---|---|---|
| 1 | China | 342,800 |
| 2 | Italy | 168,960 |
| 3 | Germany | 55,363 |
| 4 | Japan | 45,785 |
| 5 | India | 41,016 |
| 6 | United Kingdom | 40,200 |

# Quality Planning

The act of planning is **thinking out in advance** the sequence of actions to accomplish a proposed course of action in doing work to **accomplish certain objectives.**

So that the planner may communicate the plan to the person(s) expected to execute it, the plan is written out with necessary diagrams, formulas, tables, and so on.

Feigenbaum, 1983

# Quality planning tools

(especially for the **design stage** of products and services)

The quality planner has many techniques available:

1. Design review procedure
2. Failure Mode and Effects Analysis (FMEA)
3. Fault Tree Analysis (FTA)
4. ...

# Quality planning tools

## - Design review procedure-

- Used for product design or process design
- Purpose: to prevent unpleasant surprises after the design is completed
- Componence of the review team (all experts):

reliability: Will the failure rate be sufficiently low?

quality engineering: Can it be adequately inspected/tested?

field engineering: are proper installation, maintenance, and user handling features included in the design?

procurement: Can the necessary parts be acquired at appropriate cost & delivery schedule?

materials engineering: Will the materials selected perform as expected?

tooling engineering: Can the specified tolerances be satisfied by available tooling?

packaging engineering: Can the product be shipped without damage?

# Quality planning tools

## - Failure Mode and Effects Analysis (FMEA)-

- An important analytical tool to help prevent expensive failures
- Provides the design team with a methodical way of anticipating and heading off these failures
- Consists of:

1. **identify** each way (**mode**) the product/process can fail
2. **identify** all the possible **effects**/outcomes that can occur (for each mode)
3. **estimate** the **probability of occurence** and the probable cost of the occurence in tabular form

# Quality planning tools

## - Failure Mode and Effects Analysis (FMEA)-

- EXAMPLE – A match has 2 failure modes:

1. It can fail to ignite when struck

2. It can ignite when unwanted

**The EFFECTS?**

# Quality planning tools

## - Failure Mode and Effects Analysis (FMEA)-

- EXAMPLE – A match has 2 failure modes:

1. It can fail to ignite when struck

2. It can ignite when unwanted

**Effect**: 1. the user tosses it aside ad tries another match
2. could be **catastrophic**

**What can we do?**

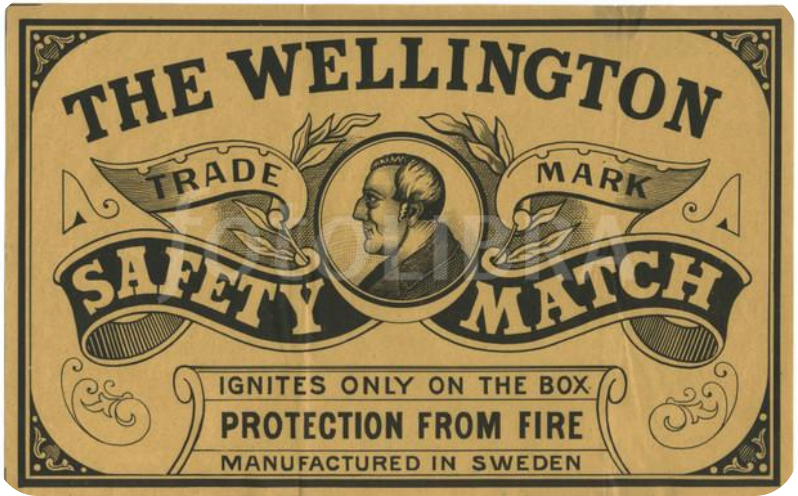
# Quality planning tools

## - Failure Mode and Effects Analysis (FMEA)-

The match MUST be designed to minimize the chance of the second mode of failure

**EVEN** at the expense of the inconvenience due to the first mode of failure

+ Packaging and warning labels (to reduce the probability of an unwanted match ignition



# Quality planning tools

## - Fault Tree Analysis (FTA)-

- Complementary to FMEA

- Identifies all the undesired events that could occur to the product (works backward to identify the cause of each event)

- A trouble and remedy diagram that illustrates the probable causes of each symptom of system failure

! FTA provides a checklist for managers to seek corrective action or develop improvement activities

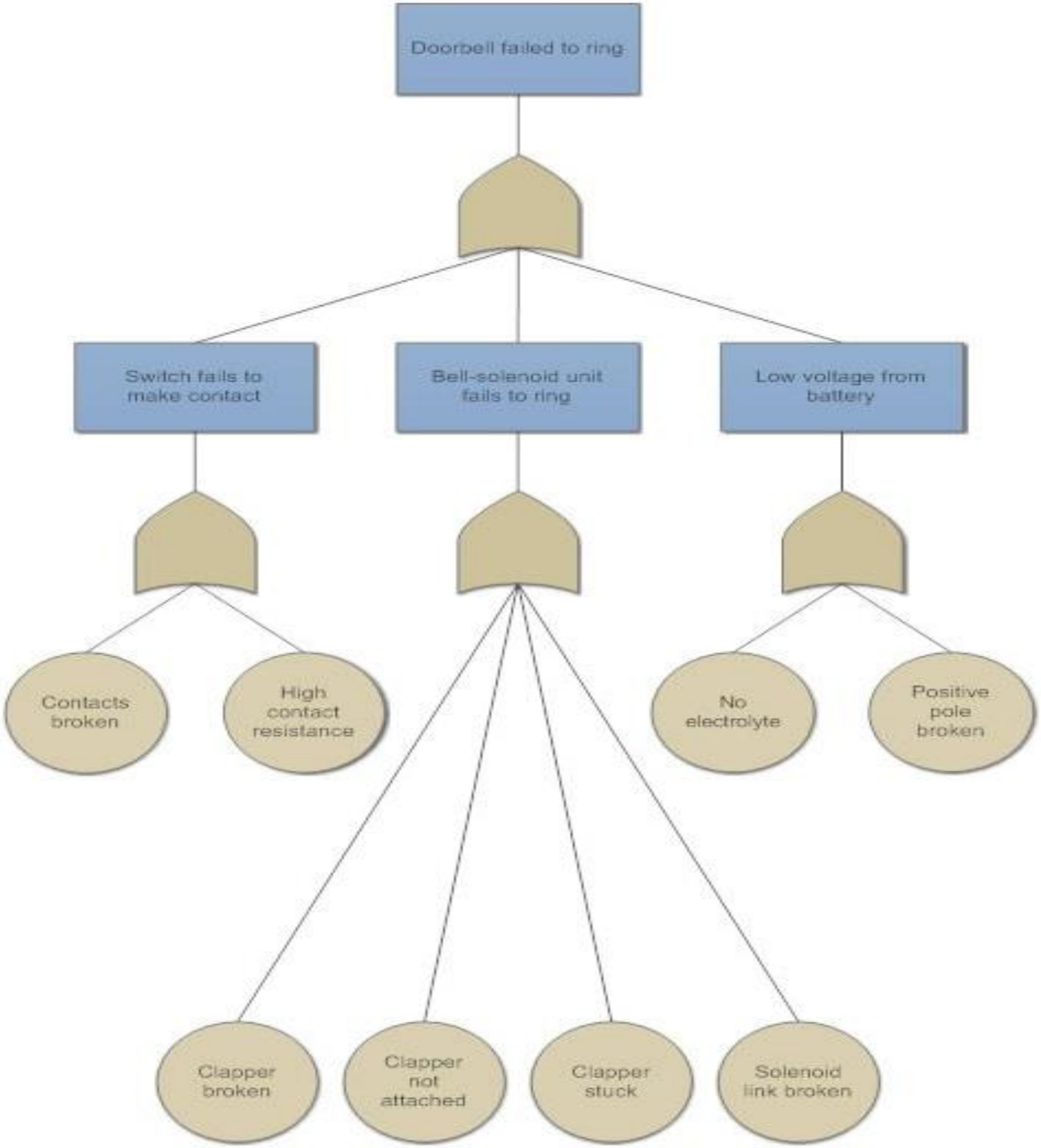
# Quality planning tools

## - Fault Tree Analysis (FTA)-

FTA will help prioritize issues to fix that contribute to a failure.

It creates the foundation for any further analysis and evaluation.

You can use a fault tree diagram to help you design quality tests and maintenance procedures.



# Statistical Process Control

- represents a set of techniques for use in the improvement of any process
- involves the systematic collection of data related to a process and graphical summaries of that data for visibility
- is quantitative problem solving consisting of diagnostic techniques to assist in locating problem sources and prescriptive techniques to help solve problems
- Is also a tool for communicating information to engineering, product operations and quality control personnel

# Statistical Process Control

The use of SPC will show that a process is:

- in control – the process variation appears to be random
- out of control – the process exhibits non-random variation
- improving as a result of planned reductions in process variation and/or moving the process average closer to a desired target

# Statistical Process Control

The principal elements of a successful SPC framework:

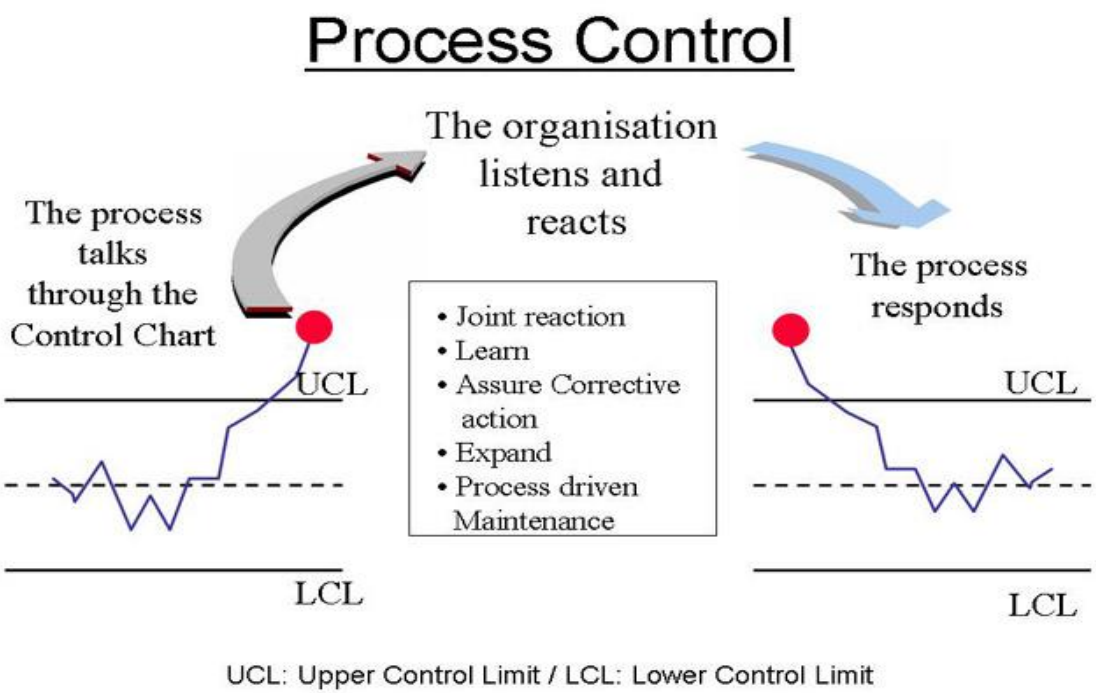
- Analysis – to understand the process
- Methods – to measure the process
- Leadership – to change the process

BENEFITS:

- continuous improvement and quality maintenance
- productivity
- process complexity reduction
- provides a common internal language for management, supervision, quality assurance

# Statistical Process Control

SPC takes a systematic approach which requires guided conceptualization first, then data collection, and finally corrective action directly linked to the data.



# Statistical Process Control

SPC includes techniques as:

- Brainstorming
- Pareto analysis
- Process analysis
- Cause-and-effect analysis
- Force field analysis
- Sampling
- Scatter diagrams
- Histograms
- Tally sheets
- Events logs
- Flowcharts
- Process control charts and process capability analysis

# Problem solving

PROBLEM – refers to uncertainties/difficulties (obstacles) encountered in getting from one situation to a preferred one (the objective)

Two types of problems:

1. **Maintenance problems** – exist where the current situation **is not as it should be** (ex. The supplier cannot deliver on time, the breakdown of a production line)

2. **Achievement problems** – where the current situation **could be better** but there are reasons why it is not (failure to achieve a sales target)

Problem solving = transforming one set of circumstances into another, preferred state by removing, overcoming or navigating around obstacles

# Problem solving

## Recognising problems

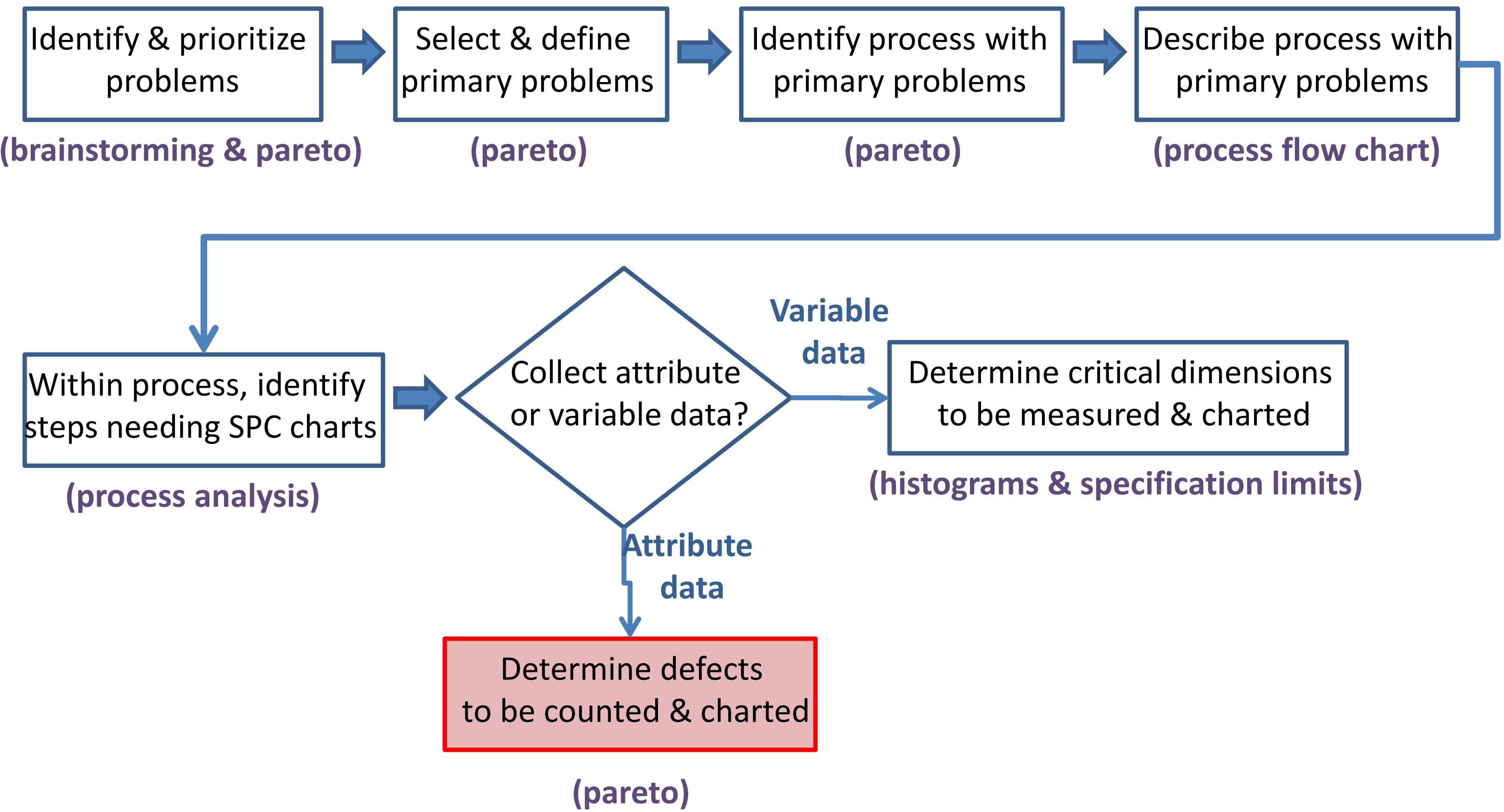
Some problems arise suddenly without warning, and are obvious by their effects.

Others develop slowly and have a more subtle influence.

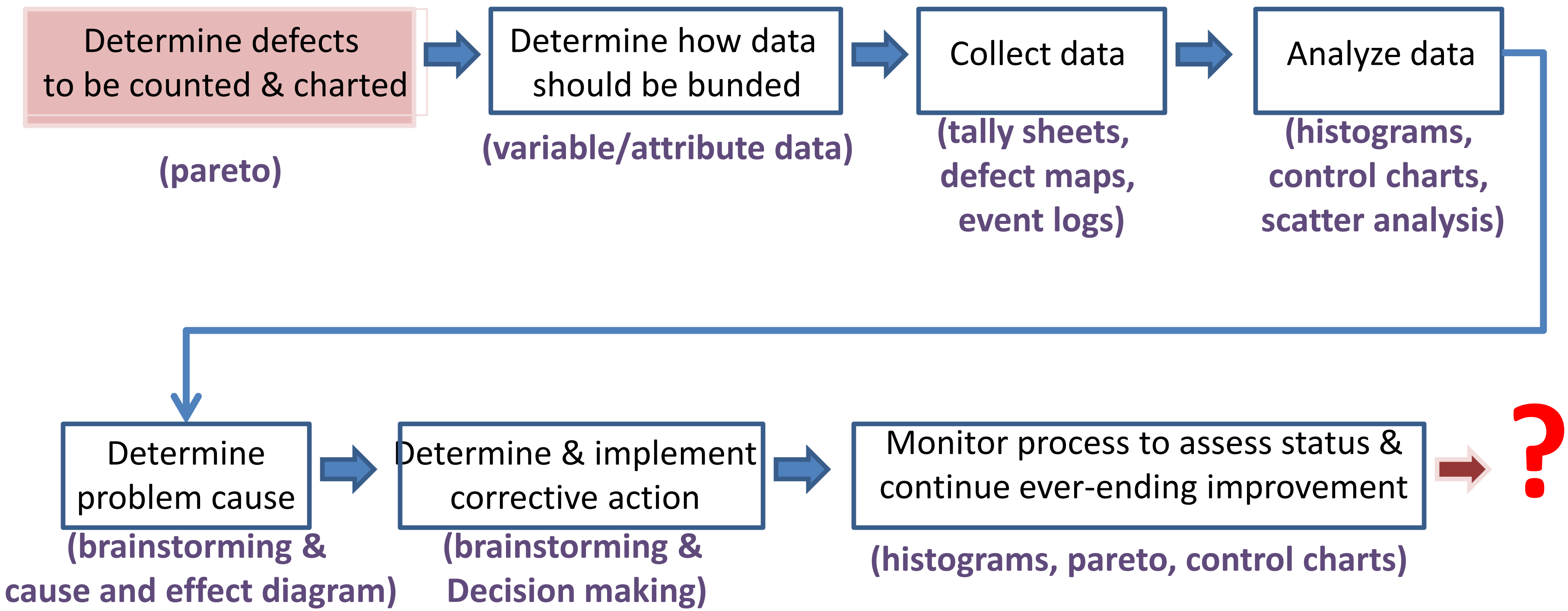
Sometimes what appears to be a problem turns out not to be a problem at all.

We need methods to help us recognise potential problems as early as possible.

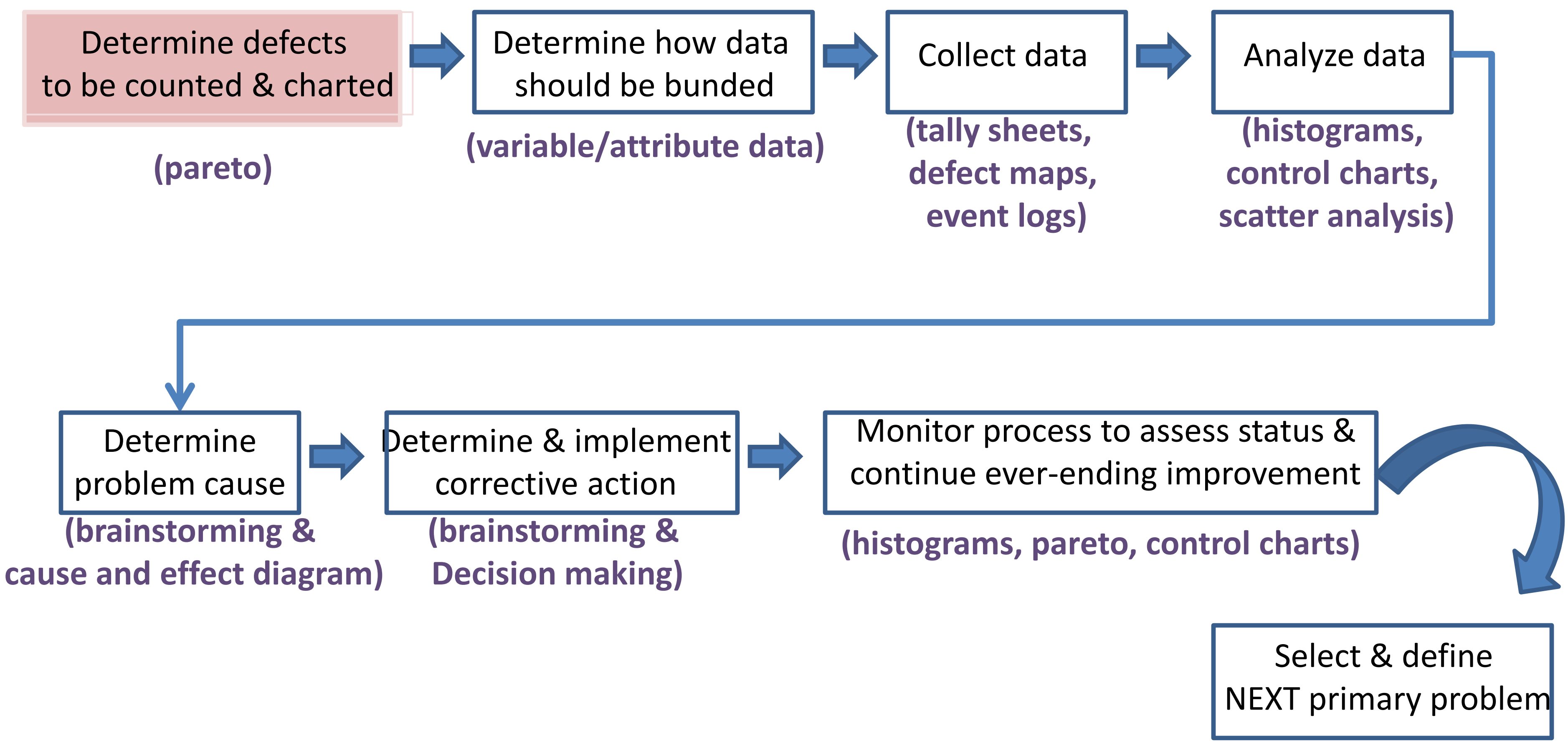
# Problem solving- a systematic approach



# Problem solving- a systematic approach



# 3. Problem solving- a systematic approach



# Team Chart Worksheet

**What do you need before you start a problem solving process?**

1. First draft of project charter from sponsors

2. Resource allocation (defined team, time of team members, initial budget)

# Team Chart Worksheet

For a project charter we need a list of team members representing key stakeholders, appropriate mix of skills, and knowledge (especially about the current process)

+ what will they do in the project (responsibilities)

# Team Chart Worksheet

Steps in developing a project organization chart:

1. Build a high-level project organization chart (sponsor, project leader, core team)

2. Determine key roles and responsibilities for all members

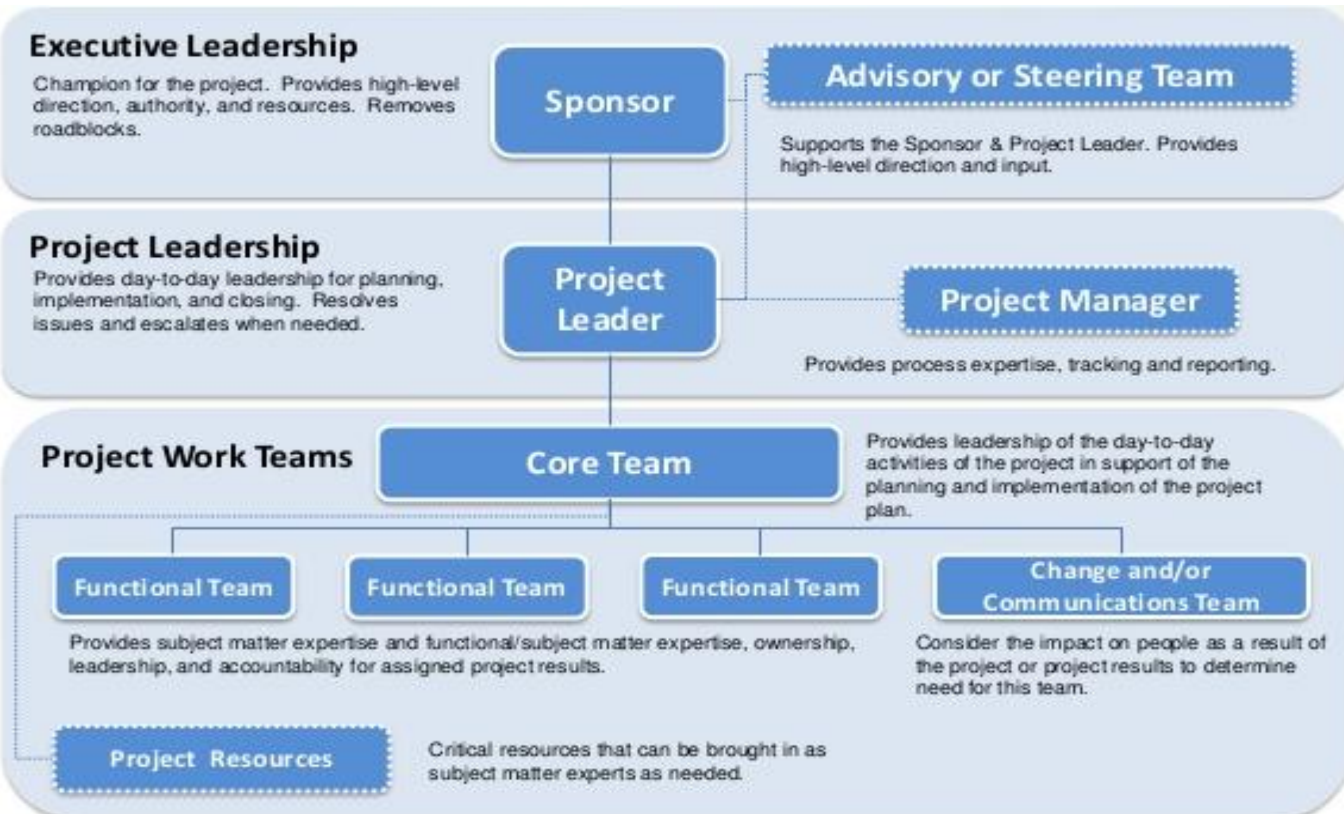
3. Build a project organization chart (names for all members)

4. List for each team member all the responsibilities and deadlines in the project

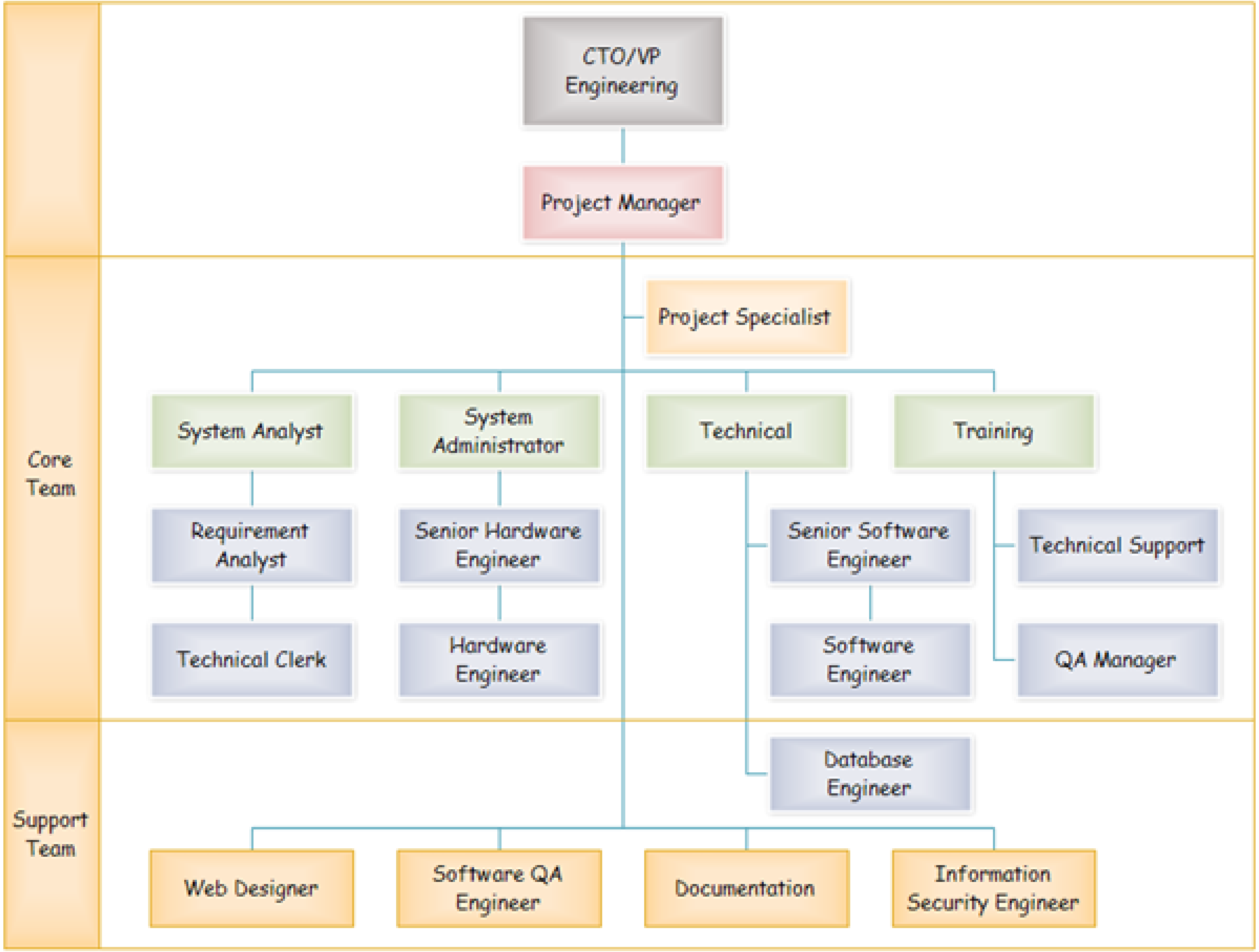
# Team Chart Worksheet

Steps in developing a project organization chart:

