



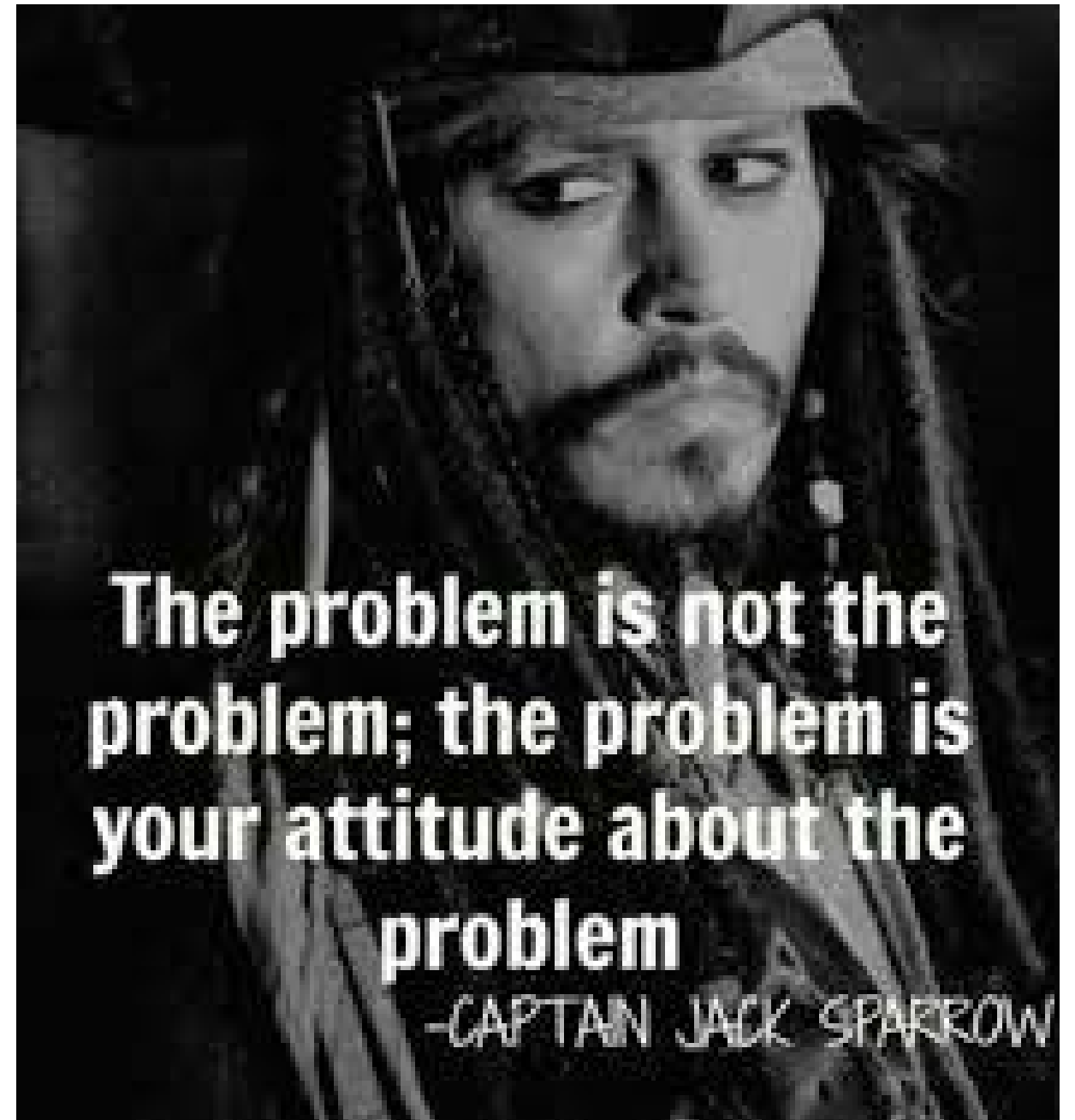
Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Richard Morgan
School of
Engineering



Root Cause Analysis (RCA) is an umbrella term for a range of Problem Investigation techniques/tools.

The primary aim is to properly understand and define the problem



Root Cause Analysis (RCA) Goals

Identify...

