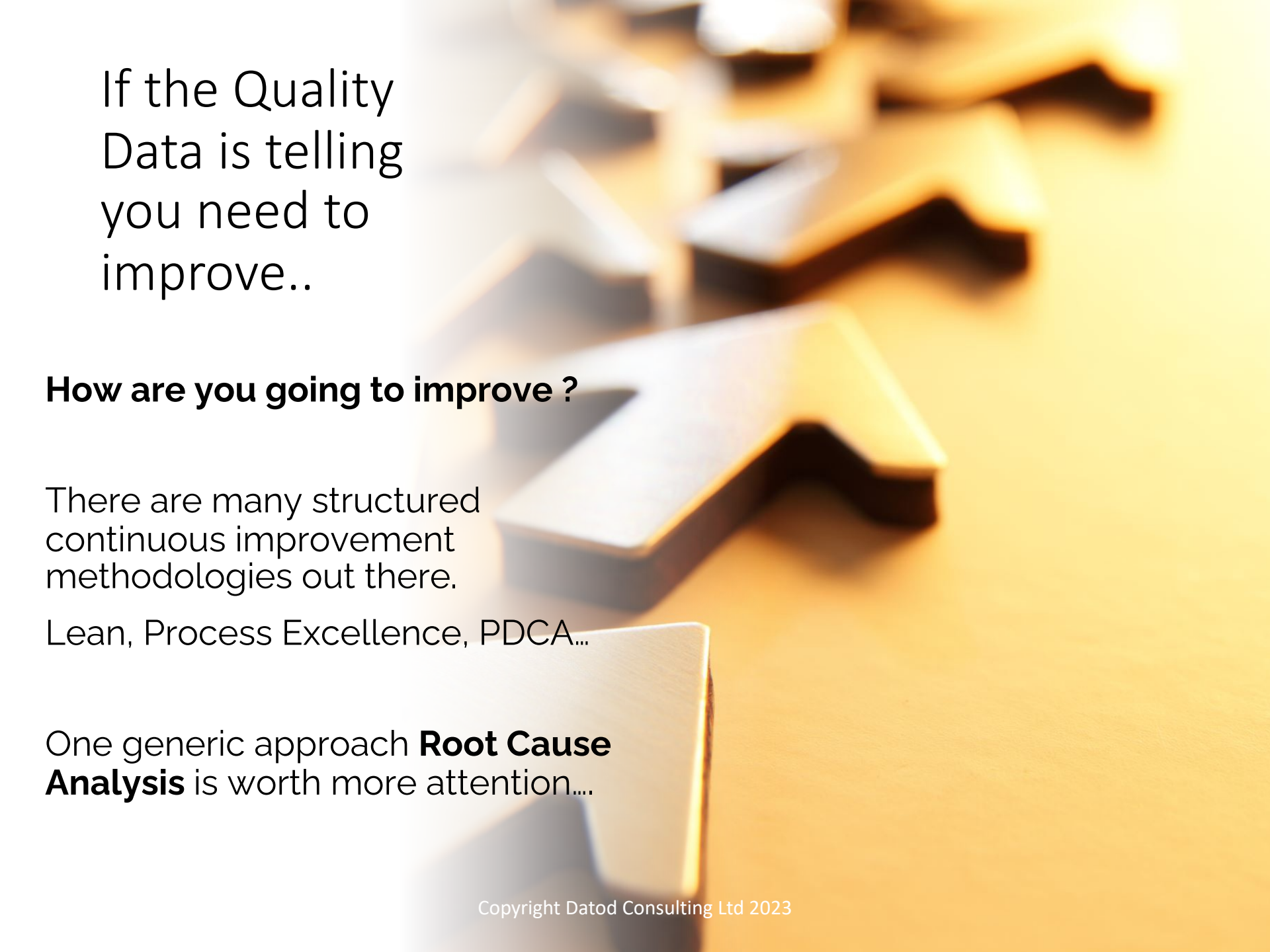


# Managing Change

## Part 2 of 4



If the Quality  
Data is telling  
you need to  
improve..

**How are you going to improve ?**

There are many structured  
continuous improvement  
methodologies out there.

Lean, Process Excellence, PDCA...

One generic approach **Root Cause  
Analysis** is worth more attention....

Source material for this section is..

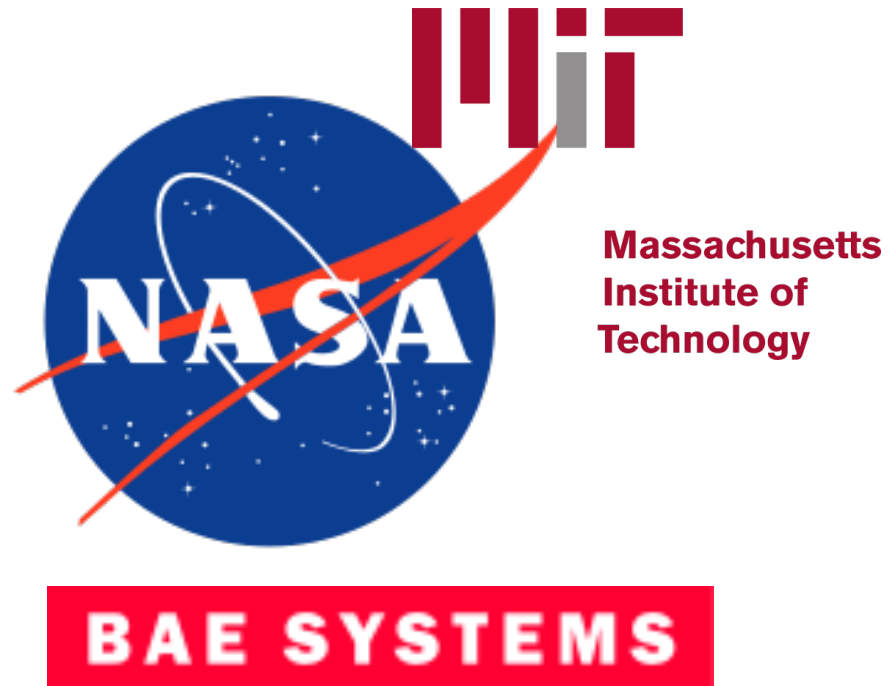
## **Root Cause Investigation Best Practices Guide – 2014**

Mission Assurance Improvement Workshop

NASA, Boeing, Lockheed, MIT, BAE Systems.



<https://apps.dtic.mil/sti/pdfs/ADA626691.pdf>



# Root Cause Analysis



ROOT CAUSE ANALYSIS (RCA) IS DEFINED AS A COLLECTIVE TERM THAT DESCRIBES A WIDE RANGE OF APPROACHES, TOOLS, AND TECHNIQUES USED TO UNCOVER CAUSES OF PROBLEMS (ASQ).

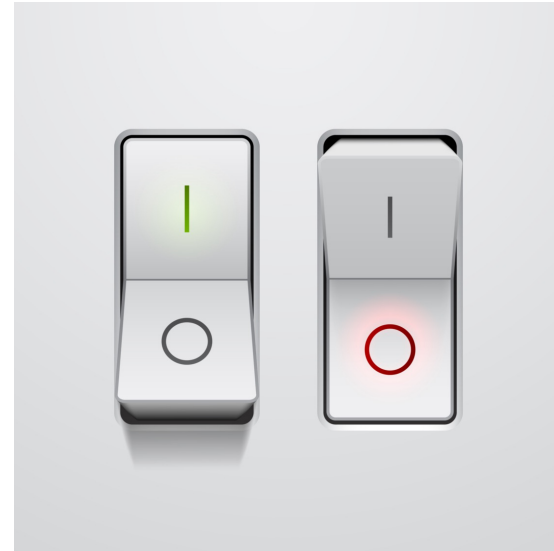


THE INVENTION OF ROOT CAUSE ANALYSIS IS CREDITED TO SAKICHI TOYODA (1867 - 1930).



IT **ASSUMES** THERE IS A **DIRECT RELATIONSHIP** BETWEEN **CAUSE** AND **AFFECT** AND WE CAN PREDICT THE WORLD EVEN THOUGH THE RELATIONSHIPS AT TIMES MAY BE **SIMPLE** OR VERY **COMPLICATED**.