1. Build a high-level project organization chart (sponsor, project leader, core team)



# Team Chart Worksheet



# Team Chart Worksheet

Steps in developing a project organization chart:

2. Determine key roles and responsibilities for all members

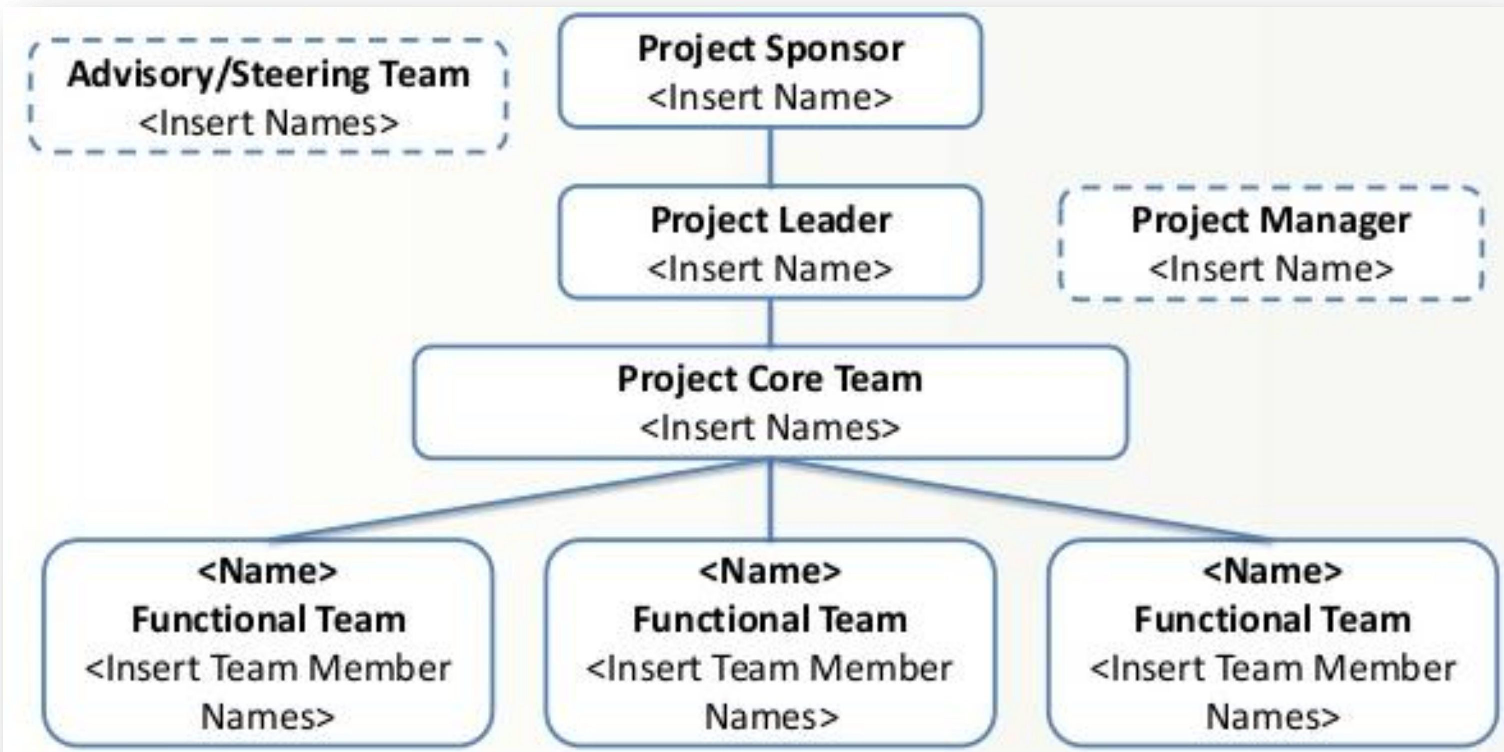
| | |
|---|---|
| **Project Sponsor**<br>*Has ultimate authority and responsibility for the project* | • Provides funding for the project (initial funding, additional funds)<br>• Approves changes to scope, as required<br>• Removes obstacles that prevent the project from moving forward<br>• Approves Project Charter and subsequent documentation<br>• Provides updates to executive management<br>• Resolves issues escalated by the project manager and/or core team |
| **Advisory or Steering Team**<br>*Supports the Sponsor & Project Leader* | • Provides high-level direction and input<br>• Provides subject matter input<br>• Helps support the resource needs<br>• Helps communicate the project benefits, etc. |
| **Project/Functional Leader**<br>*Provides subject matter expertise and functional ownership and accountability for project results* | • Develops the Project Charter and any other documentation in collaboration with the project team and resource managers for approval by the sponsor(s)<br>• Ensures all given objectives and responsibilities of the team are properly documented and approved on the Roles Matrix<br>• Leads core team meetings |
| **Project Manager**<br>*Responsible for planning, organizing, managing, controlling and communicating on all phases of a project* | • Facilitates the development of the Project C collaboration with the project team and res<br>• Ensures all given objectives and responsibili and approved on the roles matrix<br>• Facilitates the identification of project resou managers and the project leader to constru<br>• Facilitates regular core team meetings to re progress<br>• Creates regular status reports and distribut |

| | |
|---|---|
| **Core Team Members**<br>*Provides day-to-day leadership for the planning, implementation, and closing of a project* | • Resolves issues and escalates when required<br>• Manages individual sub teams<br>• Meets regularly to review issues and monitor project progress<br>• Provides status updates on open action items<br>• Manages project issues and risks |
| **Functional Team Leader**<br>*Manages the sub team and pursues the team's given objectives (i.e. project tasks)* | • Serves on the Core Team<br>• Provides regular status updates to the Project Manager/Leader, estimated time to completion, cause of variances, etc., as defined by the project<br>• Attends and actively participates in project team meetings<br>• Contributes to overall project objectives and specific team deliverables<br>• Coordinates team activities related to project schedule |
| **Team Member**<br>*Responsible for contributing to overall project objectives and specific team deliverables* | • Contributes to project schedule development in collaboration with Project Leader/Manager/Lead<br>• Performs assigned activities once the schedule is approved<br>• Communicates project risks and escalates issues to team lead<br>• Attends and actively participates in team meetings |
| **Project Resource**<br>*Responsible for providing subject matter expertise as needed* | • Contributes subject matter expertise and input as needed throughout the project<br>• Implements assigned deliverables/tasks |

# Team Chart Worksheet

Steps in developing a project organization chart:

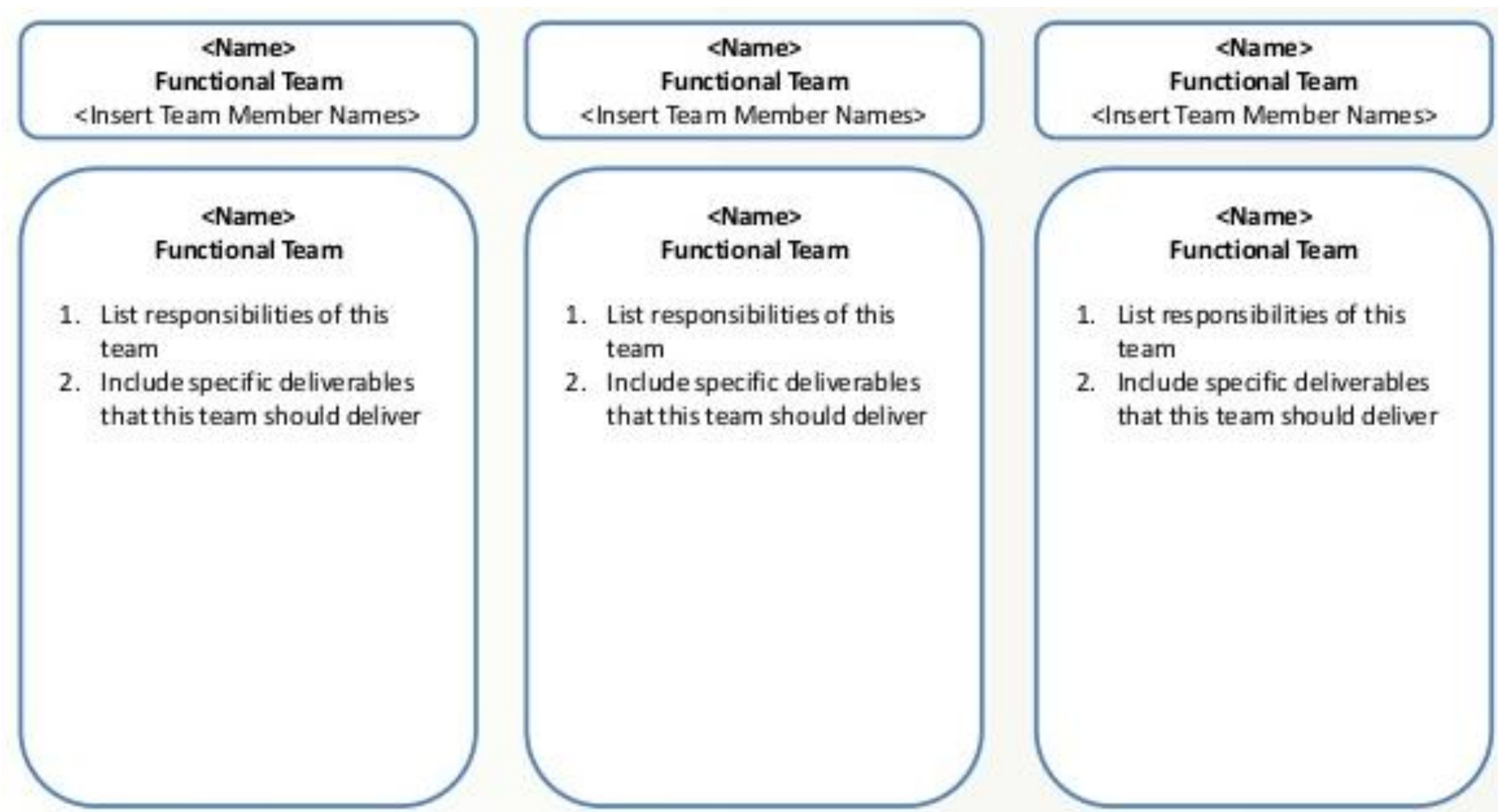
3. Build a project organization chart
(names for all members)



# Team Chart Worksheet

Steps in developing a project organization chart:

4. List for each team member all the responsibilities and deadlines in the project



# Value Stream Mapping and Process Flow Tools

**PURPOSE:**

- visually documents a process
- provides fact-based process description as basis for understanding current problems (poor flow, rework loops, delays) and opportunities
- helps the improvement team to see how the process should work in the future once they solve the identified problem

# Value Stream Mapping and Process Flow Tools

## PROCESS MAPPING:

- Documentation + active observation of the process (even if you think you know the work area)

- Realization of the flowchart with a level of detail that is helpful but not perfect (avoiding delay)

- A cross-representation involvement of those who work in the process for correct mapping

- Process maps as living documents, they MUST be used, updated with each process change

# Value Stream Mapping and Process Flow Tools

**PROCESS MAPPING STEPS (same for all maps):**

1. Review the process being studied and its boundaries as defined for your project

2. Identify the type of chart you want to create

3. Have participants identify the steps in the process (with appropriate symbols)

4. Working as a team, arrange the steps in order (eliminate duplicates, combine similar ideas and agree on wording + keep the process flow moving in one direction left-to-righ or top-to-down for adequate sequence of events)

5. Discuss the results and adjust if needed

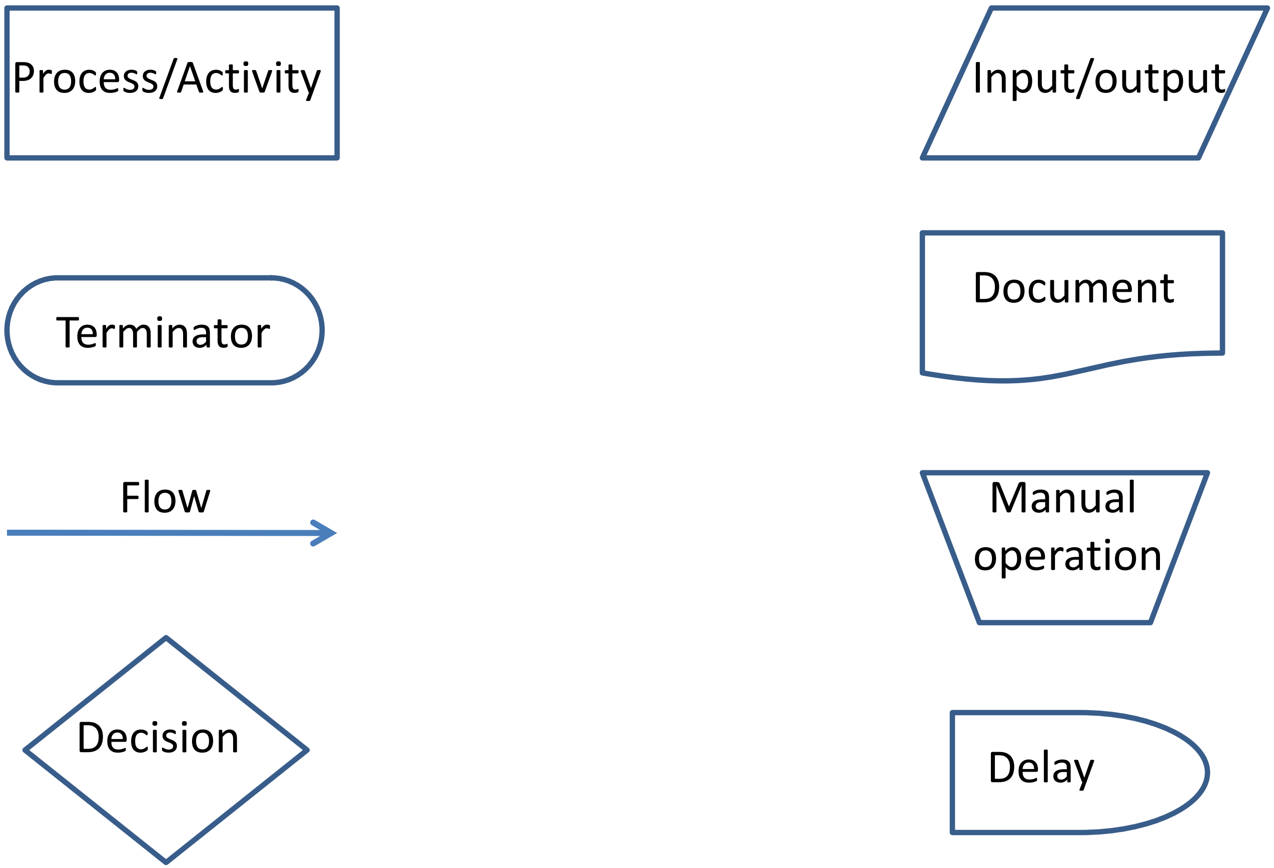
# Value Stream Mapping and Process Flow Tools

## PROCESS MAPPING STEPS (guidance):

- The process flow can go in the reverse direction if a decision calls for repetition of a step
- After the design of the process flow, walk the process forward to understand what happens, then backward pretending to be a customer – ask questions that a customer would ask like: Why do you do things that way?Would it be possible to do this other thing that would help me?
- Go to the workplace (Gemba), even videotape if possible
- Step back and talk about what metrics could be used to measure process effectiveness, efficiency, and customer satisfaction + take notes

# Value Stream Mapping and Process Flow Tools

## PROCESS MAPPING Main symbols:



# Value Stream Mapping and Process Flow Tools

## PROCESS STUDY recommendations:

- Should include a minimum : SIPOC diagram, basic value stream map with value-add vs. non-value-add identification together with other project-critical metrics and process observation

- For transactional processes (helplines, office activities, insurance industry, order processing, invocing) – **Swimlane**/functional deployment format (emphasizes the handoffs between people and groups)

- For workplace improvement – **workflow** diagram to get a visual map of the workplaces

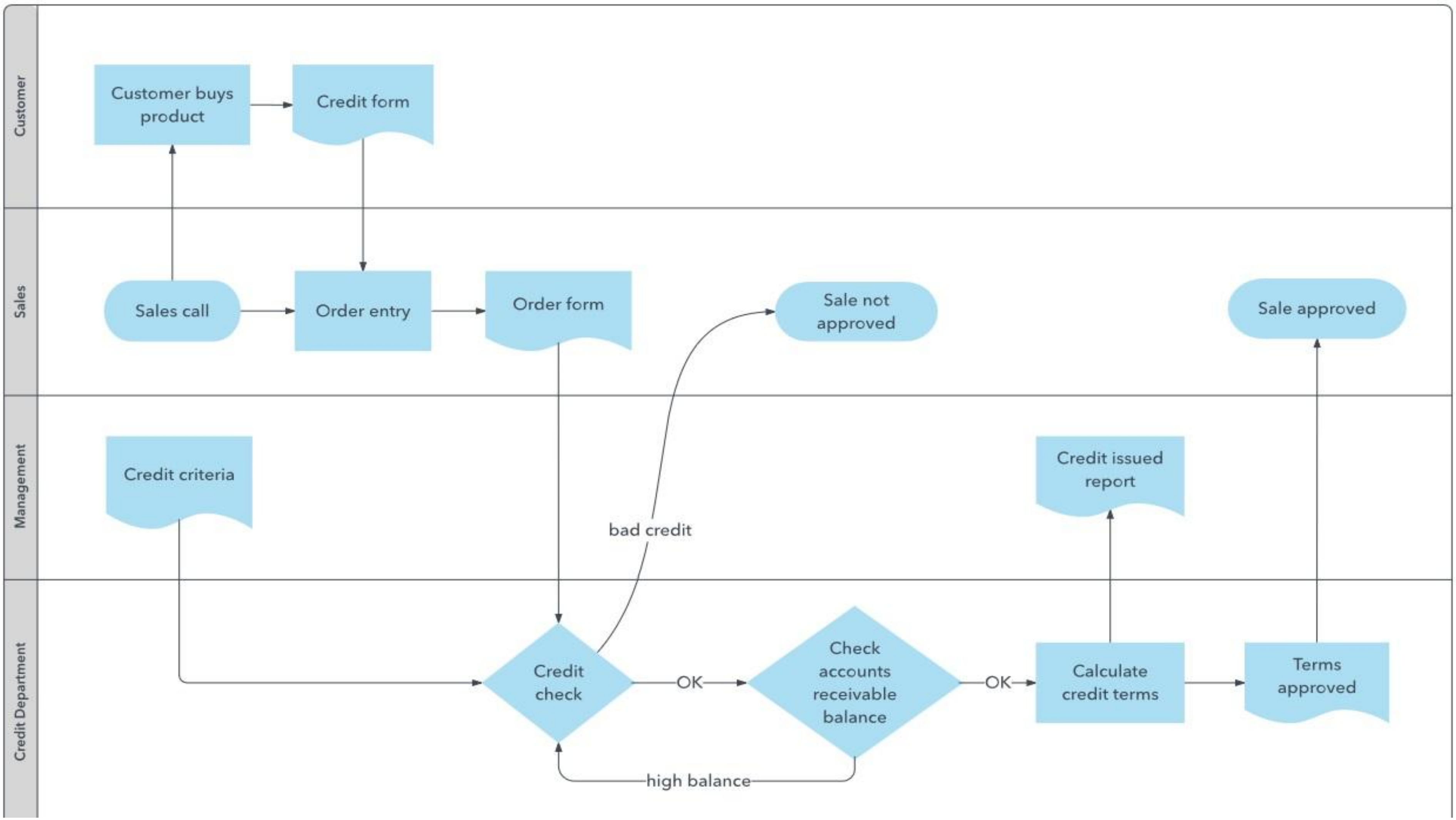
# Swim-lane diagram

- is a type of flowchart that delineates who does what in a process (which process steps are assigned to a particular actor in the organisation – identification of people and job functions involved in the process)

- like the lanes in a pool – the Swim-lane diagram provides clarity and accountability by placing process steps within the horizontal or vertical “swim-lanes” of a particular employee, work group or department

- it shows connections, communication and handoffs between these lanes, and it can serve to highlight waste, redundancy and inefficiency in a process.

# Swim-lane diagram



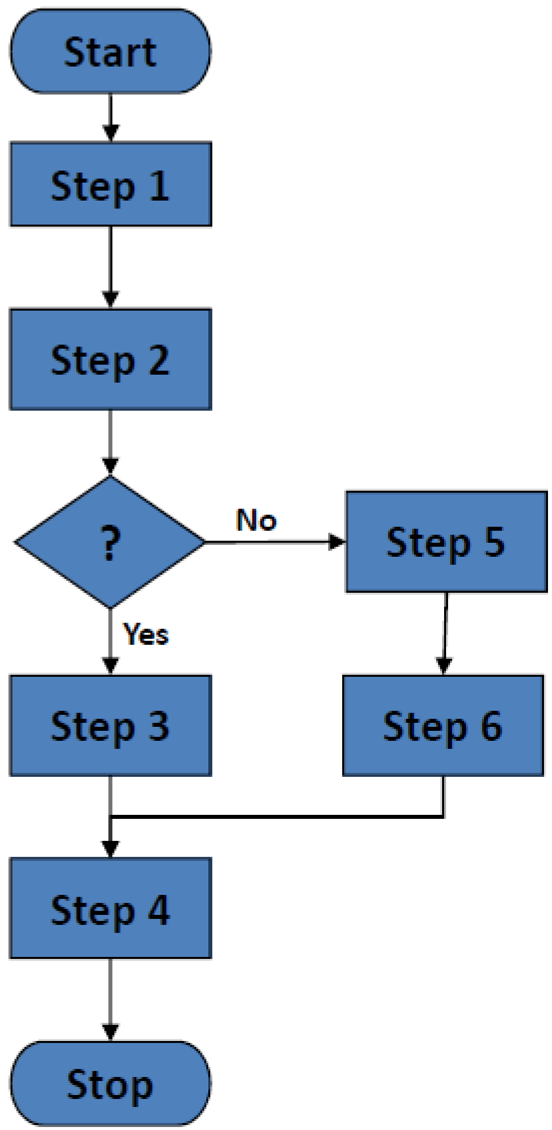
# Flowchart

## Process Flow

- Schematic representation of the current or suggested Process Flow
- Overview of activities and decision points
- Has a clear beginning (start) and end (stop)

**Also called:**

**Flowchart**



# Flowchart

## PROCESS STUDY of the flowchart level:

- HIGH-LEVEL VIEW – depicts the major elements and their interactions (useful early in a project to identify boundaries and scope; not useful during improvement because of lack of detail)

- LOW-LEVEL VIEW – depicts specific actions, workflow, rework loops, ... In a process (useful for a process of limited scope; too disturbing when all you need is a view of the overall flow)

# Flowchart

## EXAMPLE of high-level and low level flowcharts

### Creating a Process Map / Flowchart

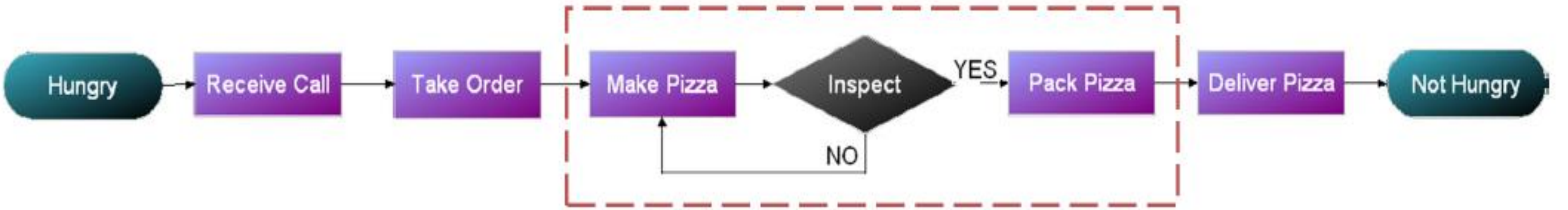
Pizza ordering process

1. **Identify the borders of the process:**
   Start: Customer calls
   End : Pizza has been paid

2. **Describe the primary purpose and activities (operational definition):**
   Process Activities:
   Answer phone → Provide accurate order to pizza chef → Bake pizza → Inspect and pack pizza → Make bill → Deliver pizza to customer → Collect money

# Flowchart

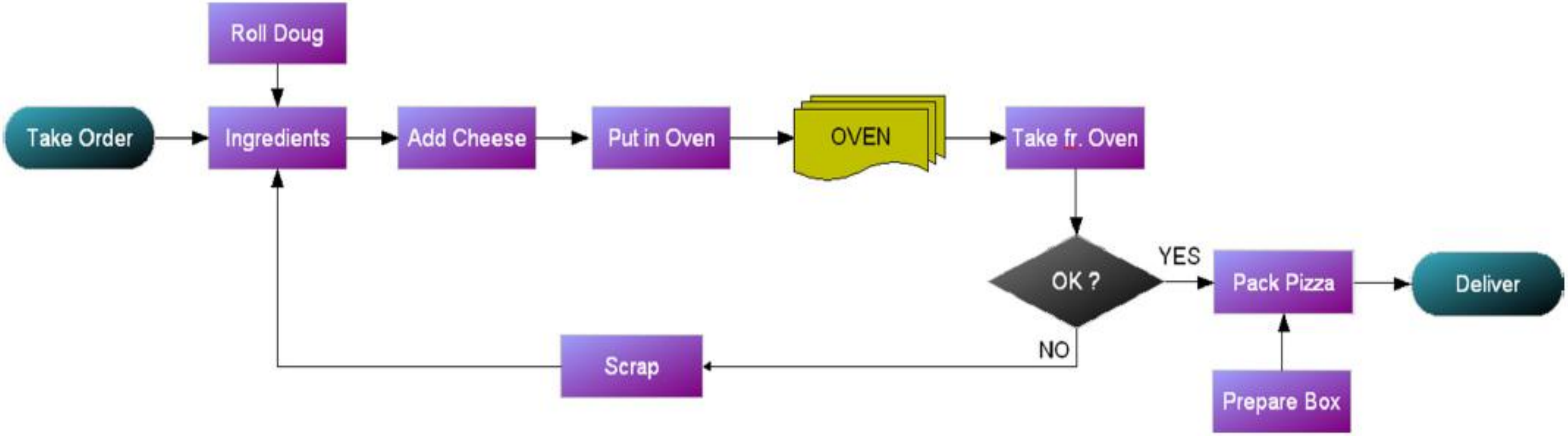
## EXAMPLE of high-level and low level flowcharts




When a 'higher level' process map is established, a more detailed map can then be created from the area we want to focus on.