1. What happened,
2. How it occurred & why it took place.
3. What we can do to prevent reoccurrence

(Rooney Heuvel, 2004)

RCA Assumptions

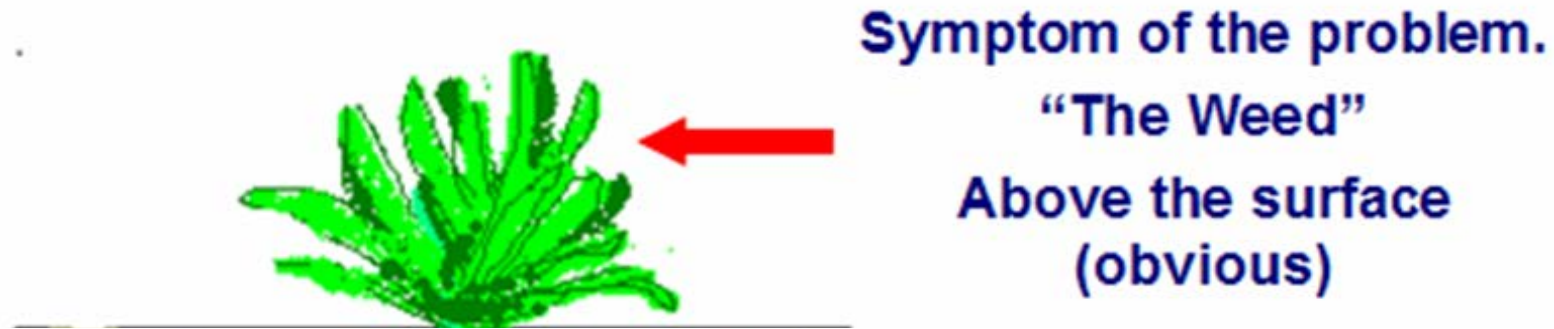
“Beneath every problem is a cause for that problem”

“If the root cause of a problem is not identified, then one is merely addressing the symptoms and the problem will continue to exist”

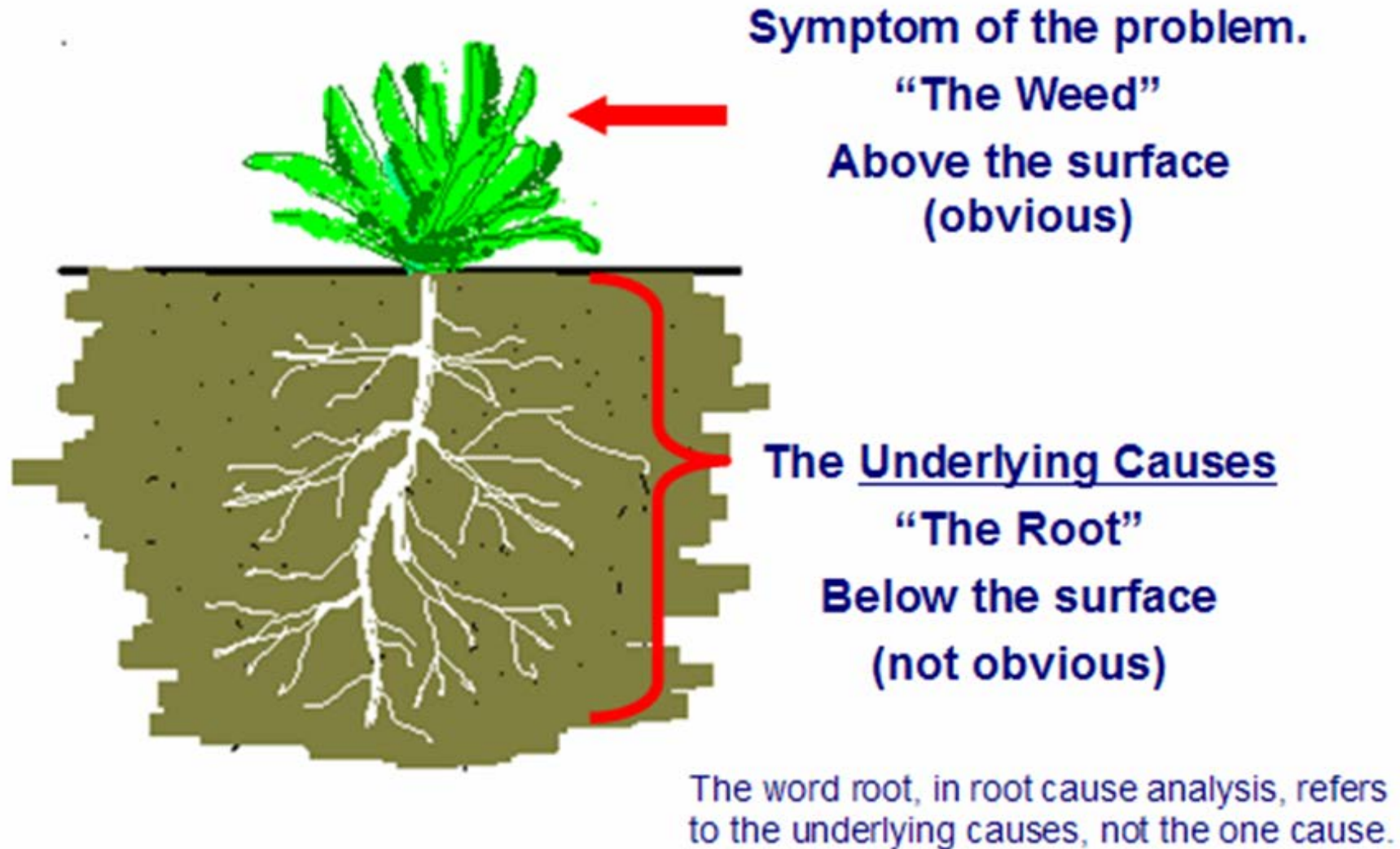
(Doggett, 2005)

