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# RISK ANALYSIS

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# ❖ RISK ANALYSIS


**Risk Analysis**: technique that considers the "risk" as a key element to drive the design choices for a product or service.

"**Risk**": expected probability that a "system" encounters problems, disruptions, failures that damage people or things or, more generally, cause losses.

"**System**": in a broad sense. It can therefore mean, for example, a manufacturing plant complex, rather than a production process consisting of several stages, or a machine consisting of several parts, or an elementary product, or a service, or, still in very general terms, a good also immaterial.

# ❖ RISK ANALYSIS

The most correct term that identifies the complete process of analysis and assessment of risks is actually "risk assessment". "Risk analysis" itself would be completed by the third step, but it is common to attribute the whole process to the term:

1. • System identification
2. • Risk identification
3. • Risk estimation
   • Risk evaluation
4. • Action for risk reduction
5. • Reached the tolerable risk, provision of information to users on residual risks and, where applicable, on appropriate measures to reduce them

# ❖ RISK ANALYSIS

Applying Risk Analysis the pursue the following **objectives** is possible:

1. To evaluate the system risk.

2. On the basis of risk evaluation, **desisgn and implement the potential safest system**;
   - then: to identify the system critical areas (providing eventually redundancies for higher safety); to decide actions and changes; to plan maintenance programs, ecc.

3. Use risk as one of the benchmarks for evaluating alternative systems.

## ❖ RISK IDENTIFICATION

The risk identification phase is linked with the origins of the project risk.

It is therefore necessary to consider:

| | |
|---|---|
| **who** | who are the project stakeholders |
| **why** | what are the objectives of stakeholders |
| **how** | how are stakeholders involved |
| **what** | which are the activities to be performed |
| **who acts** | which resources are involved |
| **when** | when it must be done |

## ❖ RISK ESTIMATION AND EVALUATION

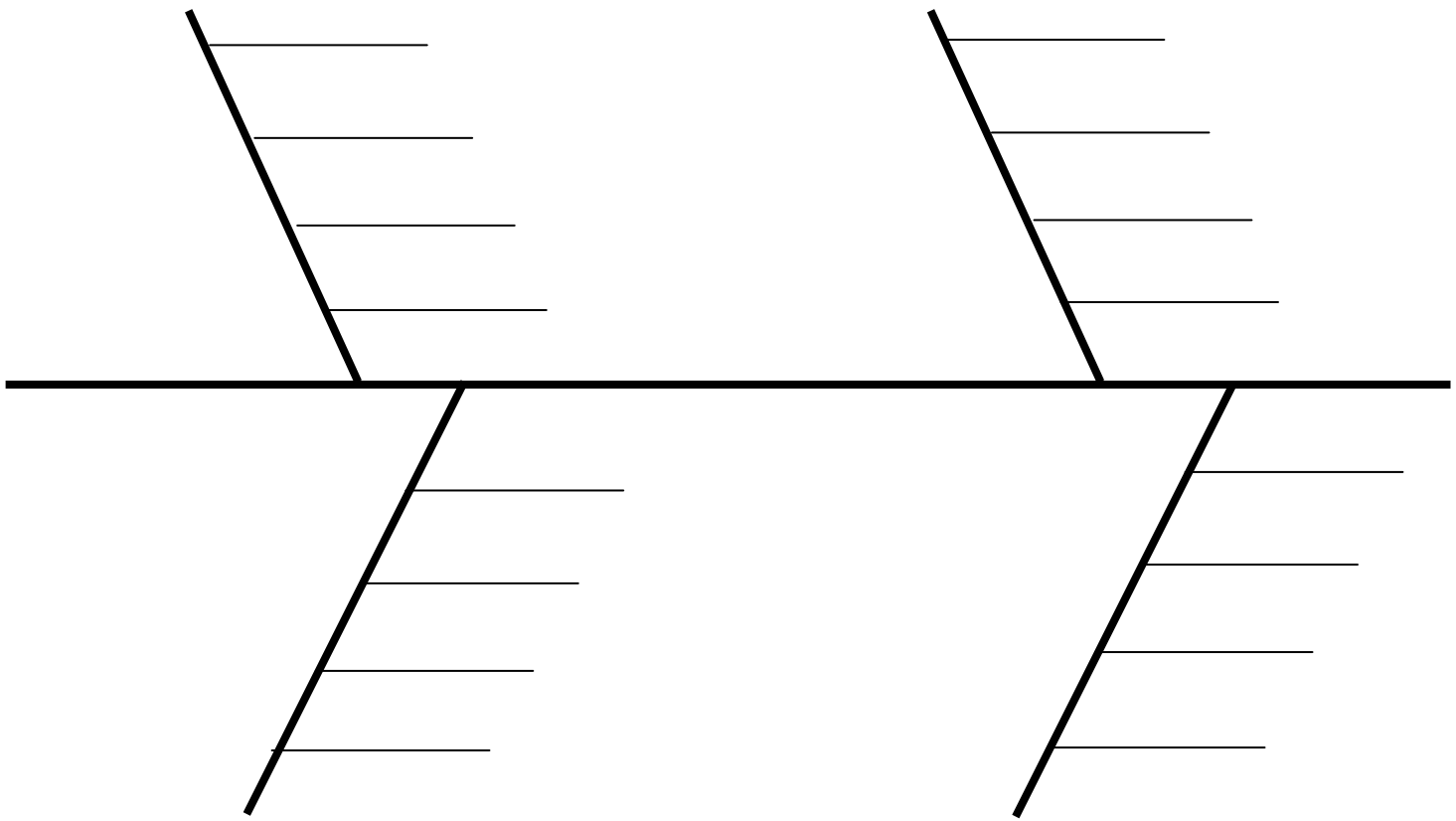
The phase of risk estimation takes to get to determine which effects a risk can cause and deciding how to act and decide on which risks to intervene

