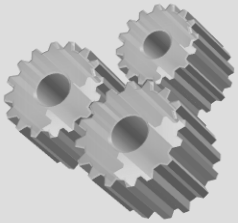


QUALITY MANAGEMENT IN INDUSTRY 4.0. LABOLATORY (30h)

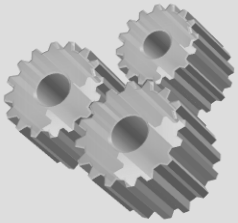
Krzysztof Knop, Ph.D. Eng.

Department of Production Engineering and Safety

contact: p. 503z, +48 34 3250 367

krzysztof.knop@wz.pcz.pl

consultations: Tuesday from 12.45–15.00,
Thursday from 16.00-16.45, room 503z



Credit conditions:

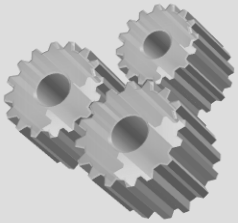
Basic:

1. Partial reports.
2. Partial tasks.

A condition for passing the course is to complete all tasks and and passing individual partial reports (obtaining at least grade of "3.0").

Additional ("+"):

1. Attendance.
2. Activity.
3. Timely completion of tasks/submission of reports.



Quality management instruments

QM tools

+

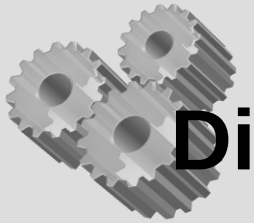
QM methods

+

QA rules

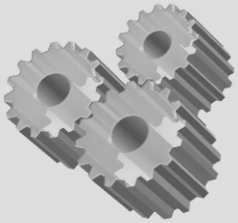
=

QM instruments



Division of QM instruments

	FEATURES AND HOW IT AFFECTS QUALITY	EXAMPLES
RULES	•define the company's strategy, •I do not provide ready-made solutions or procedures, •they guide the activities undertaken in terms of quality, they constitute a set of guidelines enabling the shaping of quality throughout the organization, •long-term impact.	• the principle of continuous improvement - Kaizen, • "zero defects" principle, • principle of teamwork.
METHODS	•are characterized by a planned, repeatable and scientifically based method of conduct in the implementation of quality management tasks, •are based on generally accepted algorithms of conduct, •“medium-term” impact	•QFD – Quality Function Development. •FMEA – Failure Mode and Effects Analysis. •AS – Acceptance Sampling. •SPC – Statistical Process Control. •DOE – Design of Experiments.
TOOLS	**• are used to collect and process data related to various aspects of quality management,** **• short-term (operational) impact.**	**•"old" tools,** •"new" tools.

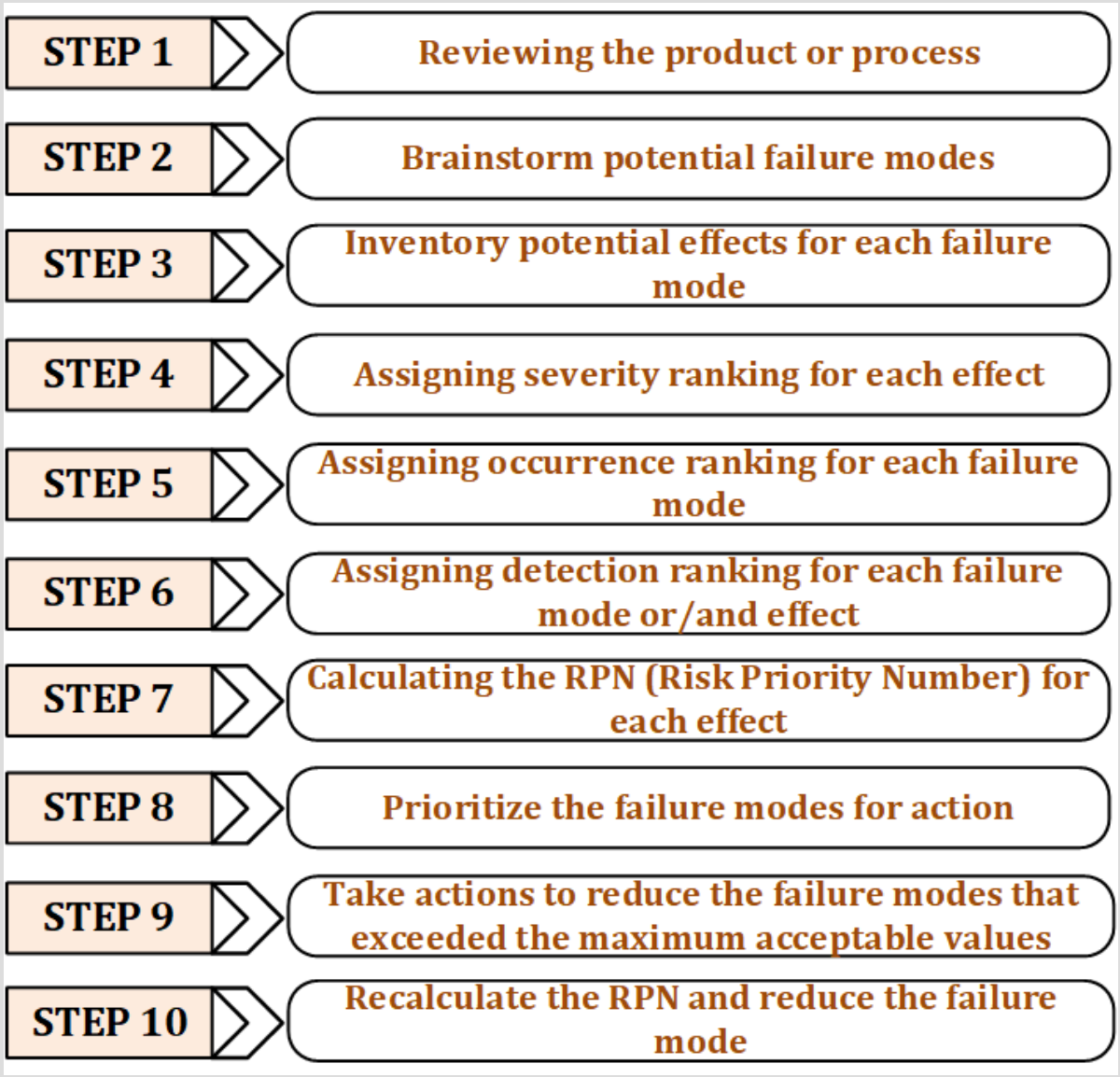


Kaizen Quotes (QM rules)

*„**When we improve a little each day, after a while big changes will start to appear**. When you improve your adaptation methods every day, over time you will achieve significant improvement. Not tomorrow, not the day after tomorrow, but ultimately you have to get really significant results. **Don't try to make big improvements quickly, but look for one small improvement opportunity every day.** This is the only way to make changes that last for good”*

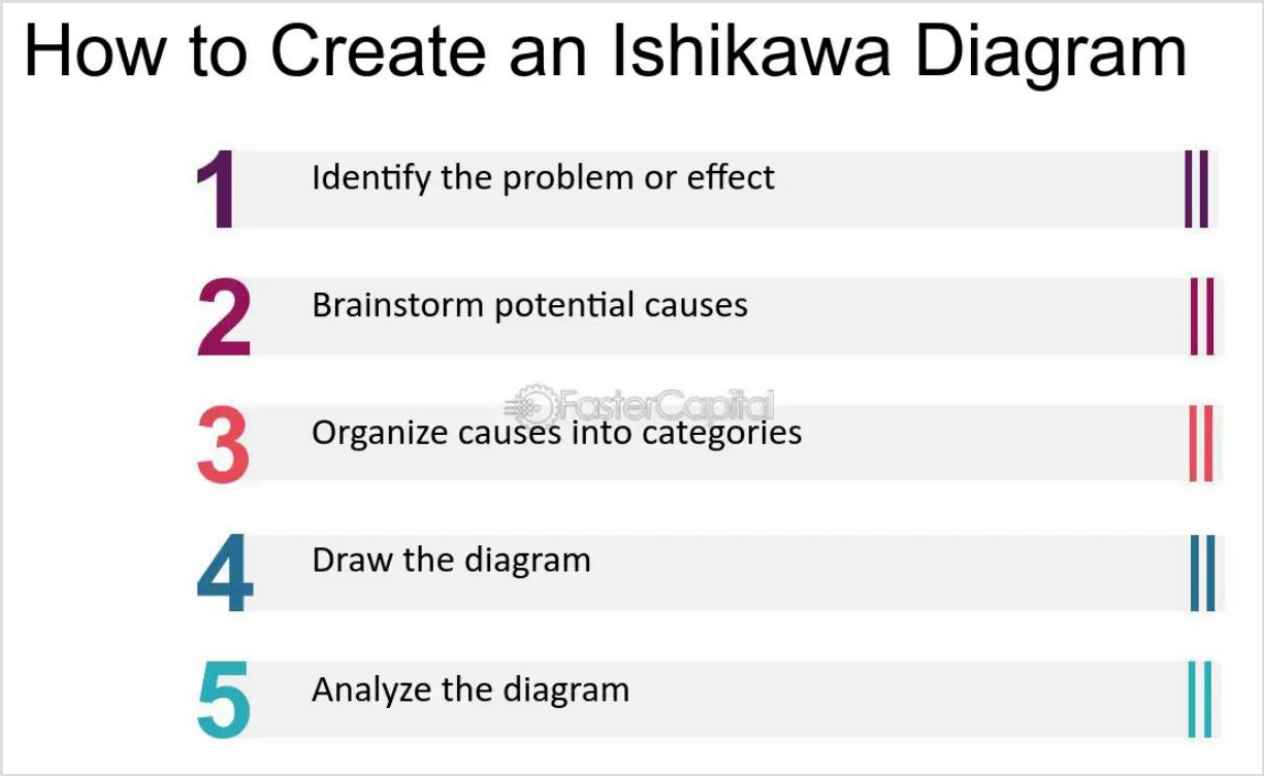
John Wooden – one of the most famous coaches of the American youth basketball league

FMEA procedure (QM methods)

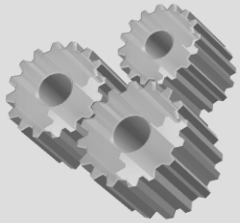


Full implementation of the PFMEA (Process Failure Mode and Effects Analysis) method **may take from several weeks to several months.**

Ishikawa diagram procedure (QM tools)



Full implementation of the diagram Ishikawy **may take from several hours to several days.**

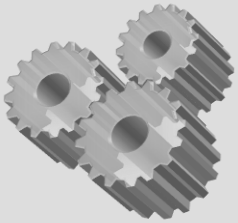


Quality management tools

or otherwise:

- **quality control,**
- **quality improvement,**
- **solving problems.**

These names are used interchangeably and are, in a way, proof that these tools can have wide range of applications, depending on the needs of the organization.



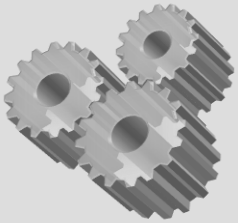
QM tools. Usage

used to:

- to collect and process data and information,
- to supervise the quality management process,
- to detect errors, defects and irregularities in process flows, products or services.

allow for:

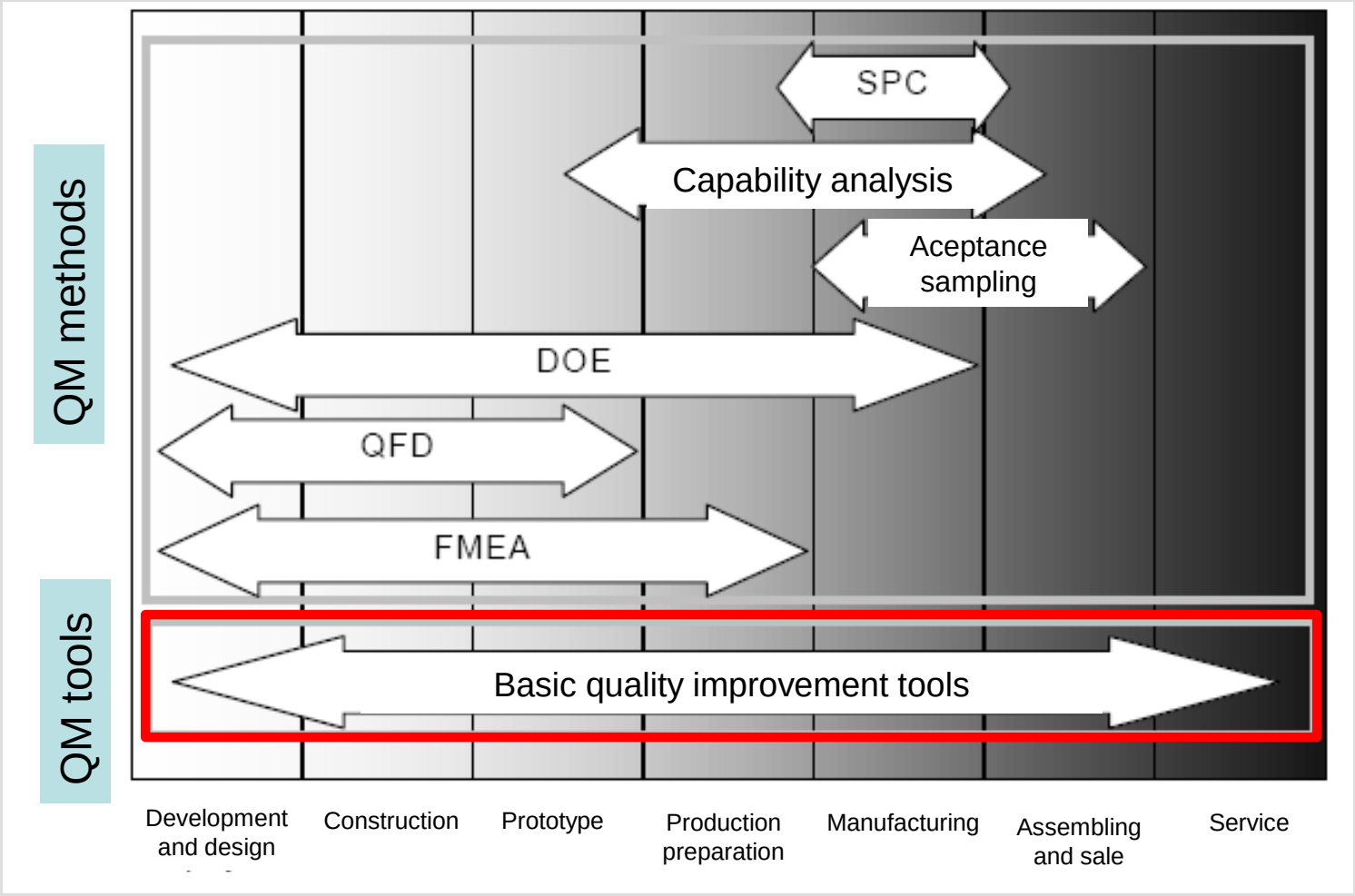
- **data visualization, monitoring and diagnosing processes,**
- **monitoring activities and processes throughout the product life cycle.**



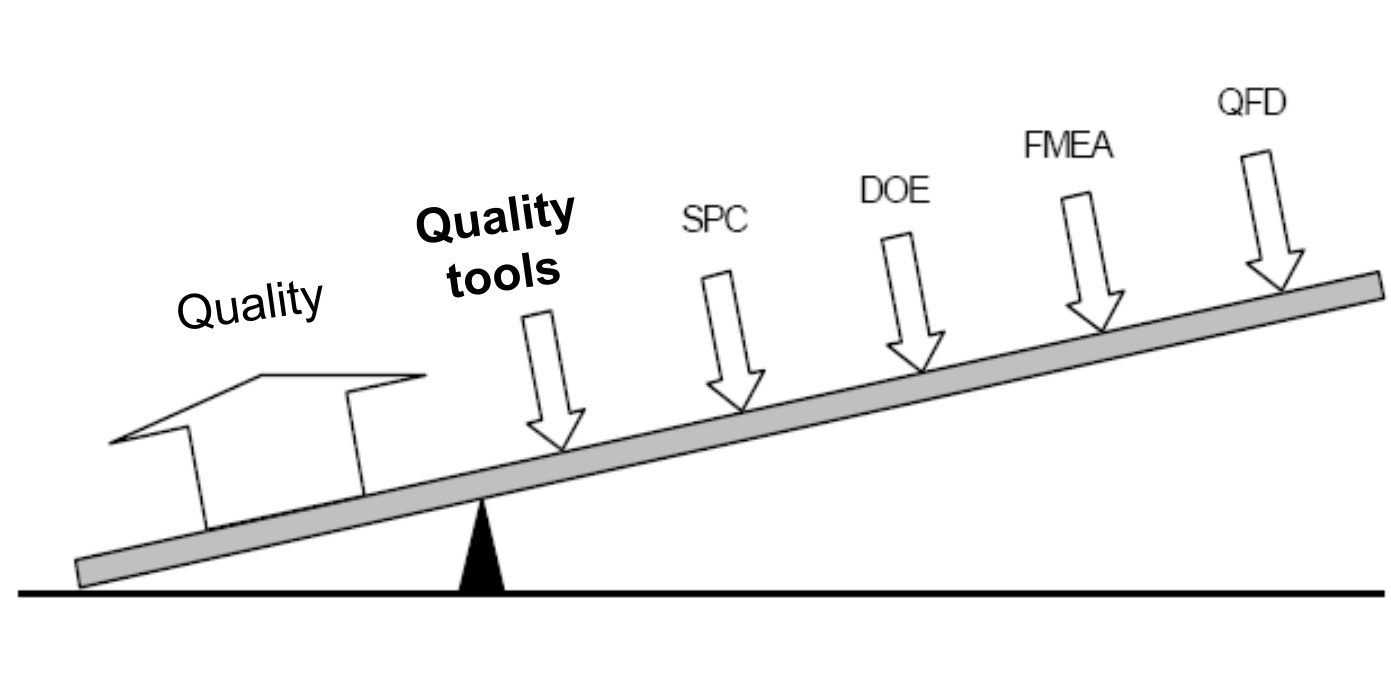
What is the "strength" of QM tools?

- **Simplicity** – uncomplicated, does not require "specialized" knowledge.
- **Versatility** – various phases of the product life cycle, various areas of activity, not only production.
- **Speed** – of implementation, analysis, interpretation, drawing conclusions, making decisions - the results of use are visible "almost" immediately!

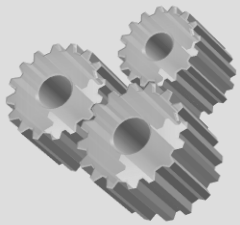
The use of QM tools against the background of QM methods in the product life cycle



Quality lever



Achieving the right level of quality in a process/product can be achieved by: **skillful use of adequate quality improvement instruments!!!**

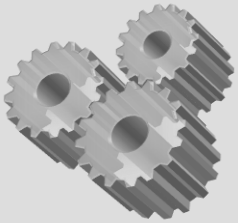


Division of QM tools

Classic/Traditional/Basic/„Old" QM tools

Modern/”New”/second seven QM tools

Additional QM tools

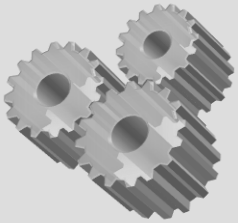


7 classic QM tools

1) Flowcharts
2) Check sheets
3) Ishikawa diagram
4) Pareto-Lorenz diagram
5) Histogram
6) Correlation diagram
7) Control charts

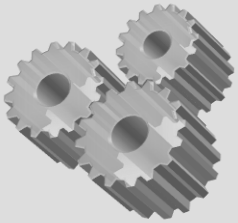
Division of QM tools

A proposal to collect these tools and the division into "old" comes from **Kaoru Ishikawa** who is at work *What is Total Quality Control* with **1982** he argued that **with their help, most, as much as 95%, of quality problems can be solved**. Kaoru Ishikawa promoted the use **seven classic tools** as part of the work cycle of quality circles.