# Flowchart

## EXAMPLE of high-level and low level flowcharts



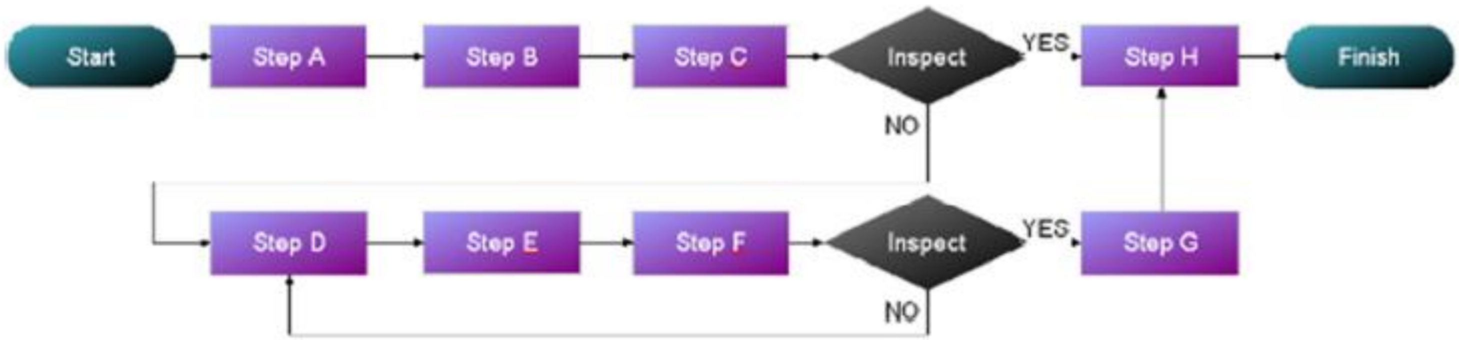

*This example is from the perspective of the Pizza Chef*

# Flowchart

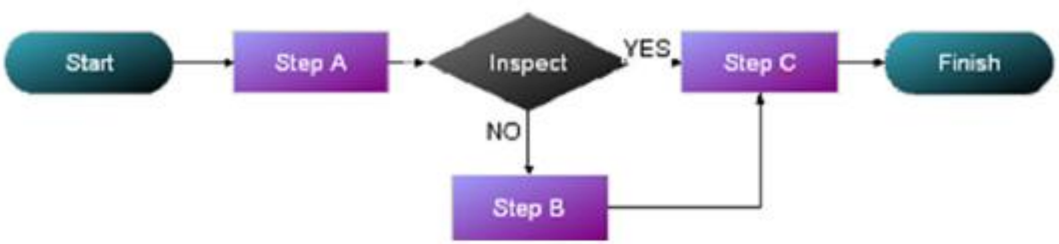
## PROCESS STUDY of the flowchart breadth:

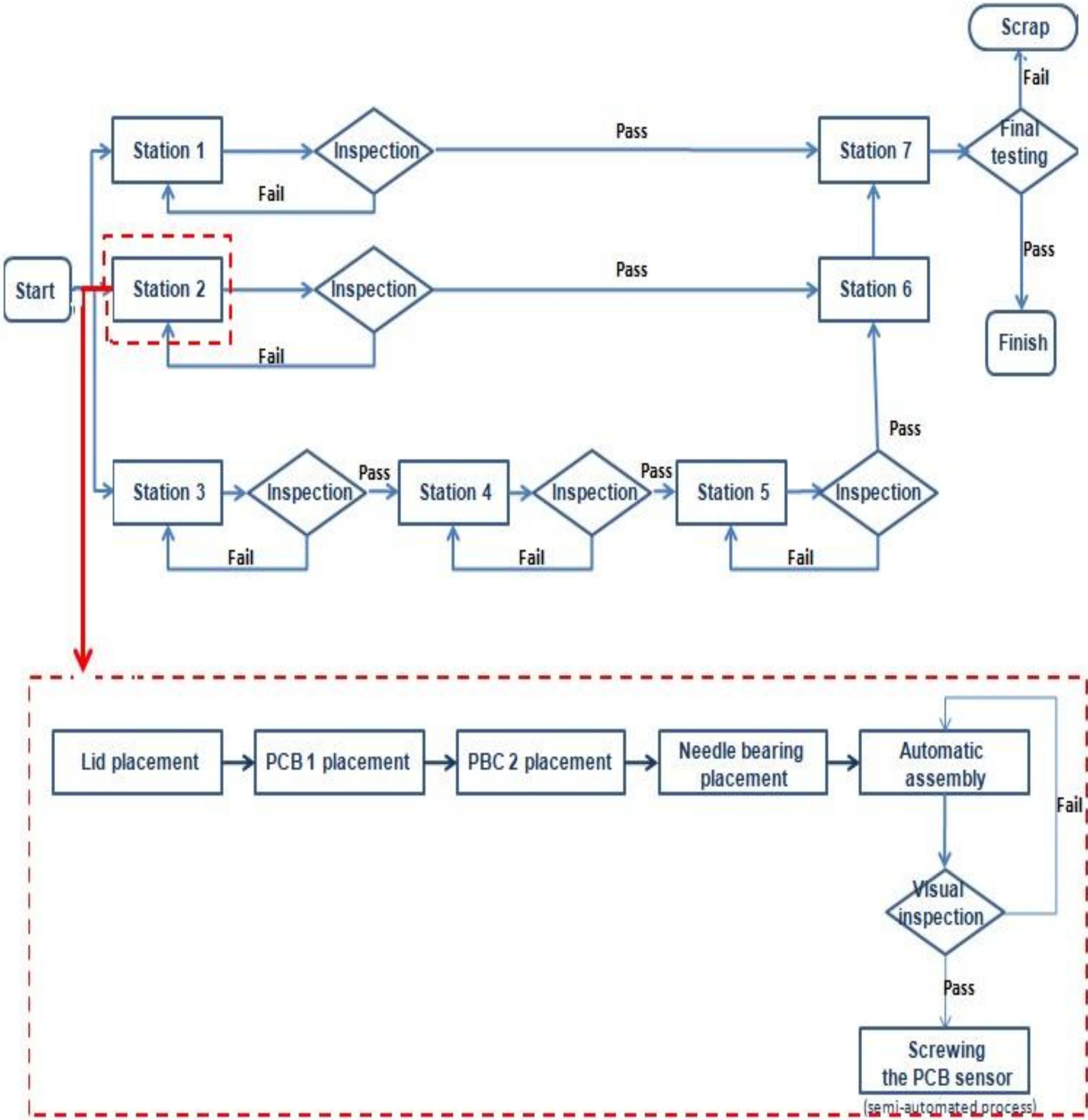
**The process as you <u>THINK</u> it is:**


**The process as it <u>ACTUALLY</u> is :**




**The process as it <u>SHOULD BE</u> :**






Flowchart for the WGA (Waste Gate Actuator) line flow

# Check Sheet Formats

- Process observation is the starting point of problem solving. By observing a process in action, team members will have a deeper understanding of reality
- Observation works best if you plan what you want to do and how you will capture and use the insights people gain

# Check Sheet Formats

To observe a process you need to:

1. Clarify the purpose of observation (a general walkthrough or a specific purpose)

2. Identify observers (experienced and novice ones)

3. Prepare an observation form and train observers (the form must capture process data)

4. Prepare staff in the workplace

5. Walk the process and carry out your observations plans

6. Have observers summarize lessons learned and present then to the whole team (discussion of results)

# Check Sheet Formats

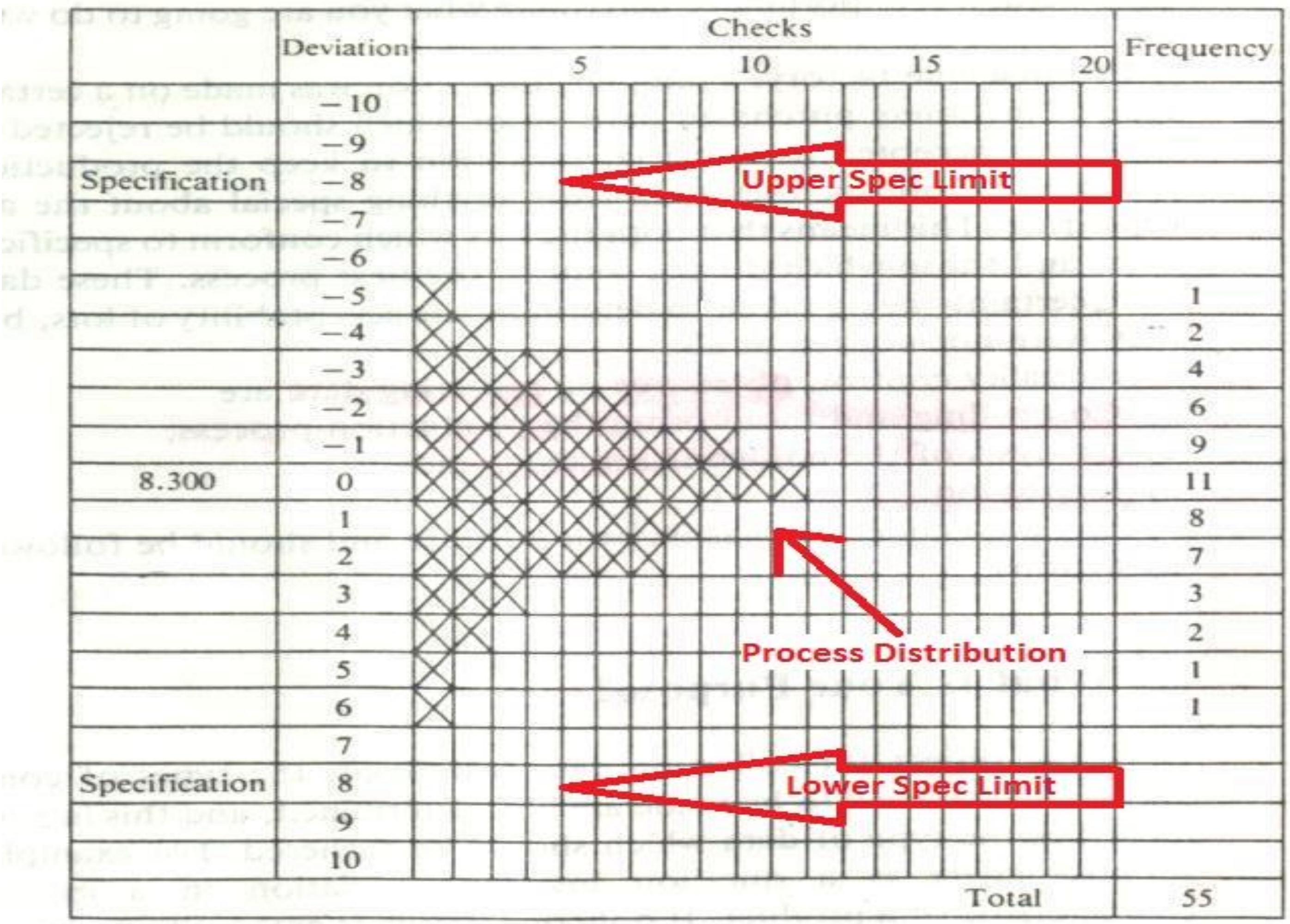
- The captured data can be qualitative or quantitative
- Data are recorded by marking checks on the form
- A typical check sheet is divided into regions
- Each check sheet must present the name of the observer, location and dates when the observation took place and what was collected

# Check Sheet Formats

USES:

- to check the shape of the probability distribution of a process
- to quantify defects by type
- to quantify defects by location
- to quantify defects by cause (machine, worker)
- to keep track of the completion of steps in a multistep procedure

- to check the shape of the probability distribution of a process



- to quantify defects by type

| Motor Assembly Check Sheet | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Name of Data Recorder: | | | | | | | | |
| Location: | | | | | | | | |
| Date of Data Record: | | | | | | | | |
| Defect Types/ Event Occurence | Dates | | | | | | | TOTAL |
| | Sunday | Monday | Tuesday | Wednesday | Tursday | Friday | Saturday | |
| Supplied parts rusted | | ~~|||~~ ||| | ||| | ~~|||~~ | || | | | 20 |
| Misaligned weld | | | ||| | | | || | | 5 |
| Inappropriate test procedure | | | | || | | | | 3 |
| Wrong part issued | | | | | || | || | | | 7 |
| Film on parts | | | | | | | | 0 |
| Voids in casting | | | | | | | | 0 |
| Wrong dimensions | | | | | | || | | 2 |
| Adhesive failure | | | | | | | | 0 |
| Insufficient masking | | | | | | | | | 1 |
| Spray Failure | | | ||| | | | | | 4 |
| Total | 0 | 10 | 12 | 11 | 6 | 4 | 0 | |

- to quantify defects by location

**Door paint check sheet**

Sheet number: 243

Paint robot number: B32A6

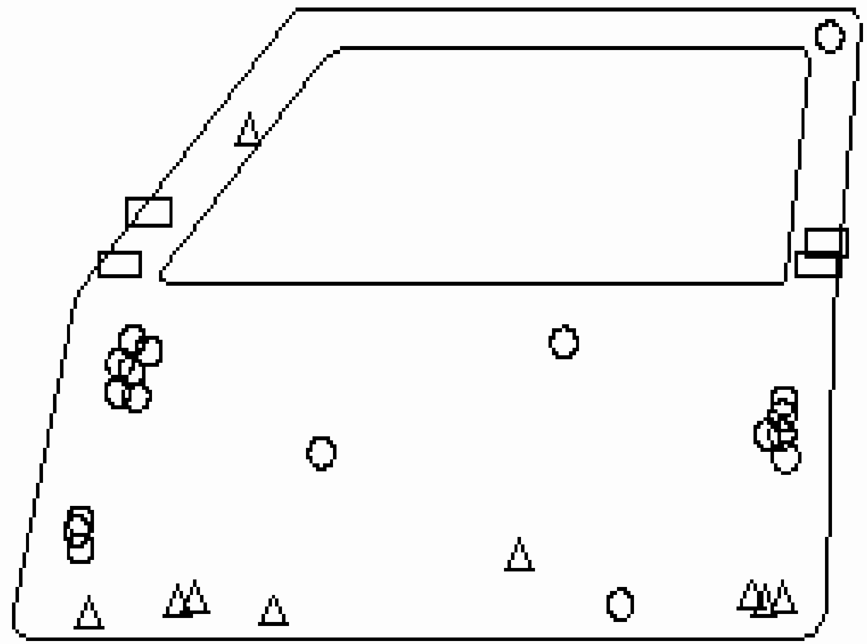
Paint batch number: A12583

Paint operator: Jim Wilkins

Date: 12th Oct

Doors painted: 𝍸 𝍸

| Defect type | symbol | count... |
|---|---|---|
| bubble | ○ | 𝍸 𝍸 𝍸 \|\| |
| run | △ | 𝍸 \|\|\| |
| scuff | ▭ | \|\|\|\| |



- to quantify defects by cause (machine, worker)

| Equipment | Worker | Monday am. | Monday pm | Tuesday am | Tuesday pm | Wednesday am. | Wednesday p.m. | Thursday a.m. | Thursday p.m. | Friday a.m. | Friday p.m. | Saturday a.m. | Saturday p.m. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Machine 1 | A | 00X● | 0X | 000 | 0XX | 000X<br>XX● | 0000<br>XXX | 0000<br>X●● | 0XX | 0000 | 00 | 0 | XX● |
| | B | 0XX● | 000X<br>X0 | 0000<br>00XX | 000X<br>X | 0000<br>00XX<br>● | 0000<br>00X● | 0000<br>0X | 000X<br>●● | 00XX<br>● | 0000<br>0 | 00X | 000●<br>X0X |
| Machine 2 | C | 00X | 0X | 00 | ● | 0000<br>0 | 0000<br>00X | 00 | 0● | 00△ | 00□ | △0 | 0□ |
| | D | 00X | 0X | 00 | 000● | 000●<br>△ | 0000<br>0X | 0●0 | 00△ | 00△△<br>□ | 0●● | □00X | XX0 |

0 Surface scratch
X blowhole
△ defective finishing
● improper shape
□ other

- to keep track of the completion of steps in a multistep procedure

## RV Kitchen Checklist

**Eating & Serving**

- [ ] Glasses: drinking & wine
- [ ] Cups/mugs
- [ ] Bowls & plates
- [ ] Forks, knives, spoons
- [ ] Salad/serving bowl
- [ ] Serving tray

**Pots & Pans**

- [ ] Pots with lids
- [ ] Frying pan
- [ ] Baking pans/sheets
- [ ] Casserole dish & lid
- [ ] Cast iron skillet

**Cleaning**

- [ ] Dish soap
- [ ] Hand soap
- [ ] Dish towels
- [ ] Sponges
- [ ] Dish rack
- [ ] Paper towels
- [ ] Spray cleaner
- [ ] Trash bags
- [ ] Broom & dust pan

**Food Prep**

- [ ] Knives
- [ ] Spatula
- [ ] Tongs
- [ ] Whisk
- [ ] Scissors
- [ ] Bottle/can opener
- [ ] Vegetable peeler
- [ ] Measuring cups/spoons
- [ ] Mixing bowls
- [ ] Cutting boards
- [ ] Colander
- [ ] Pot holders
- [ ] Blender

**Etc.**

- [ ] Matches/lighter
- [ ] Corkscrew
- [ ] Bag clips
- [ ] Tupperware
- [ ] Ziplock bags
- [ ] Aluminium foil
- [ ] Plastic wrap
- [ ] Coffee Maker

# Stratification diagram

**Stratification** → a technique used to analyze/divide/sort data into homogeneous groups (strata) that helps in deriving meaningful information to understand an existing problem

- It is a data collection and analysis tool

- It's purpose is to divide data and conquer meaningful information to solve a problem

- It serves to facilitate the work before using other tools such as histograms or scatter diagrams

# Stratification diagram

**Stratification factor** (stratifier) = a factor that can be used to separate data into subgroups

PURPOSE: to collect descriptive information that will help in identifying important patterns in the data (about root causes, patterns in use, ..)

BENEFITS: speed up the search for root causes and generate a deeper understanding of process factors

# Stratification diagram

Examples of different sources that might require data to be stratified:

- equipment
- employee shifts
- departments
- materials
- suppliers
- days of the week or time of the day
- products

# Stratification diagram

## WHEN?

- Before collecting data
- When data is retrieved from various sources/conditions (shifts, days of the week, suppliers,..)
- When data analysis requires the separation of different sources/conditions

# Stratification diagram

## HOW?

1. Before collecting data, consider which information about the sources of the data might have an effect on the results (you need to collect that information)

2. When plotting or graphing the collected data on a scatter diagram, control chart, histogram.. (other analysis tool), use different marks/colors to distinguish data from various sources(then data is stratified)

3. Analyze the subsets of stratified data separately

# Stratification diagram

- There are different ways you can slice your data to uncover relevant patterns

Examples:

- If you suspect purchasing patterns may relate to the size of the purchasing company – you need to collect information about the purchaser's size

- If it seems patterns of variation differ by time of day – you need to label data according to when it was collected

# Stratification diagram

**Un–stratified data** (An employee reached late to office on following dates)

5-Jan, 12-Jan,13-Jan, 19-Jan, 21-Jan, 26-Jan,27-Jan

**RELEVANT INFORMATION?**

# Stratification diagram

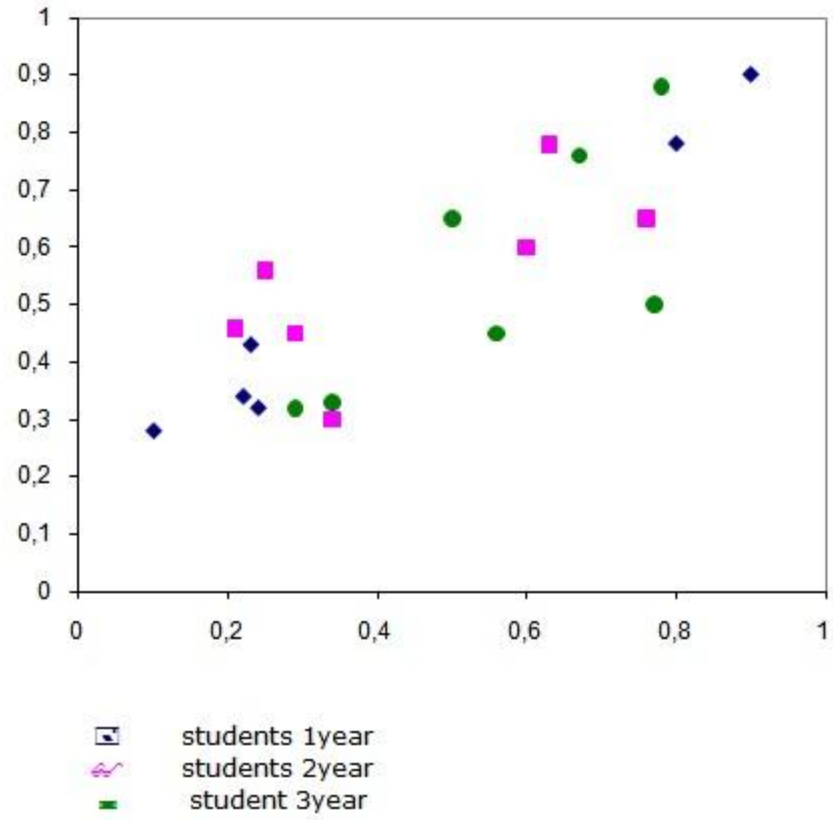
**Un–stratified data** (An employee reached late to office on following dates)

5-Jan, 12-Jan,13-Jan, 19-Jan, 21-Jan, 26-Jan,27-Jan

**Stratified data:** (Same data classified by day of the week )

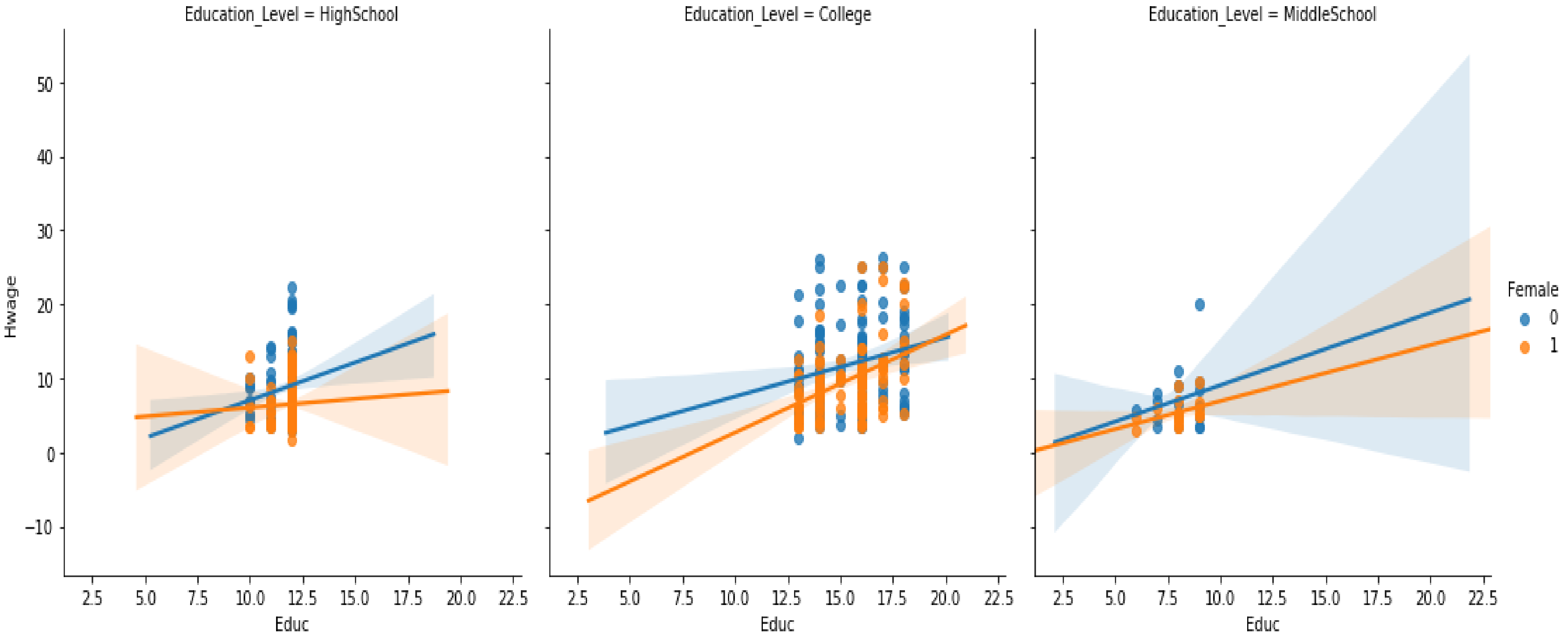
| Day | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| Frequency - Late in Office | 4 | 2 | 1 | 0 | 0 | 0 | 0 |

# Stratification diagram (examples)

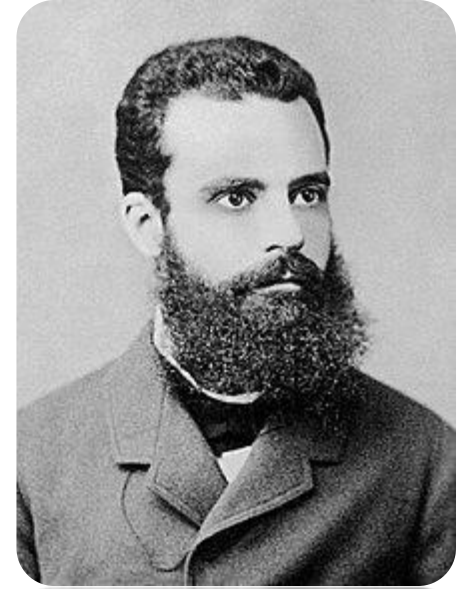



| | students 1year | | | students 2year | | | student 3year | |
|---|---|---|---|---|---|---|---|---|
| | Input (x) | Output (y) | | Input (x) | Output (y) | | Input (x) | Output (y) |
| 1 | 0,9 | 0,9 | 1 | 0,6 | 0,6 | 1 | 0,5 | 0,65 |
| 2 | 0,76 | 0,65 | 2 | 0,63 | 0,78 | 2 | 0,78 | 0,88 |
| 3 | 0,23 | 0,43 | 3 | 0,21 | 0,46 | 3 | 0,56 | 0,45 |
| 4 | 0,1 | 0,28 | 4 | 0,29 | 0,45 | 4 | 0,34 | 0,33 |
| 5 | 0,24 | 0,32 | 5 | 0,34 | 0,3 | 5 | 0,29 | 0,32 |
| 6 | 0,8 | 0,78 | 6 | 0,76 | 0,65 | 6 | 0,67 | 0,76 |
| 7 | 0,22 | 0,34 | 7 | 0,25 | 0,56 | 7 | 0,77 | 0,5 |

# Stratification diagram (examples)



# Pareto Analysis



Vilfredo F.D. Pareto 1848-1923

- observed that most wealth is concentrated in the hands of a few

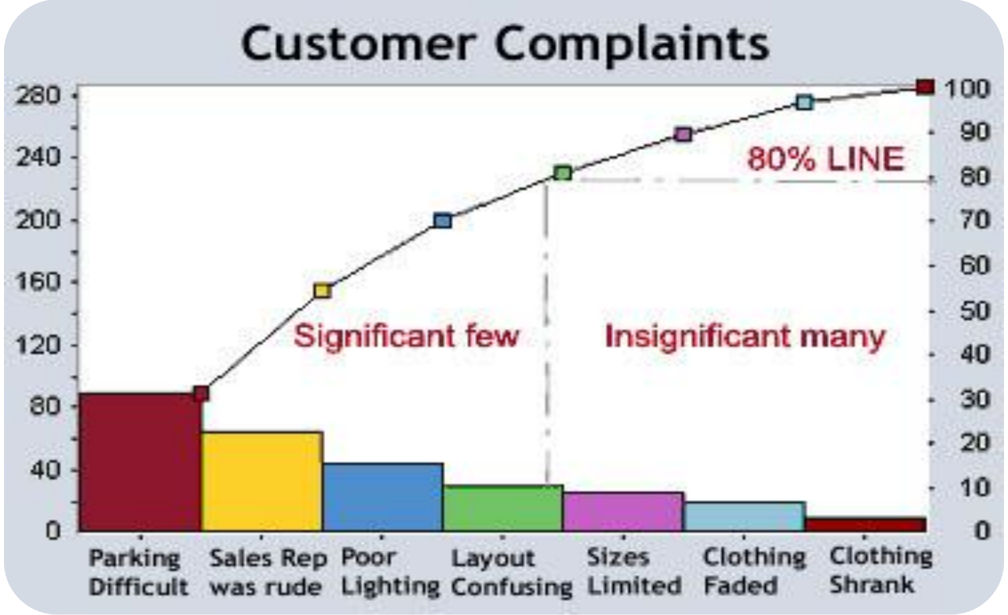
- determined the 80-20 rule (applied in all areas of QC):

80% of inventory costs accounted for by 20% of the inventory items

80% of process problems located in 20% of the process steps

# Pareto Analysis

- Can be conducted on products, services, machines, workers, ...
- Identifies the vital few problems which offer the greatest opportunity for improvement by prioritizing their frequency, cost or importance in a systematic way
- Demonstrates the results of quality improvement efforts



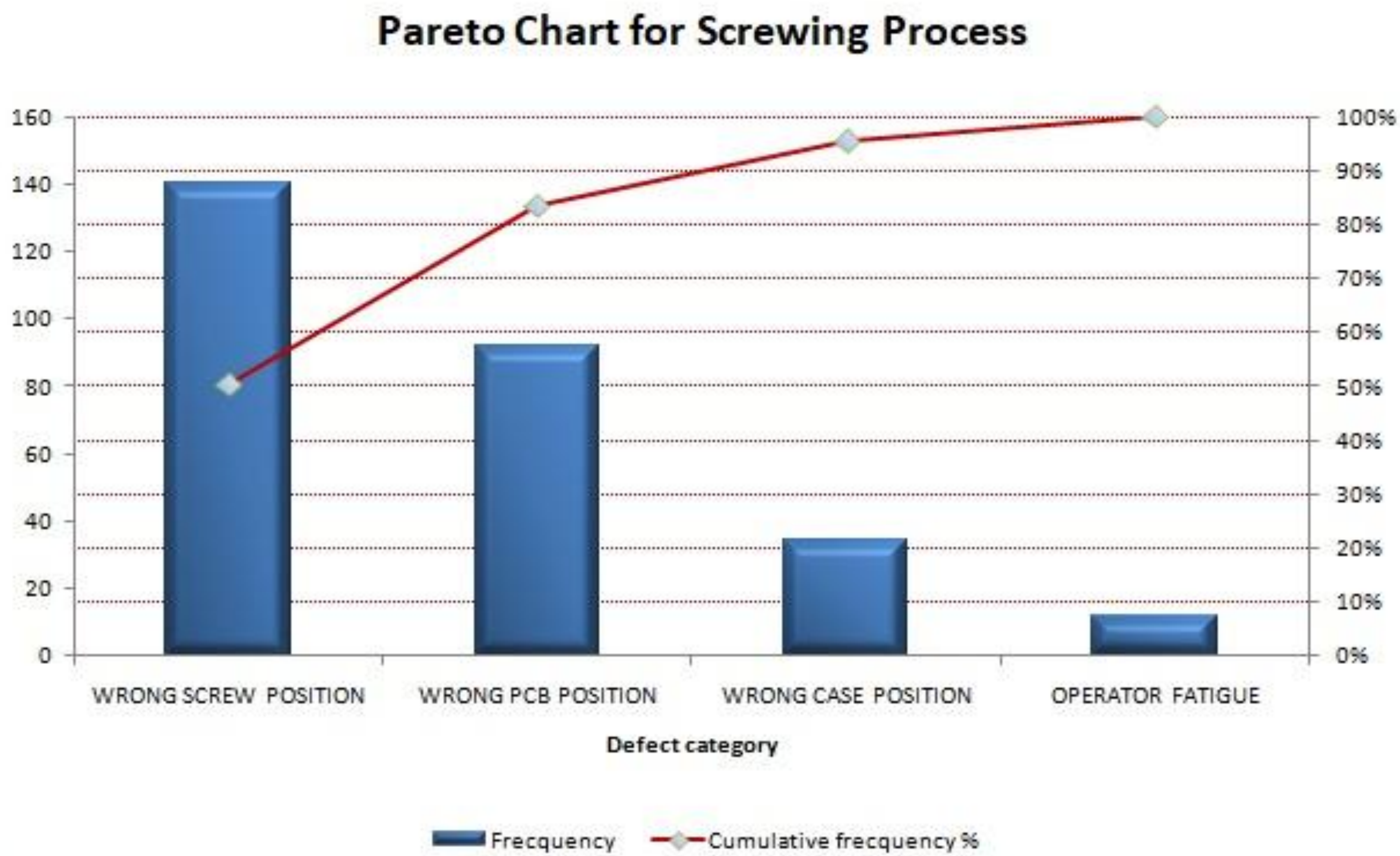
# Pareto Analysis

**STEPS:**

1. Identify all potential types of defects/causes of a problem (the categories that will be used to classify the subject)
2. Collect data on frequency of each type of defect
3. List the defects in descending order of occurence
4. The percent of each defect type is determined by dividing the number of each type of defect by the total
5. Determine cumulative percentages

# Pareto Analysis

| DEFECT CATEGORY | FRECQUENCY | FRECQUENCY % | CUMULATIVE FRECQUENCY % |
|---|---|---|---|
| WRONG SCREW POSITION | 140 | 50,36% | 50,36% |
| WRONG PCB POSITION | 92 | 33,09% | 83,45% |
| WRONG CASE POSITION | 34 | 12,23% | 95,68% |
| OPERATOR FATIGUE | 12 | 4,32% | 1 |



# Statistical Control Tools: Histograms

**HISTOGRAM** = a graphic display of the frequency distribution (variation) of a sample of data (numeric information)

Histograms can serve as a quick check on several points within a process to determine where the greatest amount of variation occurs or where specifications are exceeded

The use of histograms for variable data is similar to Pareto diagrams for attribute data: to focus efforts where the greatest amount of error occurs to prioritize problem areas.