“If I had 60 minutes to solve a problem, I'd spend 55 minutes defining it, and 5 minutes solving it.” -- Albert Einstein.

RCA - Root Cause (or usually Causes) Analysis...



RCA - Root Cause (or usually Causes) Analysis...



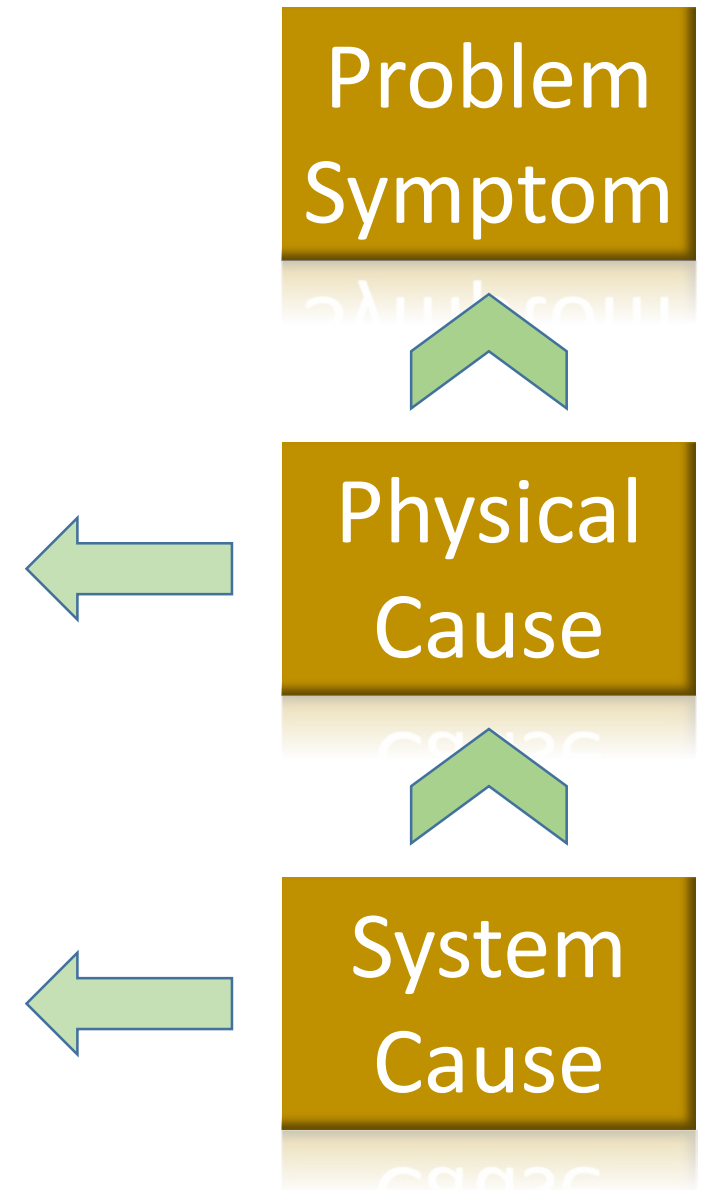
Levels of Causes

Physical Cause:

Specific physical item that, if corrected / replaced would resolve the problem.