Simple  
Cause and  
Effect



Complicated  
Cause and  
Effect



# Complex is not the same as Complicated



A car key  
is **Simple**



A car is  
**Complicated**



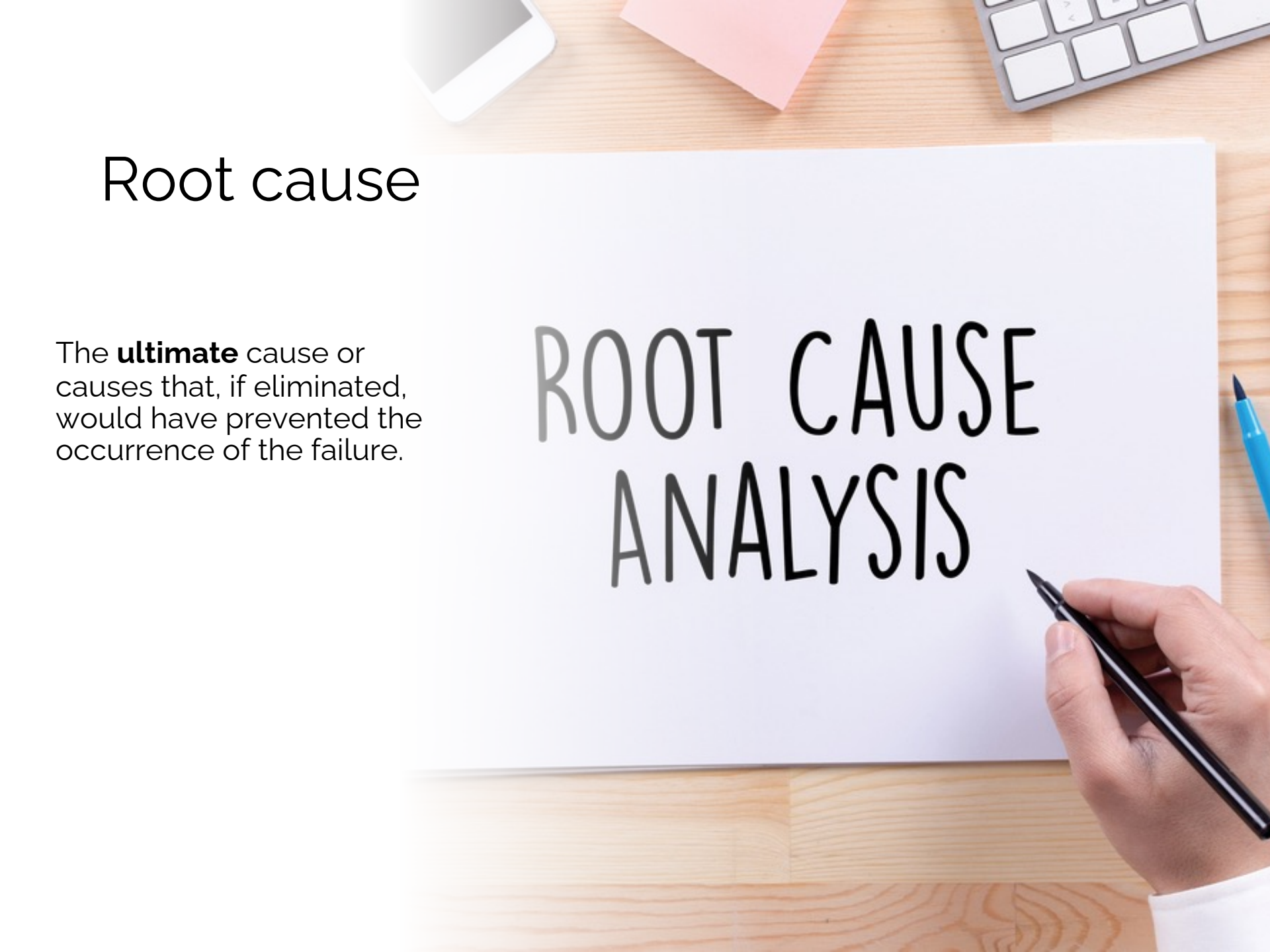
How traffic behaves  
is **Complex**

- For Complex situations, which are under constant change, the relationship between cause and effect may not always hold.
- Eg: An assembly process that is performed differently each time. One cause may have a different and non-consistent effect depending on the operator.



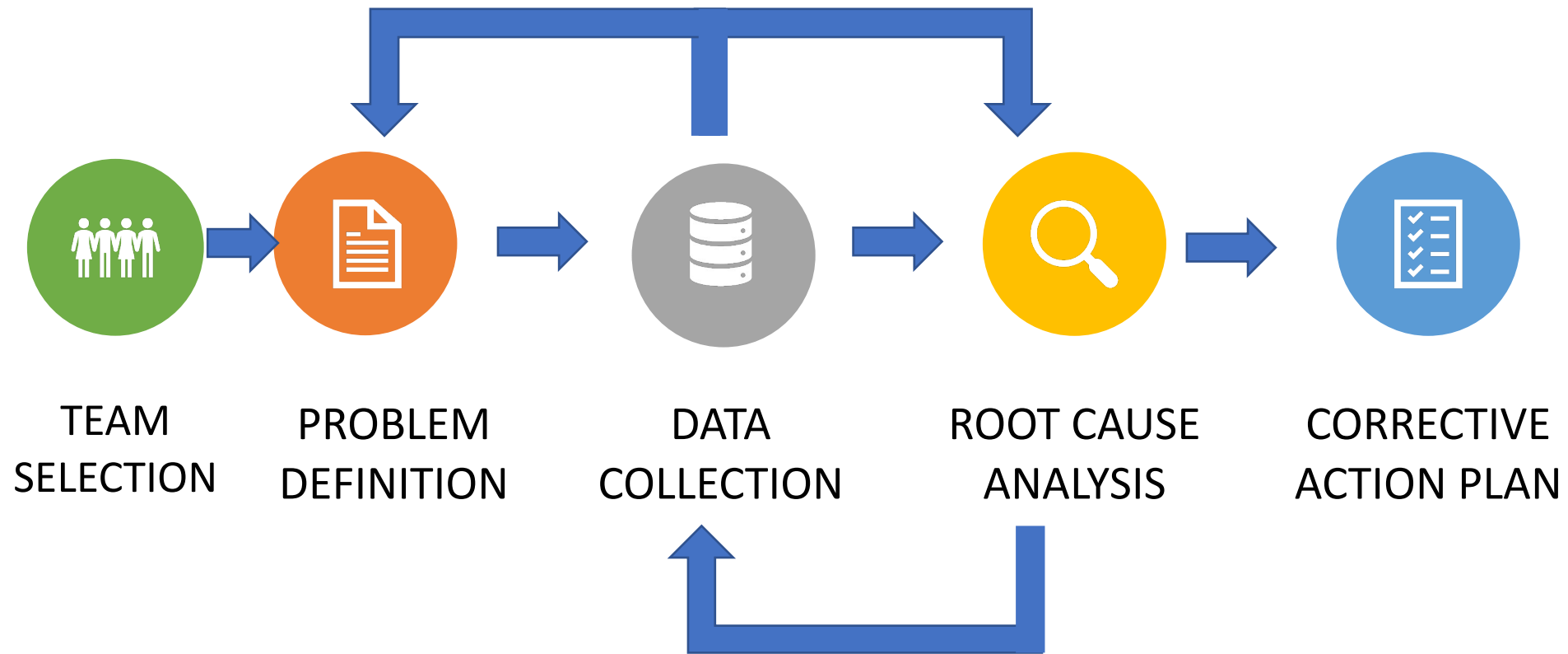
# Root cause

The **ultimate** cause or causes that, if eliminated, would have prevented the occurrence of the failure.



ROOT CAUSE  
ANALYSIS

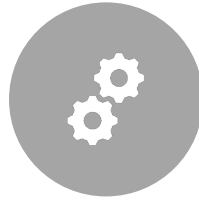
# Root Cause Analysis Flow



# Types of issues investigated with root cause analysis



PRODUCT ISSUES



PROCESS ISSUES



EQUIPMENT  
FAILURES



ORGANISATIONAL  
ISSUES



PEOPLE ISSUES



# We will need a team..

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- ❖ Need to appoint an individual to lead the investigation. It often helps to have an individual who **isn't** a subject matter expert in the process, equipment or product in question. Why ?
- ❖ Need a diverse team with skills and knowledge around the process or product that has failed. Bring in fresh eyes.
- ❖ Need to be able to objectively evaluate the data in an **unbiased** manner.
- ❖ May need a dedicated facilitator to ensure everybody stays true to the process.
- ❖ Stress that RCA isn't an exercise to apportion blame.

# Problem Definition

❖ It is critical to develop a problem definition or statement which directly addresses the issue that needs to be resolved. A tightly defined problem definition means you go in the correct direction from the beginning.

❖ **The problem is to know what the problem is.**

*"If I had an hour to **solve** a **problem** I'd spend 55 minutes thinking about the **problem** and five minutes thinking about solutions."*

**Albert Einstein**

*“ The problem isn't the problem. The problem is your attitude to the problem. “*

Jack Sparrow

The questions that you should ask yourself at the very beginning should include:-

- Is this the problem I need to fix ?
- Do I need to fix it ?
- What would be gained by solving it ?
- How much effort, time resources will this require ?
- Is it worth it ?

# Tips and Traps in Problem Definition

## ❖ Rephrase the Problem

- When a Toyota executive asked employees to brainstorm “ways to increase their productivity”, all he got back were blank stares. When he rephrased his request as “ways to make their jobs easier”, he got a different response.

## ❖ Challenge Assumptions

### ❖ Look upwards

- Is the problem part of a bigger problem ?

### ❖ Look downwards

- Is the problem part of a smaller problem

## ❖ Gather facts

# Data Collection

- ❖ **No** RCA tool will tell you the root cause in the absence of data that supports your hypothesis. It will just give you a number of possible options. You will need to gather data and supportive evidence.
- ❖ RCA tools just give you a consistent **methodology** to arrive on possible causes which you can test.
- ❖ You will need a data collection plan and resources to collect and verify the data.