# Attribute versus Variable Data

- Attribute data – focuses on numbers, simpler to gather, a yes-or-no variety (defective or not defective, product works or not, students pass or fail an exam). Ex. defects per unit DPU, parts per million PPM, etc.

- Variable data – focuses on measurements and is more useful (looks at how bad each defective product is, how badly failling students missed passing their exams) Ex. absolute, relative dimensions, deviation from normal,...

**Neighter is inherently wrong, it depends on how you want to use your data !**

# Statistical Control Tools: Histograms

Distributions of data:

- The variation that exists in a set of data is displayed by a distribution when this data is grouped in an orderly fashion.

- Since we want to present data so that it is easy to see the key information, it is often useful to construct a frequency distribution.

# Statistical Control Tools: Histograms

Ungrouped frequency distributions :

50 separate measurements in micrometers taken on the diameter of holes drilled in aluminium bars

- Raw data are not informative!

**Table A.2** Raw Data

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 63 | 84 | 93 | 68 | 52 | 73 | 112 | 84 | 75 | 77 |
| 54 | 95 | 72 | 103 | 79 | 83 | 54 | 71 | 62 | 91 |
| 72 | 67 | 58 | 94 | 93 | 52 | 69 | 55 | 88 | 84 |
| 66 | 59 | 77 | 74 | 74 | 81 | 75 | 80 | 86 | 97 |
| 79 | 87 | 81 | 66 | 66 | 90 | 72 | 48 | 66 | 74 |

# Statistical Control Tools: Histograms

The data has been arranged in order of lowest to highest

| 1 |
| --- |
| $X_i$ |
| 48 |
| 52 |
| 54 |
| 55 |
| 58 |
| 59 |
| 62 |
| 63 |
| 66 |
| 67 |
| 68 |
| 69 |
| 71 |
| 72 |
| 73 |
| 74 |
| 75 |
| 77 |
| 79 |
| 80 |
| 81 |
| 83 |
| 84 |
| 86 |
| 87 |
| 88 |
| 90 |
| 91 |
| 93 |
| 94 |
| 95 |
| 97 |
| 103 |
| 112 |
| 3775 |

# Statistical Control Tools: Histograms

The same data is displayed further in the next Table, BUT this time, rather than only listing each measurement, each value that a measurement has taken is listed.

A tally is made of the number of bars having each diameter and is displayed as a number (the frequency) in the second column.

A cumulative frequency, the percentage of bars with a diameter equal to or less than the measurement level of each row is shown in the third column. This is computed by simply adding teh frequencies in each successive row to the frequencies in all the rows above it.

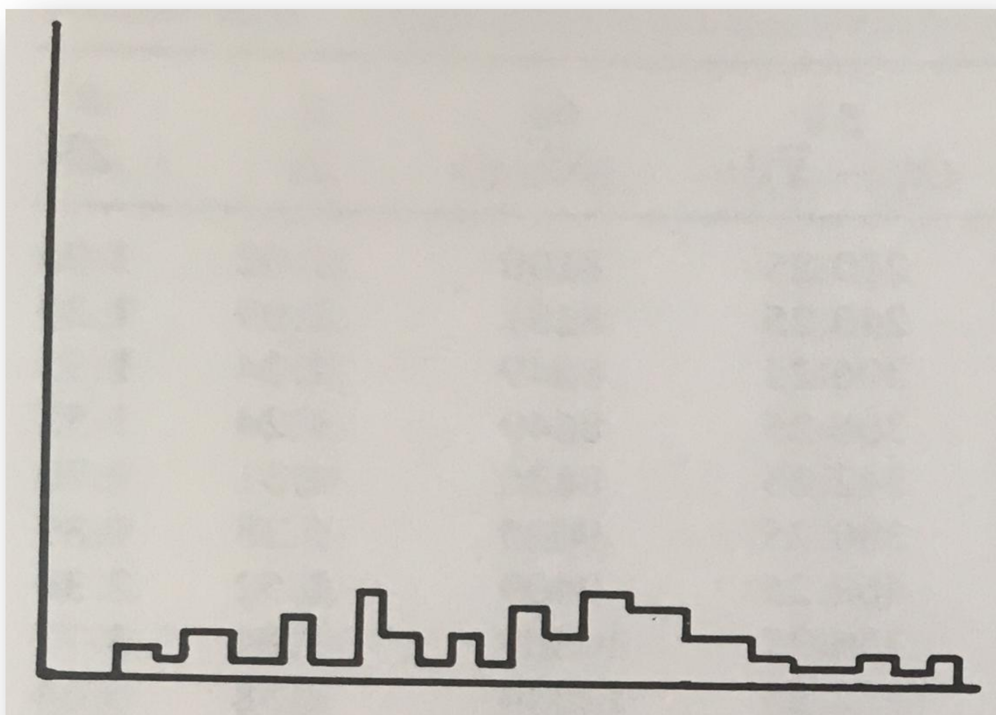
With the data arranged in this way it is easier to sense how much spread exists and where measurement values tend to cluster

**Table A.4** Frequency Data Rank-Ordered

| 1<br>$X_i$ | 2<br>$f_i$ | 3<br>Cum % |
|---|---|---|
| 48 | 1 | 2 |
| 52 | 2 | 6 |
| 54 | 2 | 10 |
| 55 | 1 | 12 |
| 58 | 1 | 14 |
| 59 | 1 | 16 |
| 62 | 1 | 18 |
| 63 | 1 | 20 |
| 66 | 4 | 28 |
| 67 | 1 | 30 |
| 68 | 1 | 32 |
| 69 | 1 | 34 |
| 71 | 1 | 36 |
| 72 | 3 | 42 |
| 73 | 1 | 44 |
| 74 | 3 | 50 |
| 75 | 2 | 54 |
| 77 | 2 | 58 |
| 79 | 2 | 62 |
| 80 | 1 | 64 |
| 81 | 2 | 68 |
| 83 | 1 | 70 |
| 84 | 3 | 76 |
| 86 | 1 | 78 |
| 87 | 1 | 80 |
| 88 | 1 | 82 |
| 90 | 1 | 84 |
| 91 | 1 | 86 |
| 93 | 2 | 90 |
| 94 | 1 | 92 |
| 95 | 1 | 94 |
| 97 | 1 | 96 |
| 103 | 1 | 98 |
| 112 | 1 | 100 |
| 3775 | | |

# Statistical Control Tools: Histograms

The ungrouped data is presented in graphic form – a histogram.



# Statistical Control Tools: Histograms

! Rather than treat each measurement discretely (71,72,73,..) we can further simplify the information by grouping the data in 3 steps:

1. Determine the adequate number of groups/classes

2. Determine the size of the class

3. Tally the number of measurements that fall within each class and determine the frequency by adding the number of tallies within each class

# Statistical Control Tools: Histograms

## 1. Determine the adequate number of groups/classes:

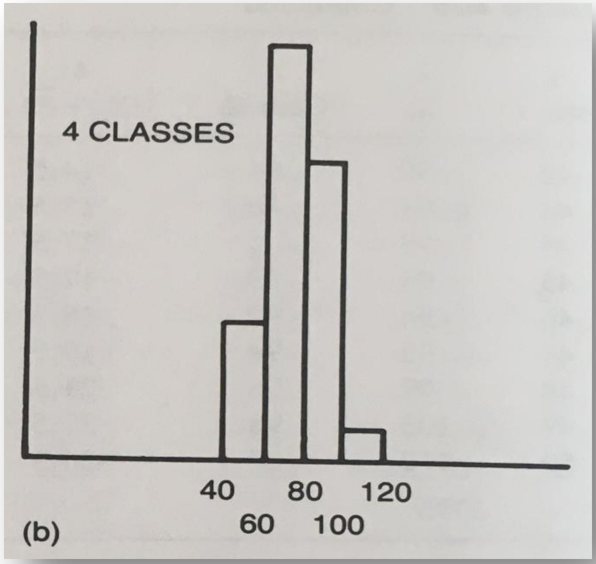
- Each class interval must be *mutually exclusive* (no measurement can be placed in more than one class), and *collectively exhaustive* (enough classes must exist for all measurements to be included)

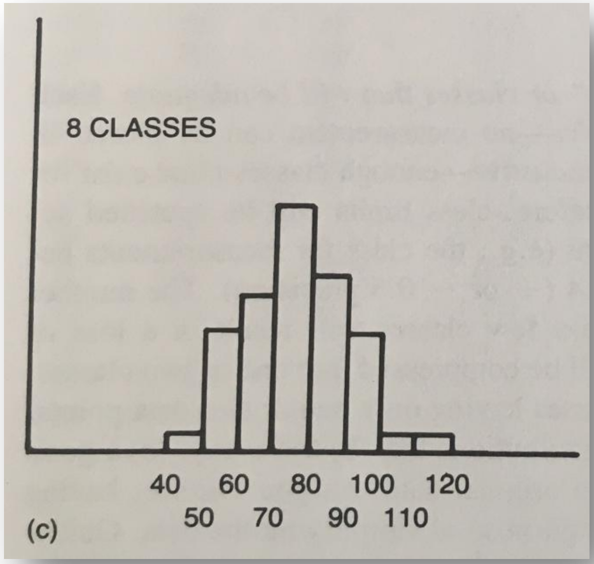
- Class limits must be specified according to the precision of measurement (ex.: the class for measurements between 70-79 is actually 69.5-79.4 with +/- 0.5 precision)

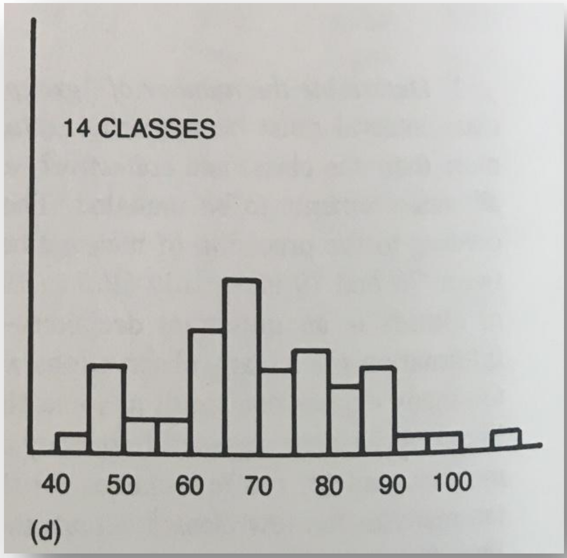
# Statistical Control Tools: Histograms

## 1. Determine the adequate number of groups/classes:

- The number of classes is important- too few will result in a loss of information, too many can result in some classes having only 1 or 2 data points



# Statistical Control Tools: Histograms

**1. Determine the adequate number of groups/classes:**

- Guidelines for choosing the number of classes, based on the number of observations, are listed in the next Table

| Observations | Classes |
|---|---|
| < 50 | 5 to 7 |
| 50 to 100 | 7 to 10 |
| 101 to 250 | 10 to 12 |
| > 250 | 12 to 15 |

# Statistical Control Tools: Histograms

## 2. Determine the size of the class

- First find the range of the measurements – the difference between the highest and the lowest measurement plus one (112-48=64+1=65) or the difference between the class limits (112.5-47.5 = 65)

- Then, determine the width of the class – divide the range by the number of classes you have (round numbers: 65/6 classes = intervals of 11 values; 65/8 classes = intervals of about 8 values). For simplicity you can choose intervals of 10

# Statistical Control Tools: Histograms

## 2. Determine the size of the class

- The first class must include the lowest observation and should start from a multiple of the class size (4 x class size 10 = 40). The first class is 40-49, the next 50-59 and so forth

- The final class must include the highest observation 112, so this final class interval (110-119) makes the total number of classes 8

# Statistical Control Tools: Histograms

**3. Tally the number of measurements that fall within each class and determine the frequency by adding the number of tallies within each class:**

- A cumulative frequency is computed by summing the frequency of occurence in each row and the frequencies above it, and then converting the results into a percentage

# Statistical Control Tools: Histograms

The results of this grouped frequency distribution are shown in the graphic form of a histogram based on the next Table.

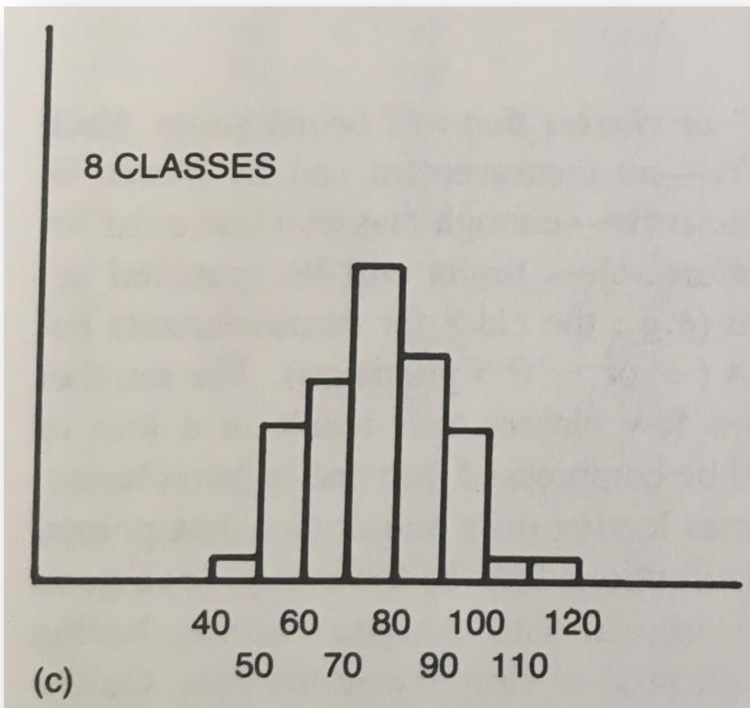



**Table A.6** Grouped Data

| 1 Interval | 2 Freq. | 3 Cum % | 4 Midpoint |
|---|---|---|---|
| 40–49 | 1 | 2 | 44.5 |
| 50–59 | 7 | 16 | 54.5 |
| 60–69 | 9 | 34 | 64.5 |
| 70–79 | 14 | 62 | 74.5 |
| 80–89 | 10 | 82 | 84.5 |
| 90–99 | 7 | 96 | 94.5 |
| 100–109 | 1 | 98 | 104.5 |
| 110–119 | 1 | 100 | 114.5 |
| | 50 | | |

# Analyse tools: Ishikawa diagram

Kaoru Ishikawa introduced a collection of graphical techniques in 1950 used to diagnose a problem or a process.

These techniques are called fishbone or Ishikawa diagrams

They provide a useful means of analyzing a problem (prior or following data collection), by organizing knowledge about a process.

They present a picture that represents a meaningful relationship between an effect (a defect, situation, problem) and its multiple causes. Thus, they help teams push beyond symptomsto uncover potential root causes

# Ishikawa diagram in problem solving

- **Symptom** = a characteristic or a complain about a certain problem

  Example: teh car does not work, the printer prints at a low quality level,...

- **Problem** = a deviation from expectations, an unexpected effect with unknown causes

  Example: the batery is low, the printer cough is on its end

***Trying to fight the symptom***

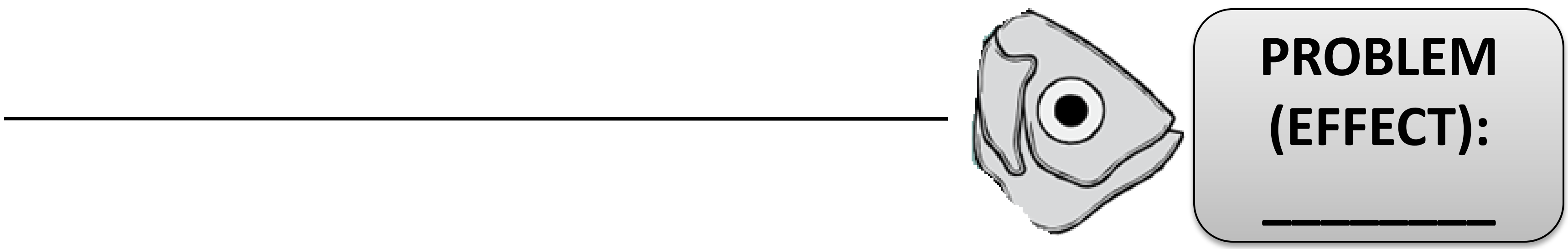
**What can we do?**

***Solving the problem through the identification of its causes and their elimination***

Short term solution, does not solve the problem on the long term

Long term solution, solves the problem definitively

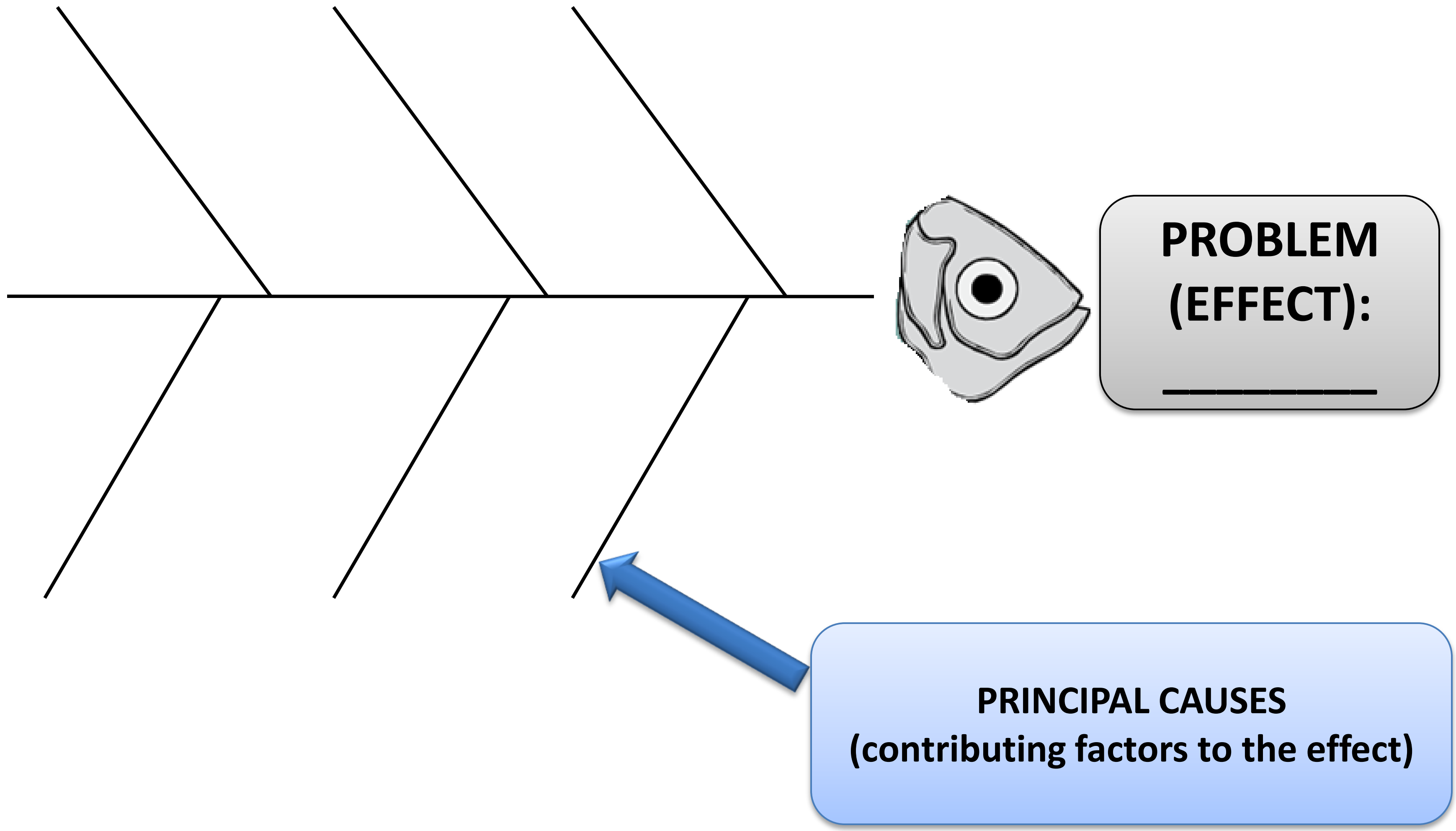
# Building the Ishikawa diagram




Name the problem or effect of interest. Be as specific as possible.

Write the problem at the head of a fishbone “skeleton"

# Building the Ishikawa diagram




Decide the major categories for causes and create the basic diagram on a flip chart/whiteboard

# Ishikawa diagram

The causes for the variation of the quality characteristics are the factors that influence the values of these charcateristics and they are usually grouped in 6 categories (6Ms):

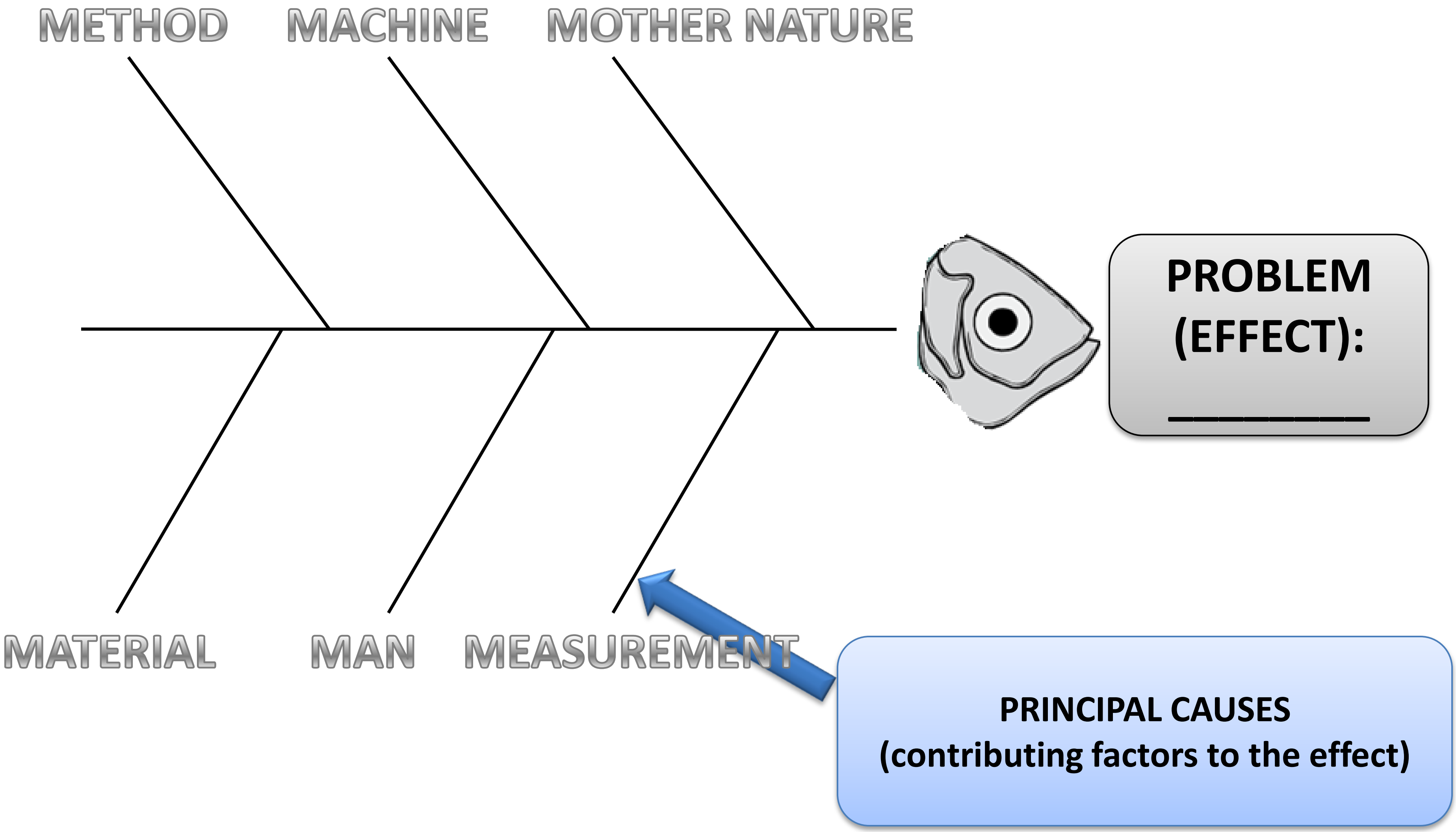
- **Man** – all involved in the process (operator, design engineer,..)
- **Method** – how the process is realized (standards, operating procedures)
- **Machine** – equipments, computers, necessary tools for our process
- **Material** – raw materials, parts necessary for final product development
- **Measurement** – general process data for quality assessment (variation)
- **Mother nature** – the conditions (temperature, time, location, culture) in which the process works (physical or political environment)

# Ishikawa diagram

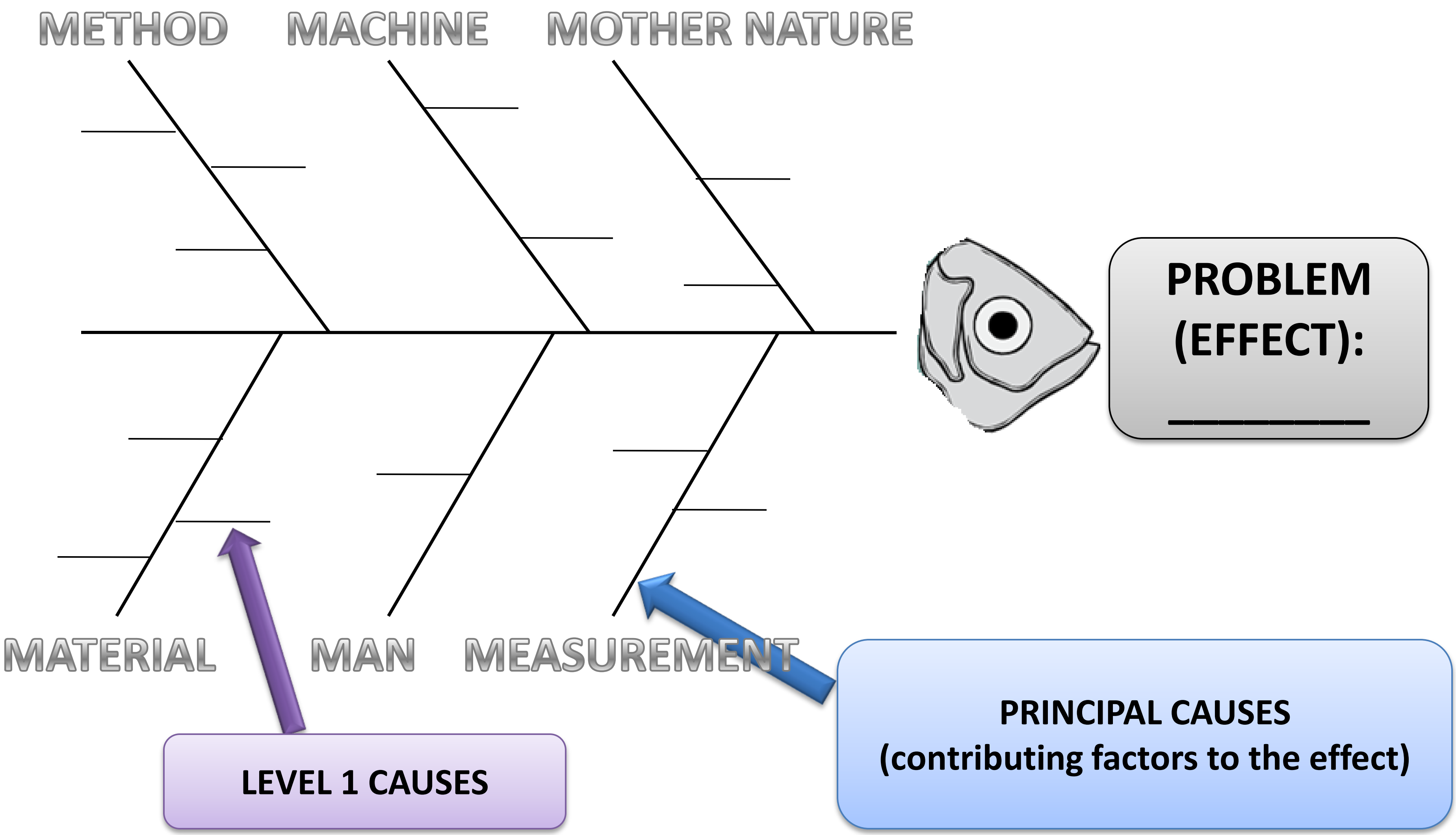
The diagram based on the 6 Ms is useful for:

- the analysis of the necessary conditions for improving quality in a product, for a better material supply or cost reductions
- elimination of conditions that cause the reject of a product or customer complaints
- employee training in decision making and in corrective actions