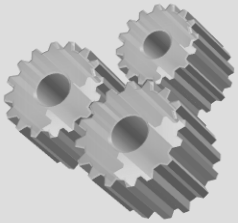
7 new QM tools/7 management and planning tools

1) Affinity diagram
2) Interrelationship diagram
3) Tree diagram
4) Matrix diagram
5) Matrix data analysis chart
6) Process decision program chart (PDPC)
7) Arrow diagram



Additional QM tools

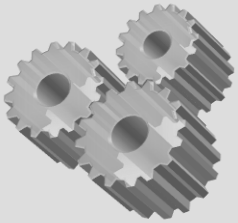
1) Data visualization
2) Force Field Analysis
3) ABCD method
4) ABC method
5) Impact analysis
6) Brainstorm



What are the differences between QM tools?

- require other types of data,
- "new" are intended for teamwork,
- "new" supports "old".

No.	"Old" tools	Data type: NU – numerical, DE – desriptive, NU-DE	"New" tools	Data type: NU – numerical, DE – desriptive, NU-DE
1	*Flowcharts*	**DE**	*Affinity diagram*	**DE**
2	*Check sheets*	**NU-DE**	*Interrelationship diagram*	**NU-DE**
3	*Ishikawa diagram*	**DE**	*Tree diagram*	**DE**
4	*Pareto-Lorenz diagram*	**NU**	*Matrix diagram*	**NU-DE**
5	*Histogram*	**NU**	*Matrix data analysis chart*	**NU-DE**
6	*Correlation diagram*	**NU**	*PDPC diagram*	**DE**
7	*Control charts*	**NU**	*Arrow diagram*	**DE**



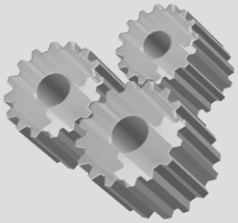
Summary

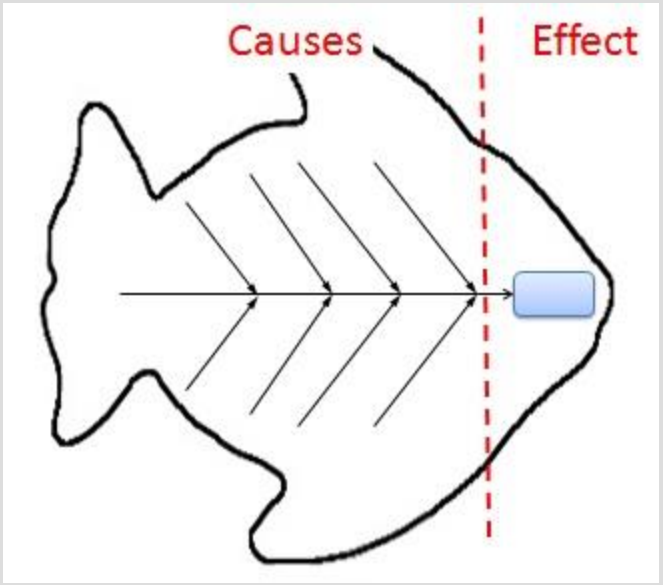
"Old" QM tools:

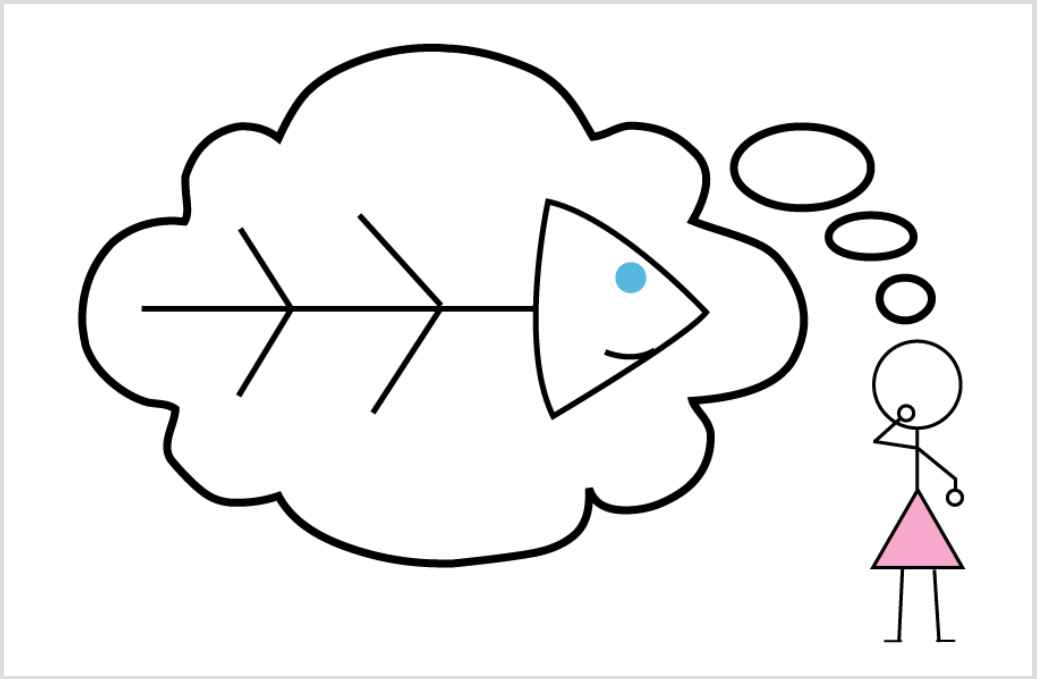
- *Propagator Kaoru Ishikawa (creator of quality circles, today Japan has 2 million quality circles bringing together 20 million employees)*
- *first use – 1960s, Japan, quality circles*
- *they are based primarily on numerical data,*
- *more popular, more frequently used.*

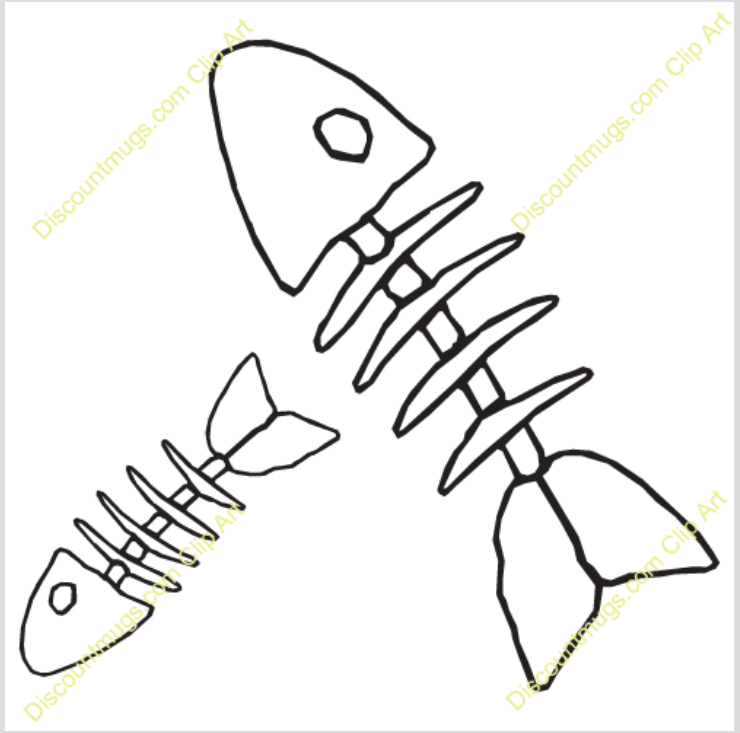
"New" QM tools:

- *complement traditional tools,*
- *require significant creativity,*
- *recommended for use in teamwork,*
- *they are primarily descriptive, qualitative, verbal, non-numerical*
- *less popular, less used.*




Causes
Effect

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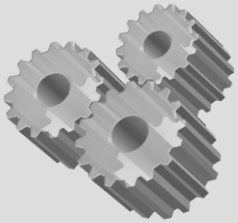


Ishikawa diagram or otherwise

=

cause and effect diagram

=

fish diagram/fishbone diagram

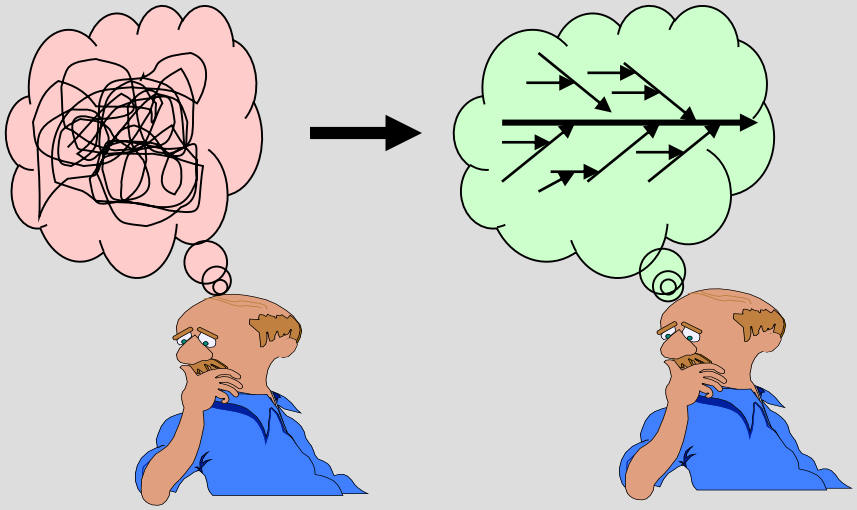
=

chevron diagram

Ishikawa diagram

What is this?

A method of ordering that enables the visualization of relationships between factors (causes) and the result (problem)



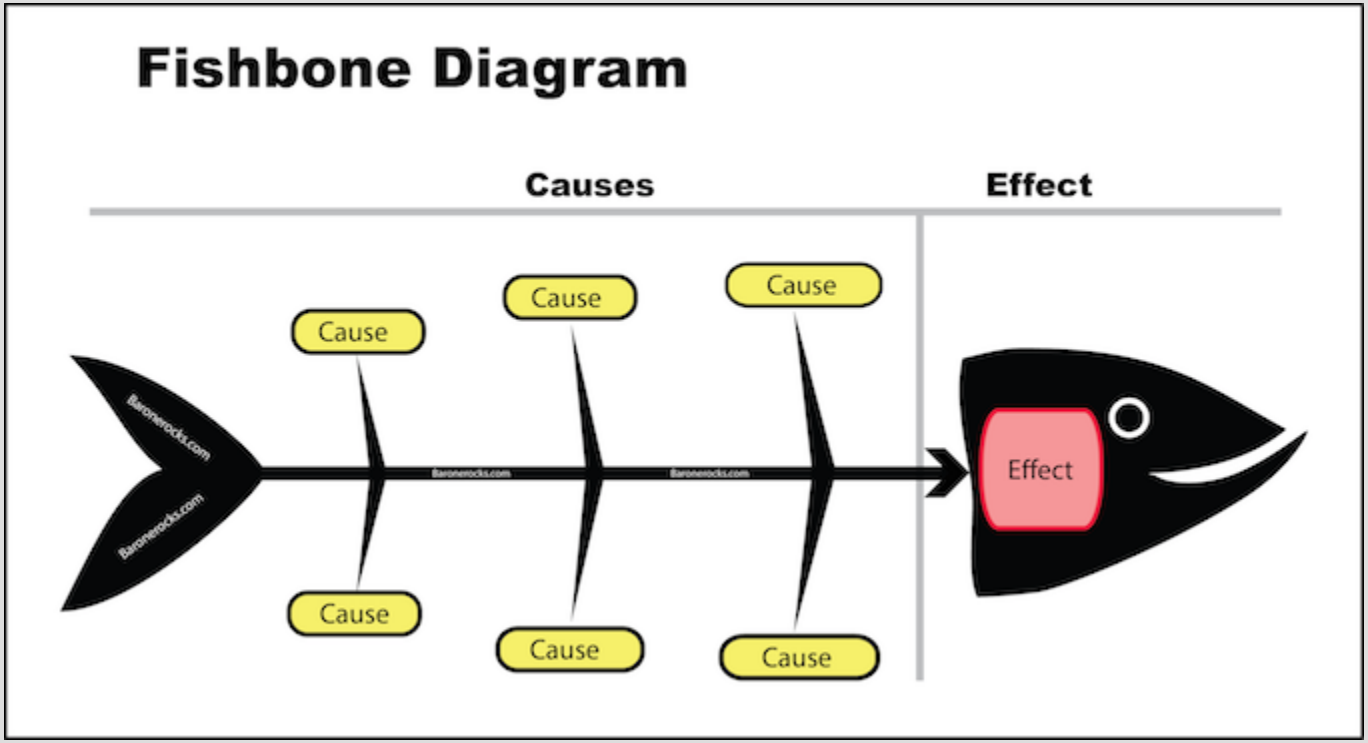
Objective:

Diagnosis of causes (*after the fact* for corrective actions or *before* - for preventive actions)

Fishbone diagram

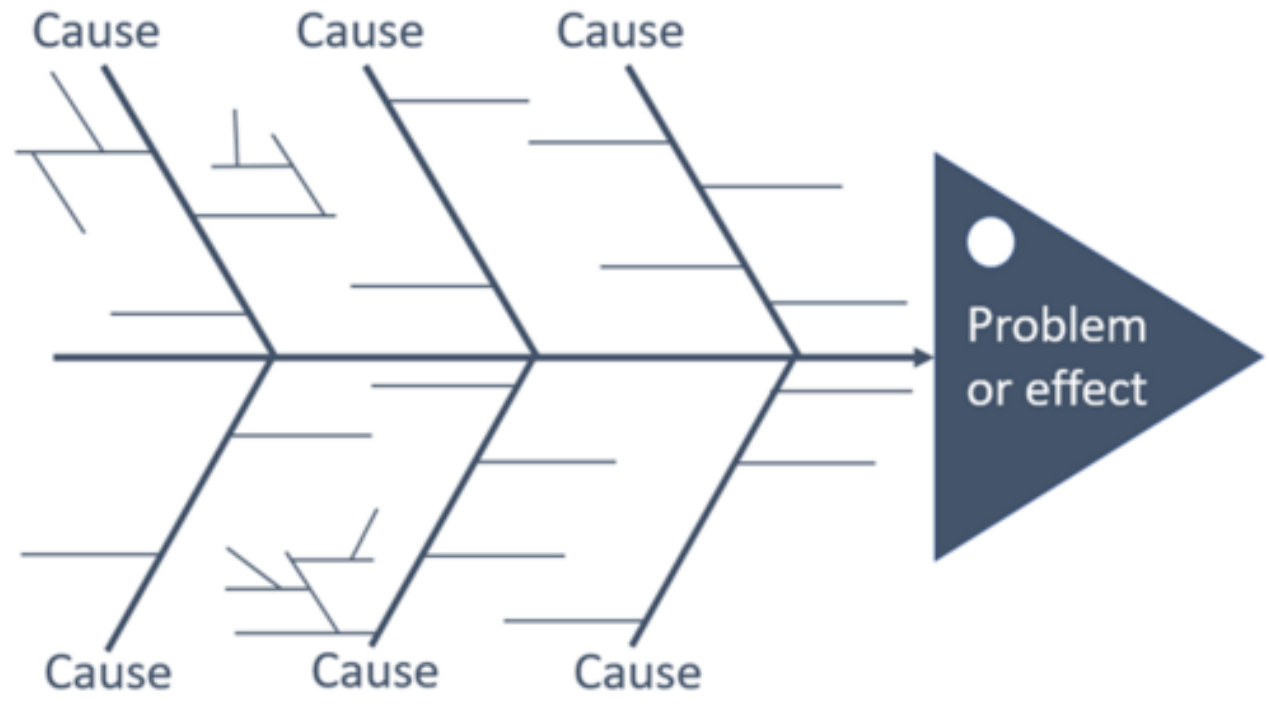
- the diagram has a shape resembling **fish bone**, where in:

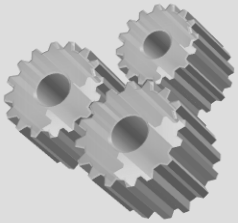
- **"fish head"**- means **problem to solve**,
- "**spine**"- brings together individual **groups (categories) of the causes of the problem,**
- **"bones"**- means probable **causes of the problem.**



Cause and effect diagram

- is used to develop, analyze and present **the cause and effect relationships of problems,**
- is used to **think about** and **present** **the connections between a given problem and its potential causes** that caused it,
- it allows you to **rank the causes** of the problem and **find relationships between them.**





STAGES OF PROCEDURE

1. **Specify the problem.**

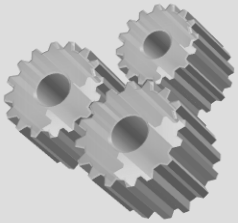
2. **Identify the causes of the problem through brainstorming.** **ATTENTION:** Don't confuse causes with solutions.

3. **Sketch a Ishikawa diagram (fish skeleton). Put the problem in place of the fish head.**

4. **Divide the causes into categories.** Review your brainstorming results to divide them into categories. Commonly used categories are ***5M – Man, Material, Machine, Method, Management.***

   NOTE 1: These five categories do not always fit the situation and sometimes a completely different division is more appropriate, but **the number of categories should never exceed 6.**

   NOTE 2: There is no one perfect set of categories.You



Categories 5M and others (4M, 6M, 6M+E, 7M, 4P, 4S)

4M. 5M. 6M. 6M+E. 7M. These are methods of grouping the causes of problems most often used to **group the causes of production and quality problems:**

- **Man – 1M,**
- **Material – 2M,**
- **Machine – 3M,**
- **Method – 4M,**

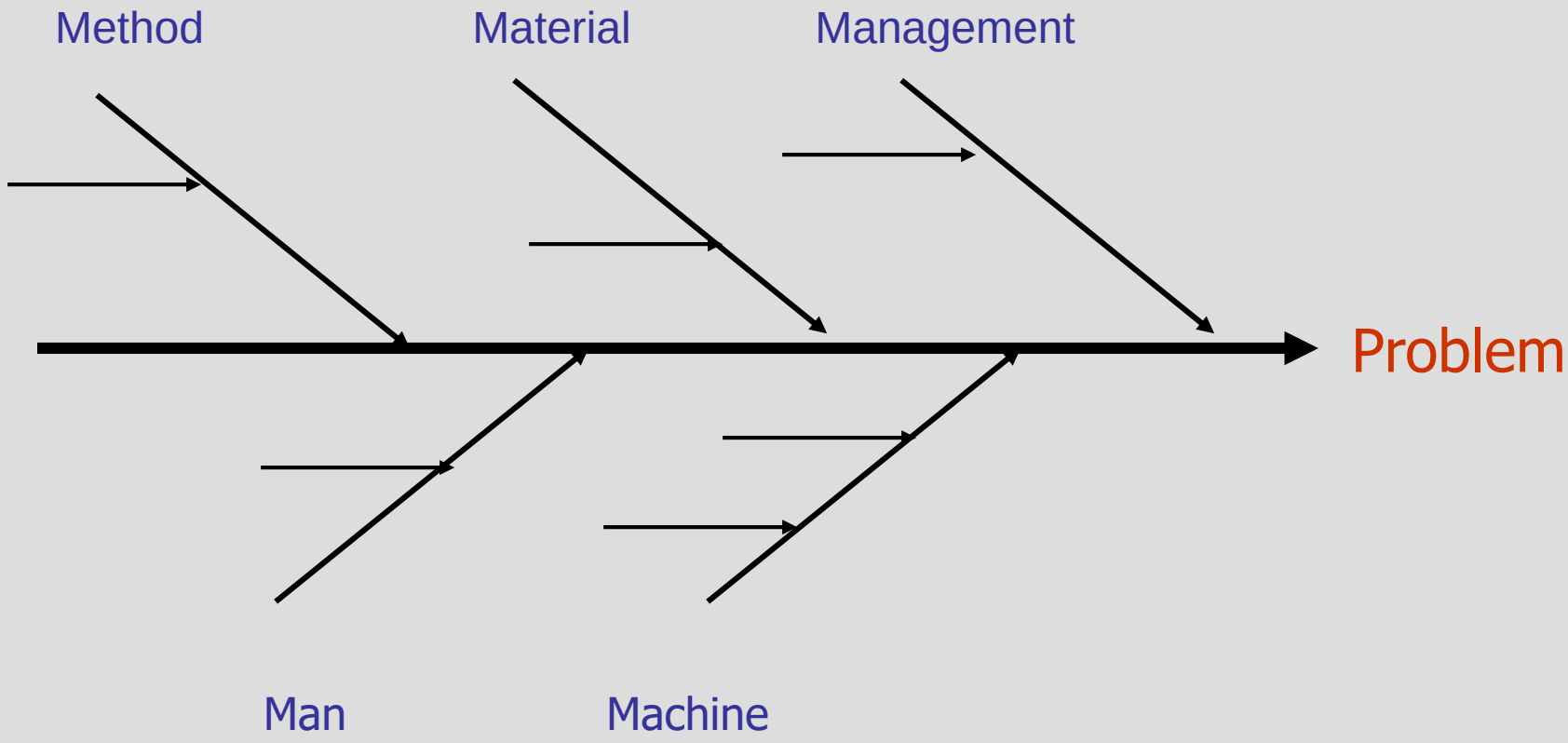
  +
- **Management – 5M.**

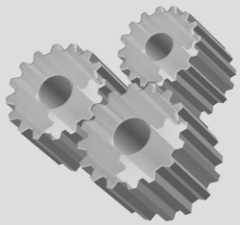
  +
- **Measurement – 6M,**

  +
- **Environment – 1E,**

  +
- **Money –7M.**

5M categories on the Ishikawa diagram





The 4M checklist as a tool supporting the identification of the causes of problems

A. *M*an (Operator)

1. Does he follow standards?
2. Is his work efficiency acceptable?
3. Is he problem-conscious?
4. Is he responsible? (Is he accountable?)
5. Is he qualified?
6. Is he experienced?
7. Is he assigned to the right job?
8. Is he willing to improve?
9. Does he maintain good human relations?
10. Is he healthy?