# Types of Data Collection

- ❖ Qualitative- Interviews (What happened when, where.)
  - Differentiate between Observation and Opinion (Record both)
    - I saw Bob weigh the ingredients
    - I don't think Bob weighed the ingredients
- ❖ Records, data-sets, test data, yield plots, and/or strip chart data.
- ❖ Obtain environmental and/or transport recorder data.
- ❖ Perform trend analysis to detect patterns of nonconforming hardware and/or processes.
- ❖ Create a timeline with major events that lead up to and through the issue.

# Data Collection Tools

Tool	Use
<b>Check Sum</b>	When collecting data on the frequency or patterns of events, problems, defects, defect location, defect causes, etc..
<b>Control Charts</b>	When predicting the expected range of outcomes from a process.
<b>Pareto Chart</b>	When there are many problems or causes and you want to focus on the most significant.
<b>Scatter Diagram</b>	When trying to determine whether the two variables are related, such as when trying to identify potential root causes of problems.
<b>Stratification</b>	When data come from several sources or conditions, such as shifts, days of the week, suppliers, or population groups.
<b>Flow charting</b>	To develop understanding of how a process is done.
<b>Histogram</b>	When analysing what the output from a process looks like.

- ❖ You will need to sort your data into the following groups. A KNOT Chart is a great tool.

<b>K</b> now	Credible Data
<b>N</b> eed To Know	Data that is required, but not yet fully available
<b>O</b> pinion	May be credible, but needs an action item to verify and close
<b>T</b> hink We Know	May be credible, but needs an action item to verify and close

- ❖ **Only** data in the **Know** category should be used to inform conclusions during the investigation. Don't let NOTs become facts if they are not.

KNOT Table is “ living document” and is returned to as the investigation unfolds.

No	Summary	Know	Need to Know	Opinion	Think we Know	Action
1	Air pressure in spec	X				None
2	Floor was wet		X			Interview cleaning crew
3	pH was in spec	X				None
4	Material was thawed				X	Check with Operator
5	Lot XZY was used		X			Check batch records
6	Filling-line appeared slower than normal			X		Check records of line rate

# Types of Data Collection

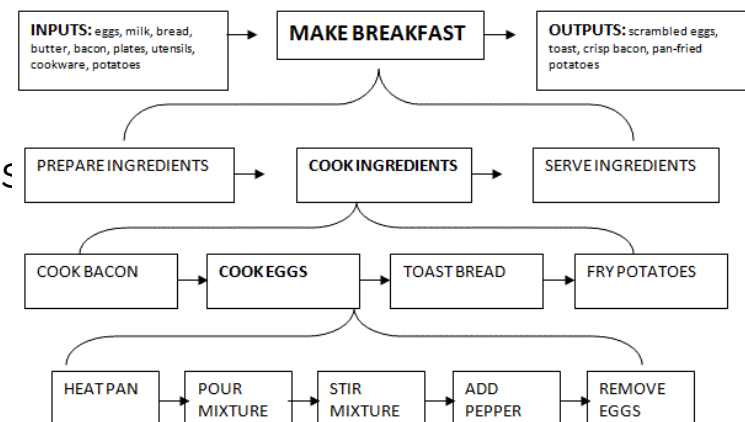
❖ **Event timeline of issue.** What happened before and after the event if it is event driven ie: something happened at point in time ?

❖ **Process Map.**

❖ Visual representation of the process at a high level so anybody not familiar with the process can understand.

❖ **SIPOC:** Suppliers, Inputs, Process, Outputs, Customers

❖ Involve individuals who have a hands on knowledge of the process and can describe the “as is” state and not the “should be” state.



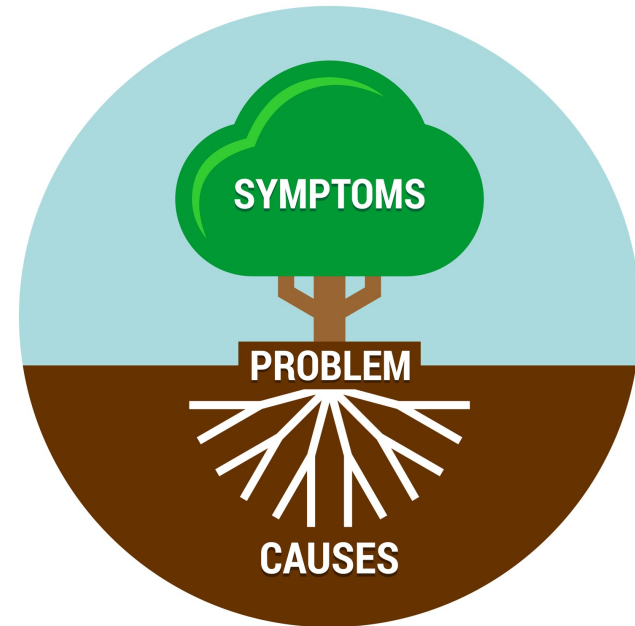
# Root Cause Analysis

## ❖ Root Cause

Root causes have no practical preceding related events, actions, or conditions

There are usually more than one root cause.

Direct causes are not root causes



# Root cause analysis techniques

❖ Important to approach Root Cause Analysis from multiple angles

- Fault tree analysis
- Fishbone
- Cause and Effect
- Event timeline mapping

Logical



- Brainstorming
- Mind-mapping

Creative

# Brainstorming



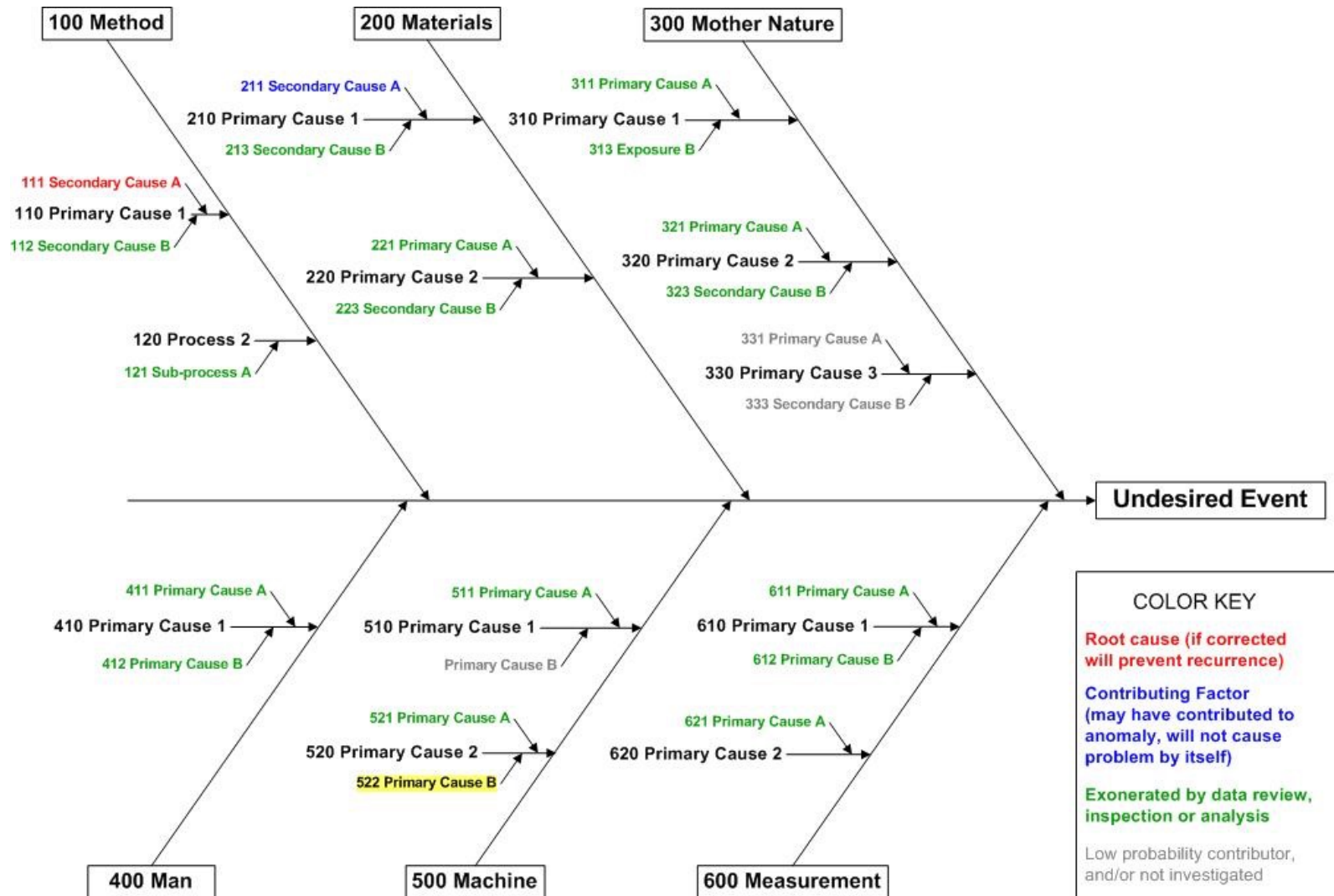
All RCA starts with some form of brainstorming to generate a list of possible causes, some may be direct causes, some may be root causes.



It helps putting them on a Fishbone diagram and the Fishbone categories help focus the brainstorming into more controllable blocks and helps stimulate thought.



Use Post-it notes on a large sheet of paper.