System Cause:

Possible underlying cause of physical failure



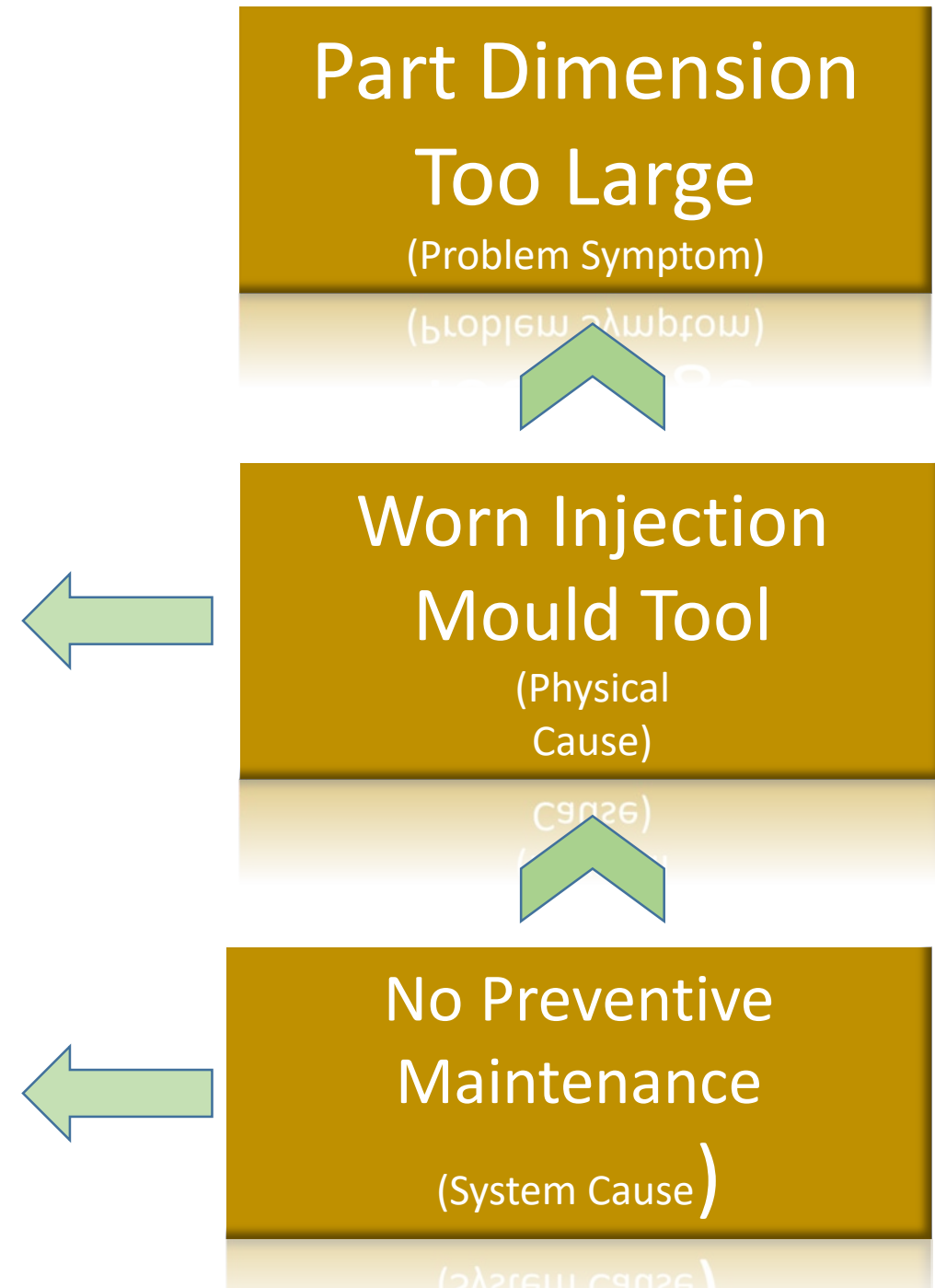
Levels of Causes – Example

Physical Cause:

Organisations have a tendency to stop at the physical cause, which may be appropriate.