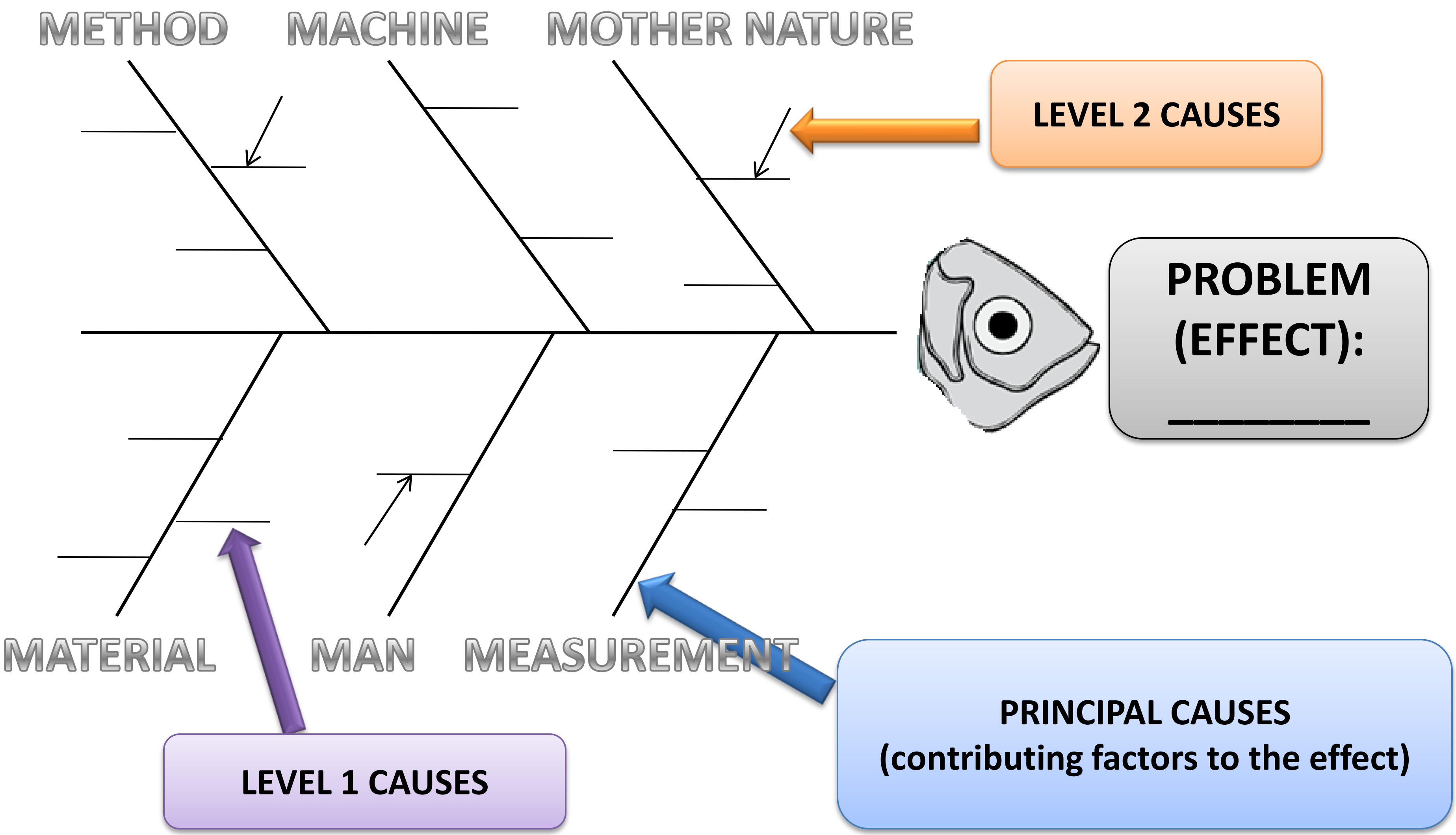
# Building the Ishikawa diagram



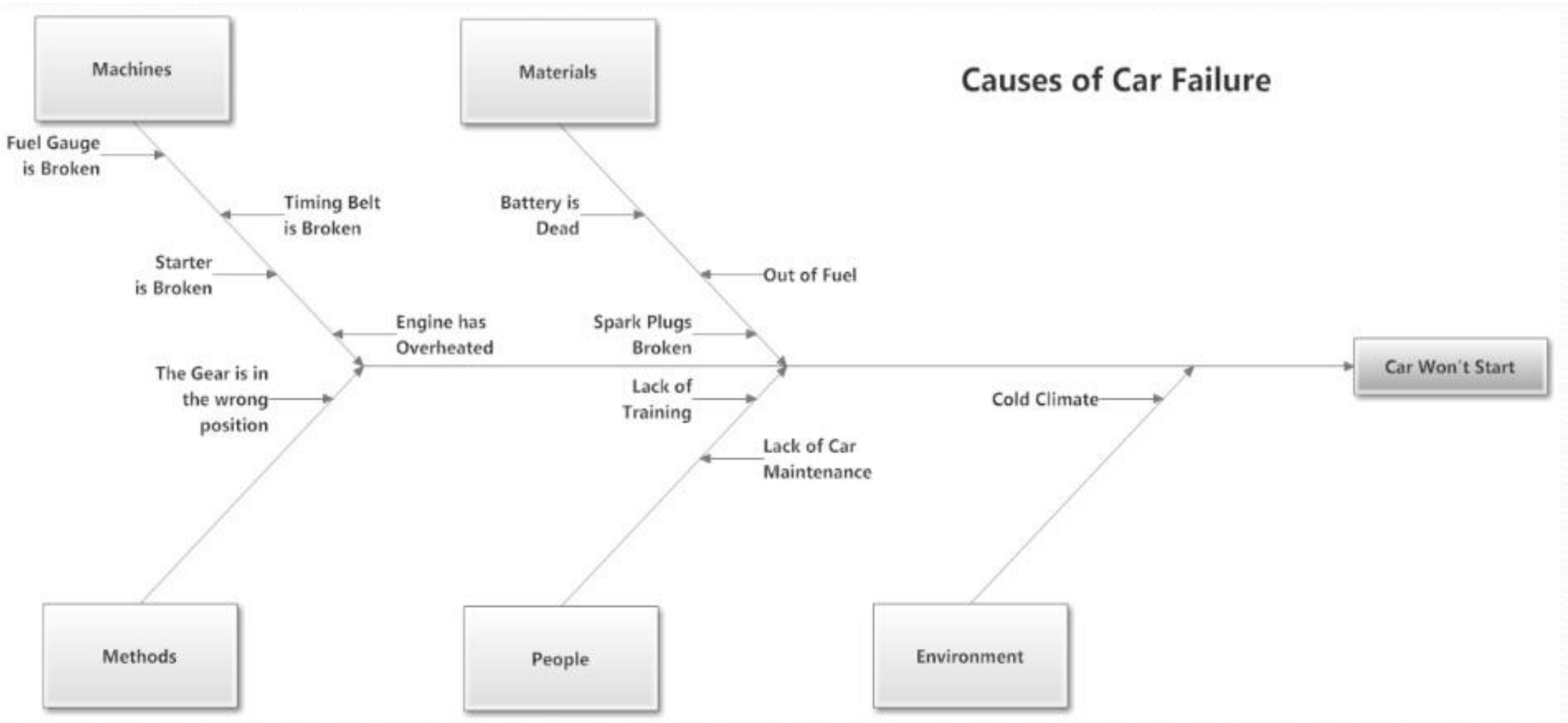
# Building the Ishikawa diagram



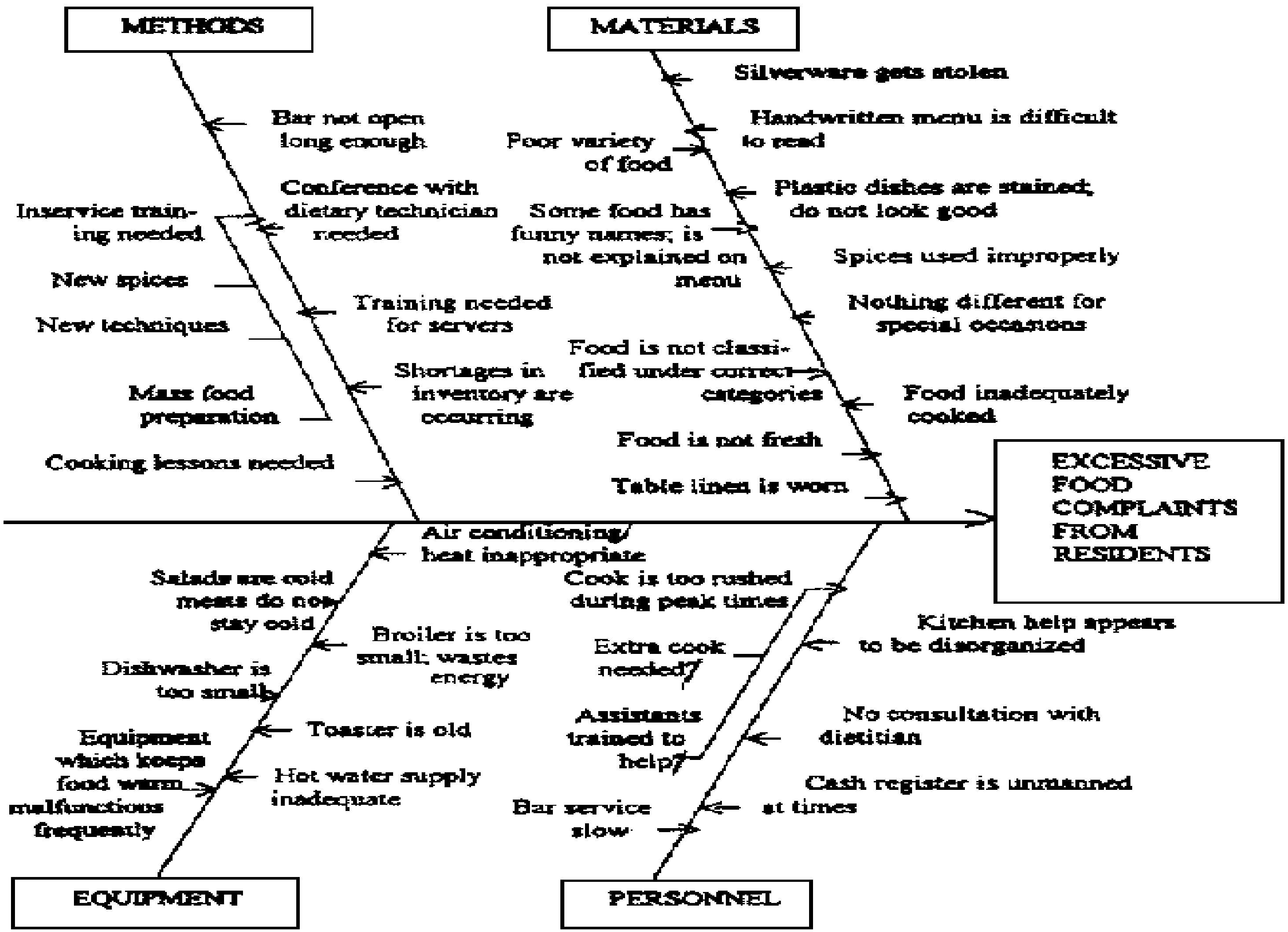
# Building the Ishikawa diagram



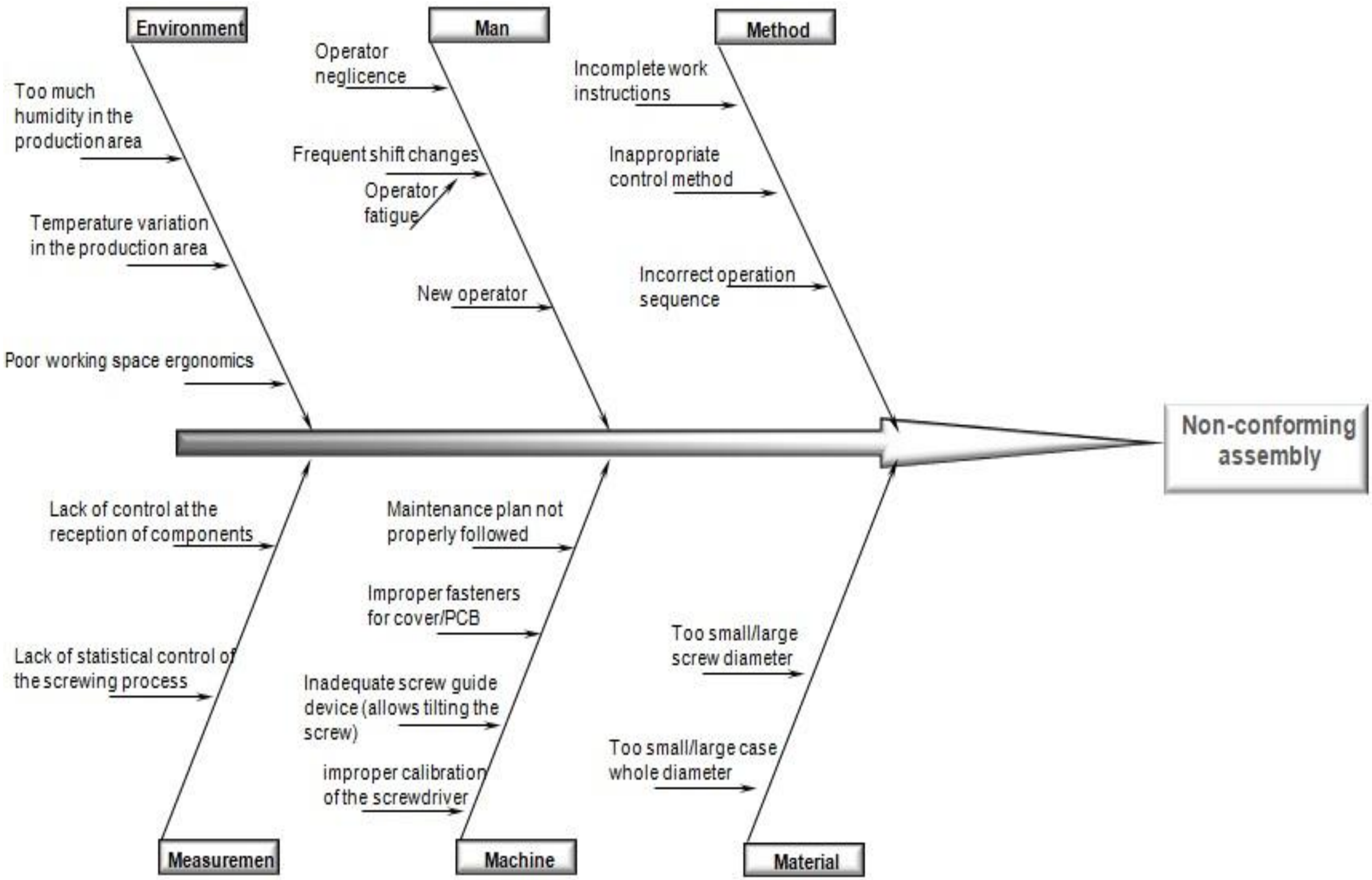
# Ishikawa diagram



# Ishikawa diagram



# Ishikawa diagram

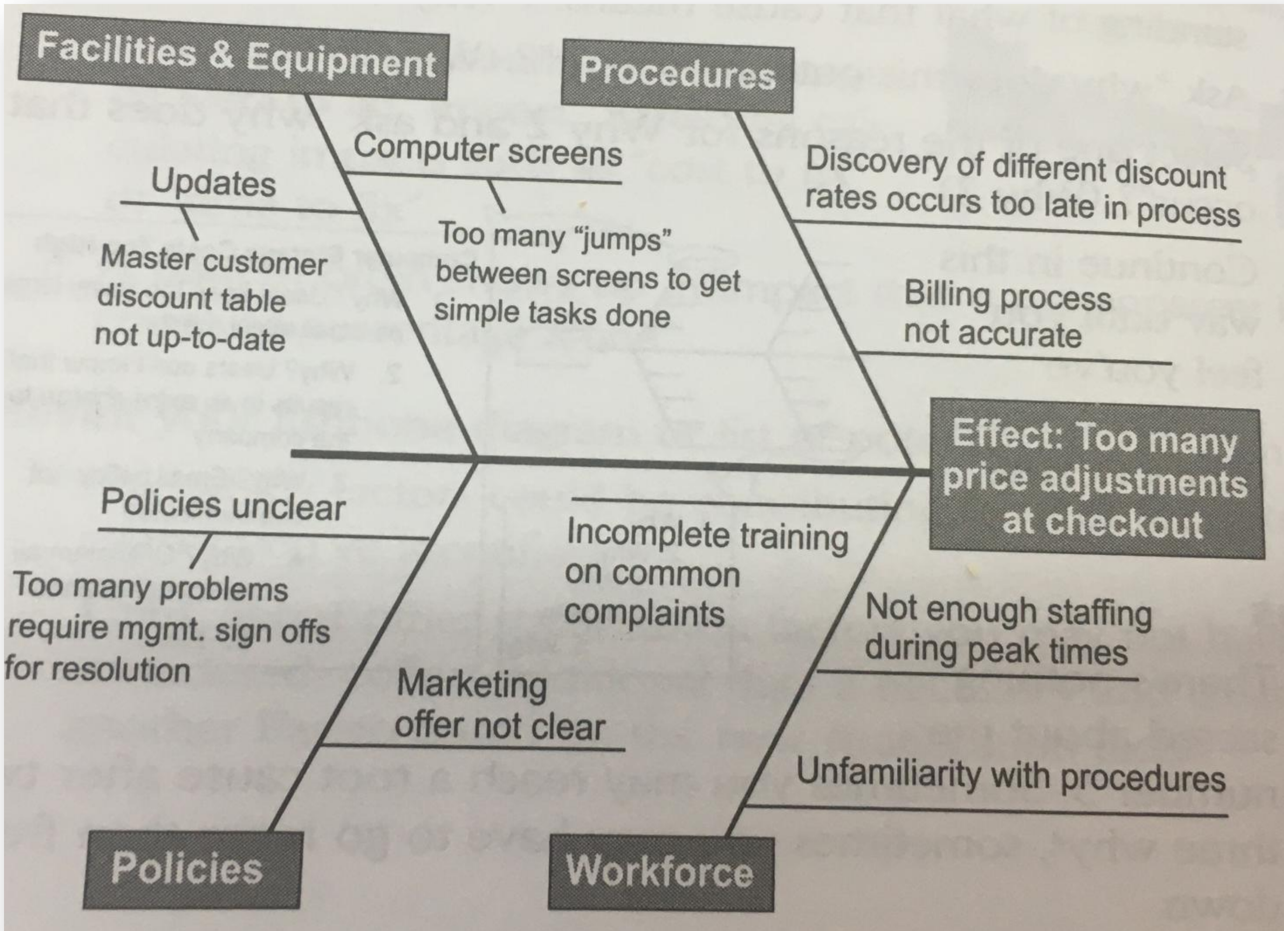


# Ishikawa diagram

For extra-productive domains diagrams based on 4 Ps are more suitable:

- Policies (HR policies, work policies or government policies,.. - covered in Method from 6 Ms)
- Procedures/Process (Methods from 6 Ms)
- Personel/People (Men from 6 Ms)
- Position/Plant (covers the Machine, Material and Work environment)

# Ishikawa diagram



# Ishikawa diagram

Once the Fishbone is populated with ideas, the next aim is narrowing the list of causes down to a manageable number to investigate

Limited resources dictate that not every cause is a candidate for verification. Nor should they be.

Multi-Voting, also known as N/3, is a simple tool that provides a quick visual prioritization.

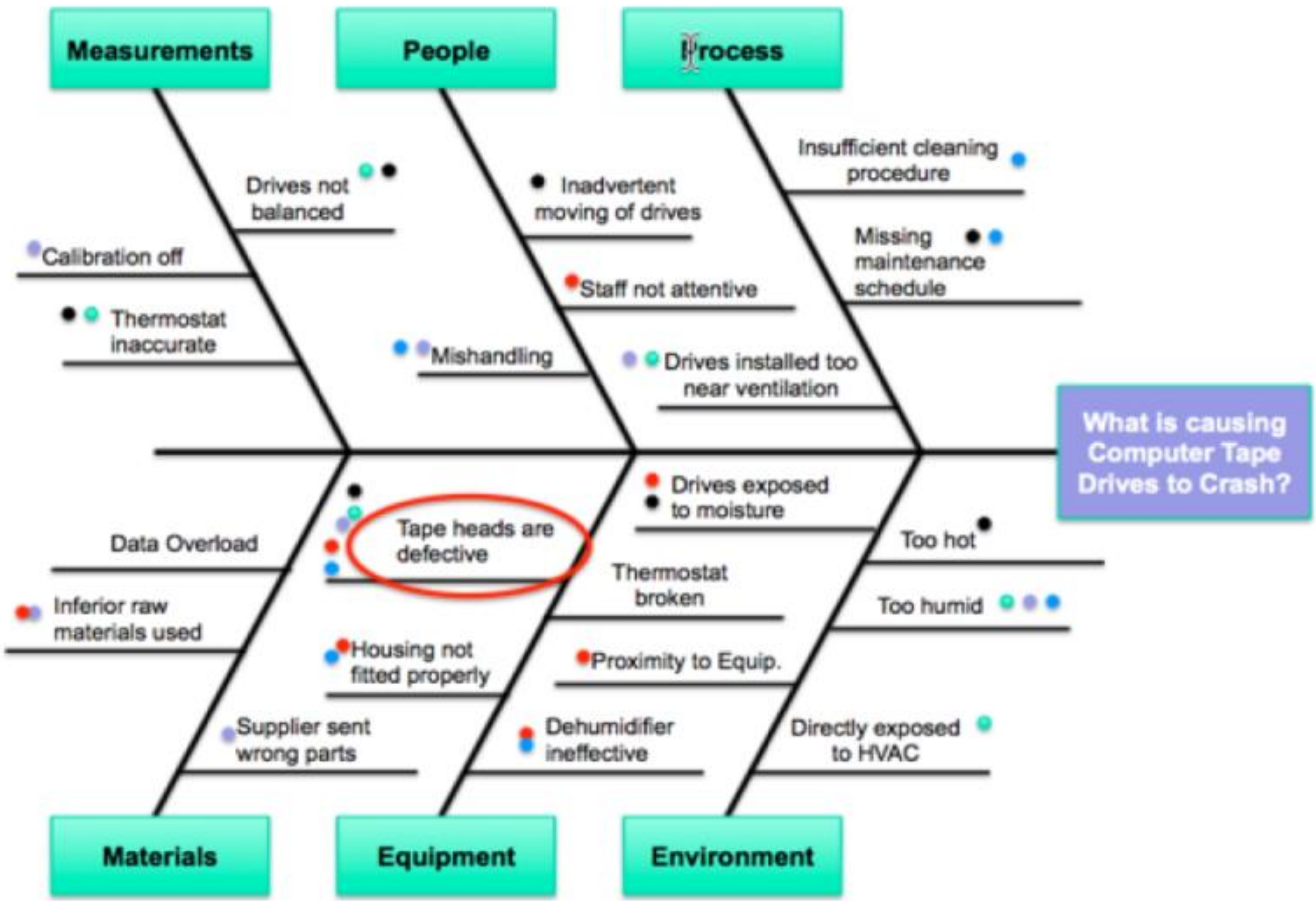
# Ishikawa diagram

MULTIVOTING steps:

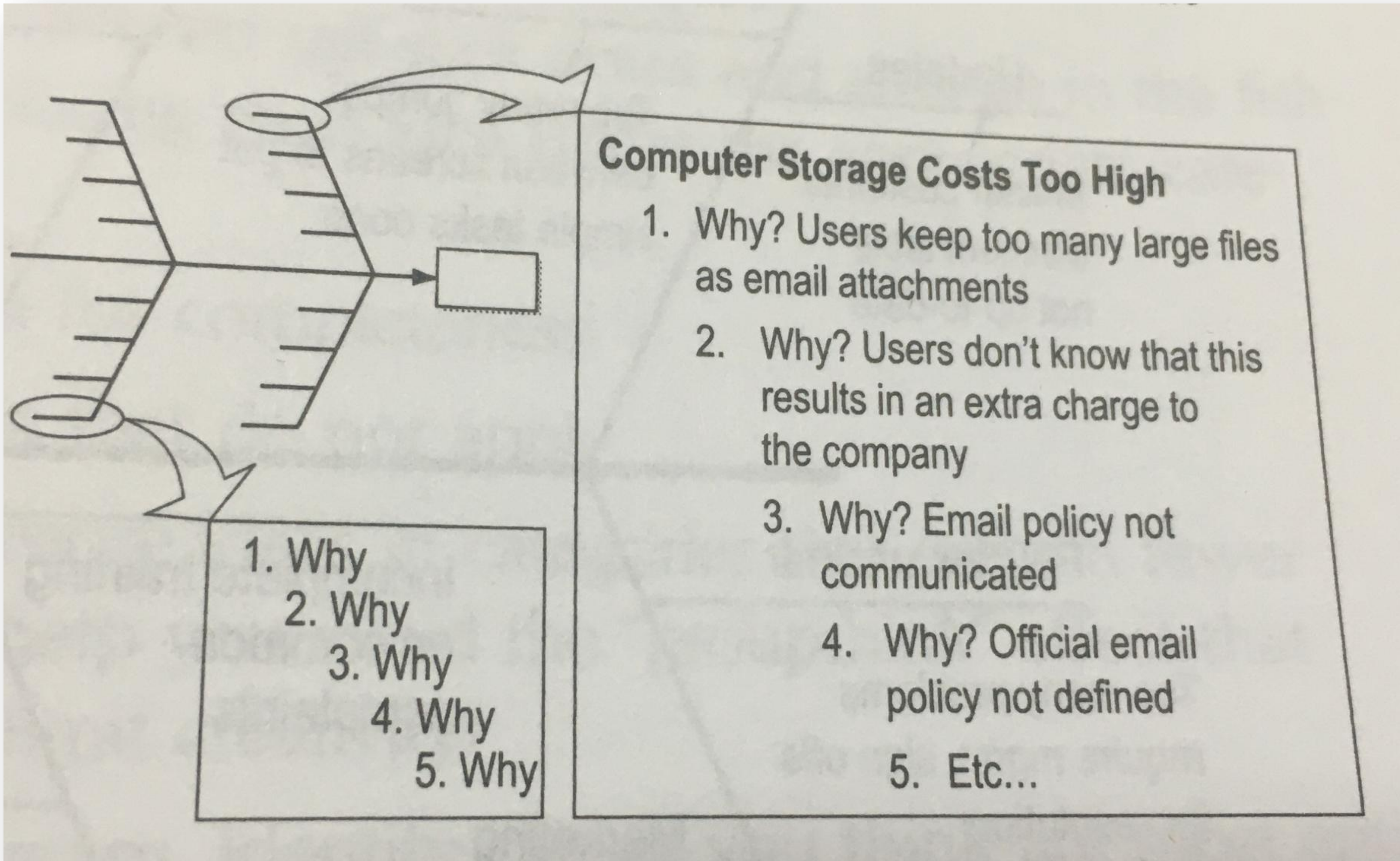
- Add up the number of potential causes
- Divide the total by 3
- Give each member of the group the resulting number of votes

For example, if there are 21 potential root causes, 21/3 = 7. Everyone gets to put a mark next to the 7 causes they'd like investigated (sticky dots are good for this). The result is an instant shortlist to pursue.