# Tips for Effective Brainstorming

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- ❖ Defer judgment.
- ❖ Encourage wild ideas.
- ❖ Build on the ideas of others.
- ❖ Stay focused on the topic.
- ❖ One conversation at a time.
- ❖ Be visual.
- ❖ Go for quantity.
- ❖ Ensure everybody has an opportunity to contribute. You may have to proactively make this happen.



# RCA Tools

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## ❖ Tree Techniques

**5 Whys**; Cause mapping,  
Advanced cause and effect  
analysis (ACEA), Fault Tree  
Analysis; **Fish-bone analysis**

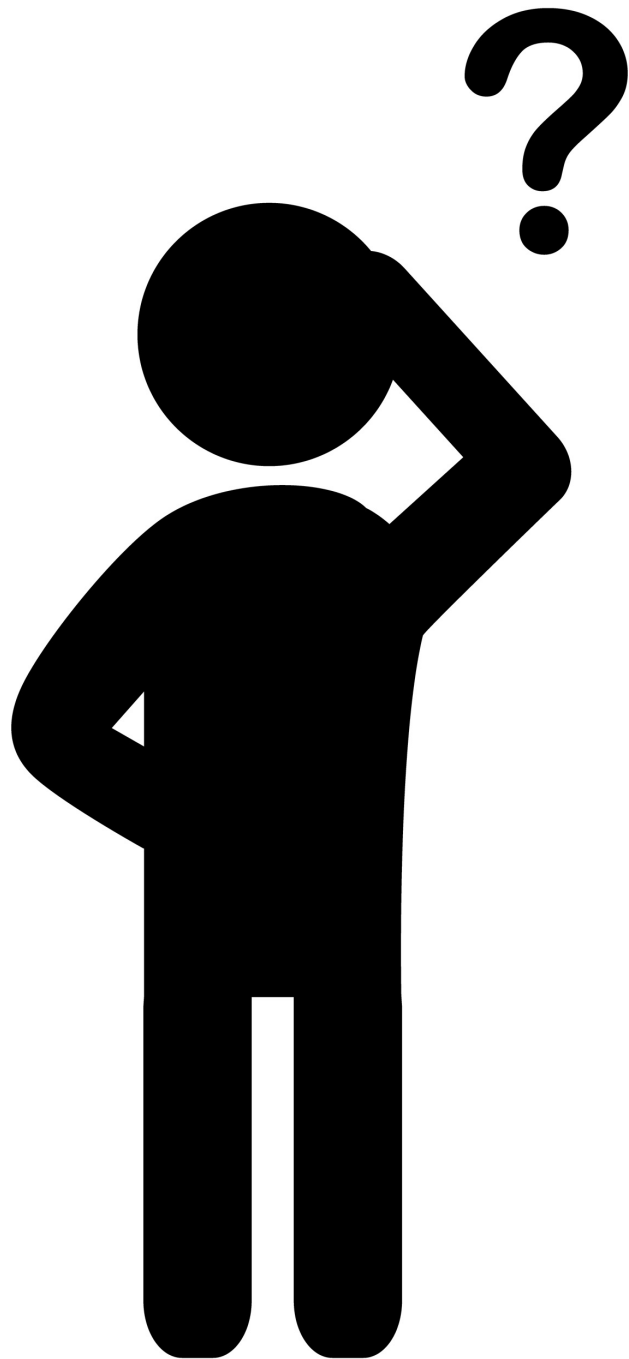
## ❖ Process methods

Process analysis /  
classification

## ❖ Mixed methods

Root Cause Analysis Stacking





# Which tool do I use ?

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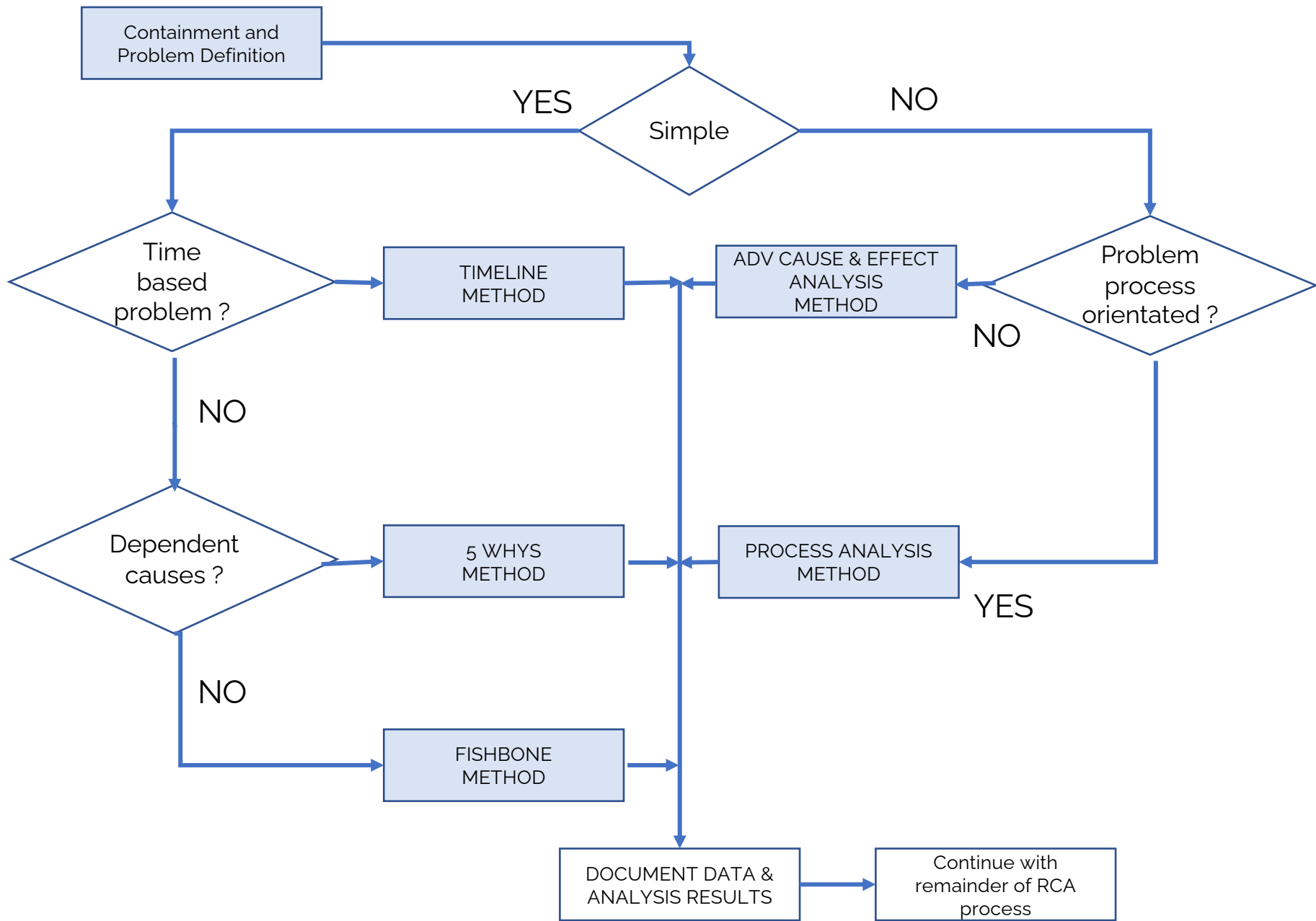
- ❖ The rigour of the investigation, and tool you will need, will depend on the **complexity** of the issue, the **severity** of its impact and the **likelihood** it will reoccur.