B. *M*achine (Facilities)

1. Does it meet production requirements?
2. Does it meet process capabilities?
3. Is the oiling (greasing) adequate?
4. Is the inspection adequate?
5. Is operation stopped often because of mechanical trouble?
6. Does it meet precision requirements?
7. Does it make any unusual noises?
8. Is the layout adequate?
9. Are there enough machines/facilities?
10. Is everything in good working order?

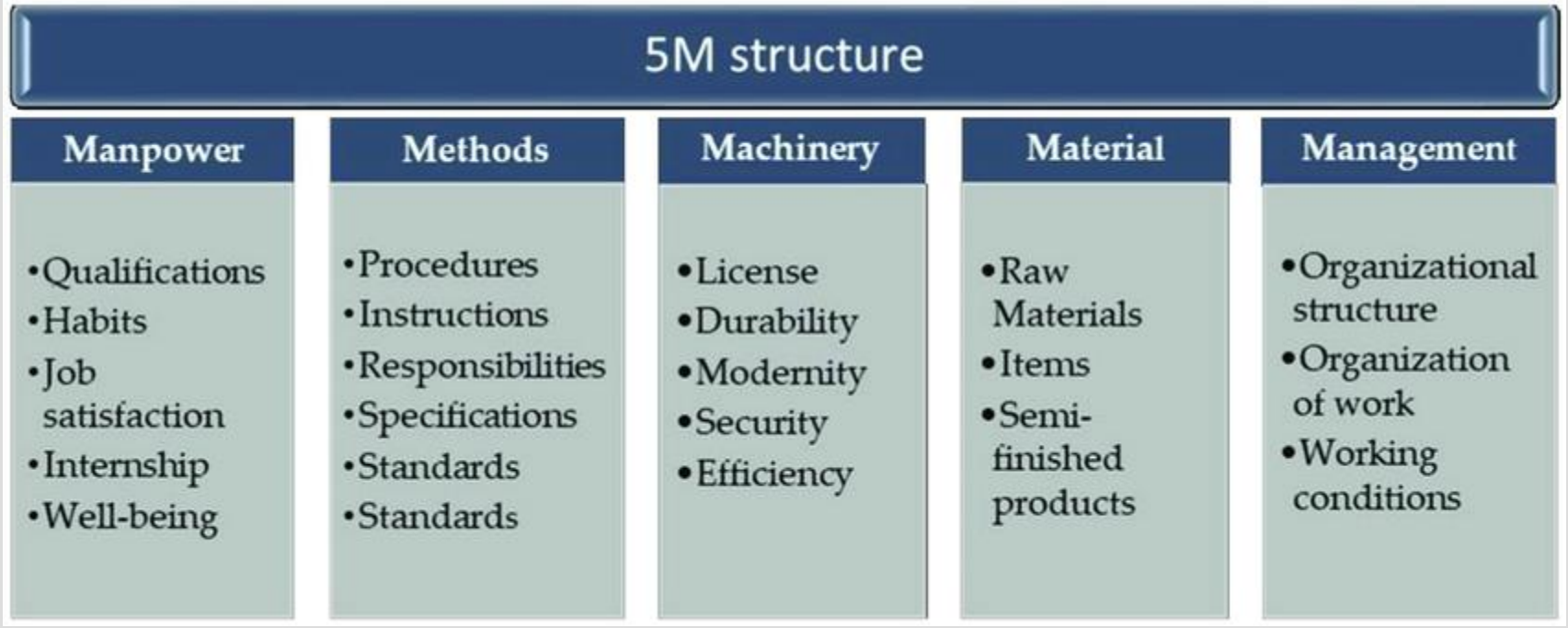
C. *M*aterial

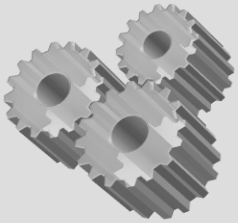
1. Are there any mistakes in volume?
2. Are there any mistakes in grade?
3. Are there any mistakes in the brand name?
4. Are there impurities mixed in?
5. Is the inventory level adequate?
6. Is there any waste in material?
7. Is the handling adequate?
8. Is the work-in-process abandoned?
9. Is the layout adequate?
10. Is the quality standard adequate?

D. Operation *M*ethod

1. Are the work standards adequate?
2. Is the work standard upgraded?
3. Is it a safe method?
4. Is it a method that ensures a good product?
5. Is it an efficient method?
6. Is the sequence of work adequate?
7. Is the setup adequate?
8. Are the temperature and humidity adequate?
9. Are the lighting and ventilation adequate?
10. Is there adequate contact with the previous and next processes?

The importance of the 5M category





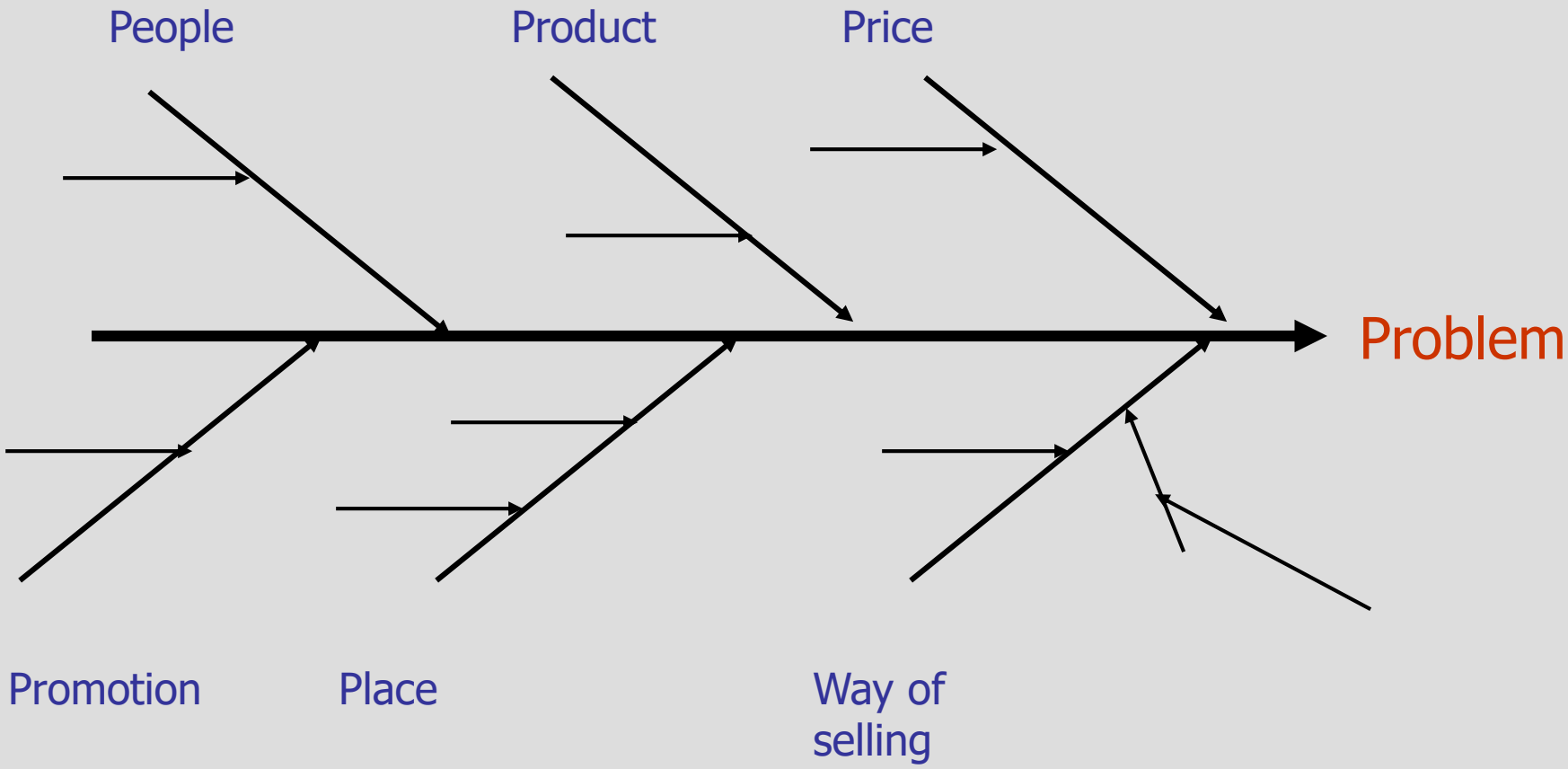
Methods of grouping causes used in services

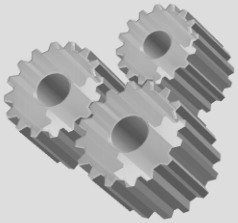
4P. 4S. You can also find other suggestions for grouping causes based on **4P**:
Place,
Procedures,
People,
Policy.

or
4S:
Surroundings
Suppliers
System
Skills

Depending on the type and field of the analyzed problem, it is also possible to use other categories of causes, e.g. **equipment, information, procedures, processes, work organization, competition, suppliers, ...**

Methods of grouping causes used in services





STAGES OF PROCEDURE

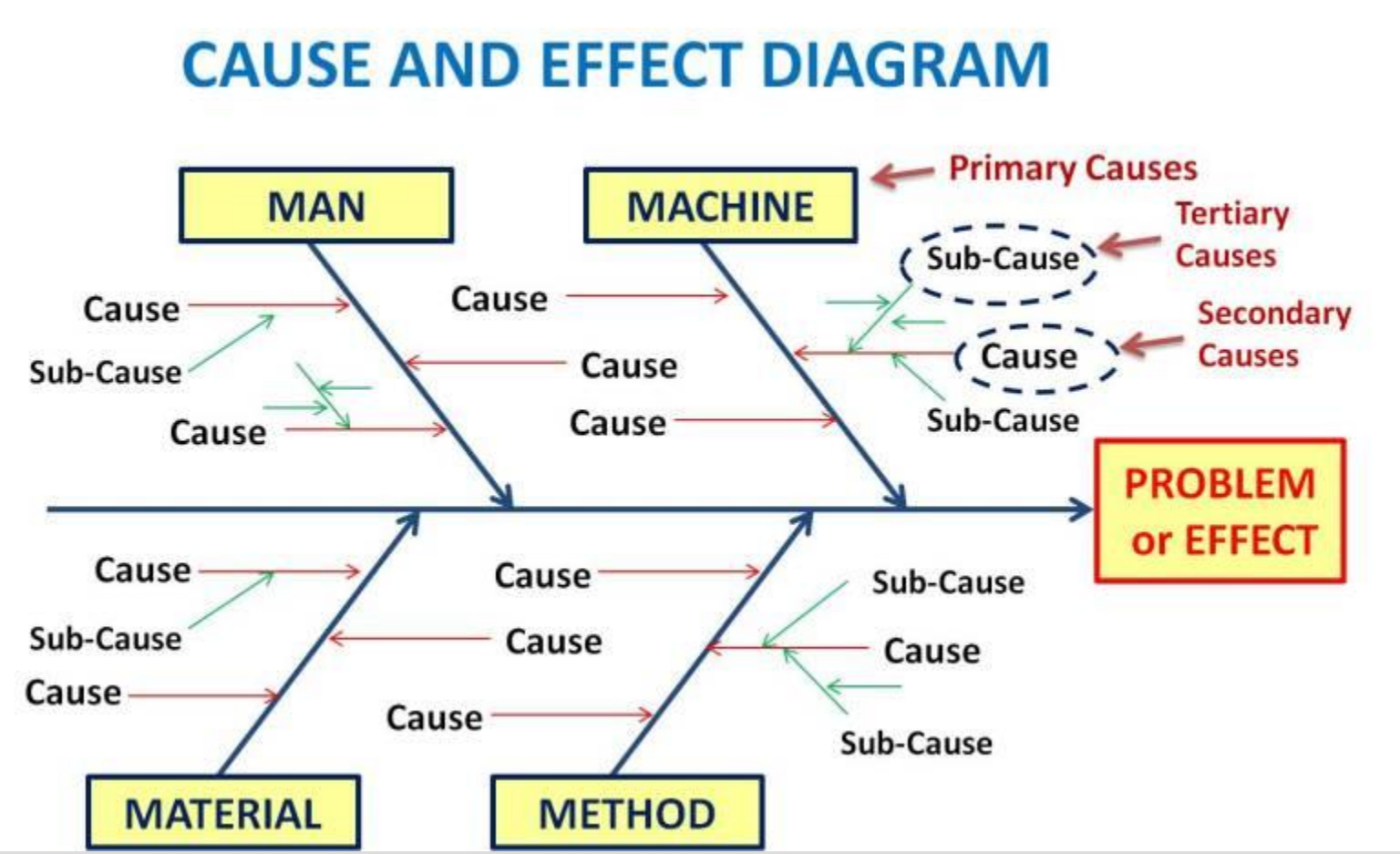
5. **Assign causes to categories.** Place the reasons written down during the brainstorming session on the diagram, assigning them to the appropriate categories.

   NOTE 1: If some **seem to fit into more than one category, you can duplicate their names.**
   NOTE 2: However, when this situation repeats, it means **that the categories have been selected incorrectly and you should return to point 4.**

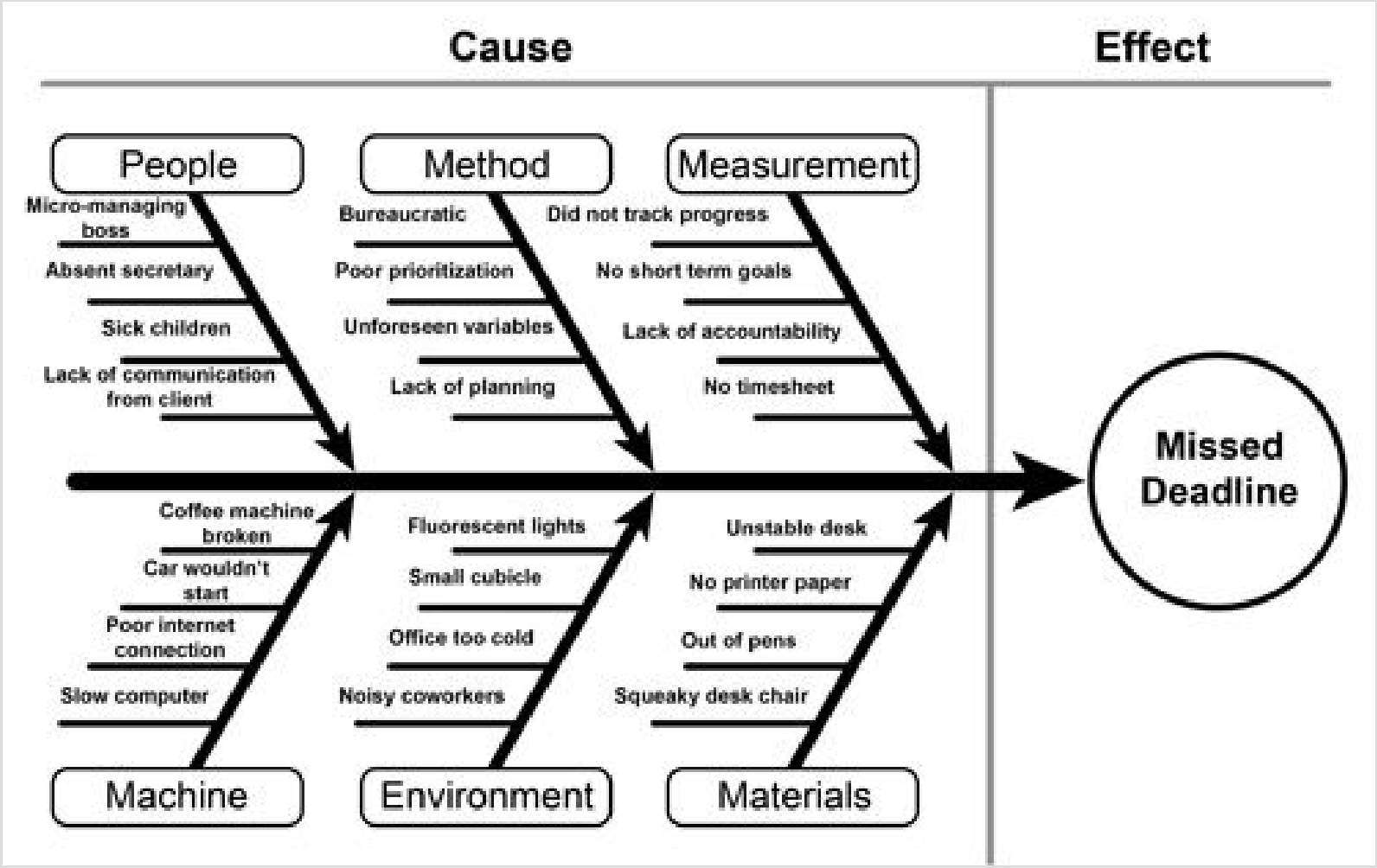
6. **Place individual causes on the chart like twigs on branches**.