System Cause:

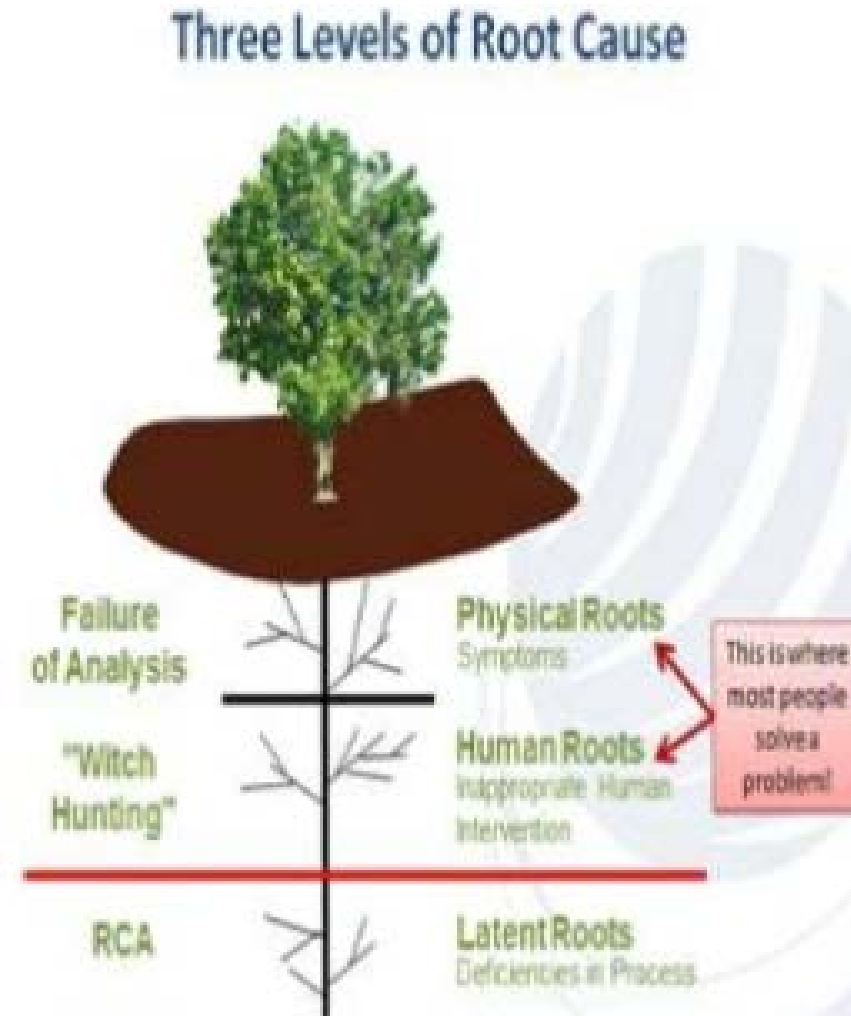
Seek system cause for problems with a high frequency, cost or risk of injury



Another way of looking at it....

The Three Basic Types of Causes:

- Physical
- Human
- Latent / Organisational



Cognitive Biases to Avoid

“A biased mind, which never sees the complete picture, cannot grasp the reality.” — Dali Lama

Two main areas of **Cognitive Biases** to be mindful of when undertaking RCA:

Cognitive Laziness

Instead of seeking the optimum result, we seek the first sufficient result.

Overconfidence

Pursuing evidence supporting our own beliefs rather than allowing the evidence or data to represent the truth.

Cognitive Biases to Avoid

Cognitive Laziness (Satisficing)

“A biased mind, which never sees the complete picture, cannot grasp the reality.” — Dali Lama

Recency Bias:

Assuming the same cause for two recent problem symptoms and therefore, not performing a more rigorous investigation.

Availability Bias:

Relying on the available data rather than collecting/generating more relevant and reliable data.