High

RCA Complexity and , Severity and Likelihood

Low

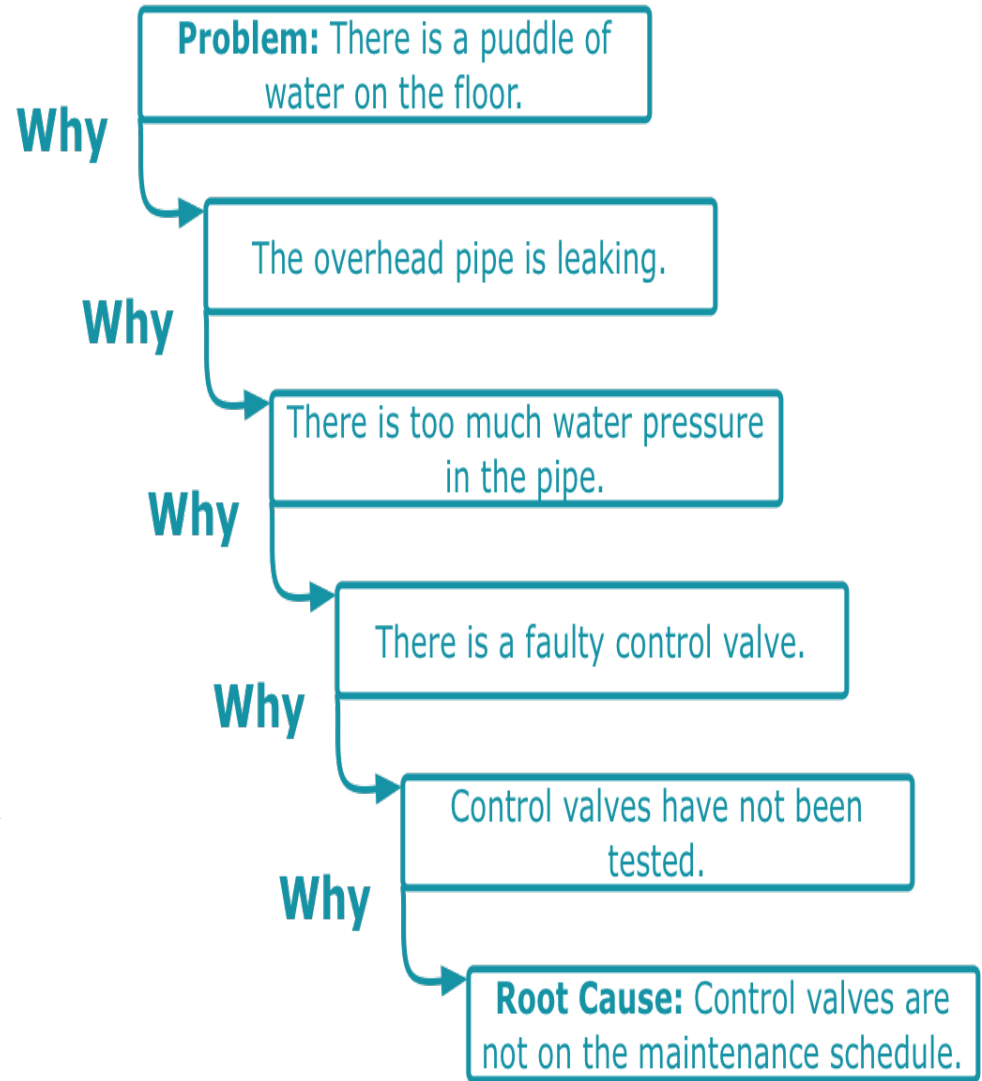
Commonly used data collection and RCA method	Time span	Output
<ul style="list-style-type: none"> <li>• KNOT Chart</li> <li>• Event Timeline</li> <li>• Process Mapping</li> <li>• Cause Mapping</li> <li>• Fishbone Diagram</li> <li>• Advanced Cause and Effect Analysis</li> <li>• Fault Tree Analysis</li> </ul>	2- 6 weeks or longer	<ul style="list-style-type: none"> <li>• RCA Findings and Conclusions</li> <li>• Validation and measurement strategy</li> <li>• Illustration of RCA</li> <li>• Company wide communication</li> </ul>
<ul style="list-style-type: none"> <li>• KNOT Chart</li> <li>• Event Timeline</li> <li>• Process Mapping</li> <li>• Cause Mapping</li> <li>• Fishbone Diagram</li> <li>• Advanced Cause and Effect Analysis</li> </ul>	4 days – 2 weeks	<ul style="list-style-type: none"> <li>• RCA Findings and Conclusions</li> <li>• Validation and measurement strategy</li> <li>• Illustration of RCA</li> <li>• User community communications</li> </ul>
<ul style="list-style-type: none"> <li>• Brain storming</li> <li>• Event Timeline</li> <li>• Cause Mapping</li> <li>• Fishbone Diagram</li> </ul>	1 – 3 days	<ul style="list-style-type: none"> <li>• RCA Findings and Conclusions</li> <li>• Validation and measurement strategy</li> <li>• Illustration of RCA</li> <li>• Affected individuals communication</li> </ul>
<ul style="list-style-type: none"> <li>• 5 Whys</li> <li>• Brain storming</li> <li>• Fishbone Diagram</li> </ul>	½ - 1 day	<ul style="list-style-type: none"> <li>• RCA Findings and Conclusions</li> <li>• Affected individuals communication</li> </ul>
<ul style="list-style-type: none"> <li>• 5 Whys</li> <li>• Brain storming</li> </ul>	1 – 4 hrs	<ul style="list-style-type: none"> <li>• RCA Findings and Conclusions</li> <li>• Affected individuals communication</li> </ul>



# Tree Techniques

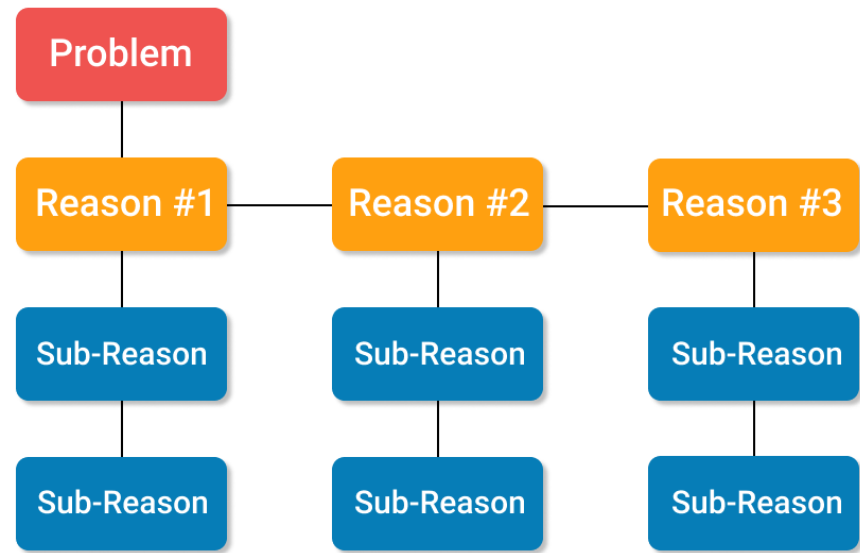
## 5 Whys

- ❖ Ask why ?, multiple times until you get a point where the cause is no longer actionable.
- ❖ Doesn't have to be five.
- ❖ Read the flow backwards to check that if the cause had been eliminated the higher level condition would have been removed.



## 5 Whys

- ❖ Important to explore multiple reasons as there are often multiple root causes.
- ❖ Need to use it sensibly.
- ❖ It won't magically tell you the root cause of an issue only potential root causes, which will have to be verified with observational data or experimental data.



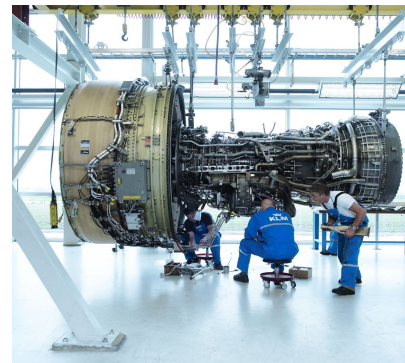
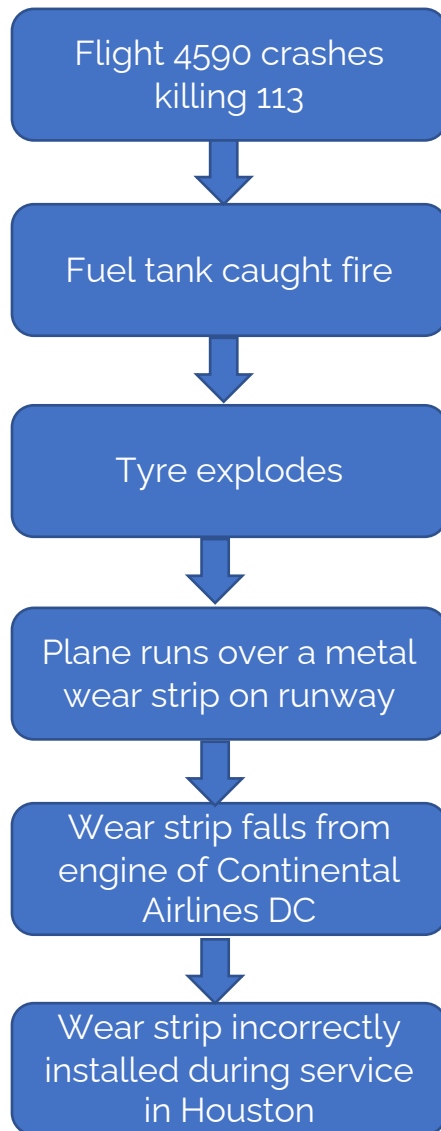
# Benefits and Weaknesses around the 5 Whys tool

Benefits	Weaknesses
Simple to use and understand.	Focuses on corrective action at the distal arm ie: 5th Why. Presumes that this is the most appropriate area to intervene. Many cases where corrective action at the more proximal arm would be equally or more effective.
Visual.	Does not find inter-relationships.
For most simple root cause investigations it is adequate.	Can focus effort on one branch only.
Can use with other tools.	Does not take into account processes only attributes.