   ATTENTION: You can further branch out branches and twigs by asking questions: **"what?", "why?", "how?" and where?".**

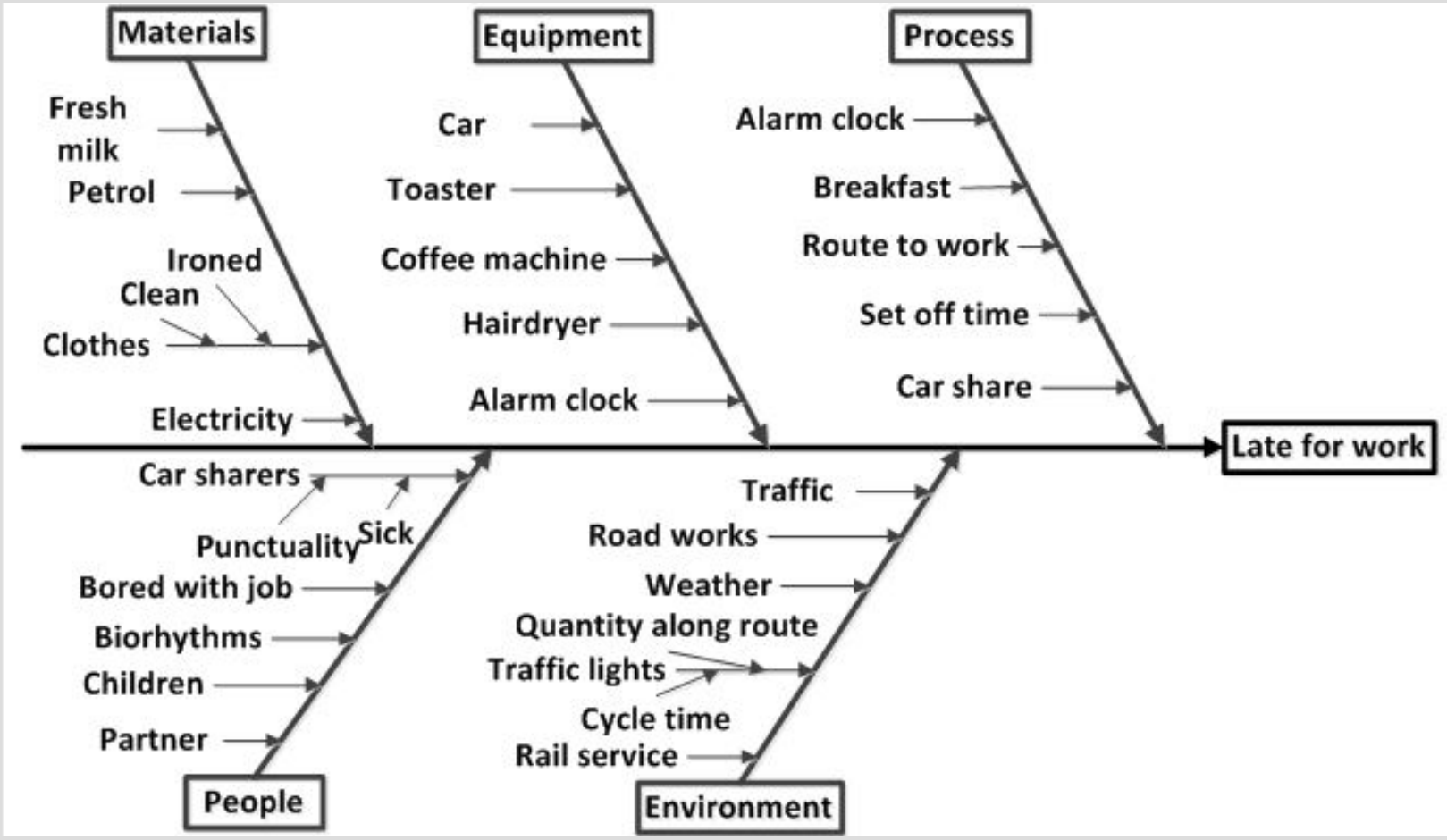
STAGES OF PROCEDURE



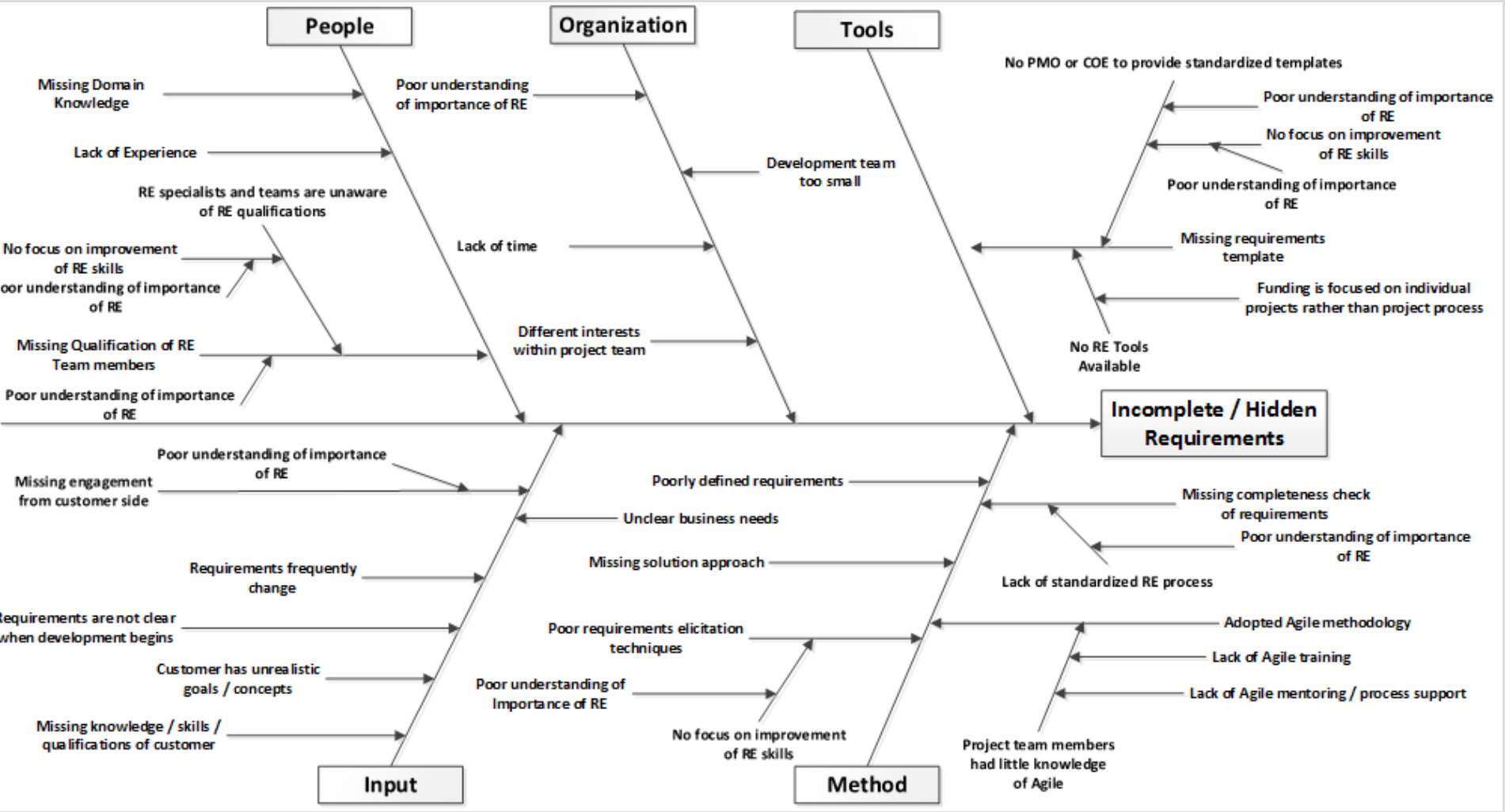
Ishikawa diagram – basic version



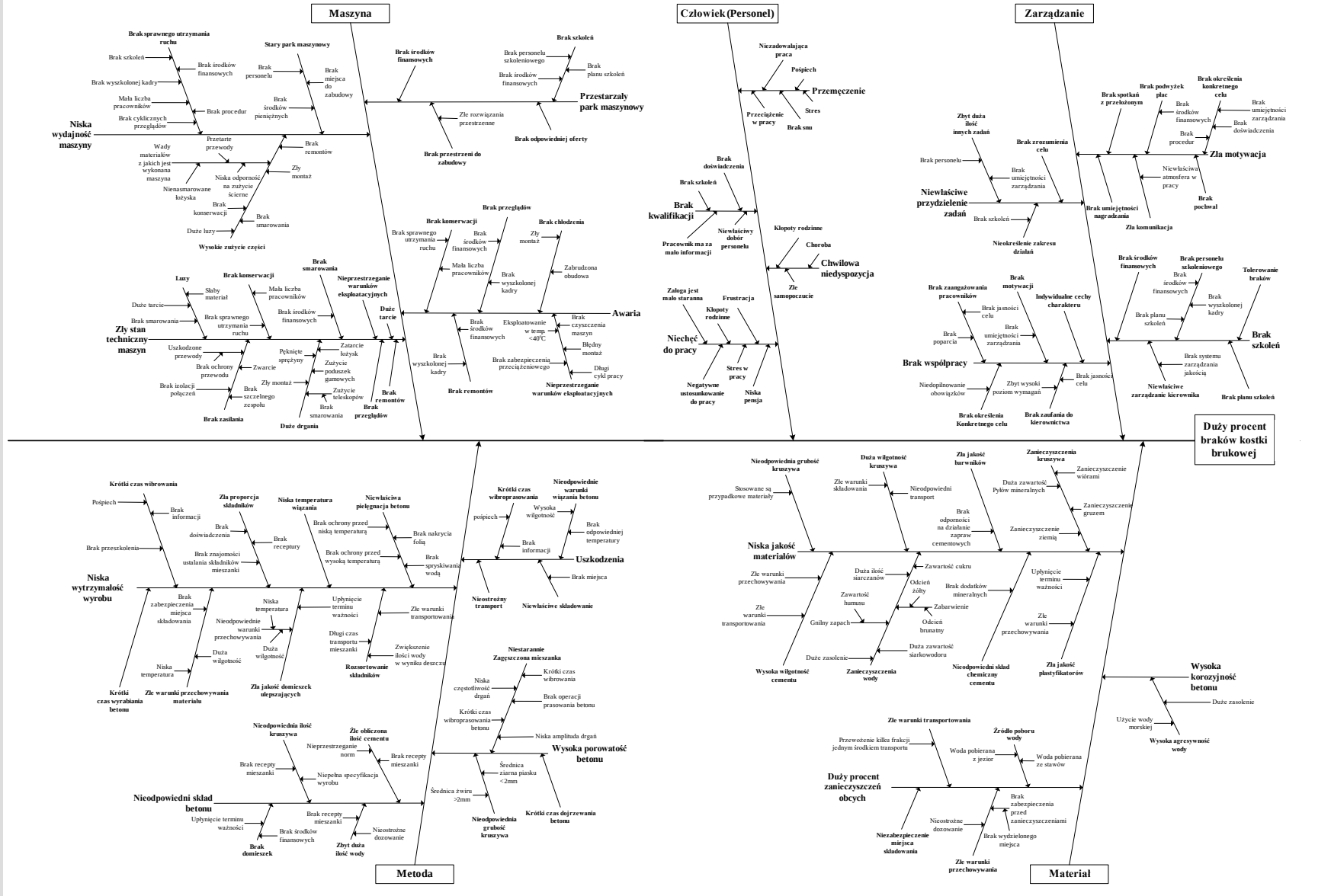
Ishikawa diagram – main causes and some sub-causes



Ishikawa diagram - extended version, deep analysis

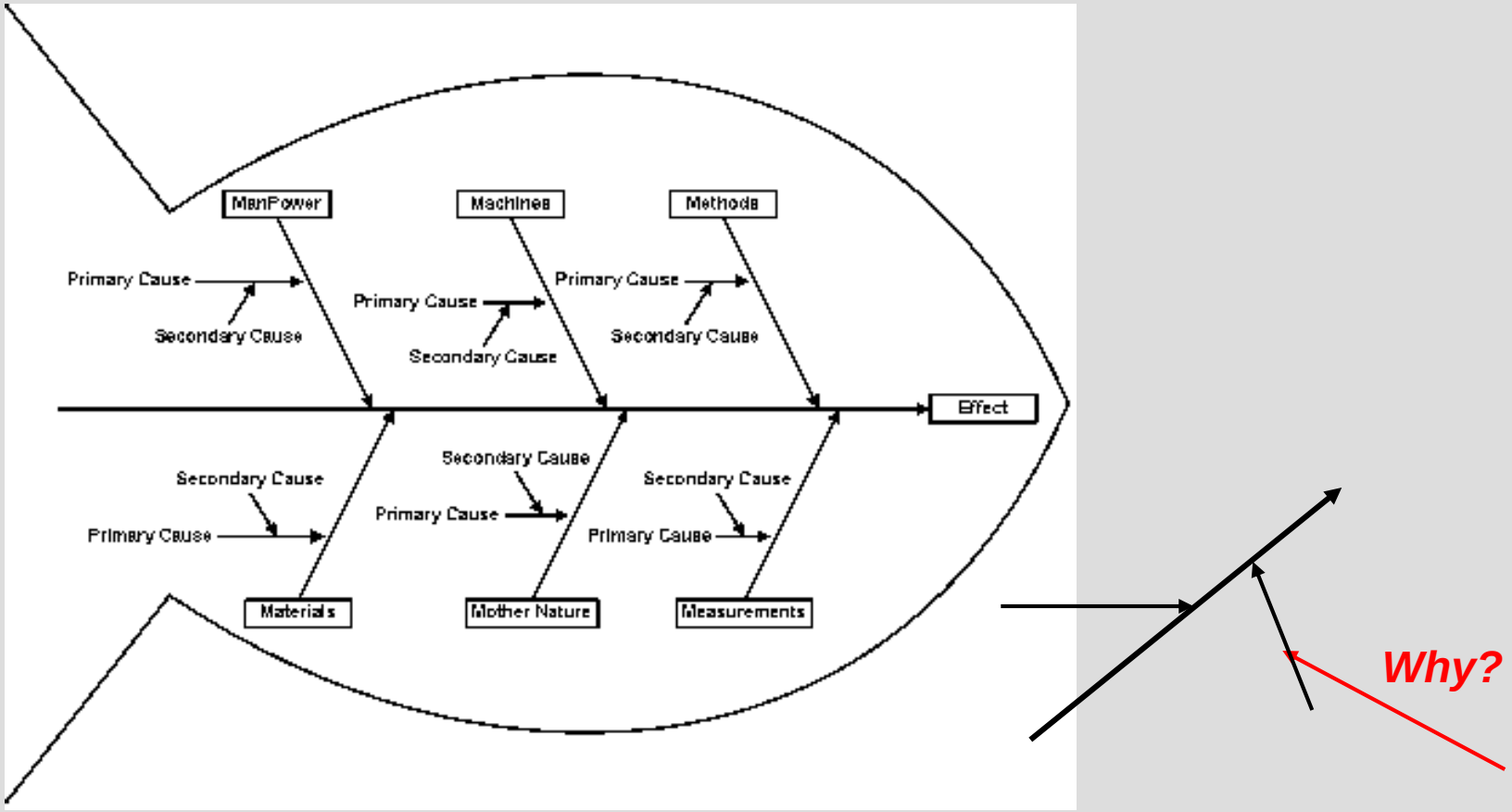


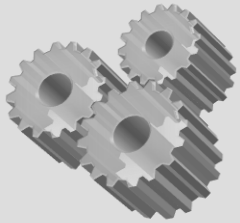
Ishikawa diagram - extended version, deep analysis



How do you go deeper into analysis using the Ishikawa diagram?

A: asking a question ***Why?*** for each of the identified root causes of problems.





STAGES OF PROCEDURE

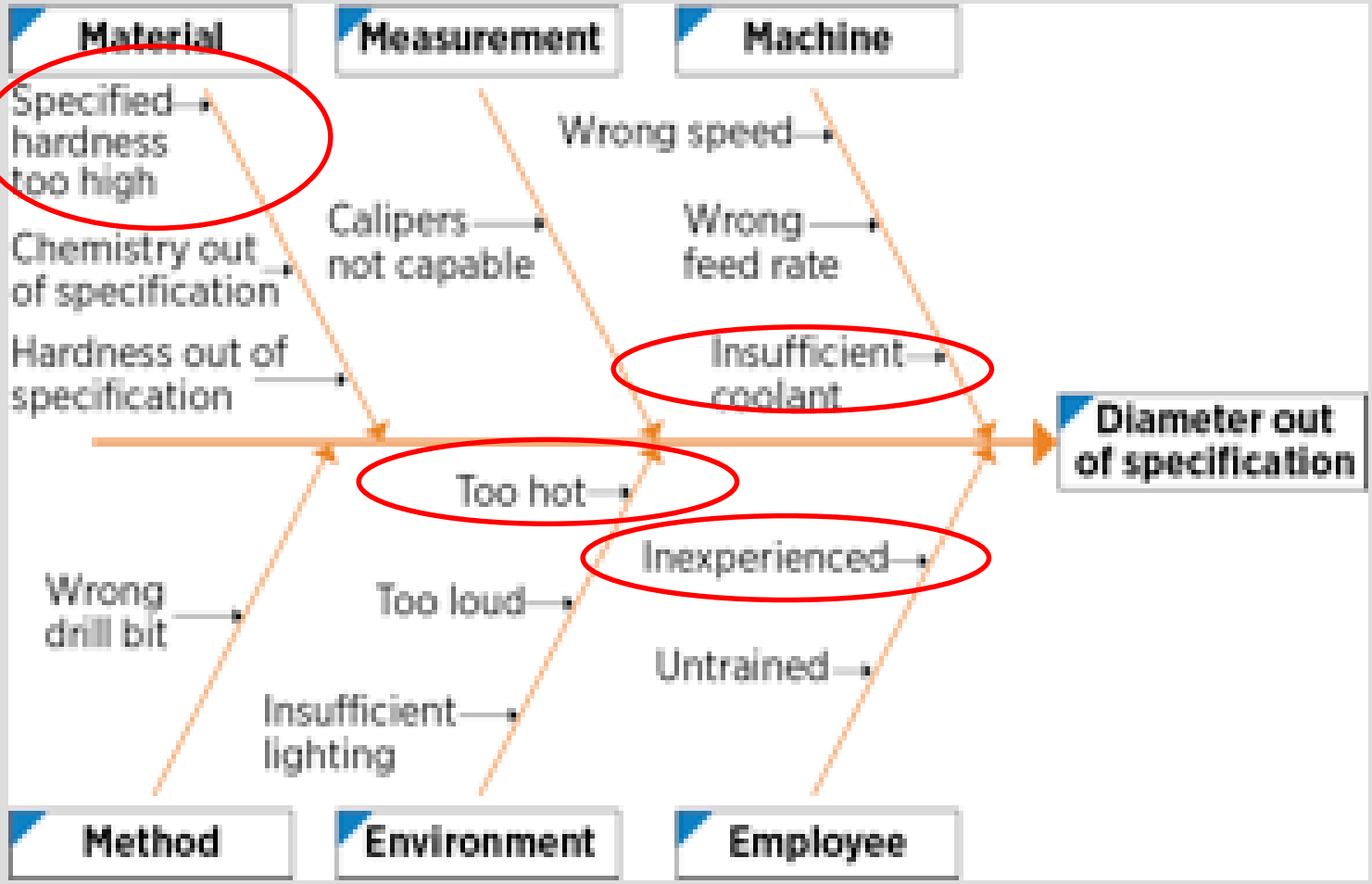
6. **Analyze root causes.** Consider which cause is most likely to cause a given effect. **ATTENTION: Select a small number (2 to 4 or 3 to 5) of causes**, which probably have the greatest impact on the problem.