(Okes, 2008)

Cognitive Biases to Avoid

Overconfidence

“A biased mind, which never sees the complete picture, cannot grasp the reality.” — Dali Lama

Anchoring Bias:

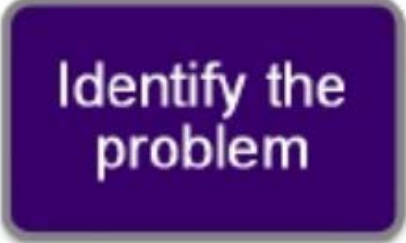
Latching on to the first data and its indications while ignoring possibly conflicting/contradictory new evidence.

Confirmation Bias:

Looking for and accepting only data which confirms our pre-existing assumptions of the cause.

(Okes, 2008)

Seven-Step Problem-Solving Model



Identify the
problem

(Westcott, 2016)

Seven-Step Problem-Solving Model



(Westcott, 2016)

Seven-Step Problem-Solving Model



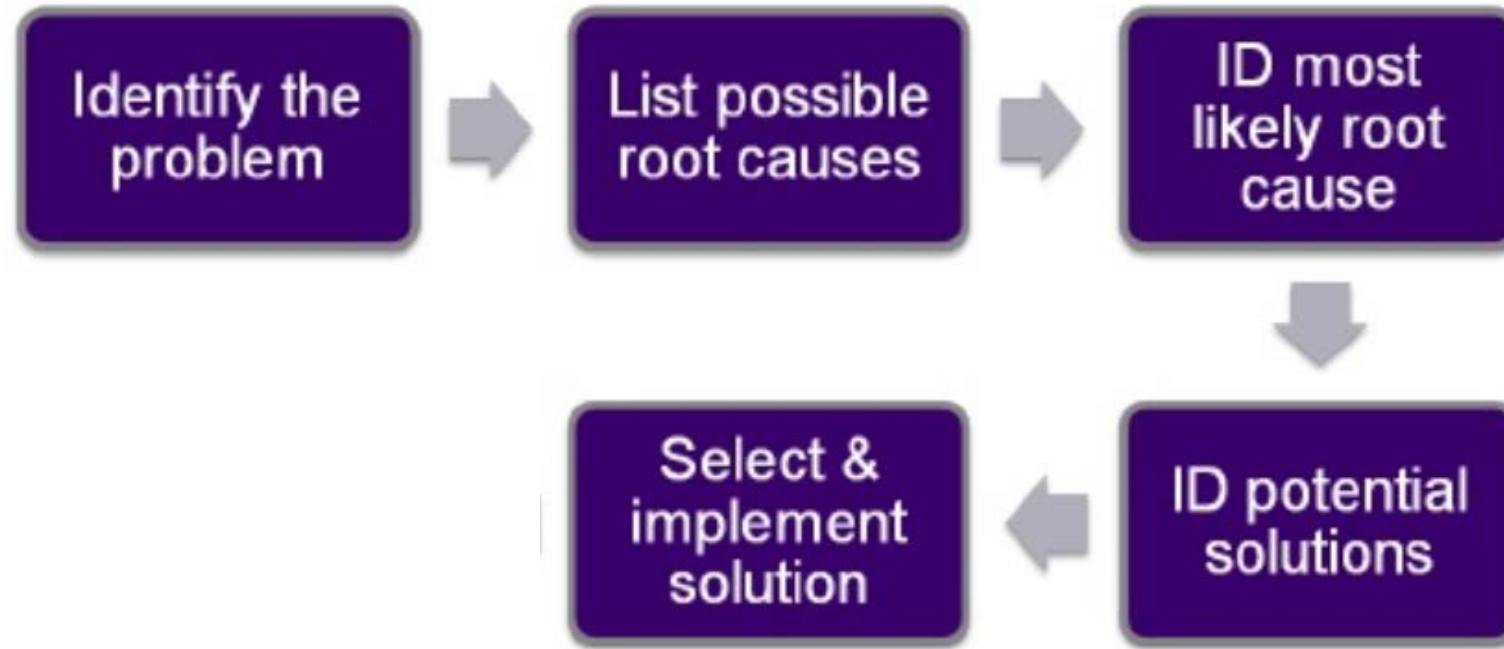
(Westcott, 2016)