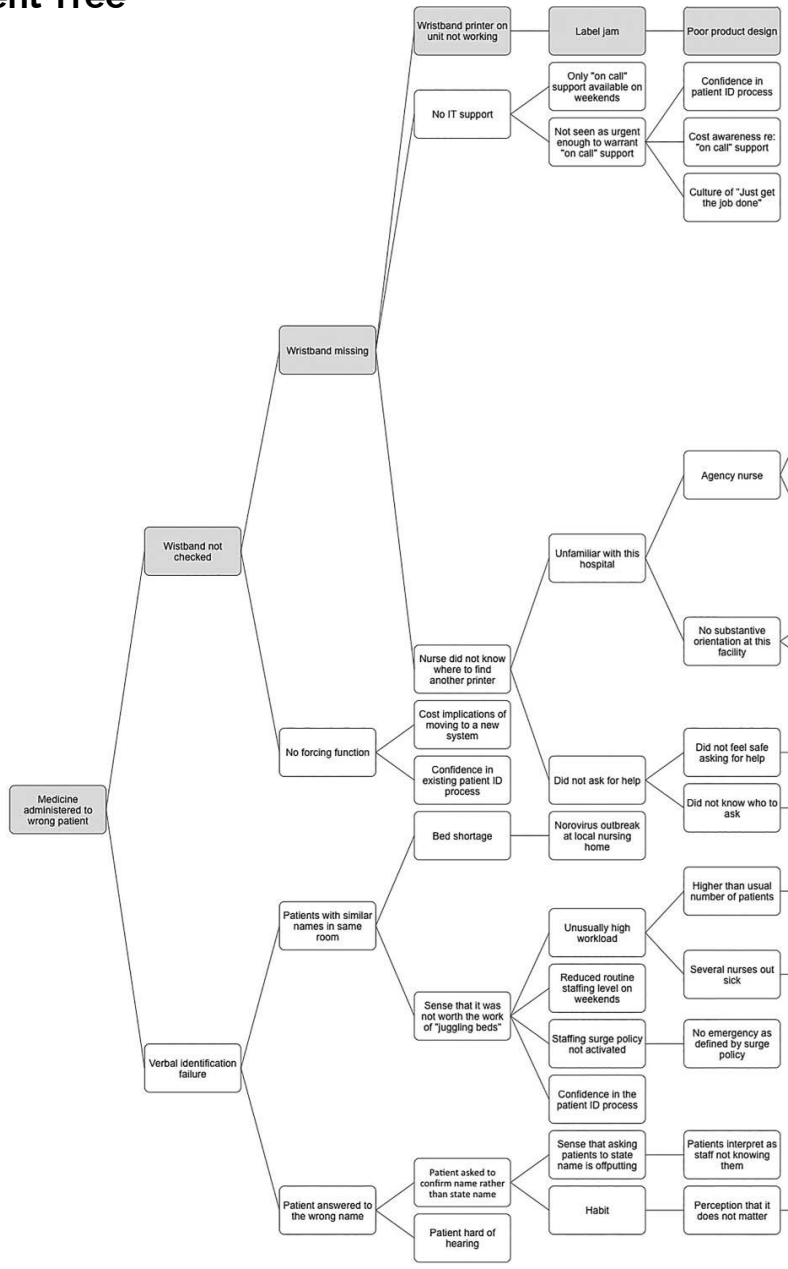
*" The positive reputation enjoyed by TPS/Lean provides an aura of credibility for '5 whys' ",*

Card A.J. 2017 The problem with "5 Whys". British Medical Journal Qual Safety. 26: 671-677

# Cascade of Consequences – Air France 4590 July 2000

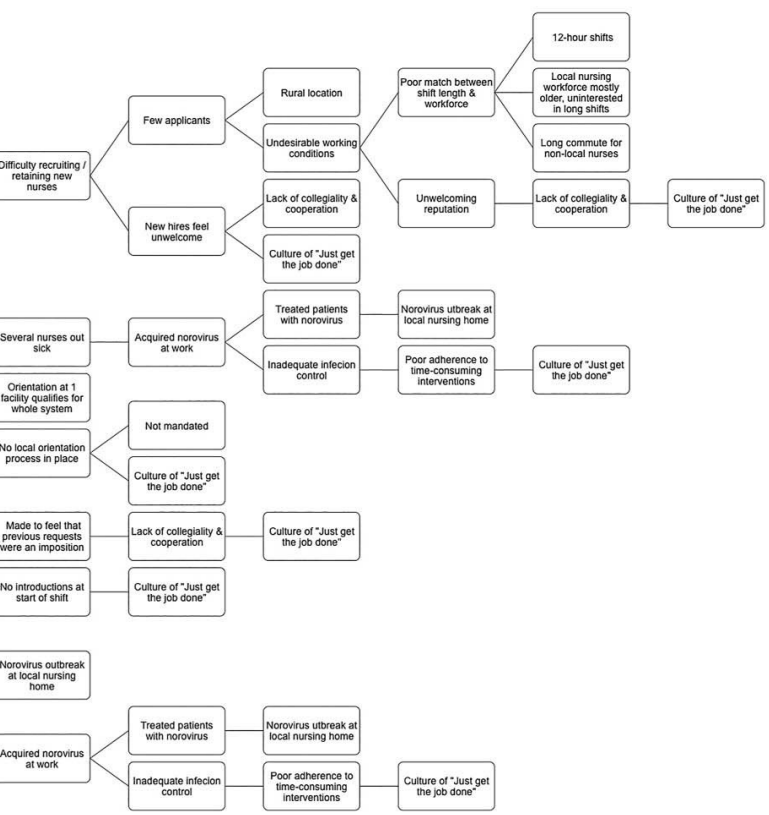


Causal Event Tree



This is a far more powerful form of the 5 Whys.

75 causes identified v 1-2 with 5 Whys.

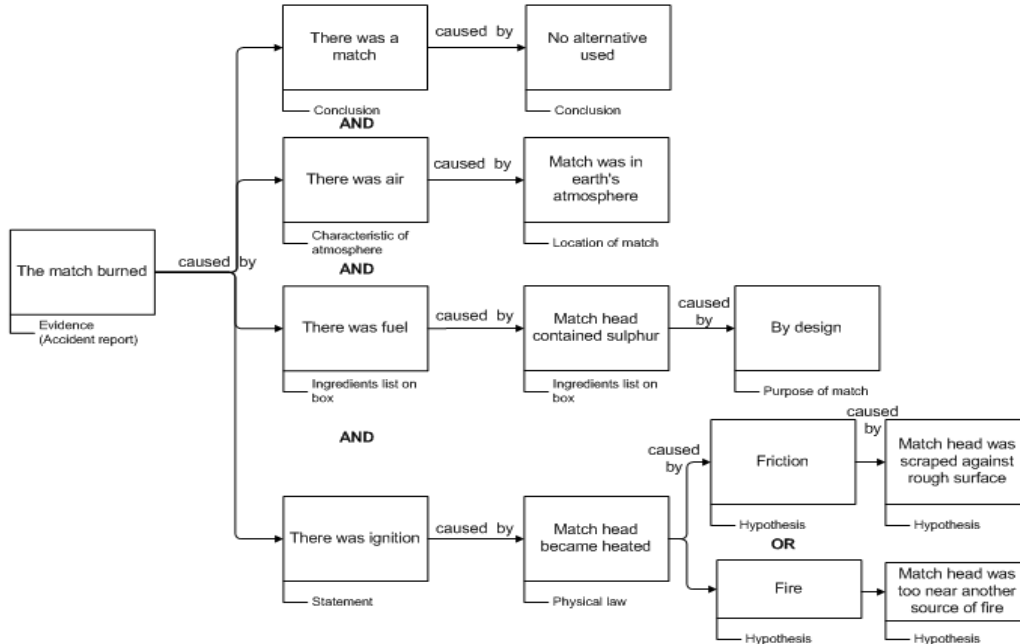


Card, A.J 2017 British Medical Journal Qual Safety. 26: 671-677

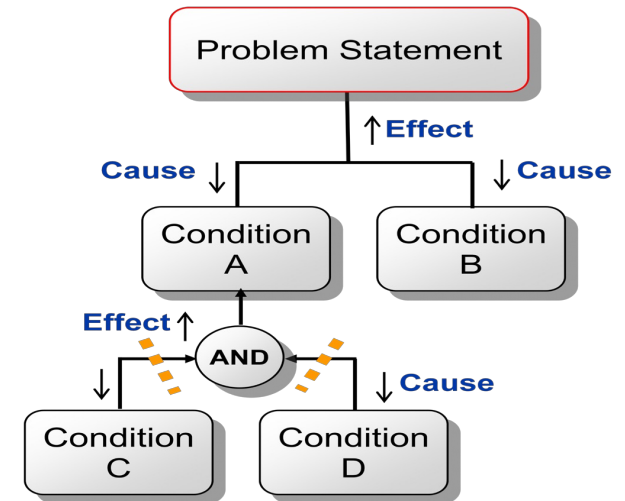
# Cause Mapping / Advanced Cause and Effect Analysis (ACEA)