7. **Confront the diagram with reality.** Check the most likely causes, e.g. **through data collection and observation**. Analyze, **whether significant causes identified actually influenced/affect the problem under study.**

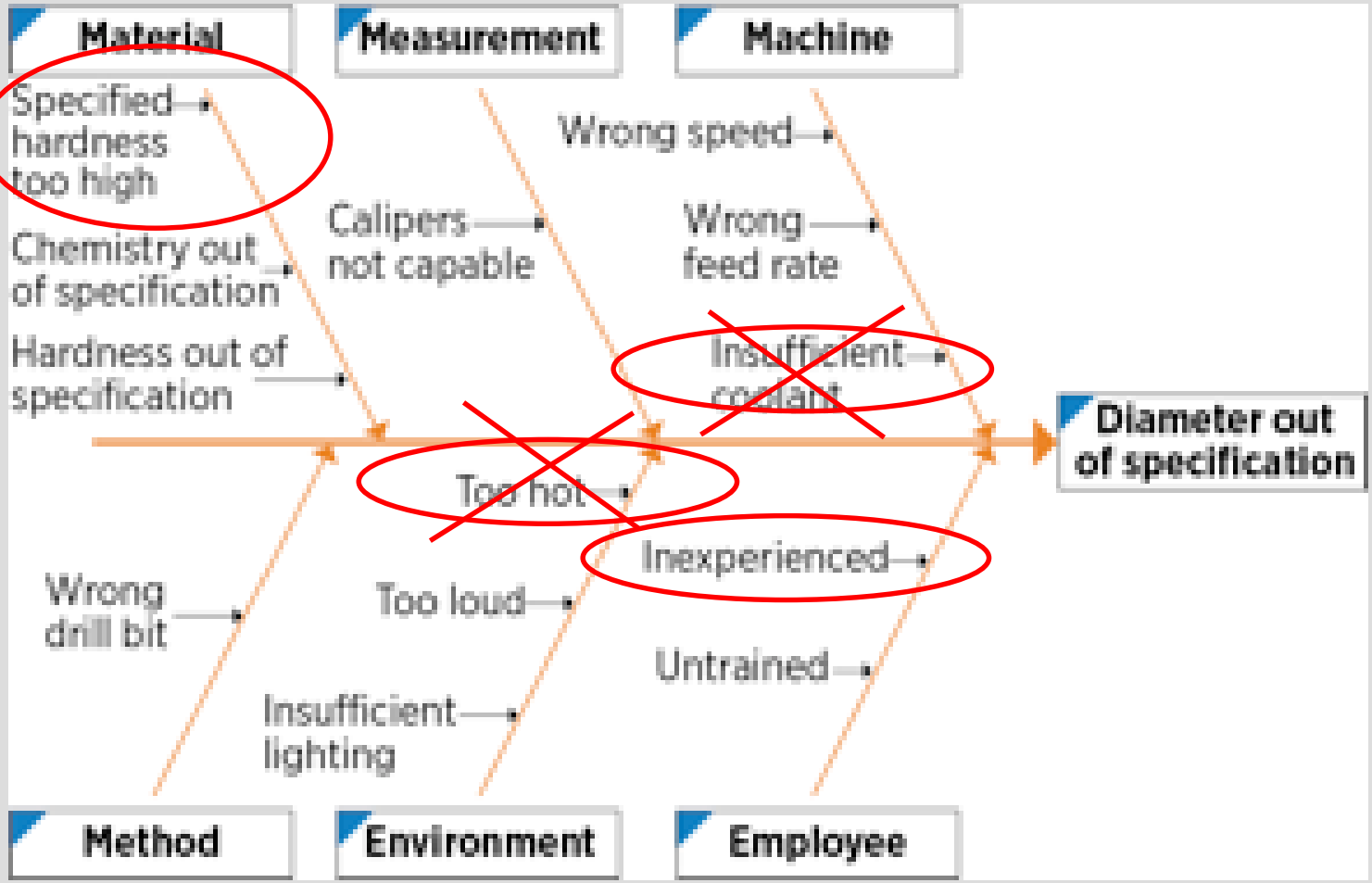
8. **Update the list of most likely causes of the problem.**

9. **Determine how to eliminate the most likely cause(s) of the problem.** Formulate conclusions from the analysis.

Ishikawa diagram – selection of the most probable causes – preliminary identification



Ishikawa diagram – selection of causes – final identification (after verification)



How to eliminate the 2 most important causes?

EXAMPLE

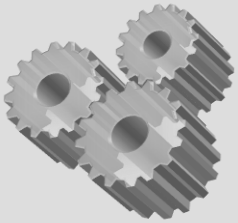
Let's assume that an attempt to turn on the bedside lamp failed. Let's consider the features and parameters that usually cause the light to come on and which may have failed. Let's use Ishikawa diagram for this purpose.

1. Define the problem.

The lamp does not work

2. Brainstorm the main causes.

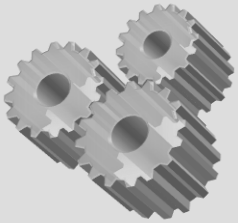
No electricity.
Blown fuse.
Burnt out light bulb.
Bulb not screwed in.
Missing bulb.
Broken cable
Plug not plugged in
Light not on
Broken switch
The dog chewed the cable
Unpaid bill



EXAMPLE

Let's assume that an attempt to turn on the bedside lamp failed. Let's consider the features and parameters that usually cause the light to come on and which may have failed. Let's use Ishikawa diagram for this purpose.

1. Define the problem.
The lamp does not work
or
2'. Through brainstorming, identify the main categories of causes.
Power supply
Plug/cable
Bulb
Lamp



EXAMPLE

3. Categorize the causes.

Power supply
Plug/cable
Bulb
Lamp

4. Assign causes to categories.

Power Light

No electricity
Not turned on
Unpaid bill
Broken switch
Blown fuse

Bulb

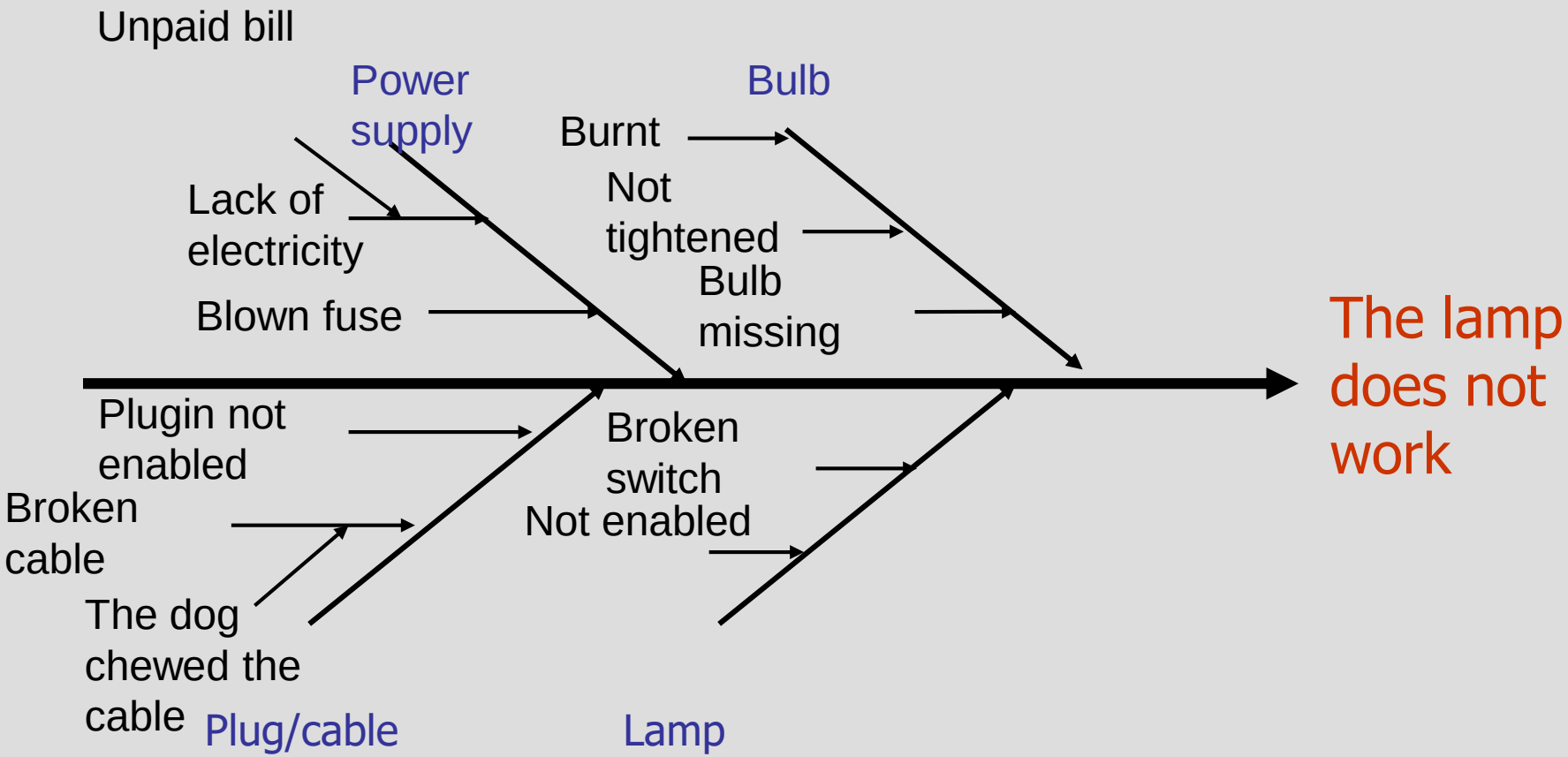
Burnt
Not tightened
Bulb missing

Plug/cable

Broken cable
The dog chewed the cable
Plugin not enabled

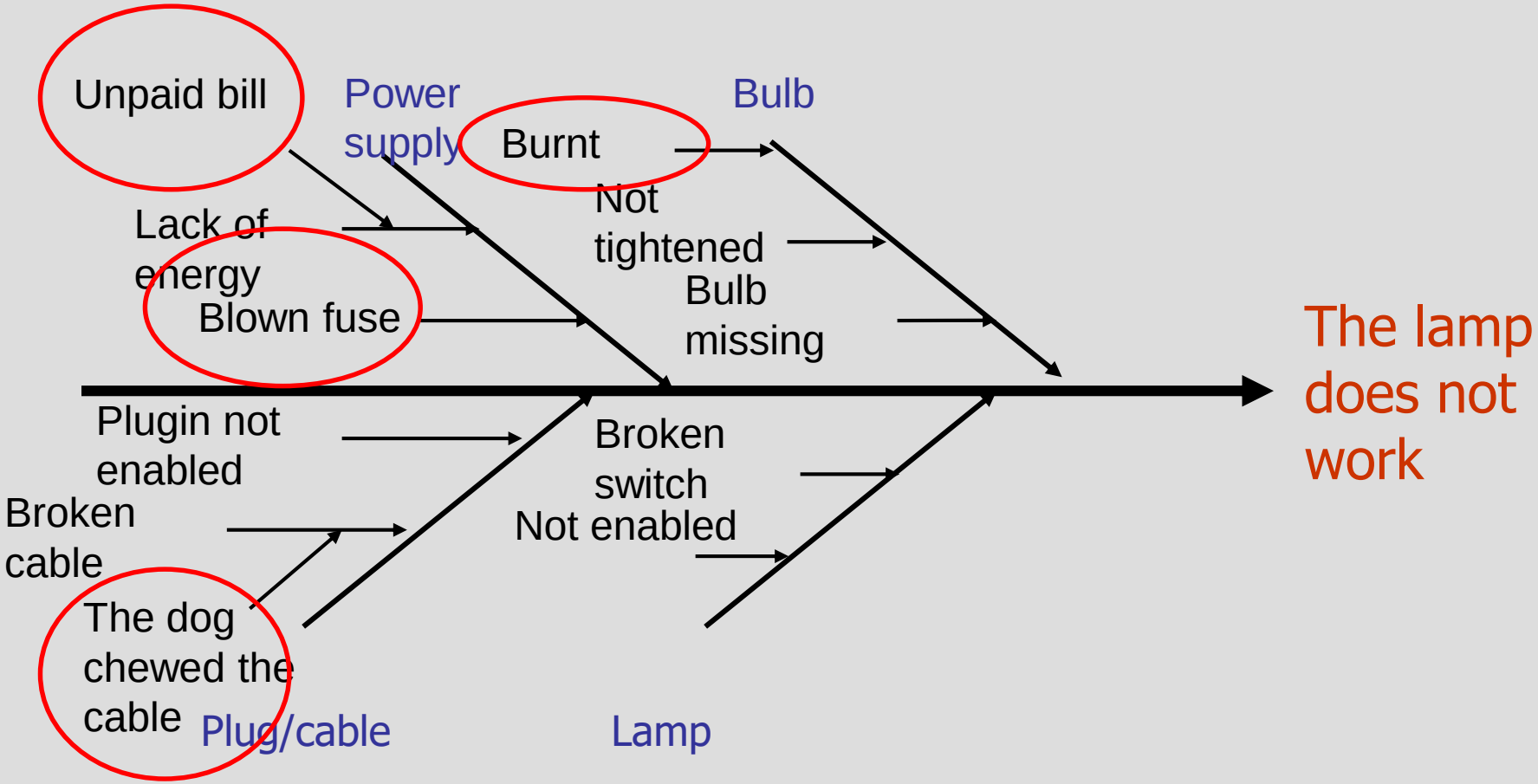
EXAMPLE

5. Place individual causes on the chart like twigs on branches.



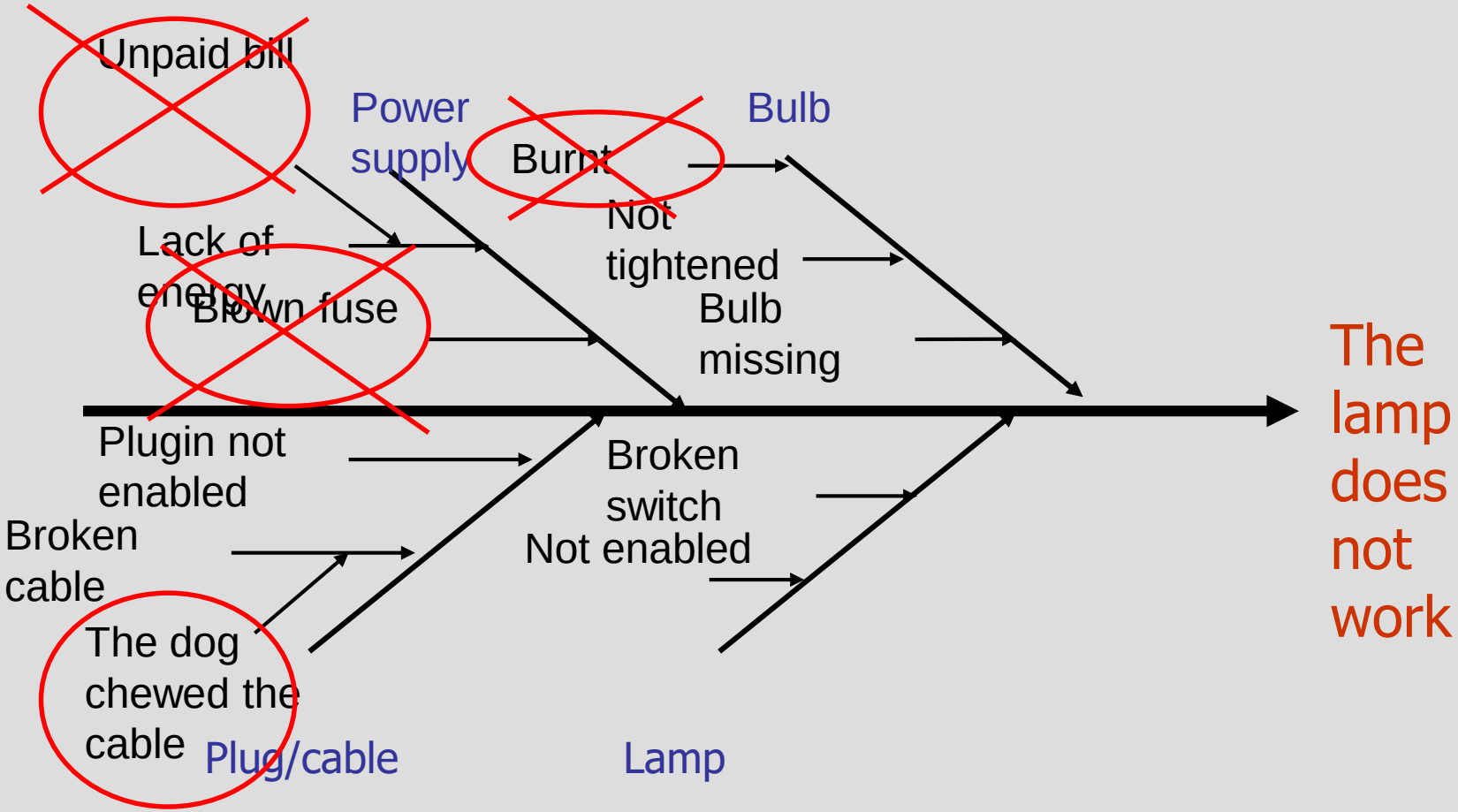
EXAMPLE

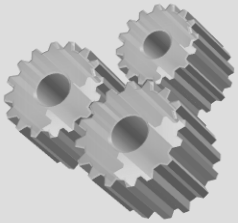
6. Analyze root causes. Select a small number (2 to 4 or 3 to 5) of causes that are likely to have the greatest impact on the problem.



EXAMPLE

7. Confront the diagram with reality.
8. Update the list of most likely causes of the problem.

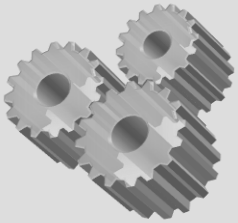




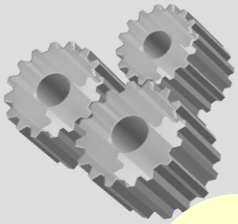
EXAMPLE

9. Determine how to eliminate the most likely cause(s) of the problem.

Do not keep your dog in the bedroom (at home).



Pareto-Lorenz diagram



Pareto analysis

What is this?

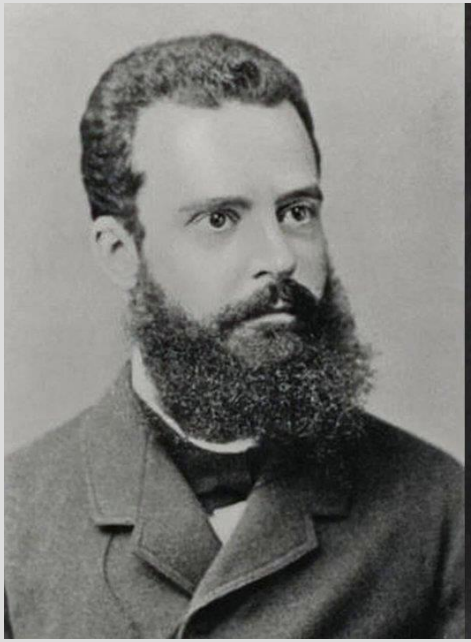
- A technique of separating important from trivial causes.
- It is used to define **the most serious causes** analyzed problem.
- It is useful in understanding **what causes/problems should be worked on first.**

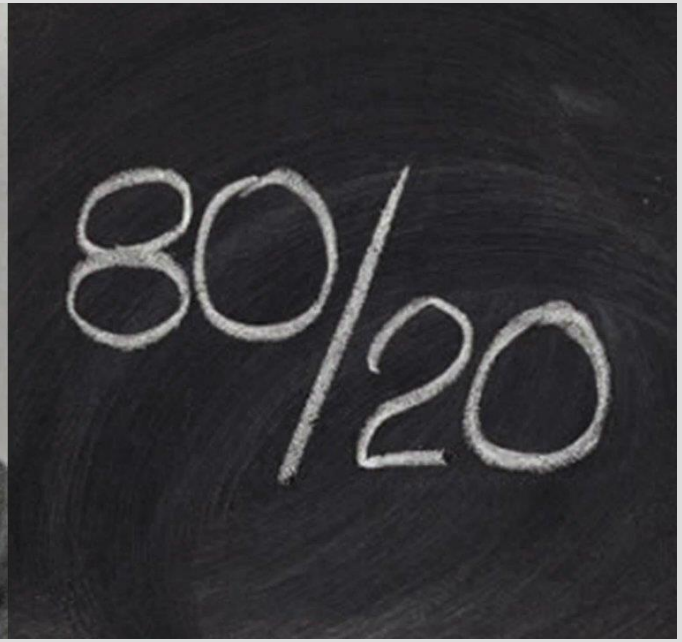
Empirical principle:

"80 – 20"/"20– 80"

80% of problems are caused by 20% of causes/
80% of the effects come from 20% of the causes
20% of the causes cause 80% of the problems

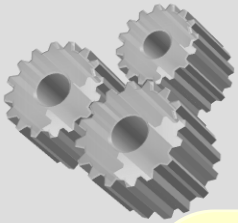
The Pareto principle and Vilfredo Pareto





Vilfredo Pareto – Italian economist and sociologist, professor at the University of Lausanne. He dealt with the issue of **unequal distribution of wealth**. His research showed that **20% of Italians own 80% of the country's wealth and vice versa - 80% of the population owns only 20% of the wealth.**

-> Pareto principle,
-> 20-80 or 80-20 rule.