# Ishikawa diagram



# Ishikawa diagram and 5 Whys



# Affinity diagram (K-J method)

- developed by Kawakita Jiro in 1960
- one of the seven management tools for planning in TQC
- organizes a large quantity of information by natural relationships by using a team's analytical thinking as well as creativity and intuition

# Affinity diagram (K-J method)

- The K-J method represents in a structural way the relationships (affinities) between ideas (opinions, reflections) regarding a certain aspect/problem

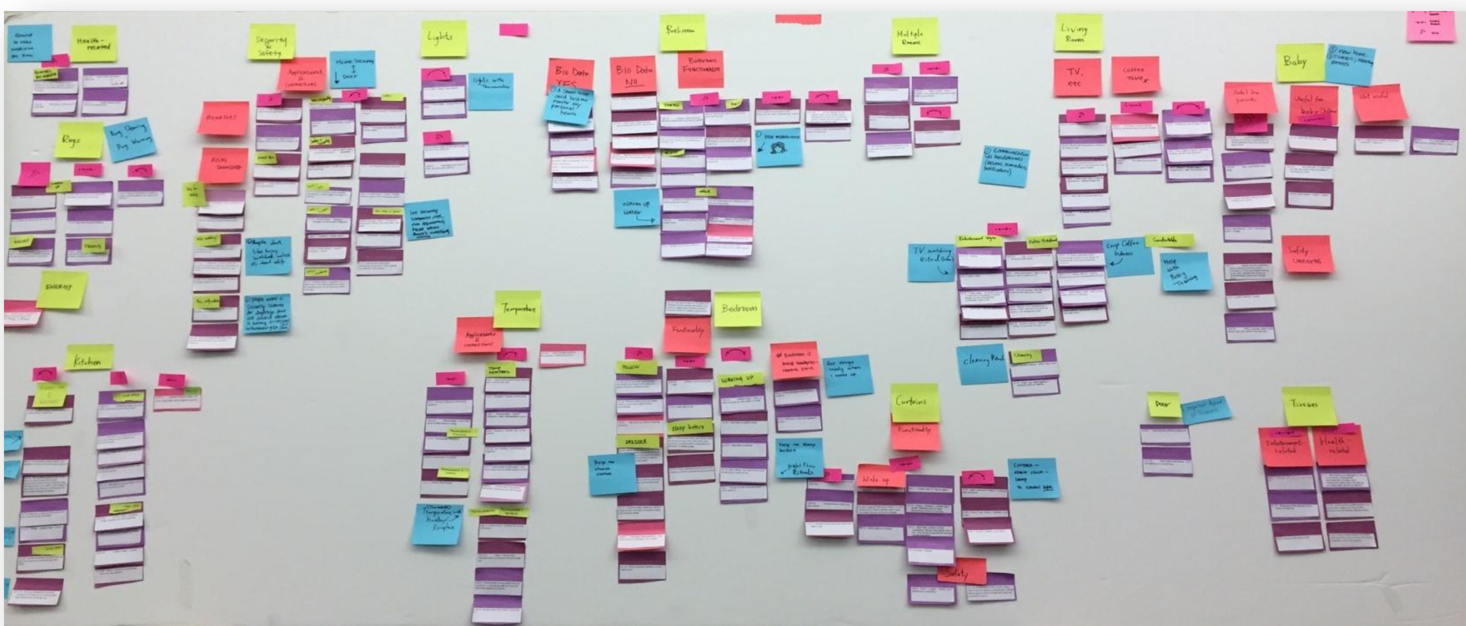
- These ideas are grouped in families, then the afinities (relationships) between the families is delineated

- After collecting a sufficient amount of ideas regarding a problem, the information is organized in groups based on the natural relationships between them

# Affinity diagram (K-J method)

- The process stimulates creativity and engages all the team members (a team consists of 3 – 8 diverse persons)

- The K-J tool can be used to organize the ideas generated thorugh brainstorming

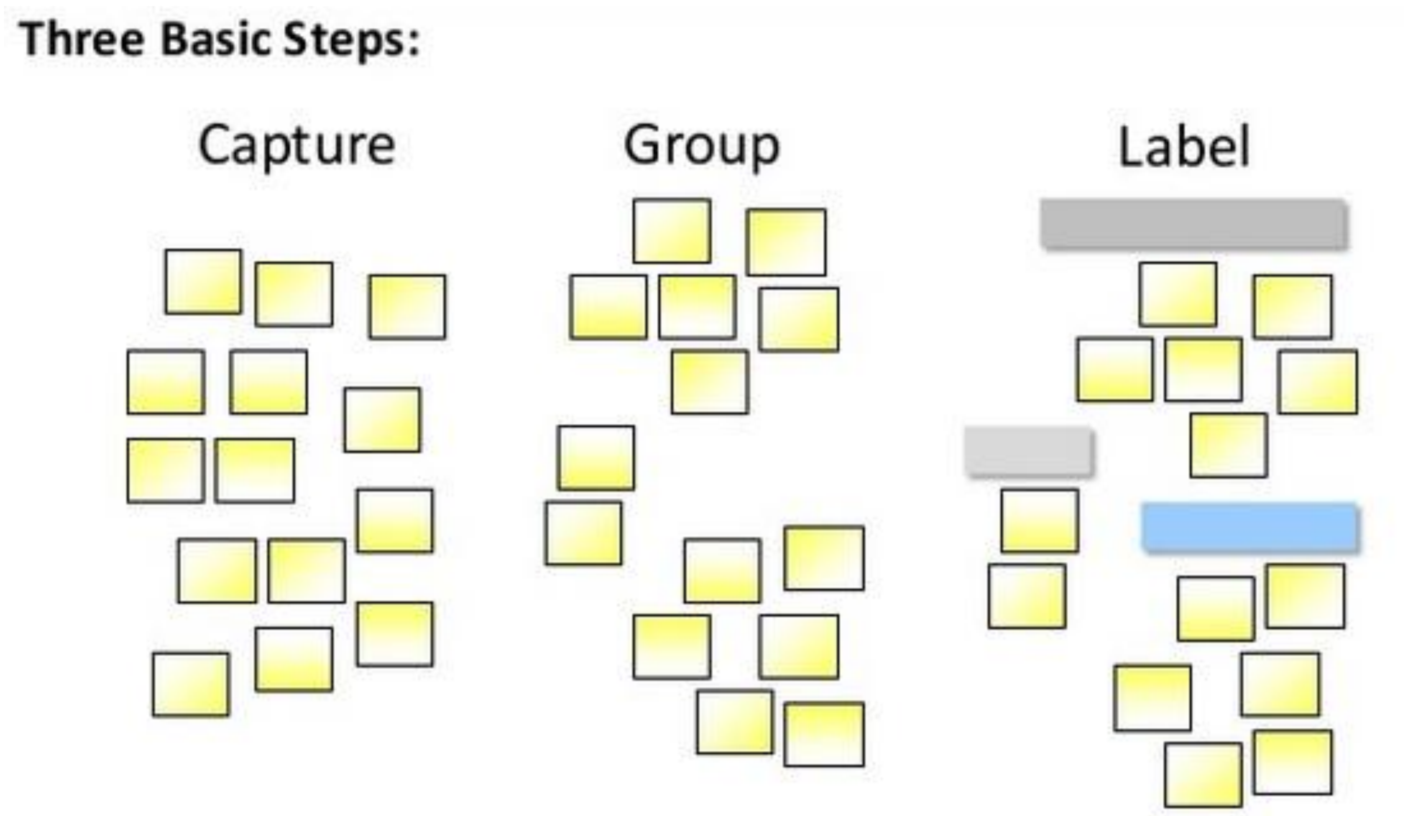


# Affinity diagram (K-J method)

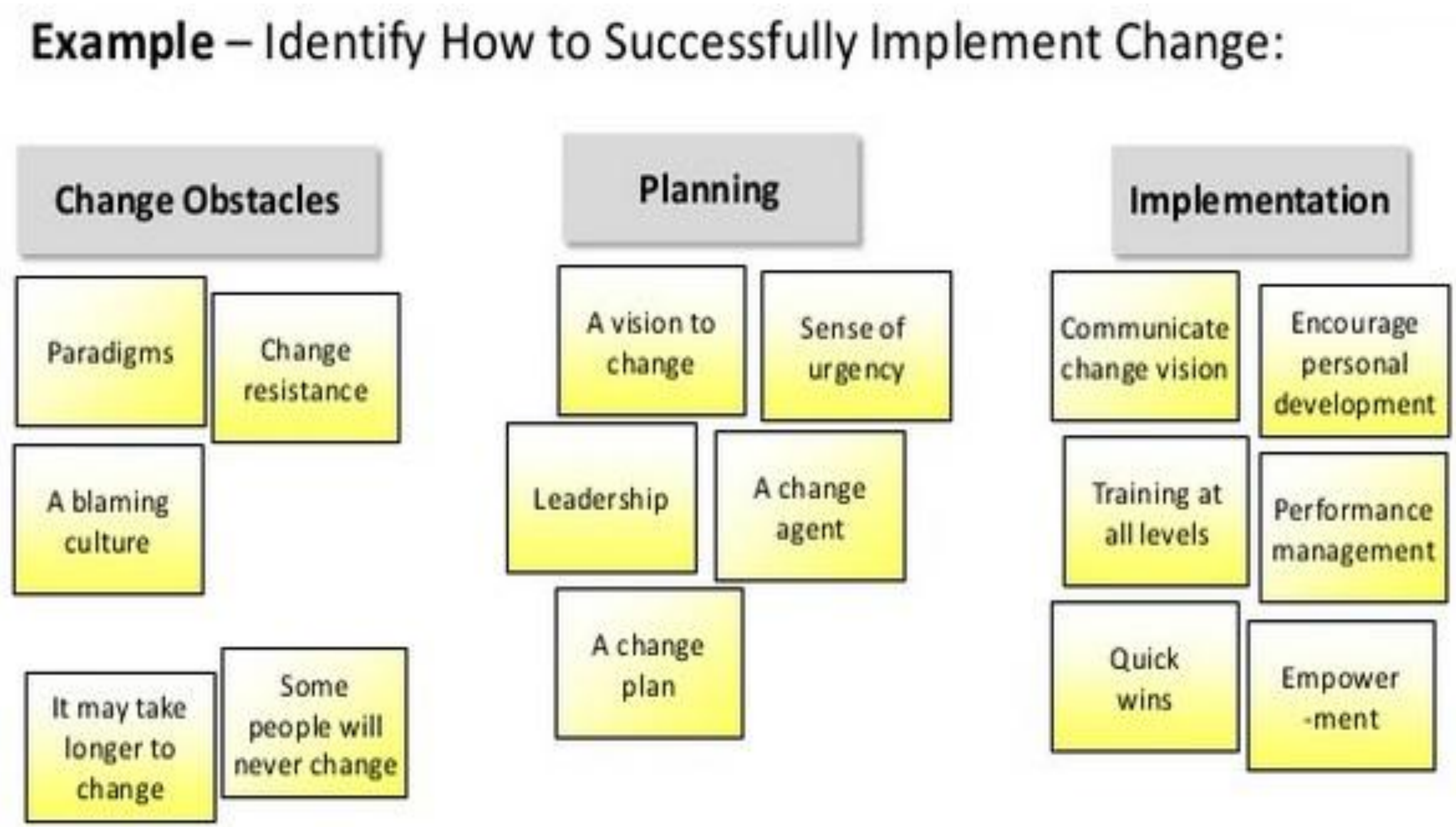
**How** to conduct an Affinity Session?

- Present the topic or the problem (not too many details, they may harm the process)
- The team receives index cards/sticky notes
- Team members are asked to write down one idea/issue per card (a considerable number of ideas, each 5-9 words including a verb and noun)
- The ideas are mixed and presented aleatory on the table
- The ideas are sorted into categories (each category is labelled, duplicate ideas are eliminated, max 10 categories)
- Arrows between groups/categories are added to show significant relationships

# Affinity diagram (K-J method)



# Affinity diagram (K-J method)



# Affinity diagram (K-J method)

**ADVICE:**

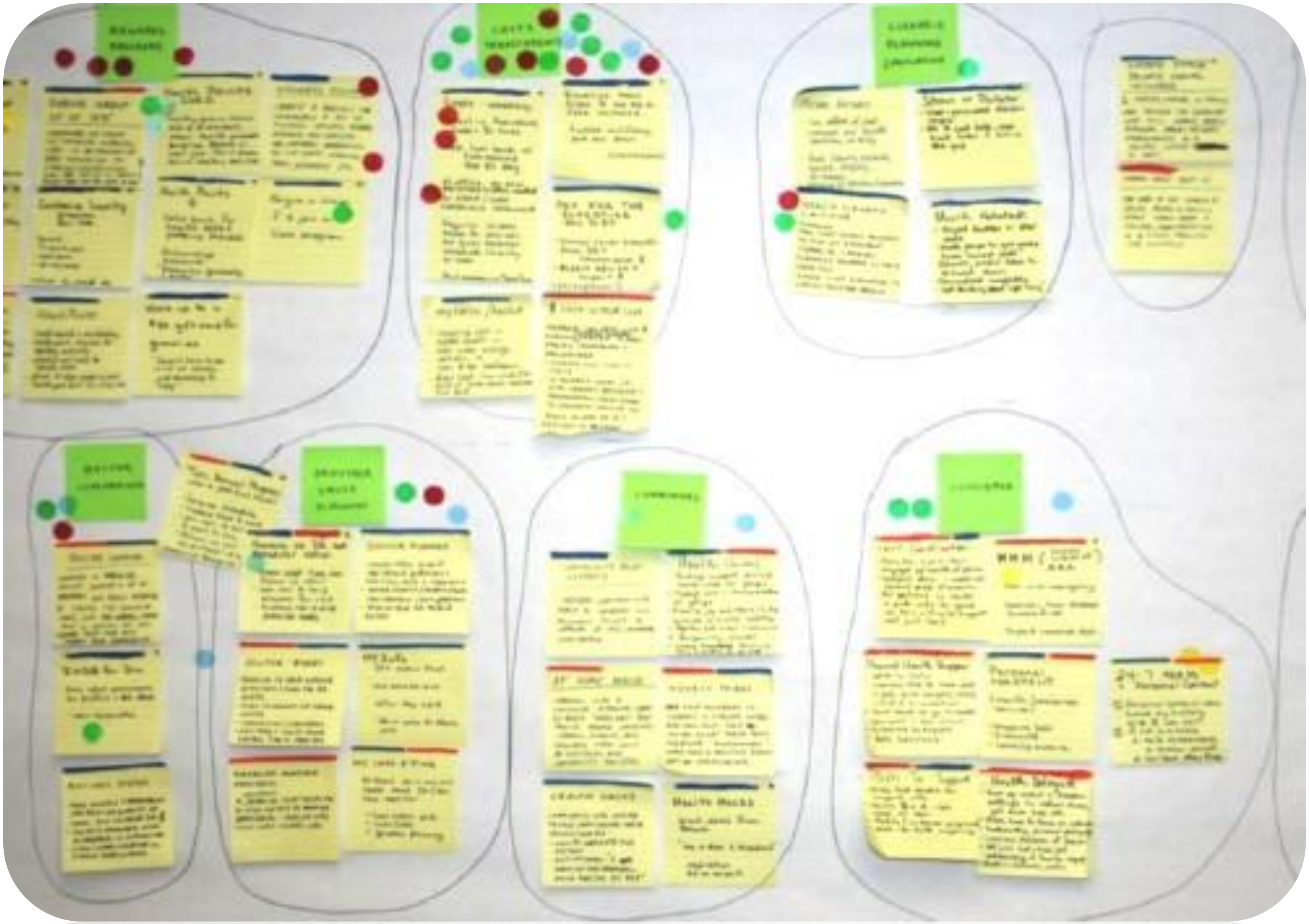
- Go for volume, suspend judgment, build on each other's ideas and set a strict time limit. Allow 30 or 40 minutes for brainstorming ideas.
- To create headers ask for each grouping: "What key words summarize the central idea that this grouping communicates?" Sometimes a post it from within the group can be used as a header.
- Do not use full sentences for headers but summarize the association with just one or two words
- If a group has two themes, then split the group into two groups

# Affinity diagram (K-J method)

For **what purposes** do we conduct an Affinity Session?

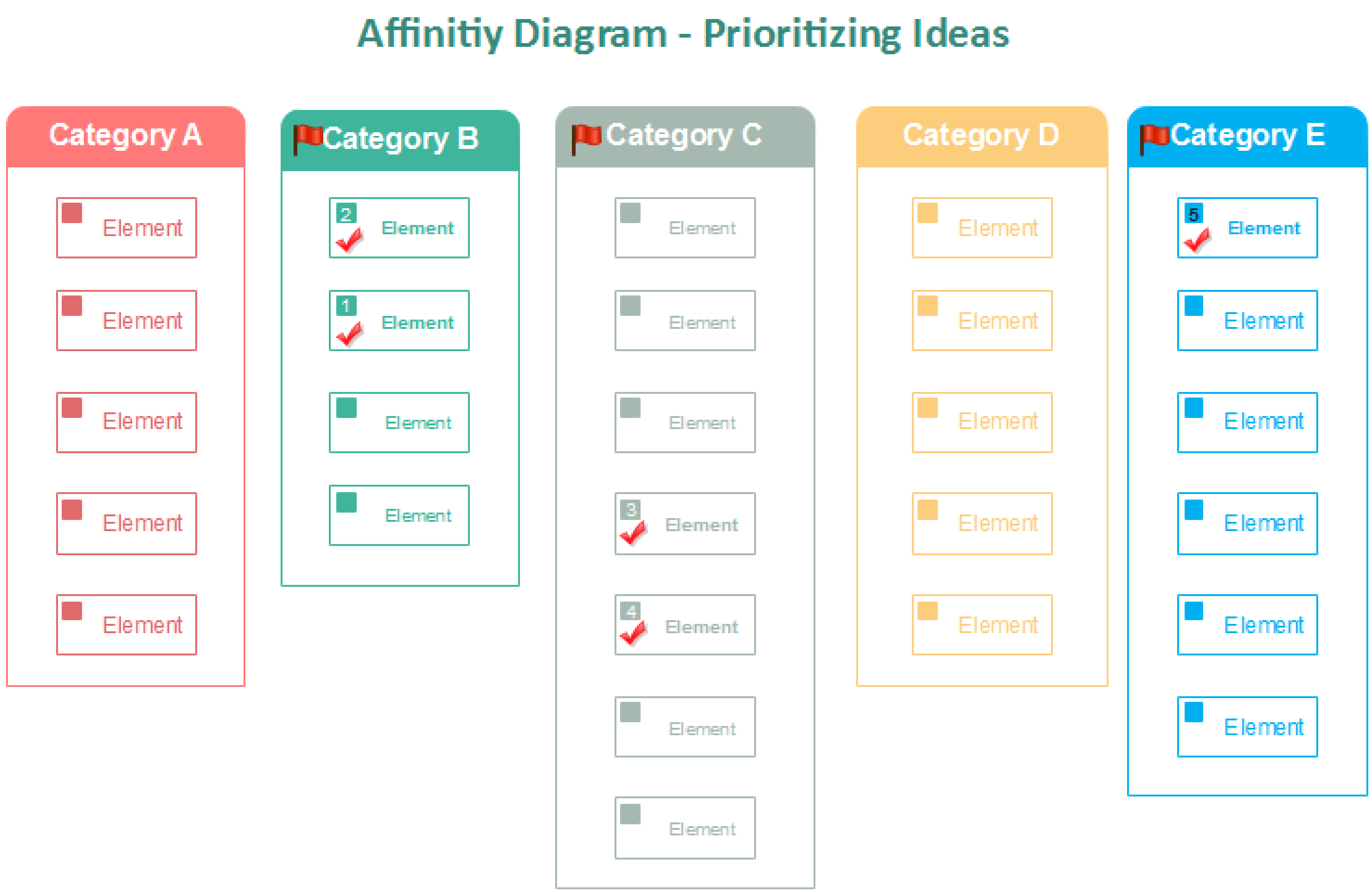
- Understand what is most important for ambiguous data
- Identify connections, create hierarchies and identify themes in complex data
- Idetify what factors to focus on (the main picture)
- Encourage new productive thinking

# Affinity diagram (K-J method)



# Affinity diagram (K-J method)

# Affinity diagram (K-J method)



# Relations diagram/ Relationships analysis

Used to generate a visual representation of the relations between an effect and its causes as well as the interrelationship between the causes in complex problems

THUS, it helps identify what factors are causes and which factors are effects

Factors help establish KPI (Key Performance Indicators) to monitor changes and the effectiveness of corrective actions in resolving a problem.

# Relations diagram

**HOW** to build a relations diagram?

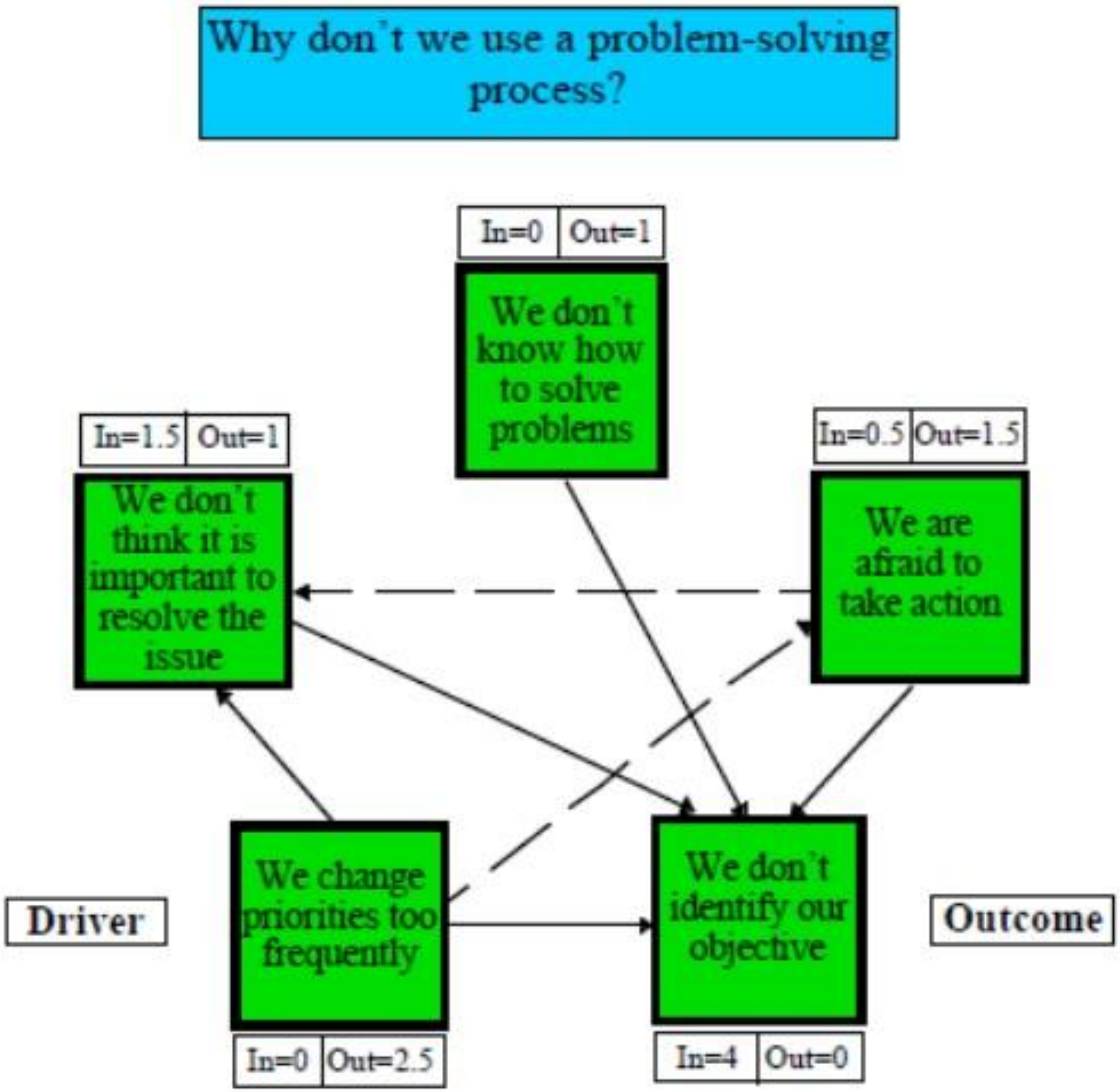
- Agree on the issue or question
- Add a symbol to the diagram for every element involved in the issue
- Compare each element to all others. Use an "influence" arrow to connect related elements
- The arrows should be drawn from the element that influences to the one influenced. If two elements influence each other, the arrow should be drawn to reflect the stronger influence.
- Count the arrows. The elements with the most outgoing arrows will be root causes or drivers. The ones with the most incoming arrows will be key outcomes or results
- If necessary, rearrange the rectangles in such a way that the connecting lines are short and the diagram compact

# Relations diagram

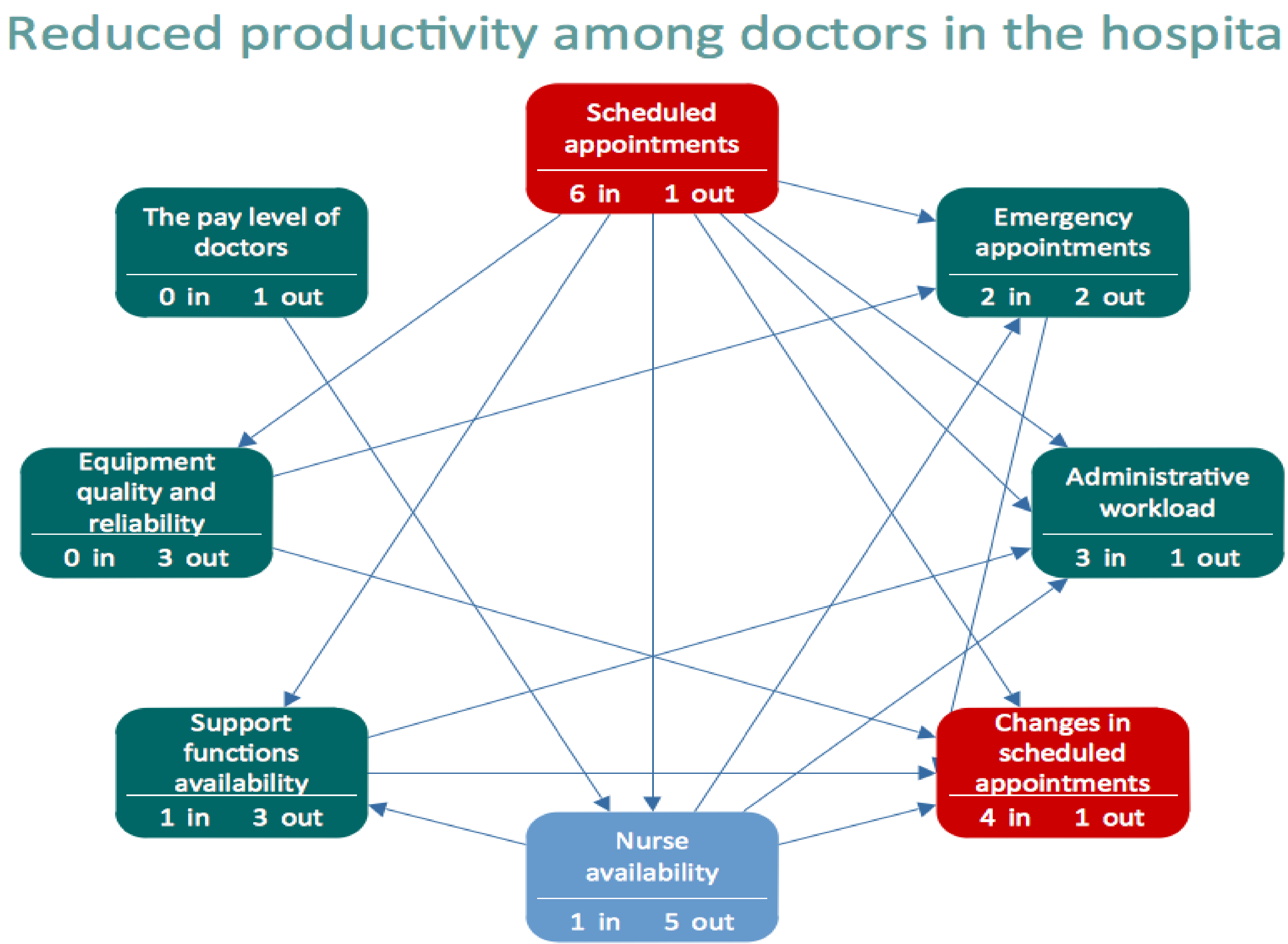
- The output of the tool is a list of root causes for the problem with some indication of their relative importance

! The output has to be considered as only an indication of the relative importance of the causes. Data has to be collected to confirm or reject the conclusions arrived at the end of the session (the perception of the team members MUST be supported by facts for corrective actions

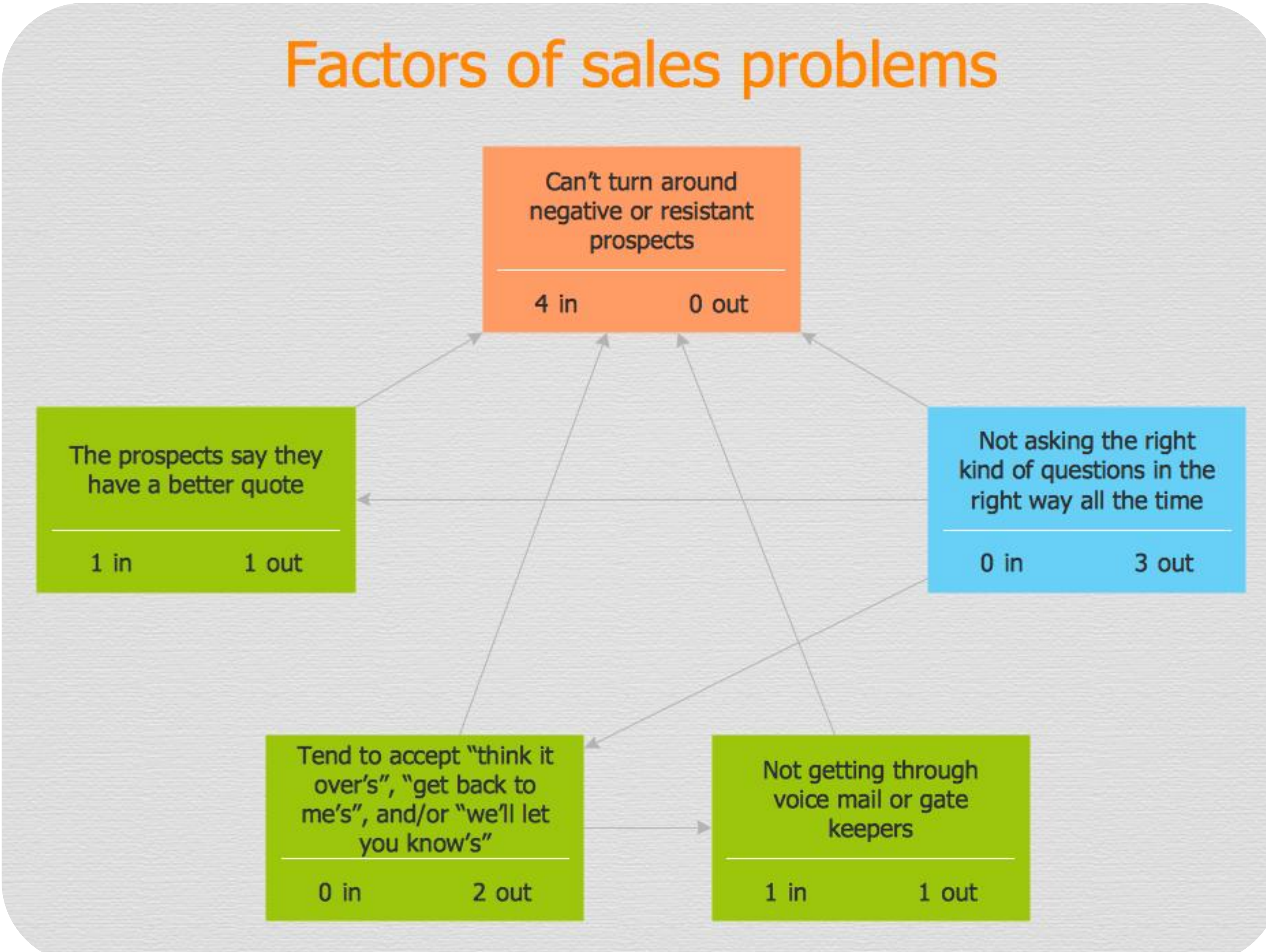
# Relationship diagram
## - examples -



# Relationship diagram



# Relationship diagram



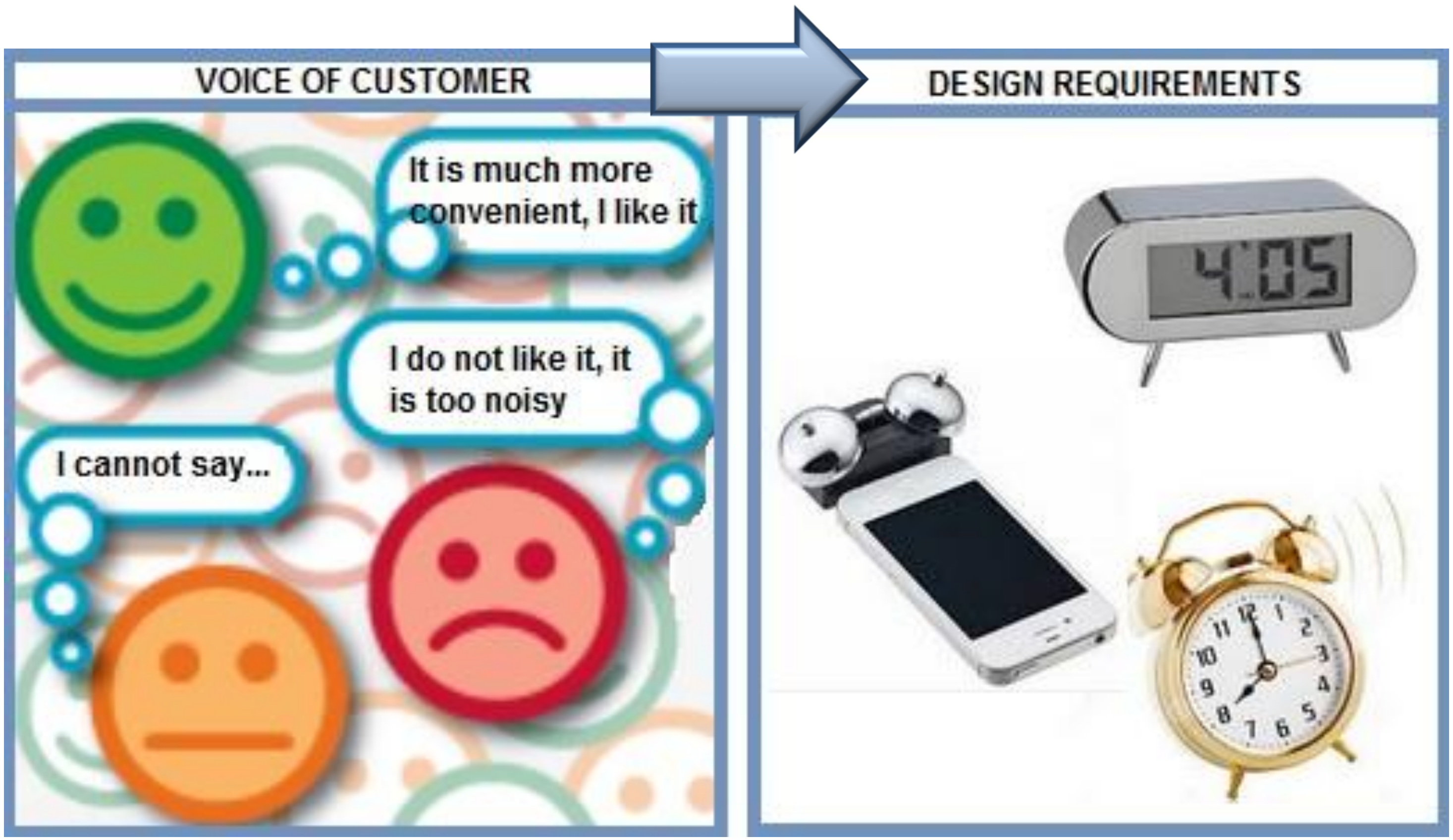
# The Kano model

- Customers' viewpoint of the quality of a product is essential and provides information on their expectations  regarding that offer