- Allows for multiple branches
- Allows for AND , OR relationships

## *Apollo Methodology - Cause & Effect Diagram Example Discovering easiest, most cost-effective solution*



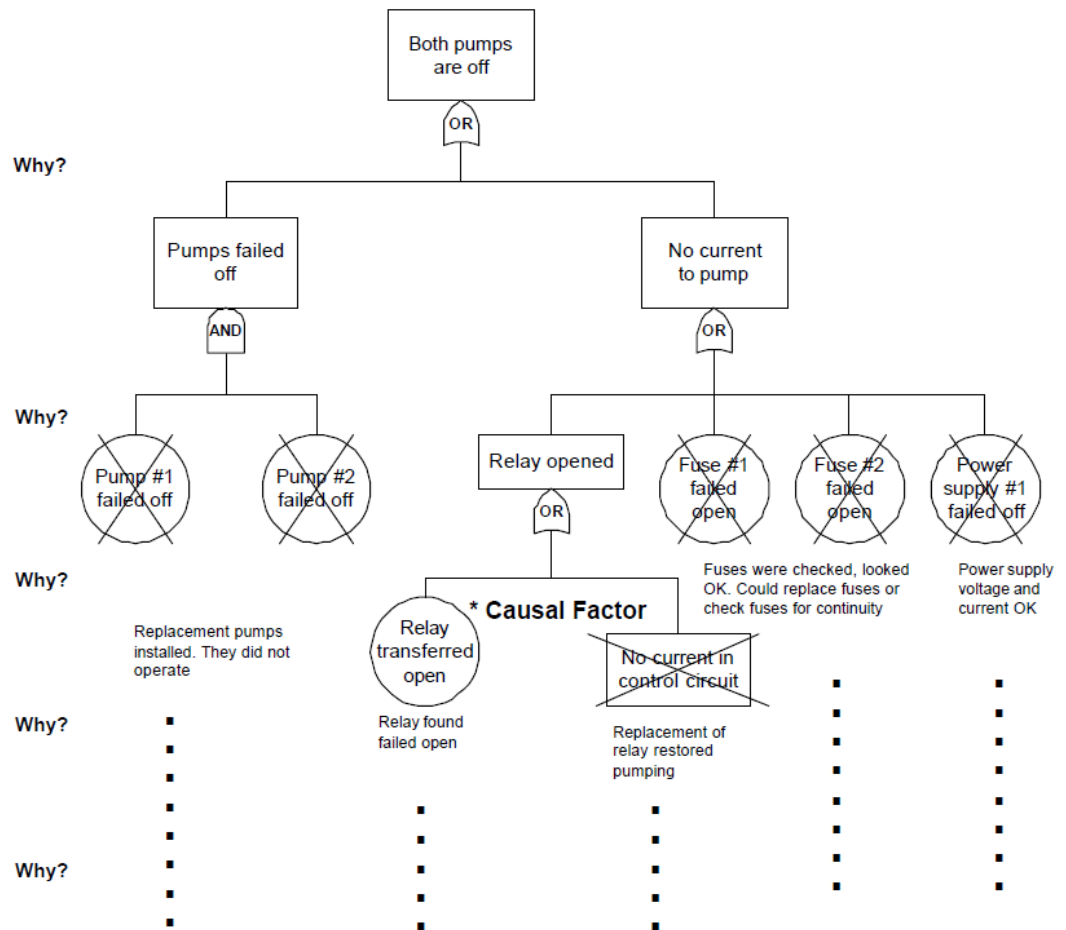
Cause Mapping



ACEA

# Fault Tree Analysis (FTA)

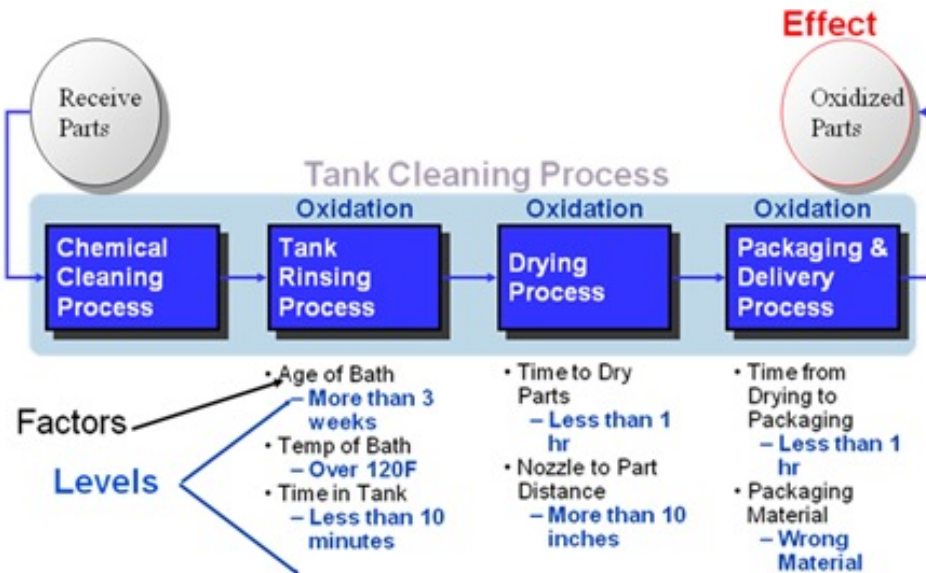
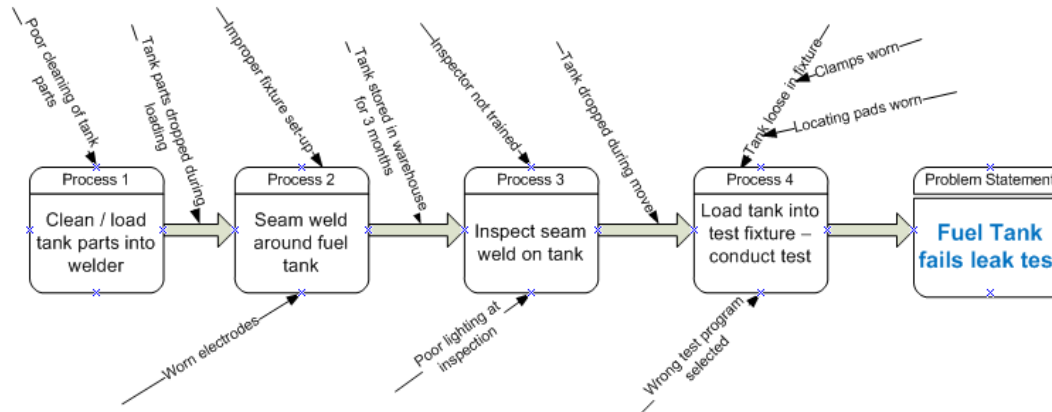
- Drill down from a condition.
- Recognised symbols for gates AND, OR etc.
- Used in Software, electrical engineering etc.
- Can get very complicated.
- Software applications used to control this level of detail.



Fault Tree Analysis

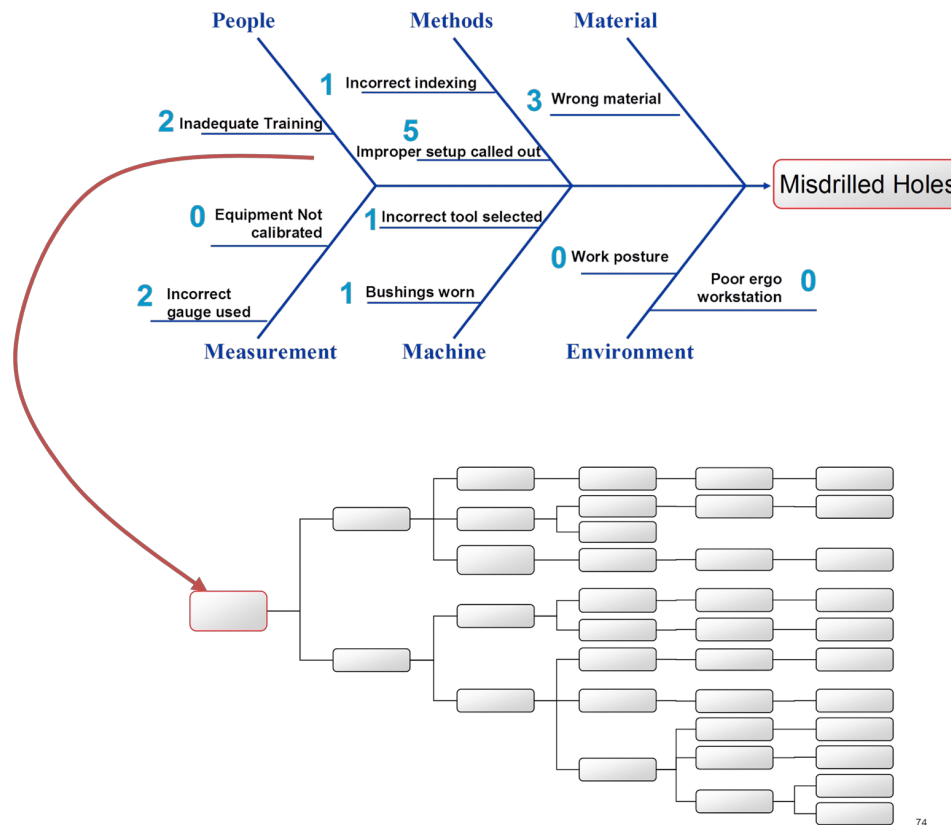
## Process Classification and Process Analysis