## ❖ RISK ESTIMATION AND EVALUATION

**How to assess the risk of a system?**

It 'should be worth starting from fish-bone diagram

# ❖ FISH-BONE DIAGRAM

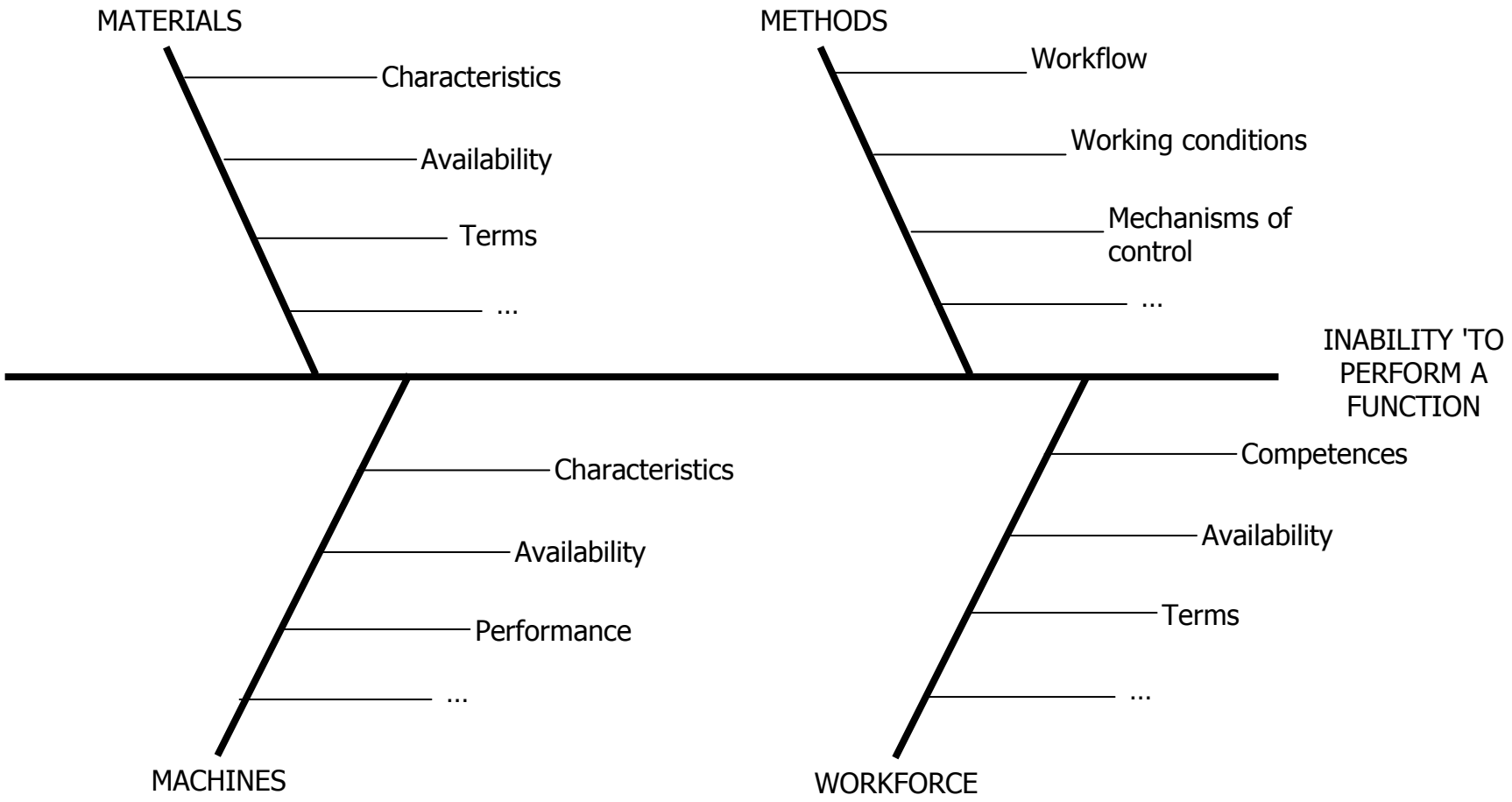


## ❖ FISH-BONE DIAGRAM

The major factors that can generate special effects (risks) are associated to the main diagram "bones". For convenience and depending on the system you are considering, these factors can be aggregated into different categories:

- The 4 M: methods, machines, materials, labor (typical in manufacturing);
- The 4 P: *place*, *procedure*, *people*, *policies* (typical in service industry);
- The steps of a process: market research, design, production, sales, delivery, service.