- Adequate tools for assessing the voice of the customer (VOC) when designing appealing products and services are neeeded

- The theory of attractive quality and especially the Kano model have transformed the way in which we evaluate quality and customer value

# Voice of the Customer



# Kano model

## WHAT does this tool provide us with?

- addresses the non-linear relationship between quality attribute performance and overall customer satisfaction (the first to demonstrate co-existing linear and non-linear product/service features)
- classifiess each product or service feature in a specific quality category (different influences on customer satisfaction when met)

# Kano model

- Developed and published in 1984 by Noriaki Kano

## **WHY use this tool?**

To better understand what value your customers place on the features of your product/service, which can reduce the risk of providing products/services that over-emphasize features of little importance or that miss critical-to-quality features (attributes)

# Kano model

## **WHEN use this tool?**

- defining your problem
- in the measuring stage where you need to understand scope and importance (improvement purposes)
- in the design stage of new offers (to know what the customers want/need) to deligh them

# Kano model

## HOW does it work?

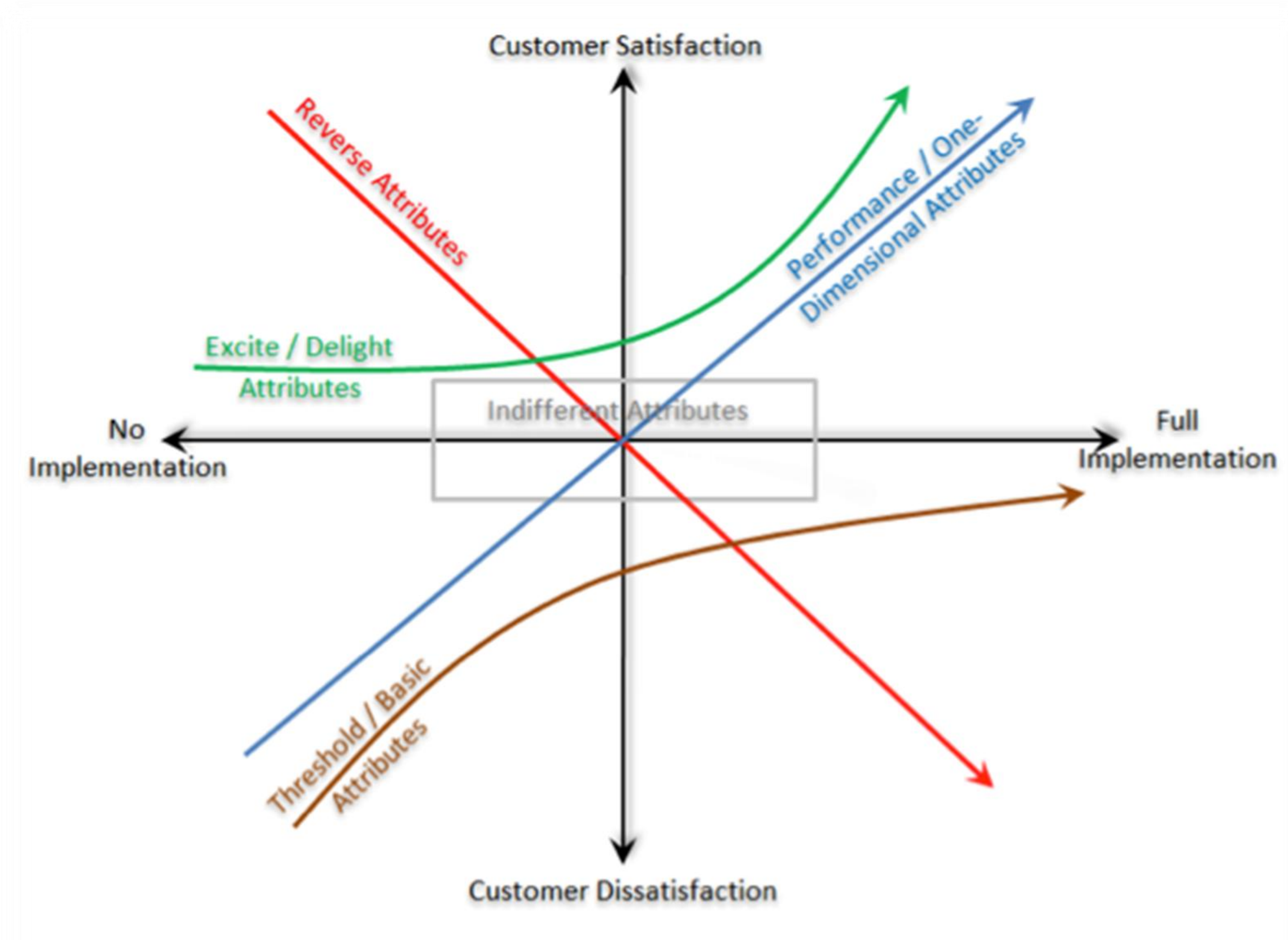
- it is a questionnaire based technique – the Kano questionnaire

- after computing the results based on a Kano evaluation table, each product/service feature receives a Kano category – guides decision making

- For more details other indicators and tools can be used together with the Kano model (QFD, Kansei, HWWP)

# Theory of attractive quality

## - Kano categories -



# Theory of attractive quality

## - Kano categories -

**MUST – BE** attributes: not explicitly demanded, considered obvious and trigger dissatisfaction if not met  (basic requirements are considered the entry point for getting into a market)

**ONE-DIMENSIONAL** attributes: specified and expected, the level of fulfilment determines proportionally customer satisfaction (satisfying performance requirements will allow you to remain in the market)

**ATTRACTIVE** attributes : not expected but the level of fulfilment determines more than proportionally customer satisfaction, even delight but does not trigger dissatisfaction if not met (satisfying excitements requirements opens the opportunity to excel, to deligh your customers, to be World Class)

**INDIFFERENT** attributes : not expected, not requested,  no influence on satisfaction

**REVERSE** attributes: the opposite is requested/desired

**QUESTIONABLE** attributes: wrong answers, wrongly built questions,

# Theory of attractive quality

## - Kano methodology -

| | | |
|---|---|---|
| 1.1 What is your perception of a packaging that protects the product? *(Functional question)* | 1. I like it that way | |
| | 2. It must be that way | |
| | 3. I am neutral | |
| | 4. I can live with it that way | |
| | 5. I dislike it that way | |
| 1.2 What is your perception of a packaging that does not protect the product? *(Dysfunctional question)* | 1. I like it that way | |
| | 2. It must be that way | |
| | 3. I am neutral | |
| | 4. I can live with it that way | |
| | 5. I dislike it that way | |

| Quality attribute | | Dysfunctional | | | | |
|---|---|---|---|---|---|---|
| | | Like | Expect | Neutral | Accept | Dislike |
| Functional | Like | Q | A | A | A | O |
| | Expect | R | I | I | I | M |
| | Neutral | R | I | I | I | M |
| | Accept | R | I | I | I | M |
| | Dislike | R | R | R | R | Q |

| Quality attribute | A | M | O | R | Q | I | Total | Grade |
|---|---|---|---|---|---|---|---|---|
| Protection | 1 | | | | | | 1 | A |
| Leakage | | | | | | | | |
| Resealability | | | | | | | | |
| … | | | | | | | | |

# Theory of attractive quality

## - Berger et al (1993)' s satisfaction coefficient -

customer satisfaction coefficient

| Product requirement | A | O | M | I | Total | Category | $\frac{A+O}{A+O+M+I}$ | $\frac{O+M}{A+O+M+I}$ |
|---|---|---|---|---|---|---|---|---|
| **Edge grip** | 7 | 33 | **50** | 10 | 100% | **M** | **0.40** | **-0.83** |
| **Ease of turn** | 11 | **46** | 31 | 12 | 100% | **O** | **0.57** | **-0.78** |
| **Service** | **66** | 22 | 3 | 9 | 100% | **A** | **0.89** | **-0.25** |

# Quality Function Deployment

- Developed by Yoji Akao and Shigeru Mizuno in 1960
- It is a planning tool with a specific aim: to design the quality of a product/service taking into consideration primarily the Voice of the customer (VOC) – client needs
- It helps design engineers to translate the VOC into design requirements
- It represents **quality**-monitoring, a focus on the **function** of execution of a quality plan, and the application of resources for **deployment** of that plan.

# Quality Function Deployment

- The final scope of QFD is to translate subjective quality criteria into objective criteria that can be adequately measured and quantified

- It is a complementary method for determining priorities in product development/improvement

- INTENTION: to obtain objective and detailed procedures in product development/improvement

# Quality Function Deployment

- Each of the 4 phases of the QFD process use a defined set of matrices for translating client requirements from initial planning phases to production control

- Each phase or matrix represents a specific aspect of product requirements. The relationships between elements are evaluated for each phase. ONLY the most important aspects from each phase are further developed in the next matrix.

# Quality Function Deployment

QFD allows us to see:

- WHAT our client expects regarding the quality characteristics of our product/service

- HOW we can meet these expectations and characteristics

# Quality Function Deployment

QFD benefits:

- **Focus on Customers** – the emphasis is placed on customer needs which are translated into design specifications. During the QFD processes, these design specifications are driven down from machine side to system and finally component level requirements. Design specifications are controlled throughout the production and assembly processes to assure the customer needs are met

- **Focused on Competitors** – the QFD **House of quality** tool allows a comparison of how your design/product/service relates to competition in meeting the VOC ( great analysis with competitive related results)

- **Focused on Efficiency** – QFD reduces the risk of late design changes because it focuses on product/service features and improvements based on VOC. Also it prevents losing time and wasting resources (analysis, structure and documentation for a historical record)

# Quality Function Deployment

QFD identifies requirements in **several steps**:

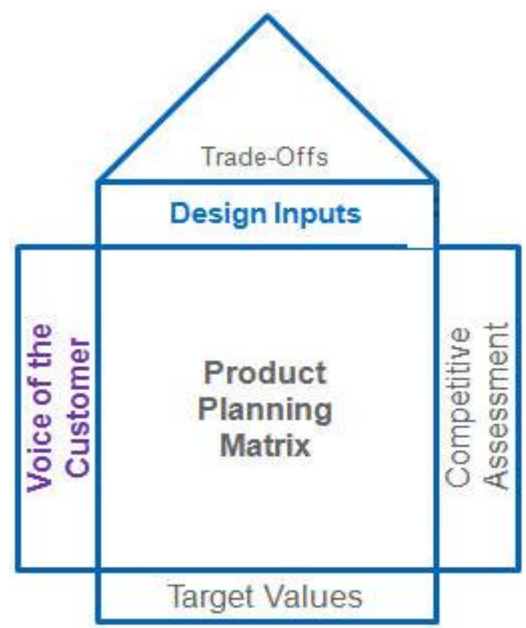
- Initial identification of client requirements (needs and functions)
- Identification of quality characteristics which correspond to client requirements (based on needs/functions already determined)
- Identification of process parameters and characteristics – technical specifications (based on quality characteristics)
- Identification of process control requirements (based on technical specifications)
- Identification of customer complaints, nonconformities or defects after production and sale of the product and redimensioning of product functions (start of another cycle)

# Phase 1. Product planning (HoQ):

- completed by the Marketing Department

- documents needed: customer requirements, warranty data, competitive opportunities, product measurements and competing products measurements

- determines the technical aspects needed to meet customer requirements



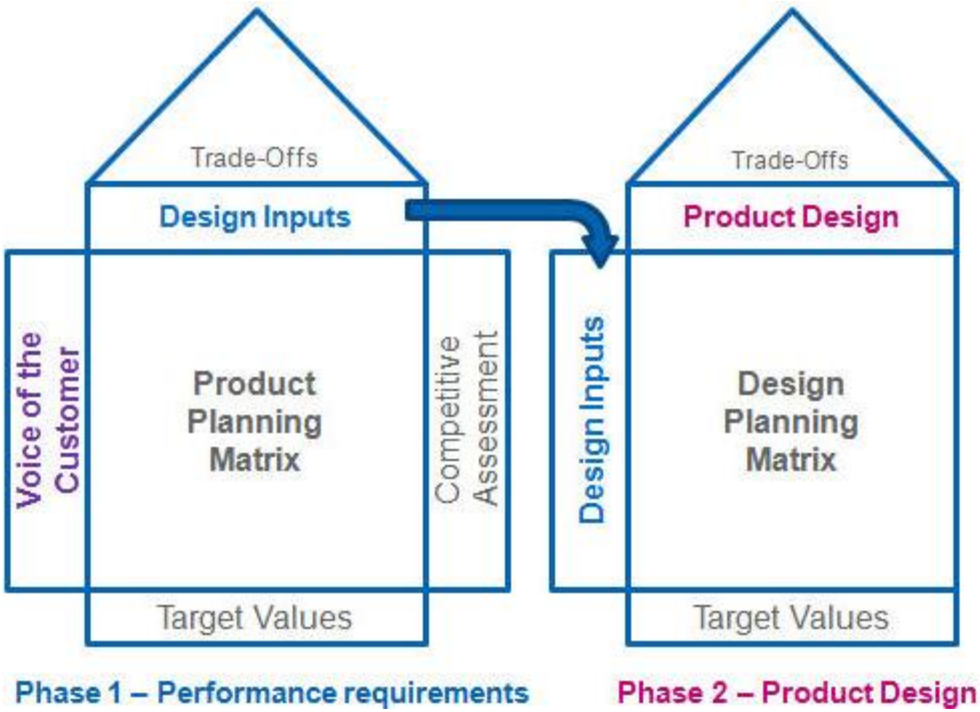

Phase 1 – Performance requirements

# Phase 2. Product design/development:

- completed by the Engineering Department

- engineers create product concepts and document part specifications

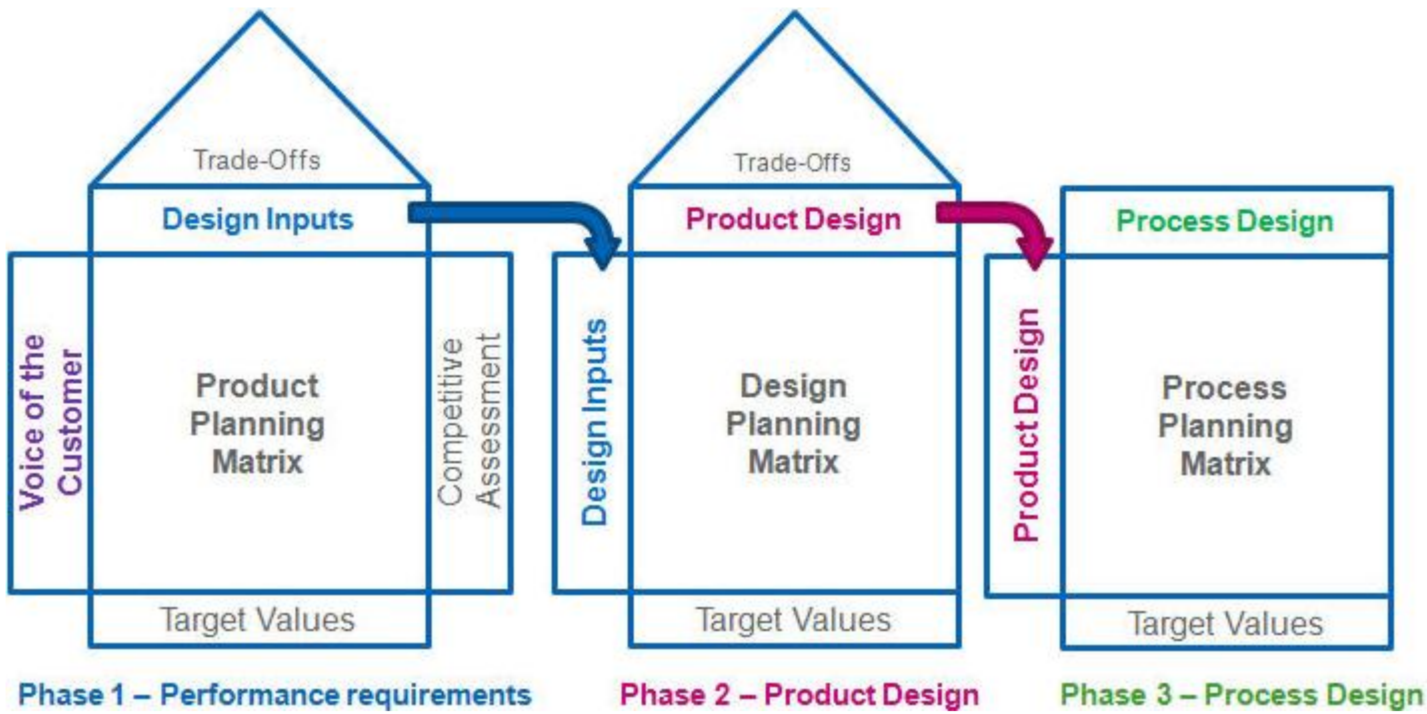
- most important parts for meeting customer needs are deployed further into phase 3



# Phase 3. Process planning/development:

- completed by the Manufacturing Department

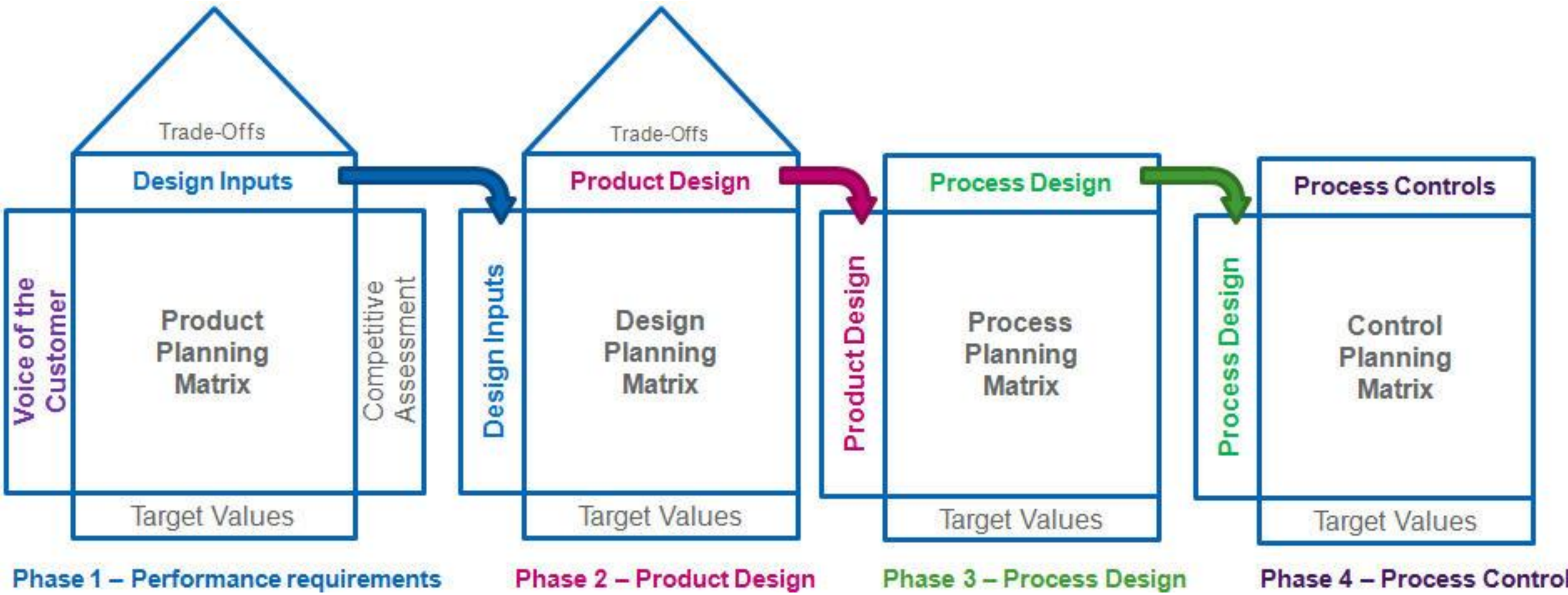
- specialists build flowcharts for manufacturing processes and document process parameters



# Phase 4. Process quality control/Production planning:

- completed by the quality assurance department

- specialists create performance indicators to monitor the production process, determine maintenance schedules, skills for operators, inspection and tests



# EXAMPLE IN WHICH CUSTOMER REQUIREMENTS ARE TRANSFORMED INTO DESIGN REQUIREMENTS

VOC

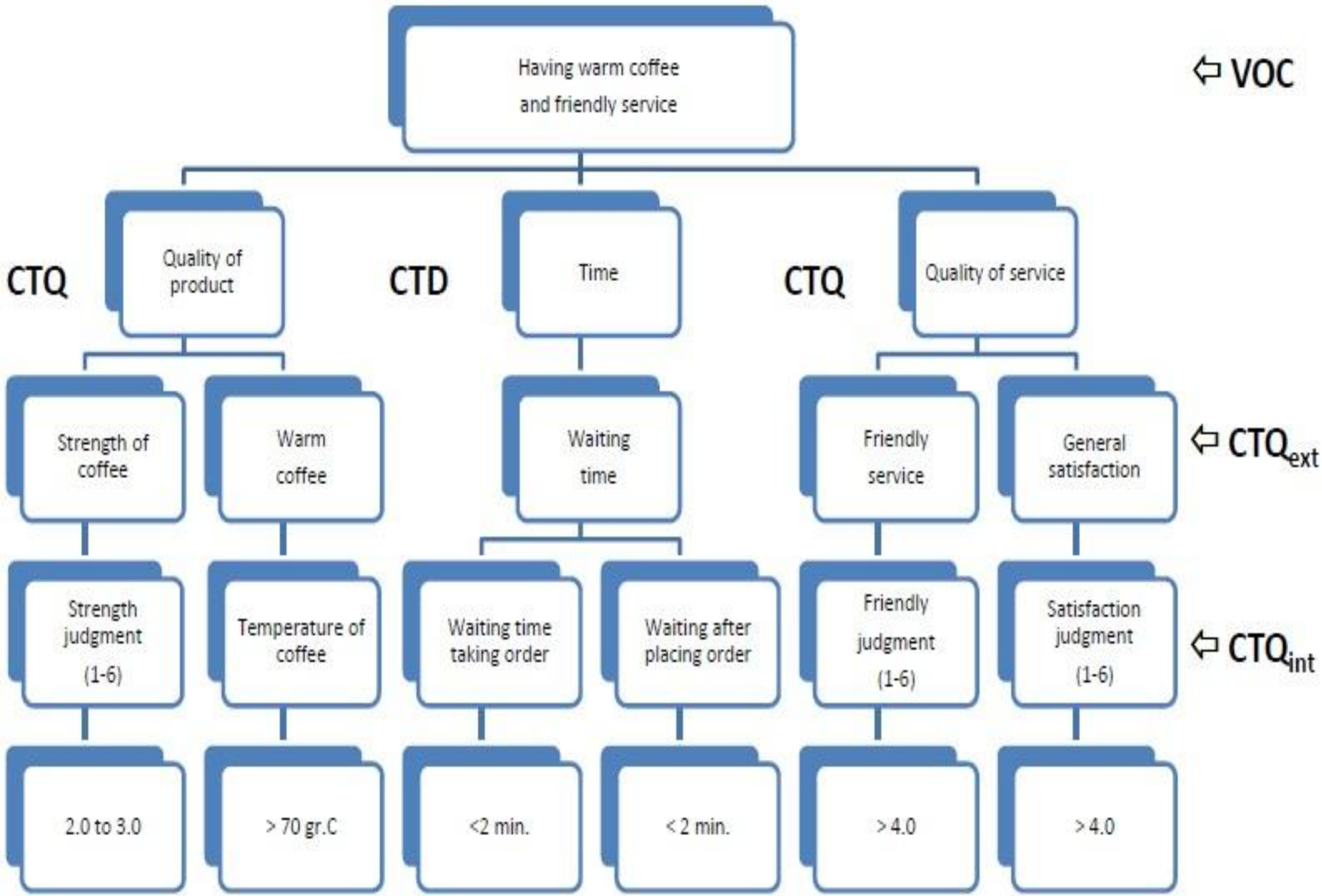
$CTQ_{ext}$

**VOC : Customer requirements**

- On Time Delivery
- Accurate
- No damage
- Good process

**$CTQ_{ext}$ : Customer specification**

- 14 days between order and delivery
- Maximum tolerance ±2%
- No scratches / Ra=0.01
- Yield >98%


Having warm coffee and friendly service
VOC
CTQ
Quality of product
CTD
Time
CTQ
Quality of service
Strength of coffee
Warm coffee
Waiting time
Friendly service
General satisfaction
CTQext
Strength judgment (1-6)
Temperature of coffee
Waiting time taking order
Waiting after placing order
Friendly judgment (1-6)
Satisfaction judgment (1-6)
CTQint
2.0 to 3.0
> 70 gr.C
<2 min.
< 2 min.
> 4.0
> 4.0

# Quality Function Deployment
# - Level 1 HOQ -

- The House of Quality is an effective tool used to translate the customer wants and needs into product or service design characteristics by using a relationship matrix. It is usually the first matrix used in the QFD process

- The House of Quality demonstrates the relationship between the customer wants – "Whats" and the design parameters – "Hows"

# Quality Function Deployment
# - Level 1 HOQ -

- WHATs – Customer wants/requirements (CR) identification + customer ratings of those wants

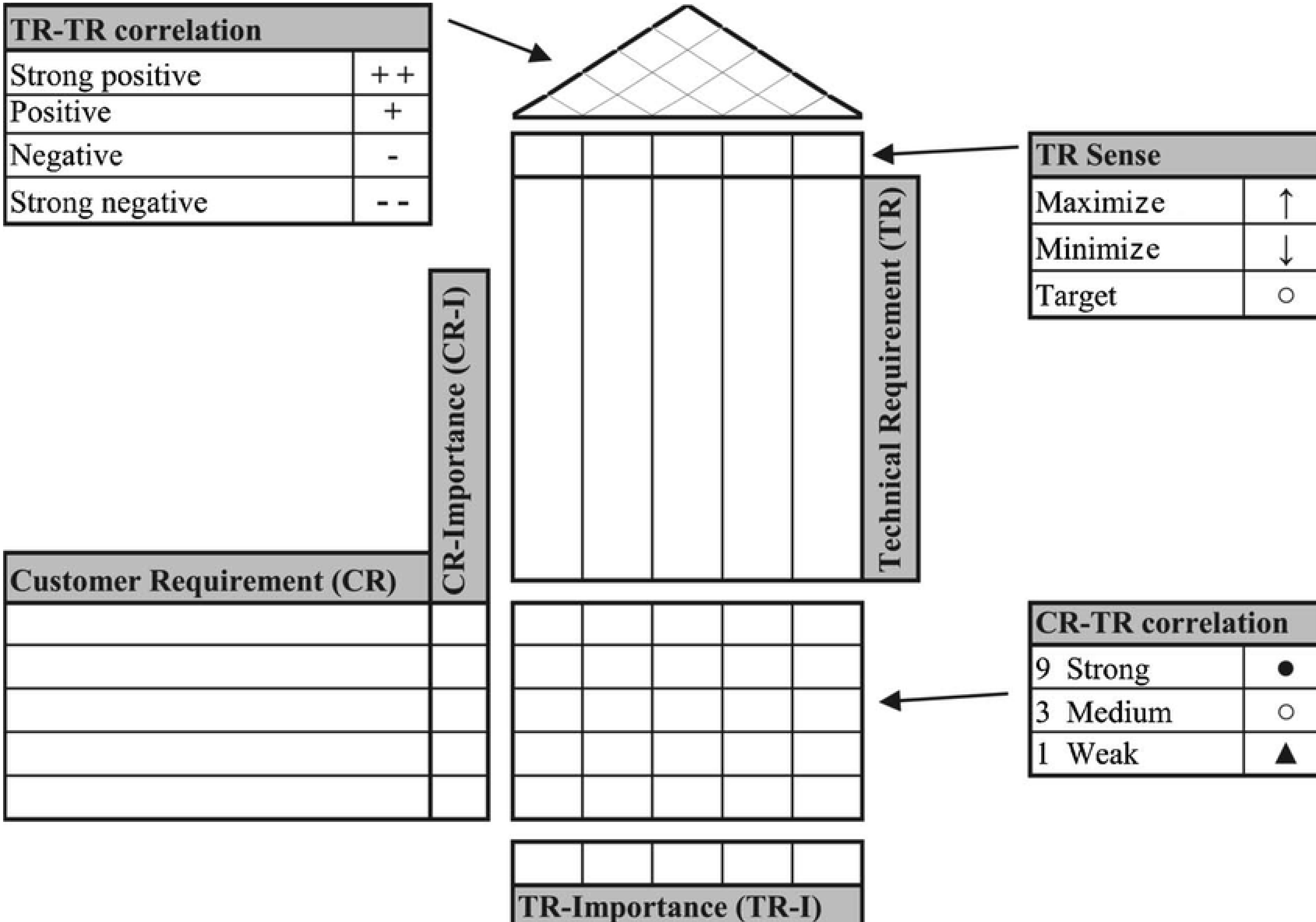
- HOWs – specific product/service features (design requirements) identification to satisfy customer needs