- Construct a process map and hang potential causes off it



# Root Cause Analysis Stacking

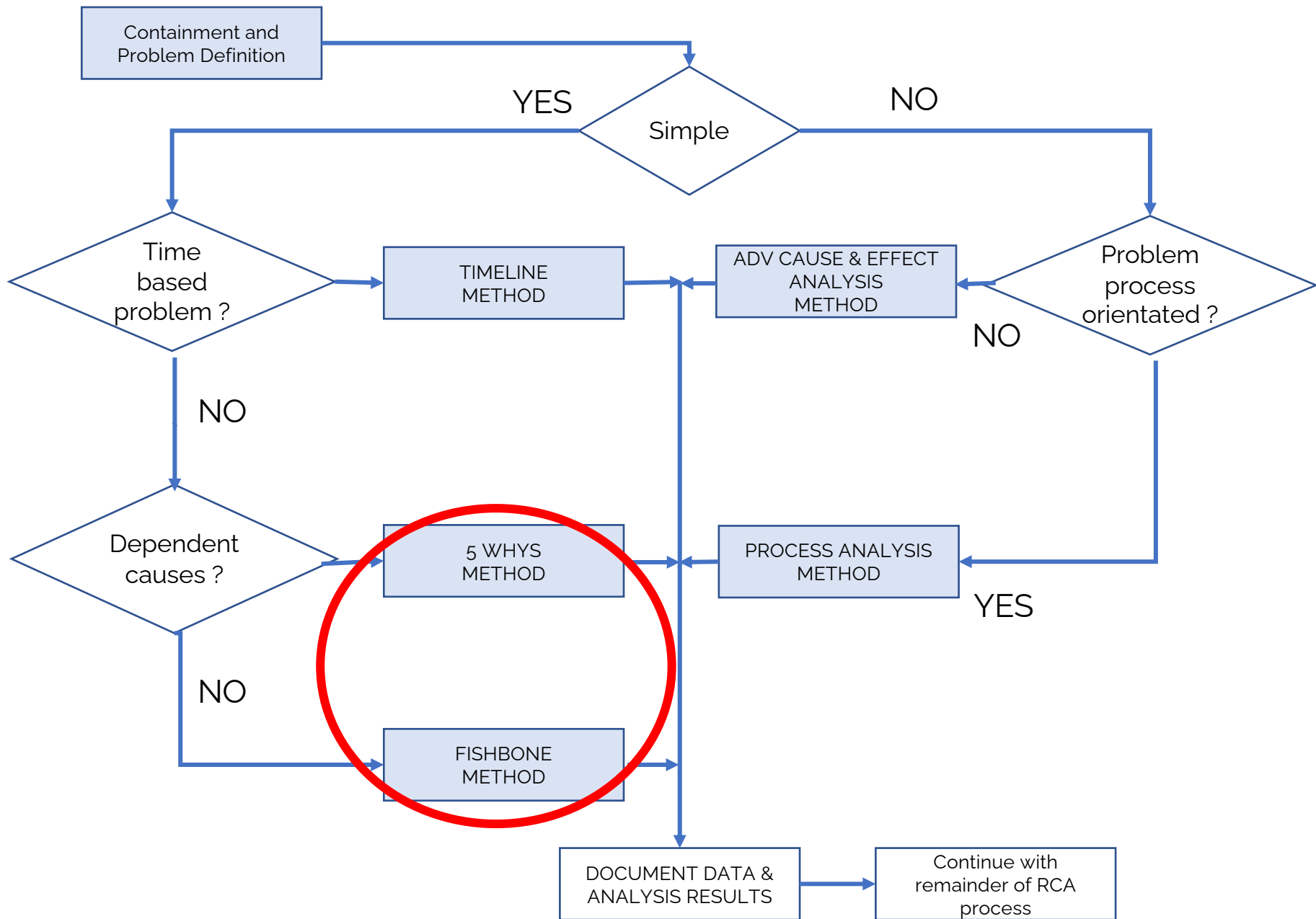
- ❖ Use two tools eg 5 Whys and Fishbone and alternate between the two.



Tool	Benefits	Weaknesses
<b>Brainstorming</b>	Good technique for identifying potential causes and contributing factors.	Is a data gathering technique not a classification and prioritization process.
<b>Cause and Effect Diagram (Fishbone)</b>	Ability to plan, execute, and record results for multiple investigative paths in parallel. Simple graphical representation of a potentially large and complex RCA. Most commonly method used in industry.	Inability to easily identify and communicate the potential inter-relationship between multiple items. Best suited for simple problems with independent causes.
<b>Fault Tree Analysis (FTA)</b>	Help to understand logic leading to top event. Many software tools available	Can get complicated.
<b>Advanced Cause and Effect (ACEA)</b>	Good tool for complex problems with dependent causes. Diligent scrutiny of cause and effect relationships of key factors and their inter-relationships.	Requires thorough understanding of cause and effect relationships and interactions.
<b>Cause Mapping</b>	Introduces other factors which were required to cause the effect to create a more complete representation of the issue.	Difficult to learn and use.
<b>Why-Why Charts</b>	A good tool for simple problems with dependent causes. Also well suited for containment.	Typically based on attribute- based thinking, rather than a process perspective. Not as robust as some of the more advanced tools.
<b>Process Classification Cause and Effect (CE) Diagram</b>	They are easy to construct and allow the team to remain engaged in the brainstorming activity as the focus moves from one process step to the next. They often get many more potential root cause ideas and more specific ideas than might otherwise be captured in a brief brainstorming session.	Similar potential causes may repeatedly appear at the different processes steps.
<b>Process Analysis</b>	Excellent flowcharting method for complex problems with independent causes.	Team-based methodology requiring knowledge of flowcharting.
<b>RCA Stacking (combining Multiple RCA methods)</b>	Allows simple tools to be used with a more complex method to find root causes quicker. 5-Why's is simple and quicker to use and often used in conjunction with other methods.	Must go back and forth from one method to another – can cause confusion.

# Which tool do I use ?





The background image shows a group of swans in a body of water. Most are white, but one black swan with a bright red beak is prominently featured in the center-right. The water is slightly rippled, and the overall scene is bright and clear.

# Hypothesis Testing

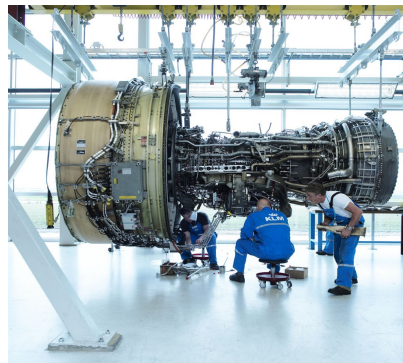
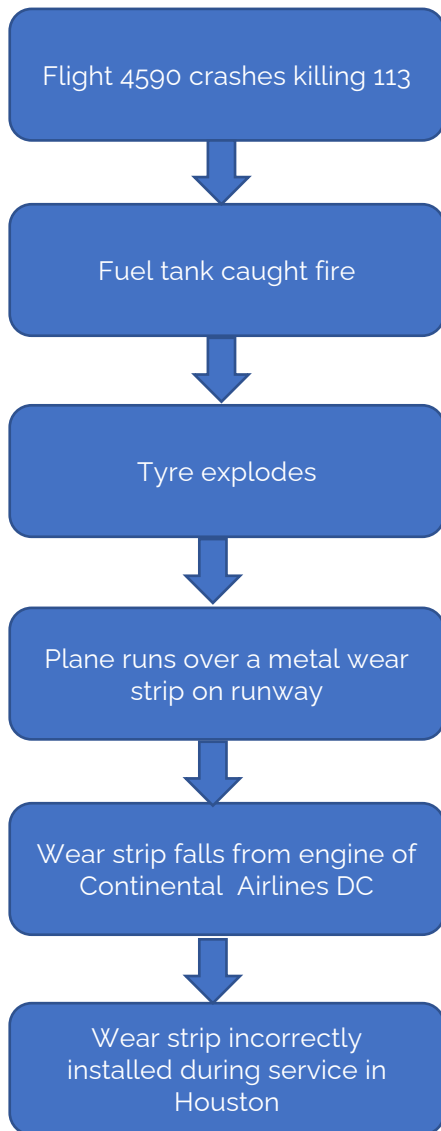
- Once you have generated feasible possibilities for the root cause you need to test your hypothesis via experimentation.
- Does your hypothesis hold up to scrutiny ?
- Is there any data that disproves your hypothesis ?
- Hypothesis: All swans are white.
- However many white swans you count you
- cannot prove **all** swans are white.
- Finding a single black swan disproves the hypothesis.

## ➤ Pit falls during Root Cause Analysis

- Are there multiple contributing root causes that have to occur simultaneously for the failure to occur ?
- Rare events are often due to multiple events all lining up.
- This has been termed the **Swiss Cheese Effect** and failure is due to:-
  - **Active errors**:- Mistakes, slips etc
  - **Latent errors**:- The organisational system creating an environment with accidents waiting to happen



## Cascade of Consequences – Air France 4590 July 2000



Other contributing factors:

- ❖ Uneven fuel load.
- ❖ The aircraft was overloaded.
- ❖ The landing gear had not been serviced correctly and a spacer was missing causing plane to move to the left on take off.
- ❖ Plane went further down runway than normal, where it ran over the wear strip.

## ❖ Target Fixation

The team or the leader has decided the root cause at the beginning of the investigation and collects data to support this known theory.

Was the evaluation truly unbiased and objective ?

❖ Is there evidence that contradicts the root cause that is being ignored ?

❖ Do you need to refresh the team with new sets of eyes to get different perspectives ?

❖ Can you turn the failure on and off ? This is an indicator of true understanding of the root cause.

❖ Incorrect data classification: Investigation is based on assumptions rather than objective evidence. Need to classify data accurately relative to observed **facts**. Importance of the KNOT chart.

# Options for Root Cause Analysis Visualisation

❖ Sticky notes on wall

❖ Excel

❖ Software

[www.lucidchart.com](http://www.lucidchart.com)



 **Lucidchart**