Seven-Step Problem-Solving Model



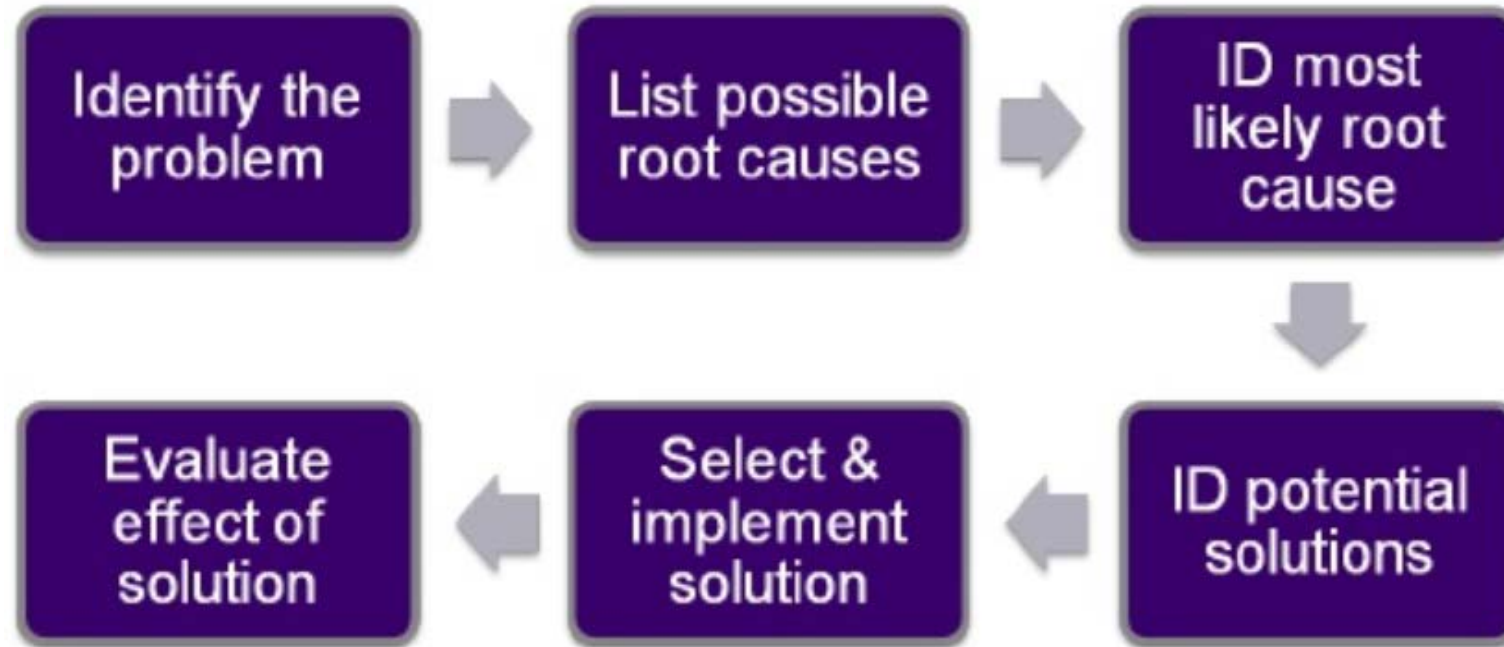
(Westcott, 2016)