Pareto analysis

The 20-80 rule

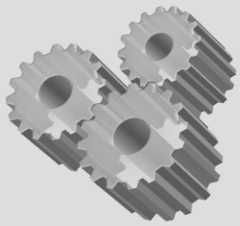
A small number of people, causes and situations are responsible for most of the phenomena that occur

Conclusion 1:

Taking corrective actions to eliminate these 20% of unfavorable factors maybe meaning improve the quality of the process

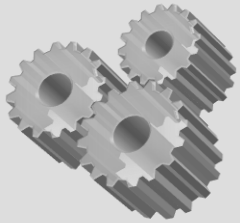
Conclusion 2:

It is worth identifying them to not fight with reasons that are insignificant



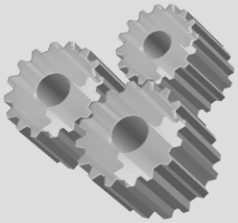
Examples of using the 20-80 rule in everyday life?

- 20% of a company's products give it 80% of its profits,
- 20% of customers bring 80% of sales value,
- 20% of employees in the company do 80% of the work,
- 20% of employees create 80% of all problems,
- 20% of criminals commit 80% of crimes,
- 20% of drivers cause 80% of accidents,
- 20% of vocabulary is enough to be able to read 80% of texts in a foreign language,
- 20% of the material takes up 80% of the exam,
- 20% of the text allows you to understand 80% of the content,
- 20% of the carpet surface accounts for 80% of the wear,
- 20% of hypermarket customers are responsible for 80% of all complaints,
- We wear 20% of our clothes 80% of the time
- 20% of politicians are visible in the media 80% of the time,
- 20% of our work gives us 80% of the results,
- 20% of our lives give us 80% of happiness.



How to pass exams using the 20-80 rule?

- Just analyze your previous experiences and think about **what "pre-exam activities" bring the greatest results.**
- Sometimes you can observe that a person who studies intensively and tries to understand everything, ends up getting a lower grade **than someone who can only learn what is actually needed to receive a specific grade in the exam.**
- By having short time, **it pays to think about it in advance to find the "valuable" 20% of knowledge that needs to be learned to ensure 80% of our success in the form of an appropriate assessment.**

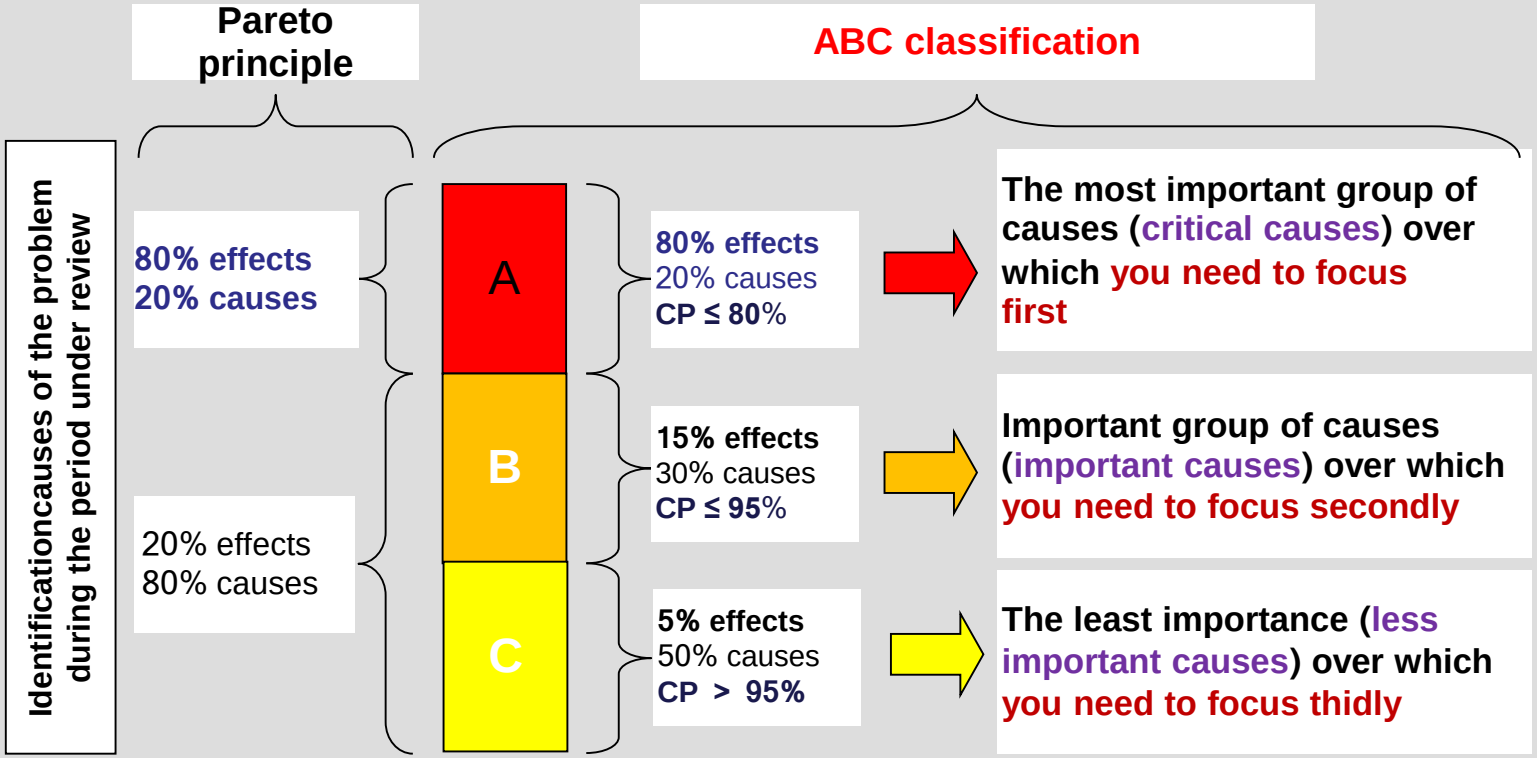


How to pass exams using the 20-80 rule

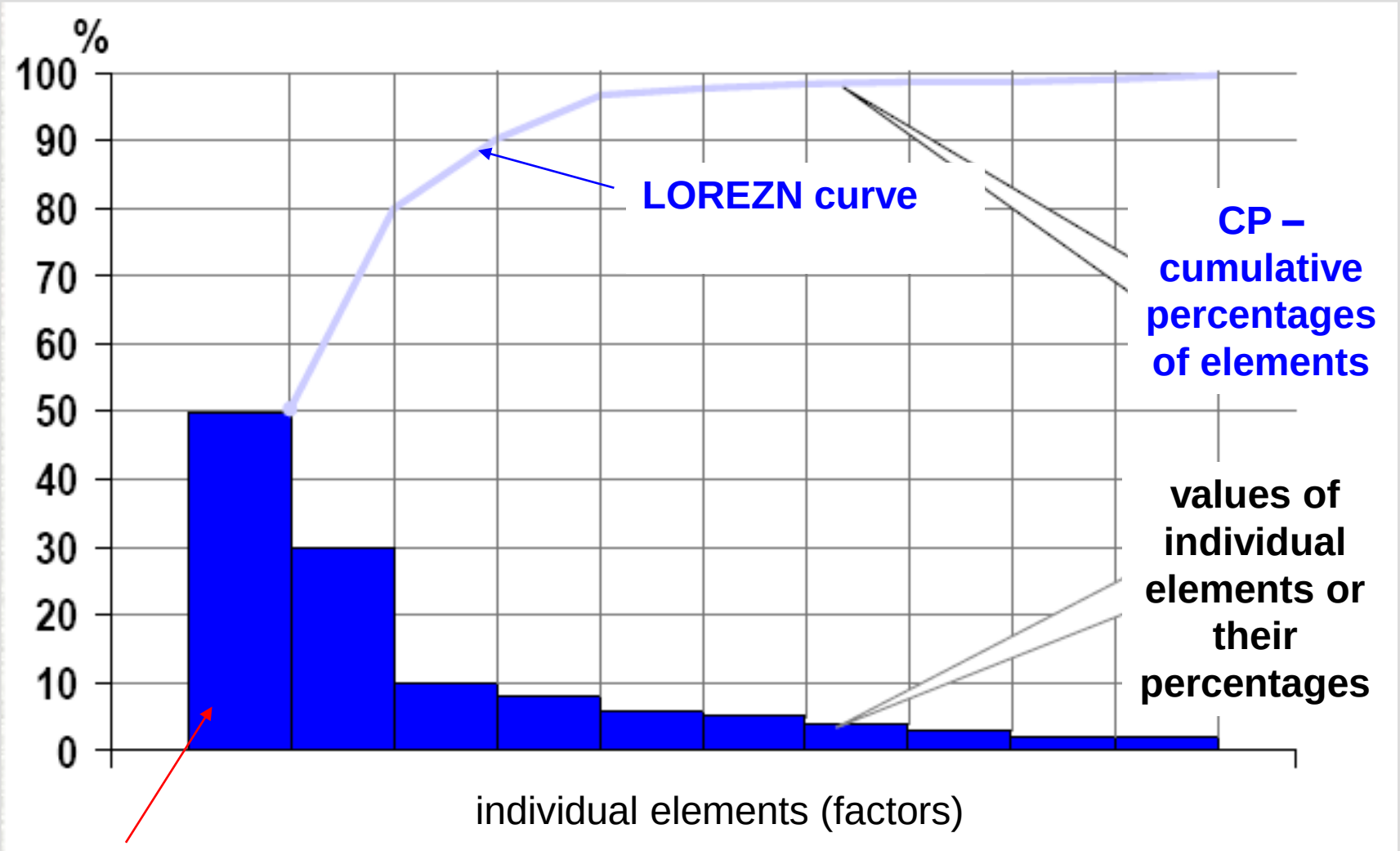
- **The problem is finding that 20%. How to do this?** You have to develop it in yourself **the ability of an analyst to reflect on every action and its consequences.**
- The end result will depend on **skills <u>drawing valuable conclusions from lectures</u>** (e.g. **remembering lecturers' favorite topics**), **<u>the art of collecting data and processing it into useful knowledge</u>.**

ABC classification as a modification of the Pareto principle

It is a modification of the Pareto principle **ABC classification**, according to which the analyzed cases are divided into: **3 groups**, not on **2** as in the case of Pareto classification...

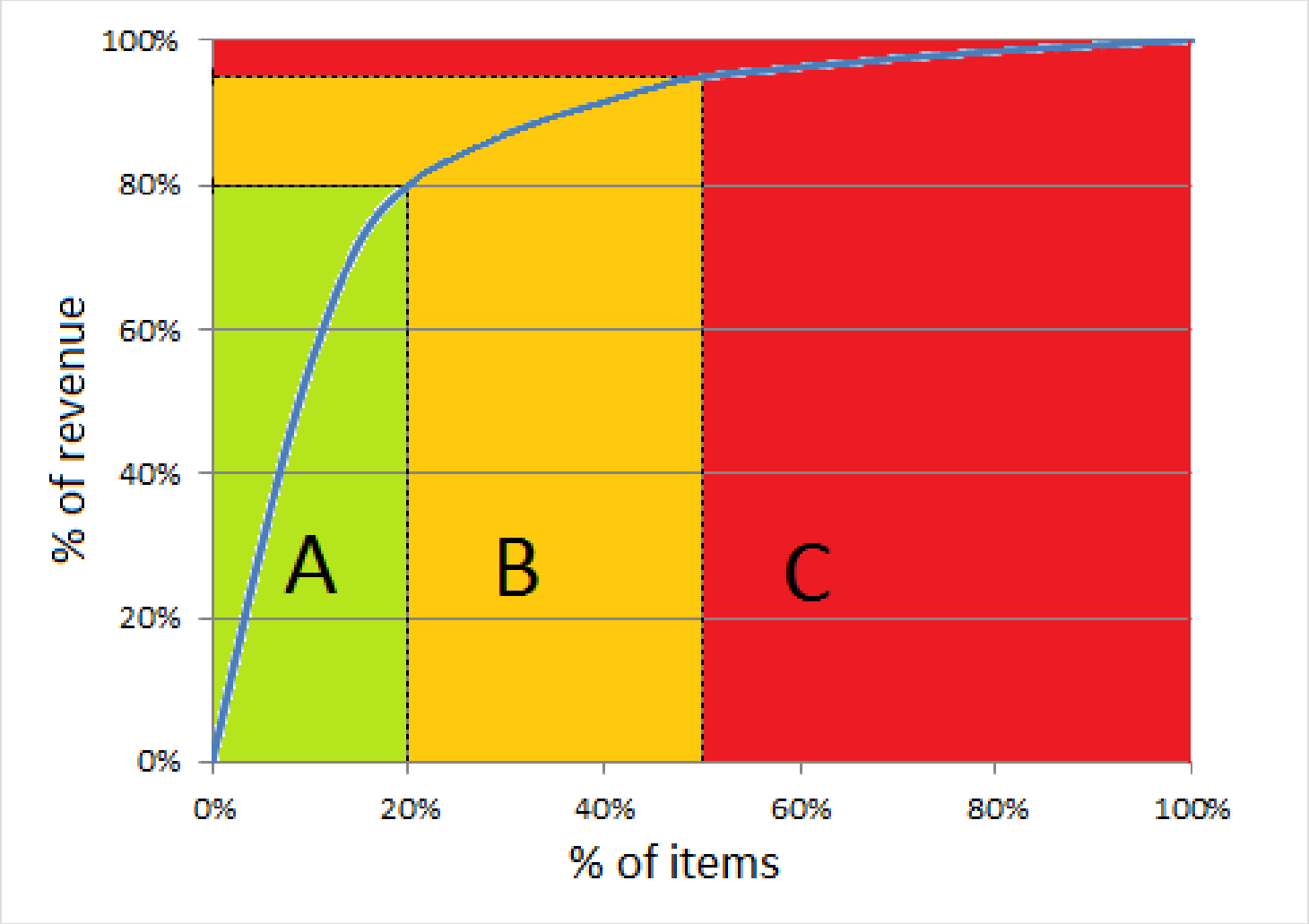


Pareto-Lorenz diagram

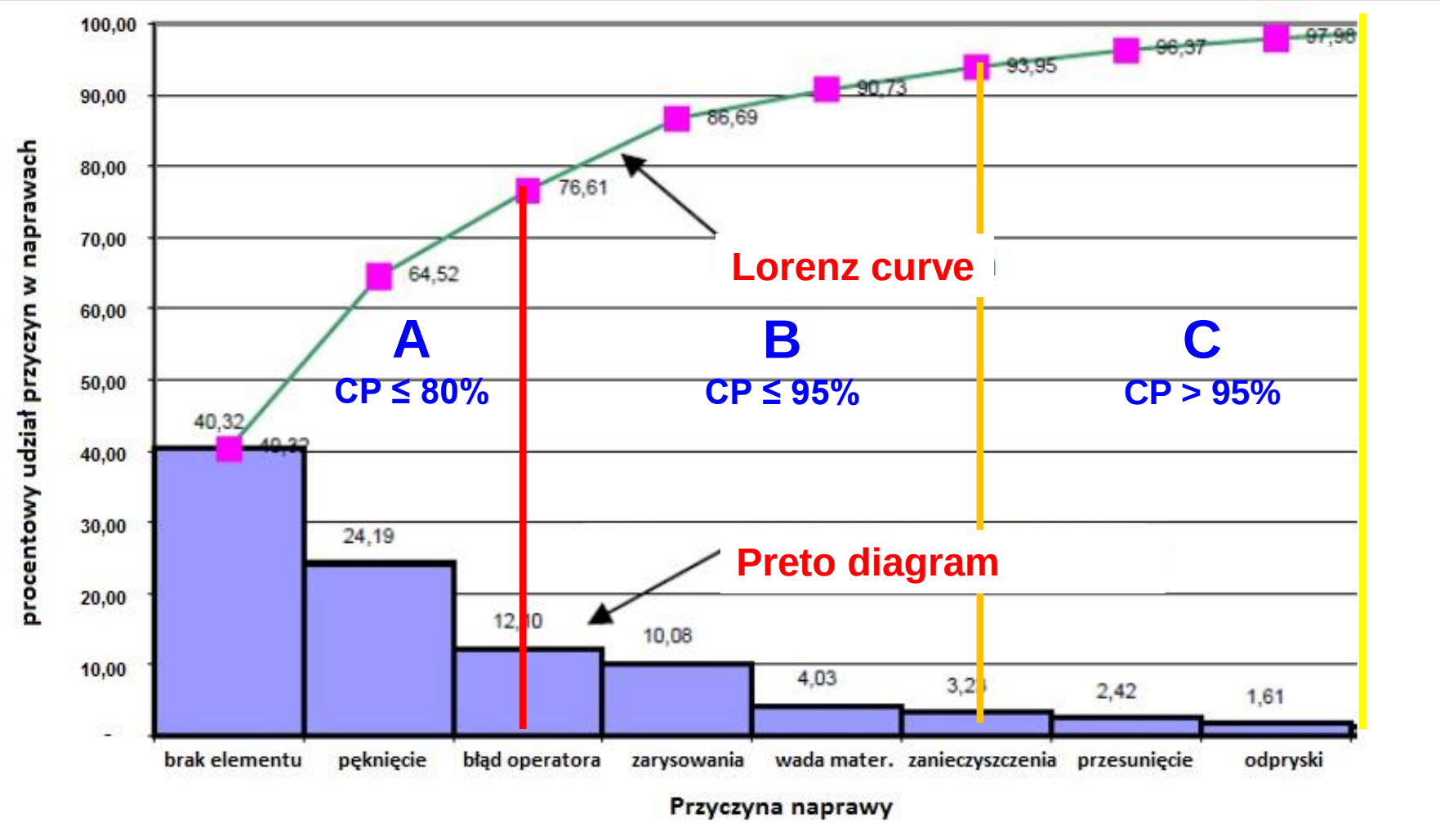


PARETO diagram

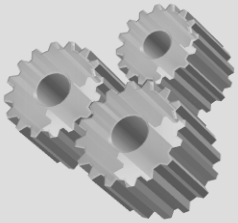
ABC classification – Lorenz curve



ABC classification – Lorenz curve



CP – Cumulative percentage



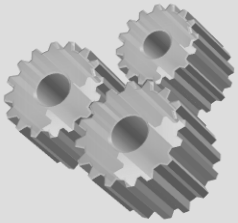
Rule is rule, but above all common sense...

	Inventory valorization	% of total inventory valor	% accumulated	ABC
Family 1	5500	43%	43%	A
Family 2	5000	39%	82%	B
Family 3	1000	8%	90%	B
Family 4	600	5%	94%	B
Family 5	400	3%	97%	C
Family 6	95	1%	98%	C
Family 7	90	1%	99%	C
Family 8	70	1%	99%	C
Family 9	50	0%	100%	C
Family 10	30	0%	100%	C
Total	**12835**	100%		

Alternative, better classification

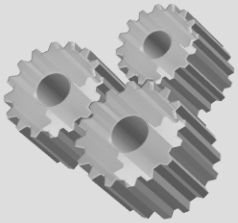
review numerical values!