- ROOF – Correlation matrix between HOWs (how do features help or hinder each other)

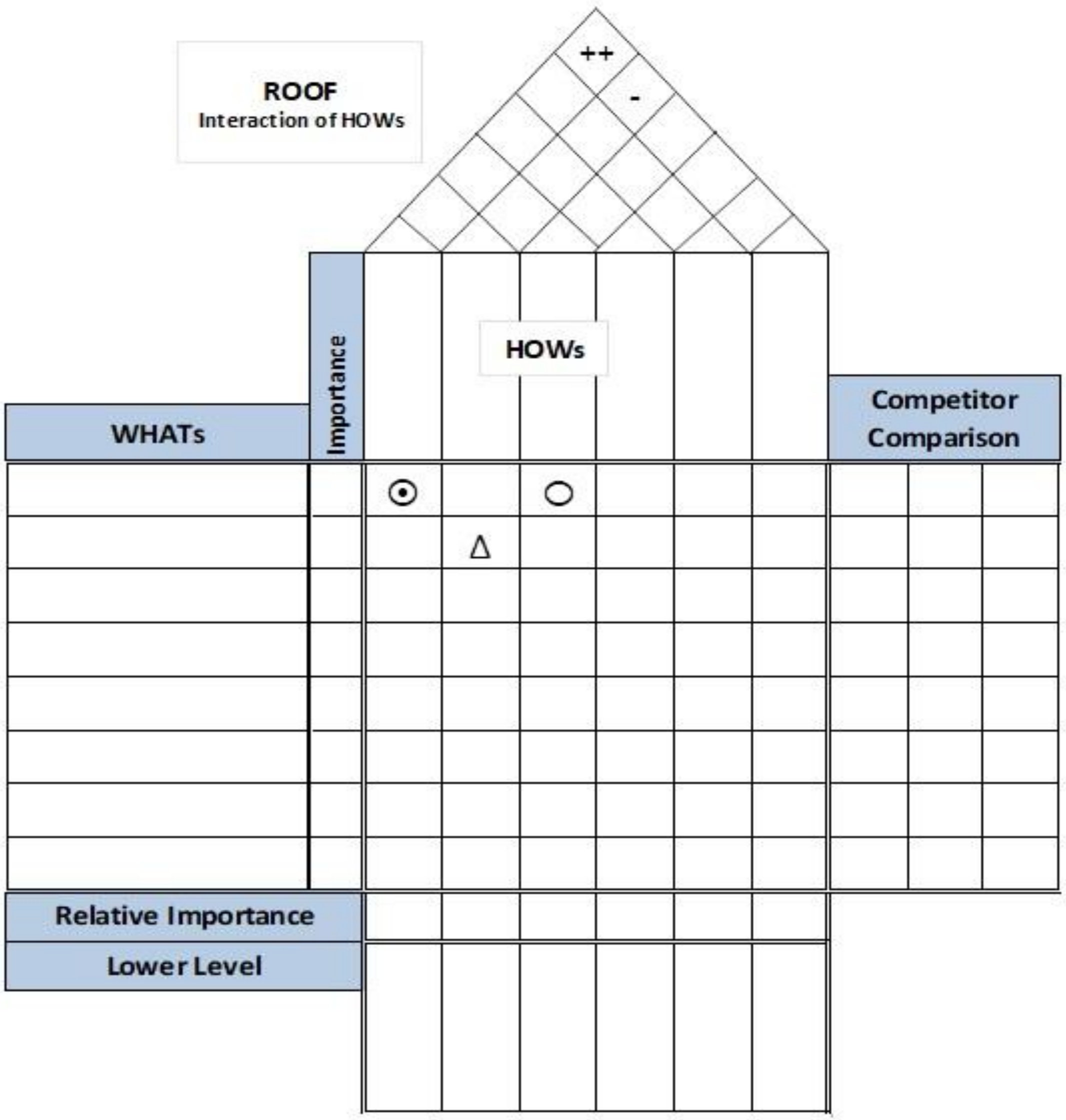
- Competition – from the customer side

- Relationship matrix – weighting the relationship between customer needs and design requirements

# Quality Function Deployment
# - Level 1 HOQ -

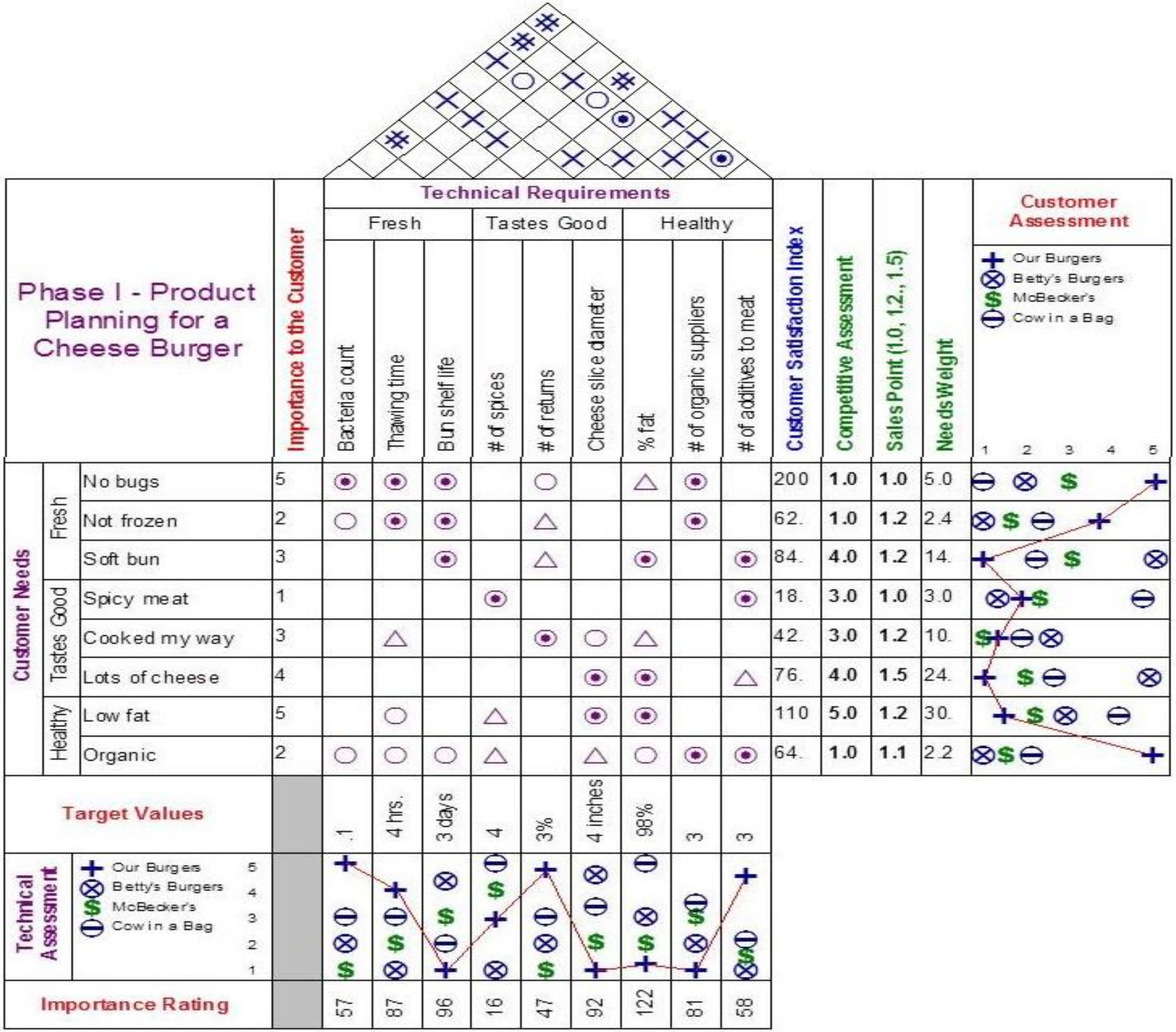


# Quality Function Deployment
# - Level 1 -



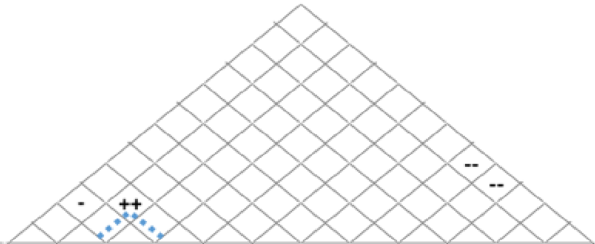

| Roof Ranking System | |
|---|---|
| + + | Strong Positive |
| + | Positive |
| | None |
| - | Negative |
| - - | Strong Negative |

| Body Ranking System | | |
|---|---|---|
| ⊙ | Strong | 9 |
| ○ | Moderate | 3 |
| Δ | Weak | 1 |
| | None | 0 |


Phase I - Product Planning for a Cheese Burger
Technical Requirements
Fresh
Tastes Good
Healthy
Importance to the Customer
Bacteria count
Thawing time
Bun shelf life
# of spices
# of returns
Cheese slice diameter
% fat
# of organic suppliers
# of additives to meat
Customer Satisfaction Index
Competitive Assessment
Sales Point (1.0, 1.2., 1.5)
Needs Weight
Customer Assessment
Our Burgers
Betty's Burgers
McBecker's
Cow in a Bag
1 2 3 4 5
Customer Needs
Fresh
Tastes Good
Healthy
No bugs 5 200 1.0 1.0 5.0
Not frozen 2 62. 1.0 1.2 2.4
Soft bun 3 84. 4.0 1.2 14.
Spicy meat 1 18. 3.0 1.0 3.0
Cooked my way 3 42. 3.0 1.2 10.
Lots of cheese 4 76. 4.0 1.5 24.
Low fat 5 110 5.0 1.2 30.
Organic 2 64. 1.0 1.1 2.2
Target Values
.1
4 hrs.
3 days
4
3%
4 inches
98%
3
3
Technical Assessment
Our Burgers
Betty's Burgers
McBecker's
Cow in a Bag
5 4 3 2 1
Importance Rating
57 87 96 16 47 92 122 81 58

# House of Quality

FlyCo Drones




| | | Engineering Specifications | Styling Jury | Weight | Size | Noise Output (dB) | Horizontal Pixels | Gyroscope Variation | Kilometers | W26 Chip | W11 Chip | Infrared Sensors | Stress Tests | Minutes | Comparitive Assessment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maximize or Minimize | | ▲ | ▼ | ▼ | ▼ | ▲ | ▼ | ▲ | ▲ | ▲ | ▲ | ▲ | ▲ | | | | | |
| | Customer Specifications / Importance | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 |
| 1 | Sylish | 2 | ◎ | △ | | | | | | | | | | | | | F | P | S |
| 2 | Lightweight | 3 | | ◎ | ◎ | △ | | | | | | | | △ | | P | | S | F |
| 3 | Quiet | 5 | | | | ◎ | | | | | | | | | P | | | S | F |
| 4 | Super HD Camera | 5 | | | | | ◎ | | | | | | | ❍ | | | P | F | S |
| 5 | Stable | 5 | | | | | | ◎ | | | | | | ❍ | | | S | F | P |
| 6 | Long Range | 4 | | | | | | | ◎ | | | | | ❍ | | | P | F | S |
| 7 | Self-Directing | 4 | | | | | | | | ◎ | ❍ | | | ◎ | | | F | S | P |
| 8 | Programmable Paths | 5 | | | | | | | | △ | ◎ | ◎ | | ❍ | | | S | F | P |
| 9 | High-Quality Finish | 2 | ❍ | ❍ | | | | | | | | | | | | | F | P | S |
| 10 | Durable Body | 3 | ❍ | | | ❍ | | | | | | | ◎ | | | F | S | | P |
| 11 | Long Drone Battery Life | 5 | | | | | | | △ | ❍ | ❍ | | | ◎ | S | | P | F | |
| 12 | Long Remote Battery Life | 5 | | | | | | | | △ | | | | ◎ | | S | | P | F |
| | | | 5-8 People | 1.81 kg | 33 x 33 x 15.24 cm | 27 dBA | 4K | -3 deg | 6.27 Km | 2 Chips | 1 Chip | 21 Sensors | 29 kg/sq m | 26 min | | | | | |
| | Importance | | 23 | 35 | 27 | 57 | 45 | 45 | 51 | 71 | 54 | 45 | 27 | 154 | 634 | | | | |
| | Importance Weight (%) | | 4% | 6% | 4% | 9% | 7% | 7% | 8% | 11% | 9% | 7% | 4% | 24% | 100% | | | | |

**Legend**

| Symbol | Meaning |
|---|---|
| ◎ | Strong Relationship (9) |
| ❍ | Medium Relationship (3) |
| △ | Weak Relationship (1) |
| ++ | Strong Positive Correlation |
| + | Positive Correlation |
| - | Negative Correlation |
| -- | Strong Negative Correlation |
| F | FlyCo |
| S | Samsung |
| P | Panasonic |

| Correlations | |
|---|---|
| Positive | + |
| Negative | – |
| Without correlation | |

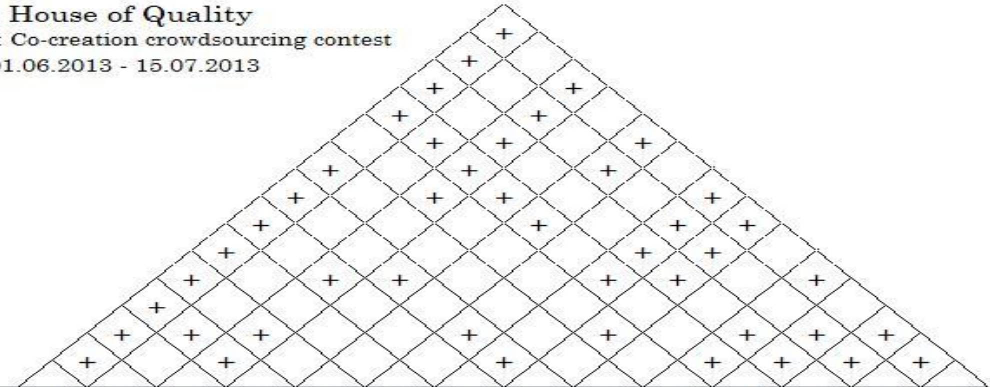
| Relationships | |
|---|---|
| Strong | ● |
| Moderate | ○ |
| Weak | ▽ |

| Improvement direction | |
|---|---|
| Maximization | ▲ |
| Accomplishment | ◇ |
| Minimization | ▼ |

# QFD: House of Quality

Project: Co-creation crowdsourcing contest

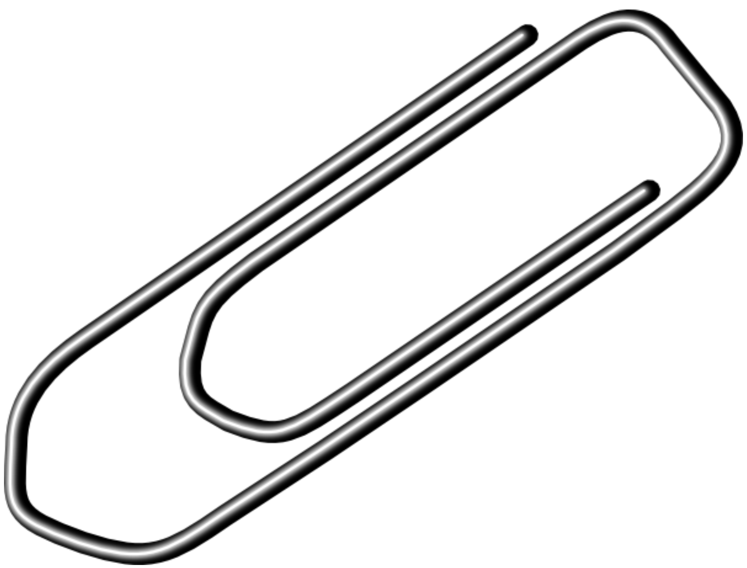
Date: 01.06.2013 - 15.07.2013




| Row | Consumer Importance | Column | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Improvement direction | ▲ | ◇ | ◇ | ◇ | ◇ | ◇ | ◇ | ▲ | ▲ | ▲ | ◇ | ◇ | ◇ | ◇ |
| | | Quality characteristics / Customer requirements | information accessibility management | loading and posting optimization | feedback management | user-centric information management | group discussion management | constant reports regarding new arrivals | transparent voting management | continuous corporate communication | attractive web design | efficient manufacturing | interactive space management | rewarding system | work ranking system management | sale&promotion of winning model |
| 1 | 7,4 | ease in finging information | ● | ▽ | ○ | ● | ○ | ● | ● | ● | ○ | | ● | | | ▽ |
| 2 | 7,3 | ease in loading artistic work | ▽ | ● | ▽ | ● | ▽ | | ▽ | ● | ▽ | | ▽ | | | |
| 3 | 6,8 | ease in voting/commenting works | ● | ▽ | ● | ▽ | ● | ▽ | ○ | ○ | ▽ | | ● | | ▽ | ● |
| 4 | 7,6 | tools&information for improvement | ● | | ● | ● | ○ | | ▽ | ● | | | ○ | | | |
| 5 | 5,1 | group discussions | ● | ▽ | ● | ○ | ● | | | | | | ● | | | ○ |
| 6 | 4,9 | new arrivals | ● | | ▽ | | | ● | | | | | | | | ▽ |
| 7 | 7 | most voted works | ● | | ▽ | | | | ● | | | ● | ▽ | ▽ | ● | ○ |
| 8 | 7,3 | corporate openness | ● | | | ● | | ○ | ● | ● | | ● | ● | ● | ● | ● |
| 9 | 7,5 | attractive graphic of the contest platform | ○ | | ▽ | | | | | ▽ | ● | | | | | ▽ |
| 10 | 7,4 | manufacturing of the winning shoe design | ▽ | | ○ | ▽ | | | ○ | ● | | ● | | ○ | ● | ● |
| 11 | 7,7 | participant engagement | ● | ● | ● | ● | ● | ▽ | ● | ● | ○ | ● | ● | ● | ● | ○ |
| 12 | 7,5 | material reward | ○ | | ▽ | | | | ▽ | ● | | ● | | ● | ▽ | ● |
| 13 | 5,6 | community winner appraisal | ● | | ● | | ▽ | | ○ | ○ | | ● | ● | ○ | ● | ○ |
| 14 | 7,8 | sales procentage for winner | ○ | | | | | | | ● | | ● | | ● | | ● |
| | | Absolute Importance | 380 | 94 | 204 | 216 | 156 | 98 | 229 | 344 | 97 | 251 | 223 | 197 | 189 | 266 |
| | | Relative Importance | 1 | 14 | 8 | 7 | 11 | 12 | 5 | 2 | 13 | 4 | 6 | 9 | 10 | 3 |

# Creativity tools: Brainstorming

Productive thinking...



**Did you know that?**

- mature people think of 50 uses
- children 4-7 years find 80-90 uses
- geniuses reach till 200 uses

# Why does this happen?

Because people think through imitation by using past experiences

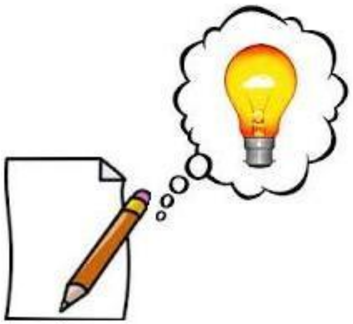
Problem solving specialists do not think reproductive BUT productive

# Possible ways in which we can creatively solve a problem

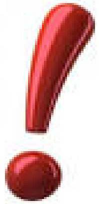
- brainstorming, brainwriting
- word combination (da Vinci technique)
- mind mapping
- 6 thinking hats (De Bono)

# Brainstorming

- The secret of creativity is collaboration due to the fact that each individual is different and adds a new viewpoint



For raising productivity: **BRAINWRITING**



- We clarify the problem, let the imagination run free
- Each idea is noted quietly on a piece of paper
- The paper with ideas is given to the coleague on the right
- The idea can be considered an inspiration for another paper which will be given to the next colleague to the right
- Then the ideas resulted are discussed in a group.

# Da Vinci technique

- Original solutions can arise from combining subjects, ideas and concepts apparently without connection

- Da Vinci analyzes the structure of a subject, then it separates the characteristics /basic factors and realises a list of variants for each factor. In the end it combines the variants

→ **Original ideas and new solutions**

# Da Vinci technique

| Head | Eye | Nose | Mouth | Chin |
|---|---|---|---|---|
| oval | wide open | hooked | dry | goiter |
| scheletic | stuffy | aquiline | small lips | beard |
| semisferic | bulging | subțire | dropped | folds |
| like a bug | shining | deformed | strident | fallen |
| like a bell | huge | bellied | arched | sharp |
| like an egg | swollen | sharp | muscular | lost |
| curved | red | long | strange | prominent |

**Result:**

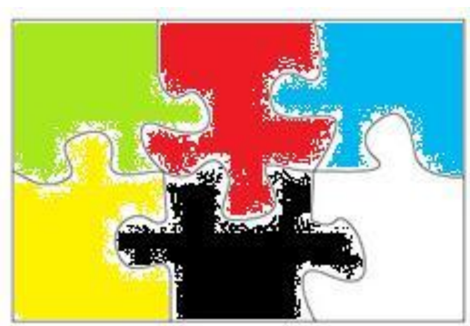
# Mind Mapping

- It eases access to the huge potential of our brain through the use of key-words
- Its a different brainstorming type that helps us discover what we already know and make new associations
- Rules: we note the principal theme and then all the thinking and associations regarding it are also noted in all directions

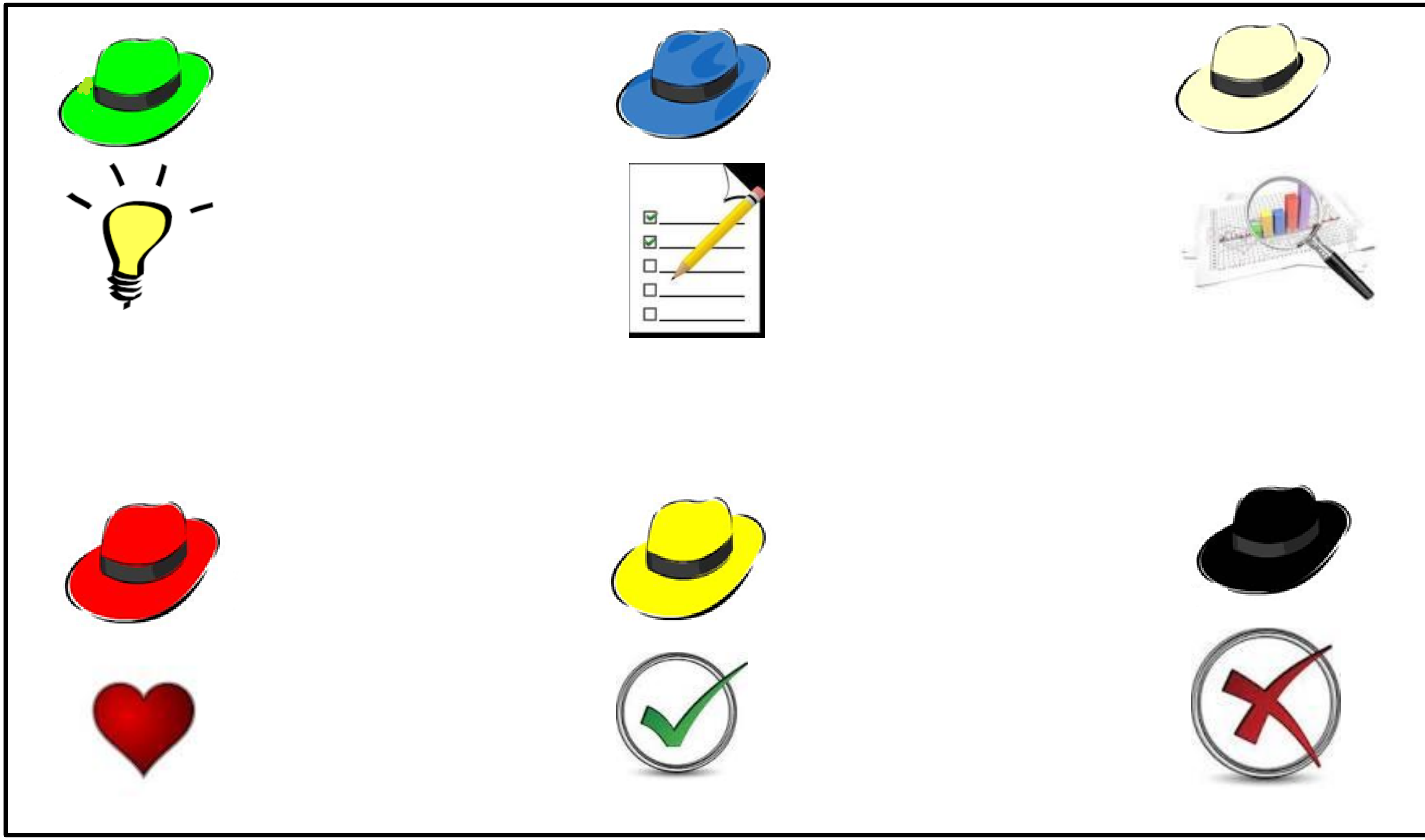
# 6 thinking hats

- This technique forces a new approach, different from the classical thinking process. In this way we see/analyse a situation from several points of view for an overall image

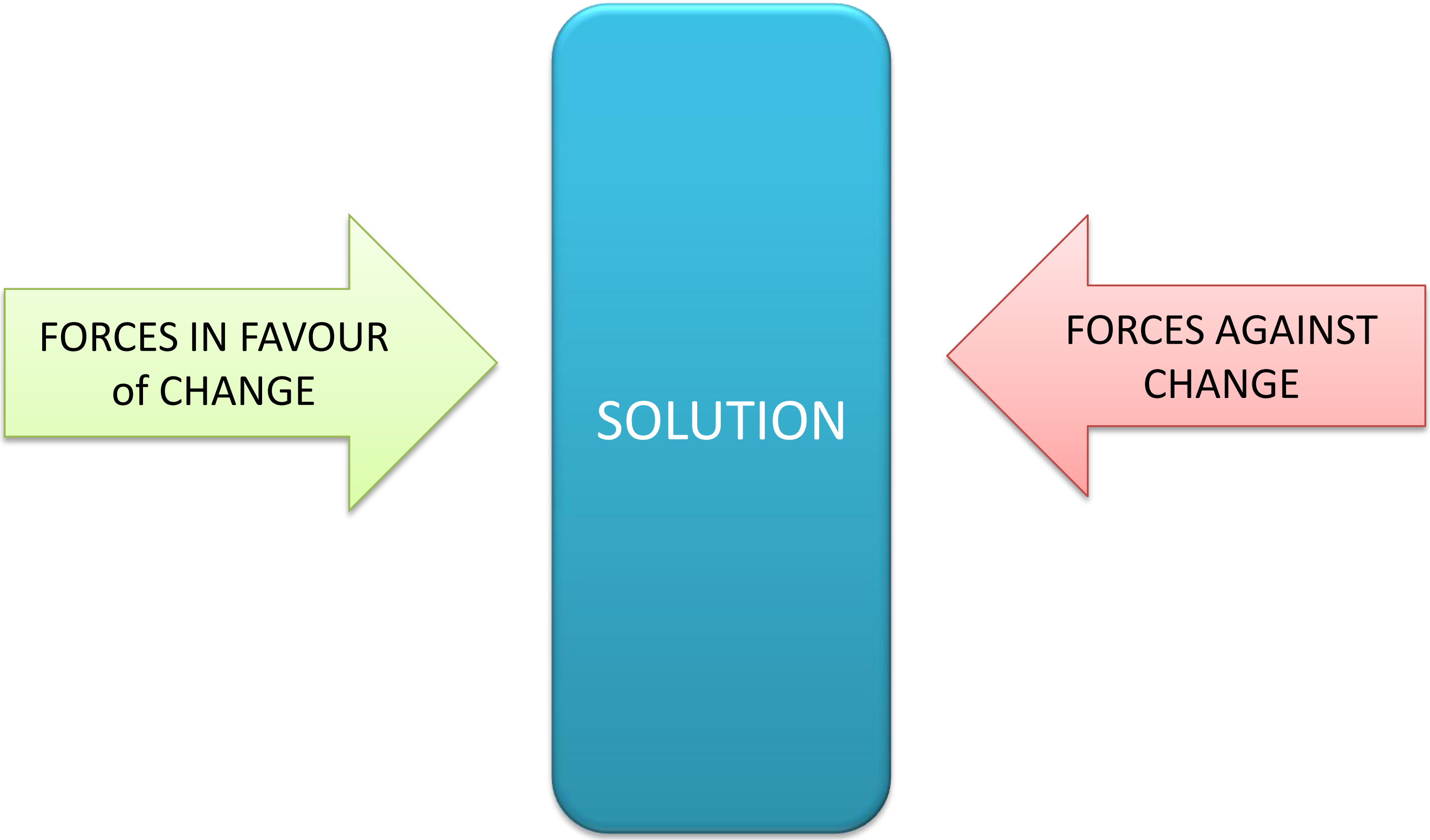
- Problem solving is realized by passing through different thinking styles: rational thinking, emotional thinking, intuitive thinking, creative thinking, positive thinking or negative thinking



# 6 Thinking hats



# Force Field Analysis
# Discovering possible obstacles for implementing the improvement solution



# Force Field Analysis