# ❖ FISH-BONE DIAGRAM



## ❖ RISK ANALYSIS

**How to assess the risk of a system?**

This can be done by following two approaches:

1. **Forward**: starting from an event that can happen to an element of the system and proceed forward to analyze which problems can be generated in the system.

2. **Backward**: starting by the disruption of the system and look for the possible causes that triggered the disruption.

# ❖ THE CAUSE - EFFECT DIAGRAM

## The cause - effect diagram

Two ways to deal with the problem:

- *Forward:* for example, evaluate what can happen to a car due to the defect of a mechanical component of the feed pump of gasoline.
  - **FMEA** *(Failure Mode and Effects Analysis*) and **FMECA** (*Failure Modes, Effects and Criticality Analysis*)

- *Backward:* going back, starting the final event, for example the lack of power to all the causes that determine.
  - **FTA** (*Fault Tree Analysis*)

# ❖ FAULT TREE ANALYSIS (FTA)

## *Fault Tree Analysis*

So using the backward approach, the FTA is a technique that correlates, through logic gates, the events that cause the final event.

The generated links allow the building of a model of the system that is represented by a tree structure.

It is possible, therefore, identifying the causal links between the variables that generate the final event in the system and assess the associated likelihood of occurrence.

# Building the *fault tree*

- 1 – Identify the final event which may occur in the system and that you want to analyze(*top event*). It deals with something that usually goes wrong.
- 2 – Identify the events that directly contribute to the problem.
- 3 – Link the founded events with the system problem using logic gates.
- 4 – For each event found in step 3, which is not considered to be sufficiently detailed so as to identify the causes that trigger and link them with the event using logic gates, Step 4 will be repeated until the desired level of detail is reached.

## ❖ *FTA*

The ***top event*** likelyhood will be:

**p = E1 + E2 + E3 + E6 + E7*E8**

If they had known the likelihood of occurrence associated with individual events are known, the likelihood of occurrence of the top event can be calculated or at least estimated.

## ❖ *FAILURE MODE, EFFECTS AND CRITICALITY ANALYSIS*

- FMEA/FMECA was proposed and developed for the reliability design of aerospace carriers and artefacts with high risk to human life.
- Its application was extended to the definition of maintenance policies and then gradually become a commonly used procedure for quality assurance in the design of products (product FMECA) and production processes (FMECA process).
- The analysis is a methodological approach to:
  - The a priori analysis of a product / process any type
  - The subsequent verification of what happened in the process for any new projects or improvements in the process.

## ❖ *FMECA*

- The FMEA / FMECA is a tool that applies the forward approach. Taking as reference the manufacture of a product, all the possible ways of defect or malfunction and their effects on product must detailed and systematically identified, for each component of the product and the relative phases of processing.

- The **difference** between FMEA and FMECA consists in the fact that with the original technique, the FMEA, you can lead only qualitative analysis of defects or failures (risk estimation). The FMECA complete the process with a critical assessment of any defect or failure (risk evaluation).

- The term FMEA is commonly used also to show the whole process of analysis.

## ❖ FMECA

FMEA execution:

1 • Identifying all possible failures or defects of the product components.

2 • For each failure / defect mode, description of the components of the effects and possible causes.

3 (FMEA) • For each failure / defect mode, investigation of possible actions to reduce the consequences (FMEA completed).

## ❖ *FMECA*

Proceeding with the FMECA, the analysis of criticality is introduced, aimed at quantifying the risk connected with the failure basic defect due to undesirable effects of the product.
The criticality of each type of failure/defect of the component product is evaluated by an index called "Risk Priority Index" (RPI) determined as:

$$\mathbf{RPI = P * S * D}$$

where:
**R** = Probability of occurrence of the base failure/defect;
**S** = Severity of the effects of the base failure/defect;
**D** = Detectability of the base failure/defect.

# ❖ FMECA

**3 (FMECA)**

- Set of the rating scales of the three parameters P, S, D with the criteria for scoring.

**4**

- Giving the scoring parameters.

**5**

- For each mode of base failure/defect calculate the RPI.

**6**

- Evaluate and decide actions to be taken in order to lower all the RPI below a predetermined threshold value, according to the judgment criterion chosen. Having to set priorities is appropriate to intervene at first where RPIs are higher.

## ❖ FMECA

- The three parameters that contribute to the determination of the RPI are, therefore, given scores on the basis of scales of default values.
- The scale of the scores could go, for example, from 1 to 10 with increasing values as a function of risk.
- Therefore:
  - the parameter **P** is assigned the value 1 if the occurrence of the defect is unlikely and increasing values with increasing its probability of occurrence;
  - the parameter **S** is assigned the value 1 if the effect of the defect is unlikely and increasing values with increasing severity of the effects;
  - the parameter **D** is assigned the value 1 if the detectability of the defect is likely to be at the beginning of process and increasing values with the detection point moves along the process.