	Inventory valorization	% of total inventory valor	% accumulated	Class
Family 1	5500	43%	43%	A
Family 2	5000	39%	82%	A
Family 3	1000	8%	90%	B
Family 4	600	5%	94%	B
Family 5	400	3%	97%	B
Family 6	95	1%	98%	C
Family 7	90	1%	99%	C
Family 8	70	1%	99%	C
Family 9	50	0%	100%	C
Family 10	30	0%	100%	C
Total	**12835**	100%		



Pareto-Lorenz diagram

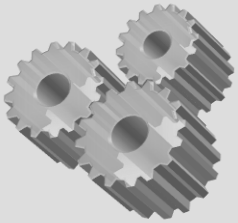
- **Graphical representation of the 20-80 rule,**
- It is **a bar chart**, where the bars are shown in descending order from left to right or top to bottom,
- **Bars** can represent defect categories, places, causes of problems, problems, etc.,
- **Bars** hide within themselves **specific number**, and therefore indicate single percentage points (in relation to the whole) referring to a given category,
- **Size (length) of the bars** may refer to frequency, percentage, cost or time,
- The most important thing to observe is **curve** (**Lorenz curve**), which indicates cumulative percentage and can help you explore the impact of different categories (**20-80 analysis, ABC analysis**).



Pareto-Lorenz diagram

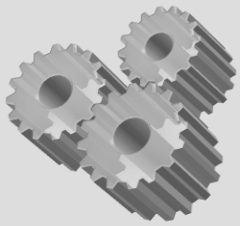
Procedure:

1. **Specify the problem that will be analyzed.**
2. **Select factors** (causes) and **unit of measurement**, e.g. *number of events, costs, etc*.
3. Choose **data collection and collection time frame.**
4. **Collect and save data** (e.g. *using check sheets*).
5. Create **data frequency table** (in ascending to descending order) and **cumulative frequency** (for a given factor is the number of appearances of a given factor plus all frequencies of factors that appeared above the considered factor).



Pareto-Lorenz diagram

6. **Plot the horizontal axis**. Divide it into equal parts in the number of factors considered.
7. **Draw a vertical axis** scaled from 0 to 100%.
8. **It will draw bars in frequency height from left to right on the horizontal axis, in descending order of the unit of measurement value.**
9. **Draw a line of cumulative frequency**by summing the values of each factor from left to right.
10. **Analyze the most important factors for improvement.** Specify the group of factors having the greatest share in the analyzed effect (**can be used for this purpose ABC classification).**



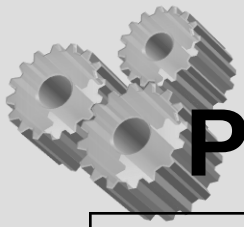
Pareto analysis. Example

Data was collected on the number of non-conformities related to the provision of a certain service. The data is presented in the table. Key groups of causes were identified using the Pareto principle (20/80).

Symbol	Non-conformity	Number of occurrences
N1	Empty window	3
N2	Illegible form	21
N3	Loss of documentation	1
N4	Long queue	61
N5	Wrong information	6
N6	No forms	14
N7	Information not available	41
N8	Extended break	1
N9	Difficult to contact by phone	3

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]

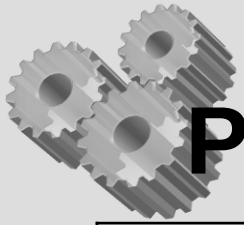


Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61		
N7	Information not available	41		
N2	Illegible form	21		
N6	No forms	14		
N5	Wrong information	6		
N1	Empty window	3		
N9	Difficult to contact by phone	3		
N3	Loss of documentation	1		
N8	Extended break	1		

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61		
N7	Information not available	41		
N2	Illegible form	21		
N6	No forms	14		
N5	Wrong information	6		
N1	Empty window	3		
N9	Difficult to contact by phone	3		
N3	Loss of documentation	1		
N8	Extended break	1		
	SUM	**151**		

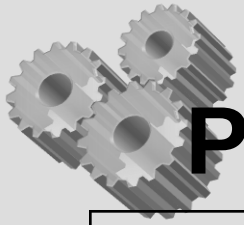


Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of discrepancies	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61		
N7	Information not available	41		
N2	Illegible form	21		
N6	No forms	14		
N5	Wrong information	6		
N1	Empty window	3		
N9	Difficult to contact by phone	3		
N3	Loss of documentation	1		
N8	Extended break	1		
	SUM	**151**		

PS for N4→(61/151)*100%=40.40%

PS for N7→(41/151)*100%=27.15%



Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	
N7	Information not available	41	27.15	
N2	Illegible form	21	13.91	
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	**151**	**100.00**	

Up for N4→(61/151)*100%=40.40%

Up for N7→(41/151)*100%=27.15%

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	= 40.40
N7	Information not available	41	27.15	
N2	Illegible form	21	13.91	
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100	

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	= 40.40
N7	Information not available	41	+ 27.15	
N2	Illegible form	21	13.91	
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100	

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	= 40.40
N7	Information not available	41	+ 27.15	= 67.55
N2	Illegible form	21	13.91	
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100	

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	40.40
N7	Information not available	41	27.15	**67.55**
N2	Illegible form	21	**13.91**	
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100	

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	40.40
N7	Information not available	41	27.15	**67.55**
N2	Illegible form	21	**13.91**	**81.46**
N6	No forms	14	9.27	
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100.00	

Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]
N4	Long queue	61	40.40	40.40
N7	Information not available	41	27.15	67.55
N2	Illegible form	21	13.91	**81.46**
N6	No forms	14	**9.27**	**90.73**
N5	Wrong information	6	3.97	
N1	Empty window	3	1.99	
N9	Difficult to contact by phone	3	1.99	
N3	Loss of documentation	1	0.66	
N8	Extended break	1	0.66	
	SUM	151	100.00	

Pareto analysis. Example

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N7	Information not available	41	27.15	67.55
N2	Illegible form	21	13.91	81.46
N6	No forms	14	9.27	90.73
N5	Wrong information	6	3.97	94.70
N1	Empty window	3	1.99	96.69
N9	Difficult to contact by phone	3	1.99	98.68
N3	Loss of documentation	1	0.66	99.34
N8	Extended break	1	0.66	= 100.00
	SUM	151	100.00	

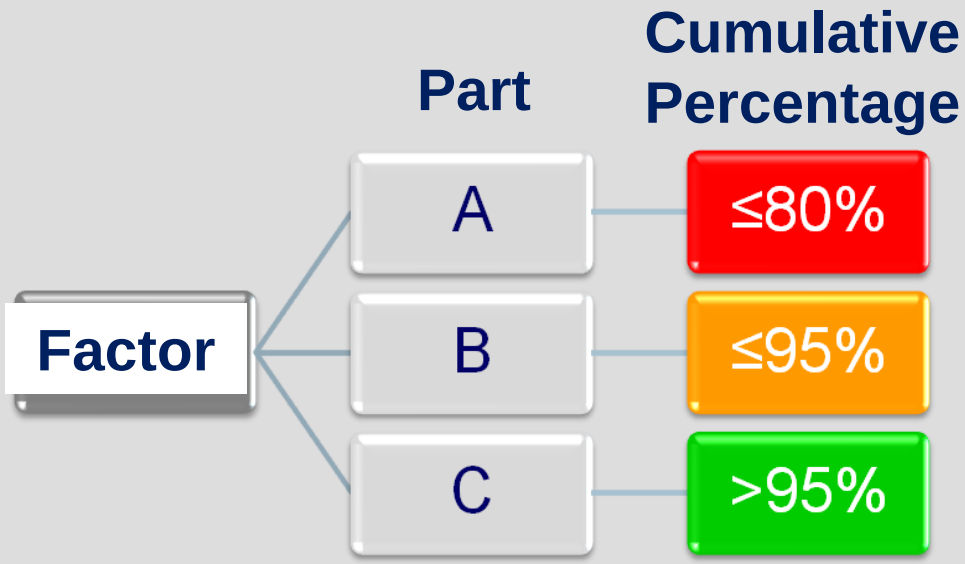
PARETO diagram

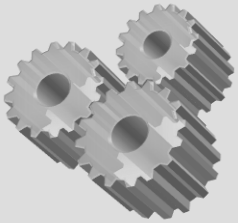
LOREZN curve

ABC method

The concepts of the ABC method can be used to divide factors into three groups:

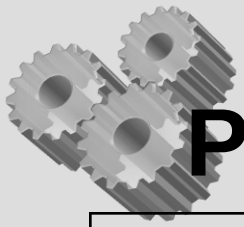
- ✓ factors will belong to part A if **in its case the cumulative percentage is less than or equal to 80%,**
- ✓ factors will belong to part B if **in its case the cumulative percentage is less than or equal to 95%,**
- ✓ factors will belong to part C if **in its case the cumulative percentage is greater than 95%.**





ABC method

Important: a common mistake is to underestimate groups B and/or C, focusing on the critical group of causes, which is group A. Groups B and C should not be ignored. All of these groups are interconnected in some way and**none of them should be marginalized.**



Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]	ABC method
N4	Long queue	61	40.40	40.40	
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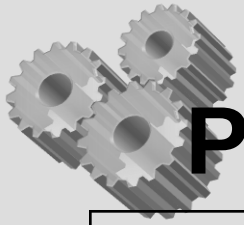
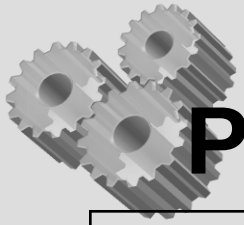
N8	Extended break	1	0.66	100.00	
	SUM	151	100.00		



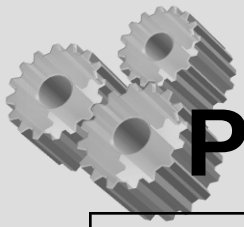
Pareto analysis. Example

Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]	ABC method
N4	Long queue	61	40.40	40.40	**A**
N7	Information not available	41	27.15	**67.55**	**A (CP≤80)**
N2	Illegible form	21	13.91	81.46	
N6	No forms	14	9.27	90.73	
N5	Wrong information	6	3.97	94.70	
N1	Empty window	3	1.99	96.69	
N9	Difficult to contact by phone	3	1.99	98.68	
N3	Loss of documentation	1	0.66	99.34	
N8	Extended break	1	0.66	100.00	
	SUM	151	100.00		



Pareto analysis. Example

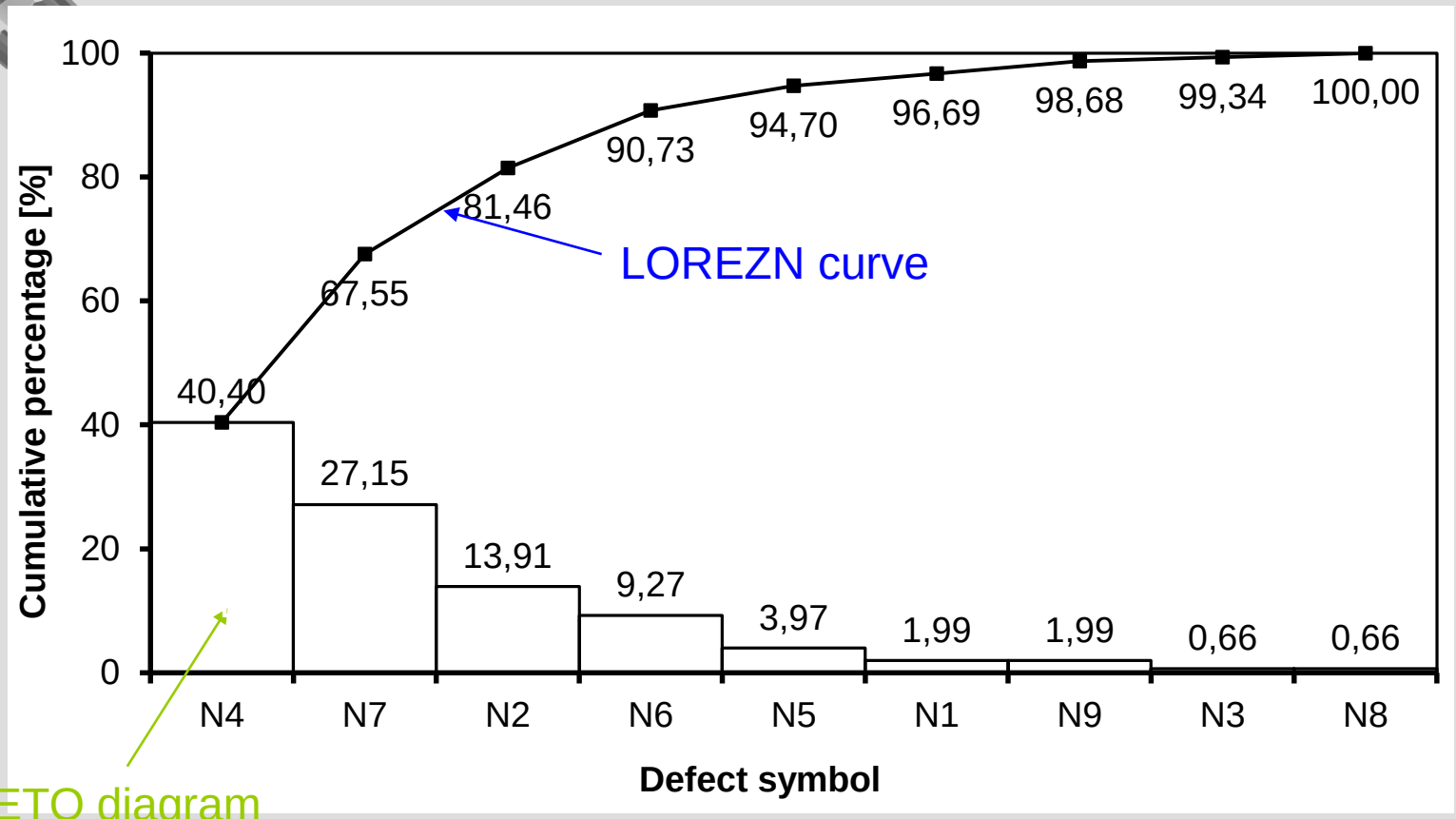
Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]	ABC method
N4	Long queue	61	40.40	40.40	A
N7	Information not available	41	27.15	67.55	A
N2	Illegible form	21	13.91	81.46	B
N6	No forms	14	9.27	90.73	B
N5	Wrong information	6	3.97	**94.70**	B **(CP≤95)**
N1	Empty window	3	1.99	96.69	
N9	Difficult to contact by phone	3	1.99	98.68	
N3	Loss of documentation	1	0.66	99.34	
N8	Extended break	1	0.66	100.00	
	SUM	151	100.00		



Pareto analysis. Example

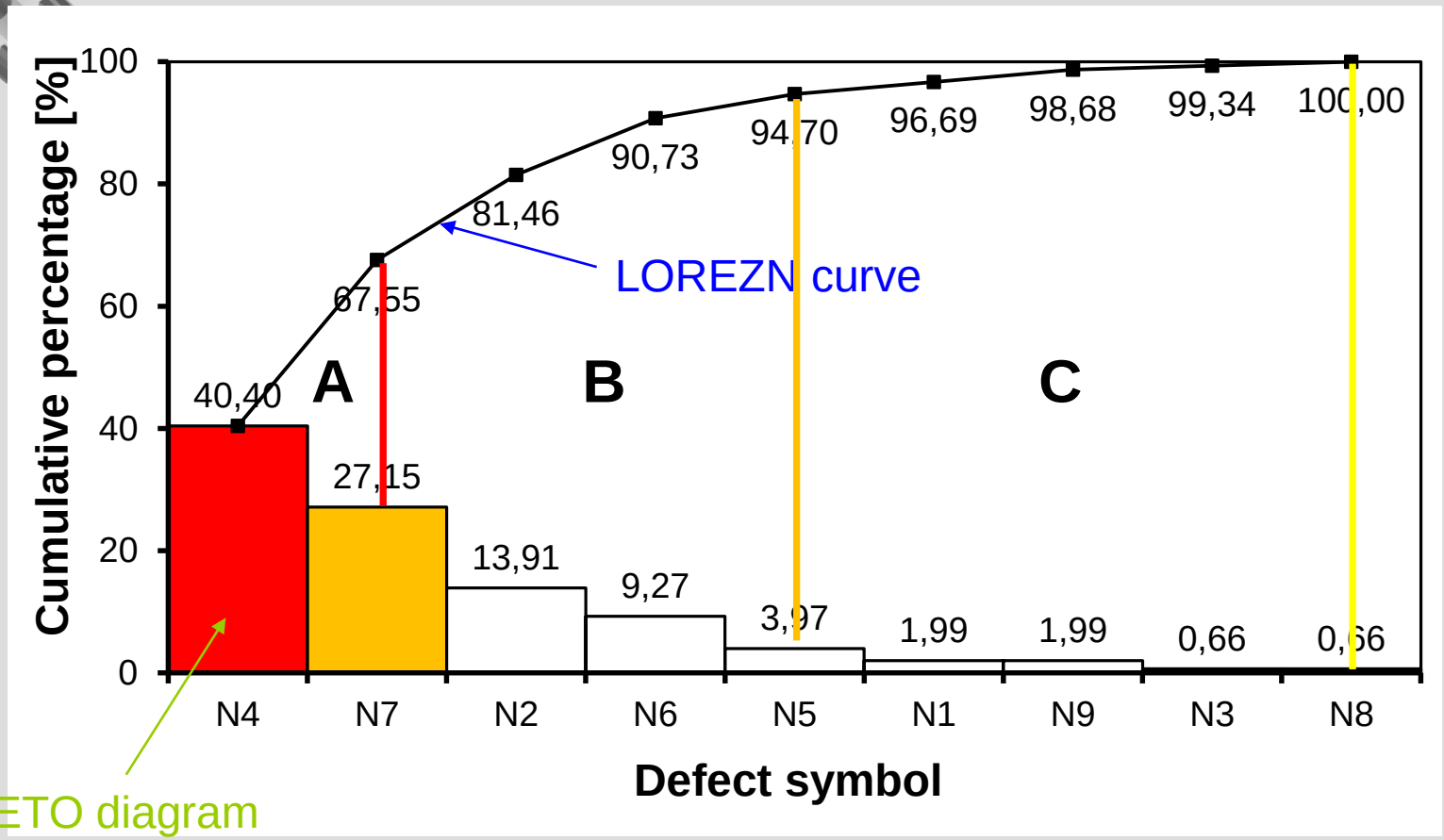
Symbol	Types of non-conformities	Descending ordering of non-conformities	Percentage share [%]	Cumulative percentage share [%]	ABC method
N4	Long queue	61	40.40	40.40	A
N7	Information not available	41	27.15	67.55	A
N2	Illegible form	21	13.91	81.46	B
N6	No forms	14	9.27	90.73	B
N5	Wrong information	6	3.97	94.70	B
N1	Empty window	3	1.99	**96.69**	C **(CP>95)**
N9	Difficult to contact by phone	3	1.99	98.68	C
N3	Loss of documentation	1	0.66	99.34	C
N8	Extended break	1	0.66	100.00	C
	SUM	151	100.00		

Pareto analysis – continued

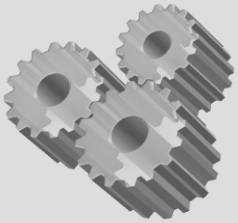


PARETO diagram

Pareto analysis – continued

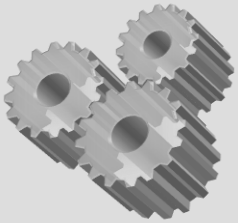


The Pareto-Lorenz diagram shows us **that 2 (from part A) non-conformities from 9 (so 22.2% cause factors) cause 67.55% of all complaints (effects**). Therefore, to improve the situation, **these factors should be eliminated first,** i.e., *long queues and unavailable information.*



Pareto analysis – continued

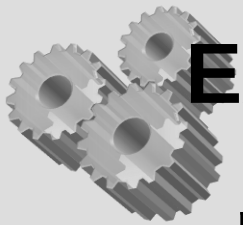
Example 2



Example 2

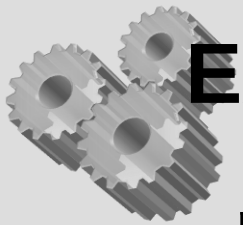
It was agreed that the test would concern the defects of the XHL-Large entrance doors. It was decided to collect the data from the website and the complaints office. There are 9 types of door defects that may occur and it was assumed that the measure would be the number of cases of a given defect occurring in the last year.

