Chapter 3
Cause-Effect Diagrams

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Slides related to the book

System Reliability Theory Models, Statistical Methods, and Applications
Wiley, 2004

Homepage of the book:
http://www.ntnu.edu/ross/books/srt
What is a cause-effect diagram?

- A tool to identify, explore, and graphically display – in increasing detail – all the possible causes related to a specified problem
- The cause-effect diagram is established by a team of analysts
- The analysis is based on brainstorming
- Created by Professor Kaoru Ishikawa, Tokyo University in 1943
- Adopted by W. Edwards Deming
- Also known as Ishikawa or Fishbone diagrams
- A cause-effect diagram is not a quantitative tool
Why use cause-effect diagrams?

In the context of this book, a cause-effect diagram may be used:

- To identify all the possible causes of a (system or subsystem) fault
- To display the relationship between the causes and the fault
- To suggest solutions to the problems
Step 1

Identify, describe, and delimit the main problem (e.g., a system fault). Briefly describe the problem in a box at the right-hand side of a page, draw a long arrow across the page pointing at the box. The arrow is sometimes referred to as the spine of the (fishbone) diagram.
Step 2

Agree on 4-7 main *categories* of causes (e.g., manpower, methods, materials, machinery, milieu). Draw arrows pointing at the main arrow (spine), and write a category of causes in a box at the end of each arrow.
Step 3

For each category (e.g., Materials), identify *factors* that may contribute to the main problem.

- Factors are identified by repeatedly asking: “Which *factors* may contribute within this category?”
- Carefully define and delimit each factor.
- Draw arrows pointing at the category’s arrow and enter the factors identified.

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Factors

- Inadequate material
- Too high humidity

Materials
- Methods
- Manpower

Milieu
- Machines

System fault
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Step 4

For each factor (e.g., Too high humidity), identify sub-factors (i.e., causes) that may contribute to the factor. Define and delimit the sub-factors and draw arrows pointing to the arrow from the factor.

Continue the identification of sub-factors and sub-sub-factors until the desired level of resolution is reached.
Step 4 – Example

Assume that we are analyzing an automobile that has crashed and identified the factor “Brake failure”. This factor may be further analyzed by asking the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Possible answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why did the brakes fail?</td>
<td>Brake pads were worn</td>
</tr>
<tr>
<td>Why were the brake pads worn?</td>
<td>They were not checked</td>
</tr>
<tr>
<td>Why were they not checked?</td>
<td>The automobile was not properly serviced</td>
</tr>
<tr>
<td>Why was the automobile not properly serviced?</td>
<td>The importance of regular servicing was not realized</td>
</tr>
</tbody>
</table>
Step 5

Analyze the obtained cause-effect diagram.

- Check the logic and the completeness of the diagram
- Look for causes that appear repeatedly
- Look for what you can measure in each cause so you can quantify the effects of the changes you make
- Identify and circle the causes you can take action on
Step 6

Prioritize and plan actions.

- Decide which of the cause-effect chains that are the most likely causes of the problem (e.g., system fault)
- Identify actions needed to remove the causes or reduce the likelihood of the problem
- Decide on
  - What to do?
  - Who is going to do it – or be responsible?
  - When should it be done?
Categories of causes - 1

Categories for Step 2 used in the *manufacturing* industry are:

- Machine (technology)
- Method (process)
- Material (incl. raw materials, consumables, information)
- Manpower (physical work) and Mindpower (brainwork)
- Measurement (inspection)
- Milieu (the environment)

Two additional categories are sometimes added:

- Management / Money power
- Maintenance
Categories of causes - 2

Categories for Step 2 used in the *service* industry are:

- Surroundings
- Suppliers
- Systems
- Skills
- Safety
Benefits

- It generates a structured list of possible causes of the specified problem (e.g., a system fault)
- The graphical form of the diagram helps to present the results to others
- The causes can be prioritized
- It encourages group participation and makes use of group knowledge
- It uses an orderly, easy-to-read format to show the cause-effect relationships
- It increases the system knowledge and helps the participants learn more about factors influencing the system performance
- It identifies areas where data should be collected for further study