Symbol	Type of defect	Number of cases
W1	Dirt	50
W2	Traces of corrosion	70
W3	Zipper sticking	34
W4	Creak	2
W5	The door does not fit perfectly to the frame	10
W6	Scratches in the door leaf	15
W7	No spare keys	10
W8	Scratch marks on the glass	5
W9	Incorrect material structure	4



Example 2

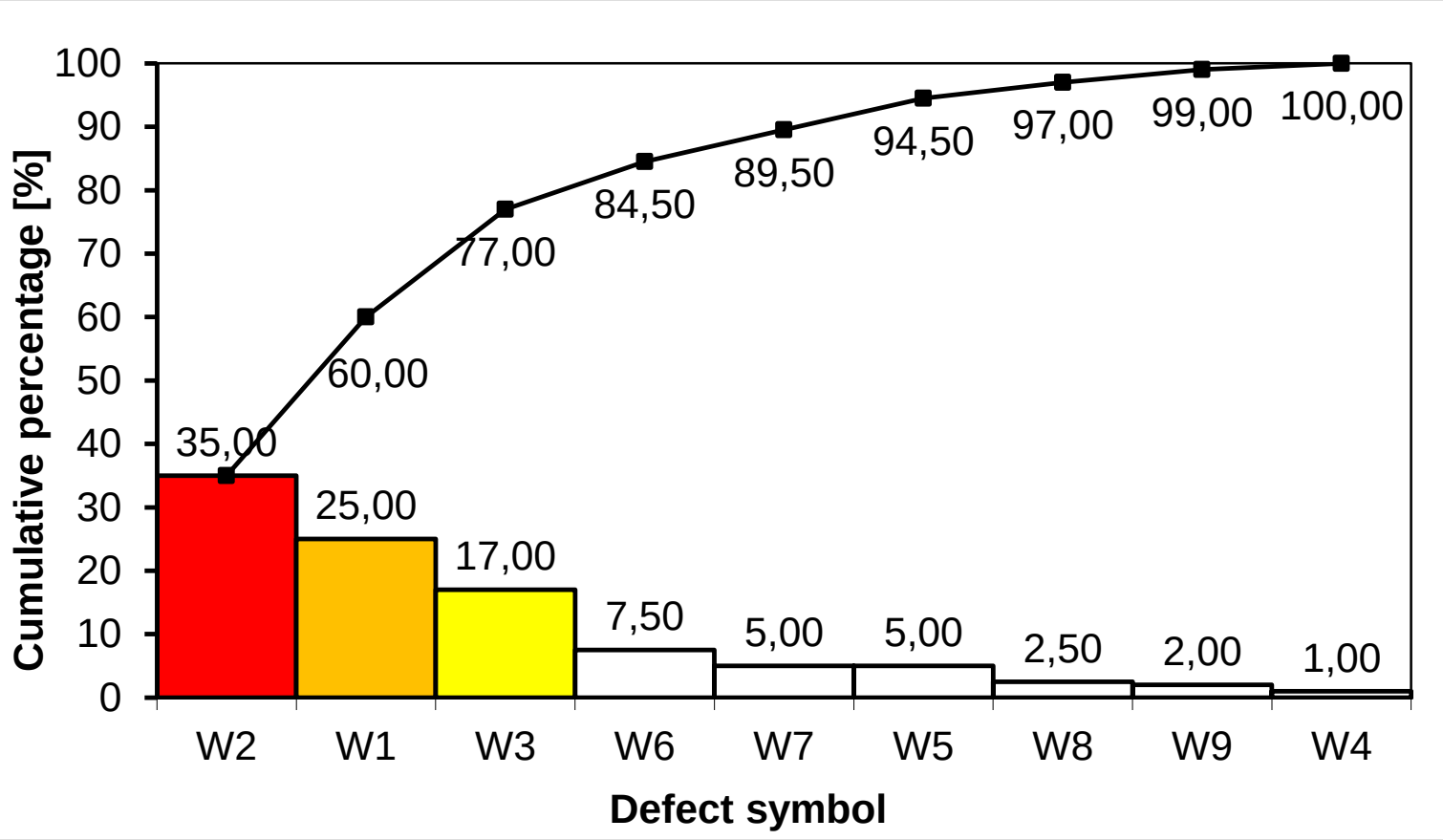
Defect symbol	Descending order	Percentage share [%]	Cumulative percentage share [%]	ABC method

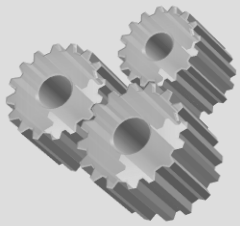


Example 2

Defect symbol	Descending order	Percentage share [%]	Cumulative percentage share [%]	ABC method
W2	70	35.00	35.00	A
W1	50	25.00	60.00	A
W3	34	17.00	77.00	A
W6	15	7.50	84.50	B
W7	10	5.00	89.50	B
W5	10	5.00	94.50	B
W8	5	2.50	97.00	C
W9	4	2.00	99.00	C
W4	2	1.00	100.00	C
SUM	**200**	**100.00**	**X**	**X**

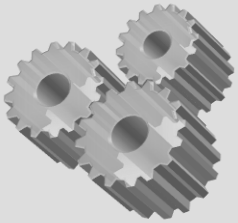
Example 2


Cumulative percentage [%]
100
90
80
70
60
50
40
30
20
10
0
35,00
60,00
77,00
84,50
89,50
94,50
97,00
99,00
100,00
25,00
17,00
7,50
5,00
5,00
2,50
2,00
1,00
W2
W1
W3
W6
W7
W5
W8
W9
W4
Defect symbol

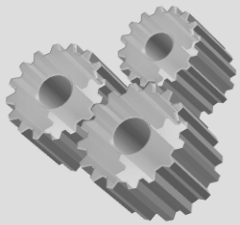


Interpretation

- The developed diagram shows that **3 types of door defects out of 9 (i.e. 33.33% of defects) contribute to 77.00% of complaints (effects) of this product.**
- These defects are defects marked with the symbol **W2, W1 and W3.**
- Therefore, **in order to reduce the cases of complaints, it is necessary to address tchem primarily these defects**, i.e. *traces of corrosion and dirt and the zipper getting stuck.*



Matrix Data Analysis



Matrix Data Analysis Chart

The Matrix Data Analysis Chart (or MDAC) **helps classify items by identifying two major characteristics common to all items and then plotting each item as a point on a standard x-y chart.**

This makes it easier to see **how the individual items relate both to the characteristics and to one another**, thus:

Matrix Data Analysis Chart

Measured Item	Character-istic A	Character-istic B
Item 1	10	8
Item 2	5	-4
Item 3	-8	-5
Item 4	-5	3
Item 5	7	-5
Item 6	8	9

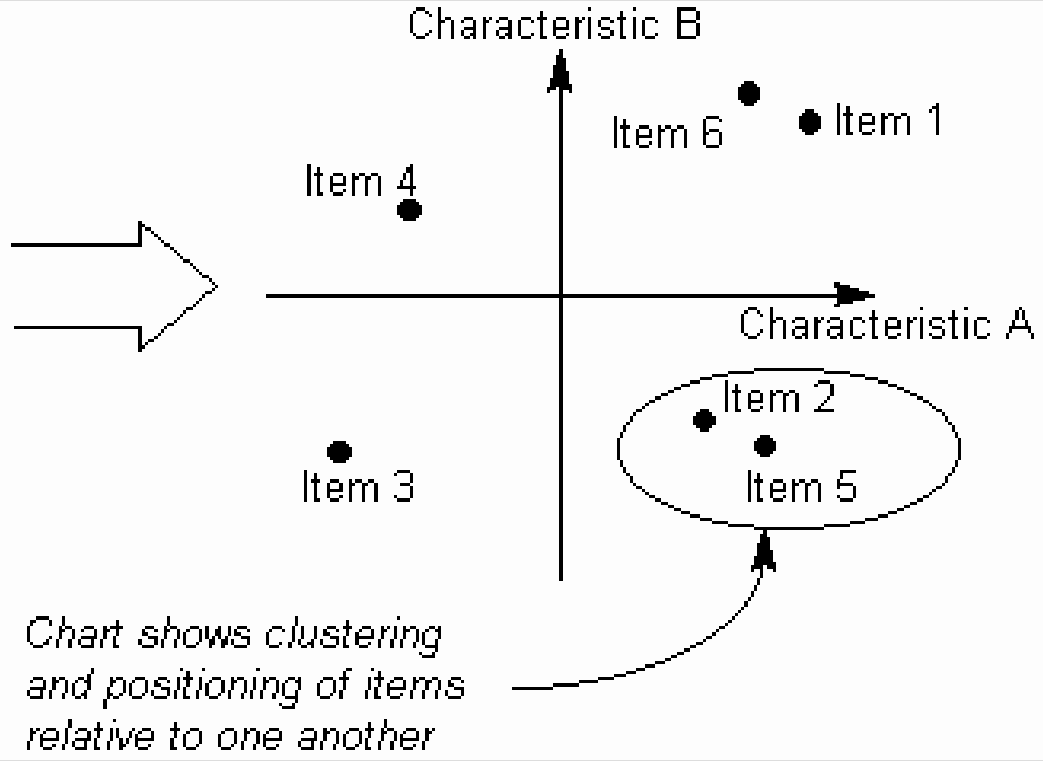
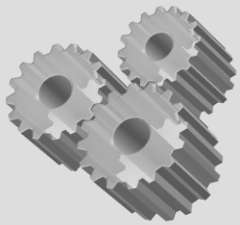


Fig. 1. MDAC plot



Matrix Data Analysis Chart

A key interpretation point about an MDAC is to **consider how points on the chart group together or form into clusters** (this may be contrasted with the Scatter Diagram, which looks for linear trends).

This interpretation is helped by highlighting significant groups of points with linear links, as in Fig. 2.

Matrix Data Analysis Chart

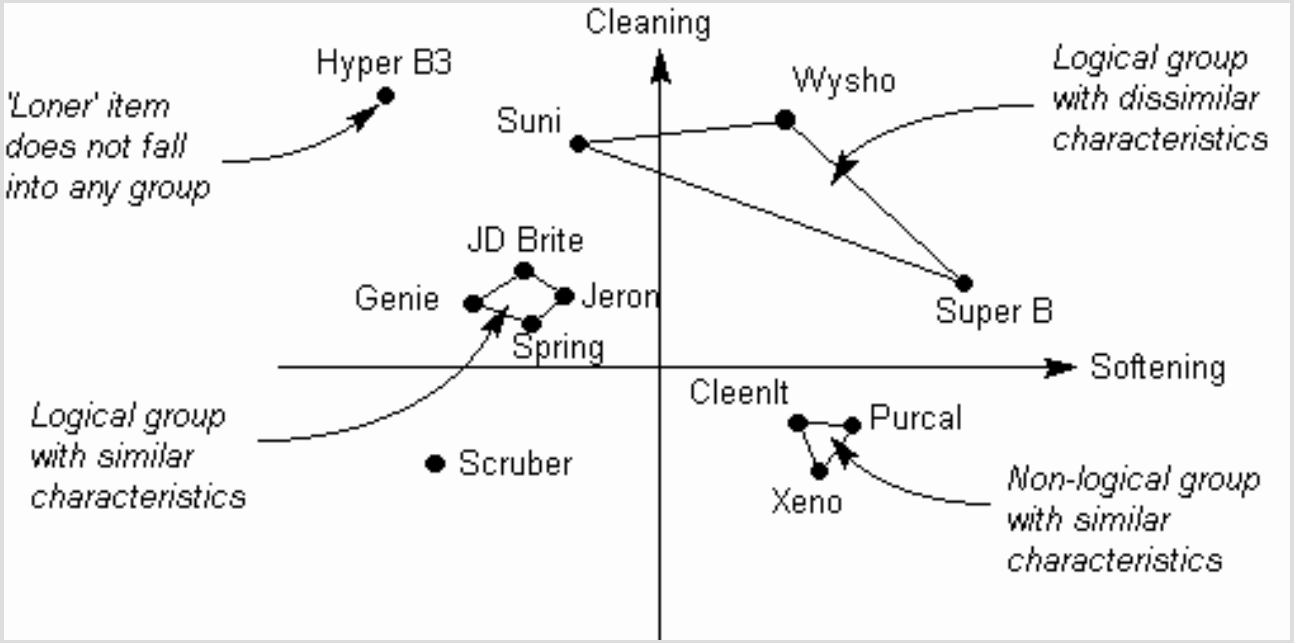
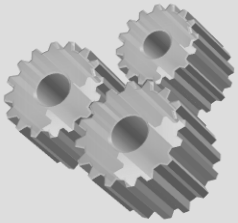


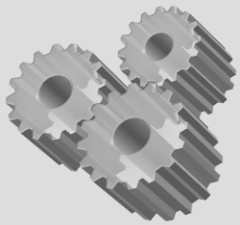
Fig. 1. Clustering

Typical items of interest on an MDAC include:

- The behavior of logical groups of items, which might be expected to form close clusters. For example, in a washing powder test, logical groups might be woolen items, acrylics and mixtures.
- Actual clustering on the chart which might highlight divergence from expected behavior, and prompt new actions. For example, investigation of an unexpected cluster of different fiber types might show that they come from one manufacturer who has developed processes to give different fibers with similar specifications.



ABCD-Suzuki method

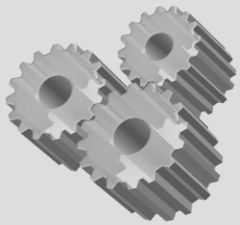


ABCD-Suzuki method

The ABCD method is a very simple and widely used method that allows to determine the **importance and rank of individual causes of the problem (but not only).**

The basic assumption of this method is the **active participation of a selected team of employees.**

Team members **should be specialists in their field and know the analyzed problem from experience.**

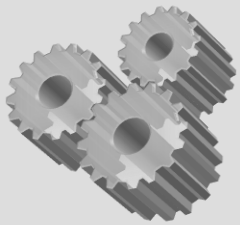


ABCD-Suzuki method

The ABCD method can be used in **all enterprises**, regardless of the business profile or size of the company.

Application:

1. When it is not known **which causes from a broader set have a greater, smaller or even minimal impact on the analyzed problem.**
2. It allows you to **narrow down the field of action** thanks to the ability to determine the most important causes affecting the analyzed issue.



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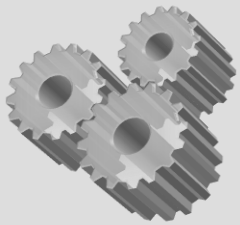
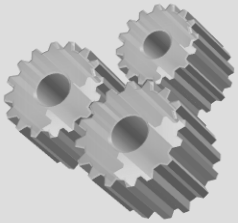


ABCD-Suzuki method

Steps of the ABCD method

1. Determining the causes of the problem.
2. Sorting out the causes (A, B, C, D, ...).
3. Preparing and completing the table of individual rank choices.
4. Preparing and completing a summary table.
5. Ranking of causes according to importance (rank).



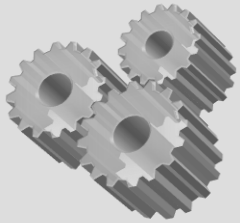
ABCD-Suzuki method

Table 1. Table of individual rank choices

importance of the factor on the analyzed problem ←

Cause		Rank (importance) of the cause										Comments
Symbol	**Name**	1	2	3	4	5	6	7	8	9	10	

Remember the rule: The greater the impact of a given factor on the analyzed problem, the lower the value on the rating scale we assign to it!

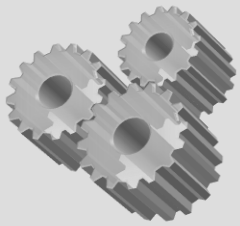


ABCD-Suzuki method

Table 1. Summary table of assessments

Cause		Rank (importance) of the cause										CS	NUA	RI	R
Symbol	**Name**	1	2	3	4	5	6	7	8	9	10				

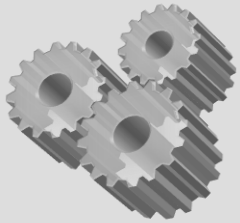
Designation: CS - Corrected Sum of Meanings; NUA - number of undeleted answers; RI - rank indicator; R - rank



ABCD-Suzuki method

Example

The ABCD method was used to identify and sort out the causes of a large number of non-compliant products in the production process. The result of the work of a 10-person team is a collective evaluation table.

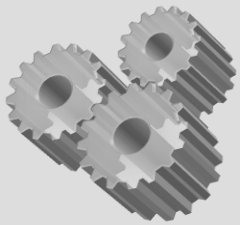


ABCD-Suzuki method

Table 1. Summary table of assessments for the causes of a large number of non-compliant products in production

Cause		Rank (importance) of the cause										CS	NUA	RI	R
Symbol	**Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**				
A	Machine breakdowns		5	3	2										
B	Outdated technology			3	2	4	1								
C	Lack of proper training of employees	5	2	3											
D	Low quality raw materials		2	3	2	2	1								

Designation: CS - Corrected Sum of Meanings; NUA - number of undeleted answers; RI - rank indicator; R - rank



ABCD-Suzuki method

Cause		Rank (importance) of the cause										CS	NUA	RI	R
Symbol	Name	1	2	3	4	5	6	7	8	9	10				
A	Machine breakdowns	4	~~5~~	3	~~2~~	1						21	8	2,6	2
B	Outdated technology		2	~~3~~	2	4	~~1~~	0				34	8	4,2	4
C	Lack of proper training of employees	~~4~~	5	2	~~3~~	2						14	8	1,7	1
D	Low quality raw materials		~~2~~	3	2	2	~~1~~	0				29	8	3,6	3

Calcualtion:

CSa = 2*4+3*3+4*1=21; **RI=**21/8=2,6; **R=**1.

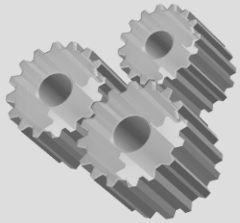
CSb= 3*2+4*2+5*4+6*0=34; **RI=**34/8=4,2; **R=**4.

CSc= 1*4+2*2+3*2=14; **RI=** 14/8=1,7; **R=**1.

CSd= 2*1+3*3+4*2+5*2+6*0=29;**RI=** 29/8=3,6; **R=**3.

ABCD-Suzuki method

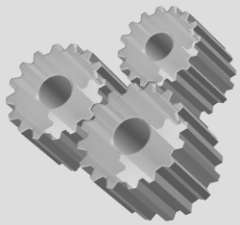
Just like in ski jumping - **the two extreme scores - i.e. the lowest and the highest - are rejected!**



ABCD-Suzuki method

Comment:

In the case of a group of 10 experts, it is recommended to remove 1 extreme answer on each side (2 answers in total), while in larger groups of experts (over 15) you can remove 2 extreme answers on each side (4 anwers in total).



ABCD-Suzuki method

Conclusions from the ABCD analysis:

In the analyzed example, the most important factor influencing the number of non-conforming products is **the lack of proper employee training.**

This factor should be addressed by the company first.