Seven-Step Problem-Solving Model



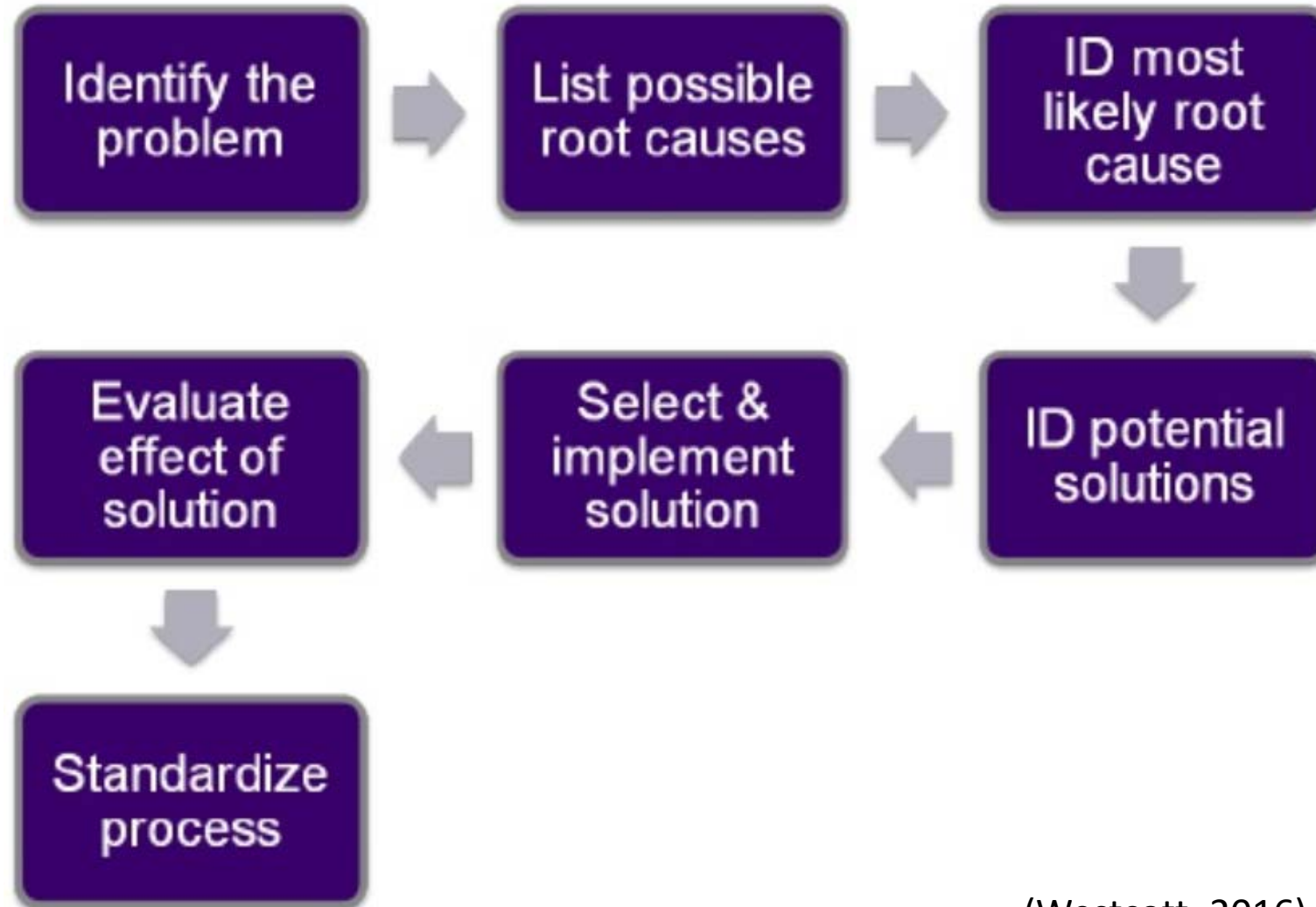
(Westcott, 2016)

Seven-Step Problem-Solving Model



(Westcott, 2016)

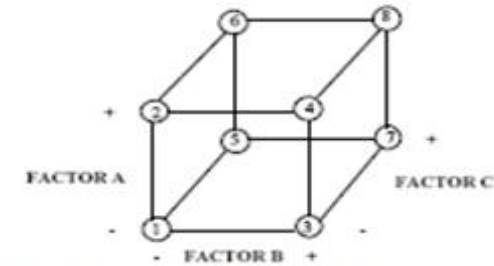
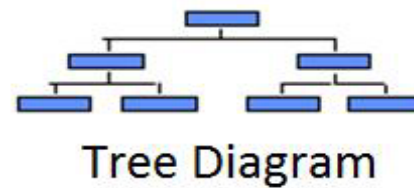
Seven-Step Problem-Solving Model



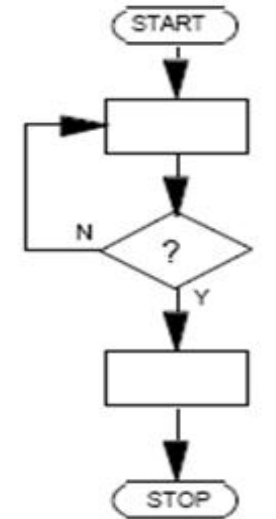
(Westcott, 2016)

RCA Tools

There are many RCA tools and techniques. They include:



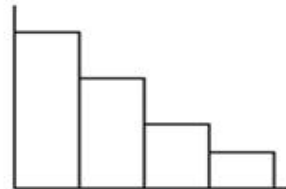
Design of Experiments



Flowchart



Brainstorming



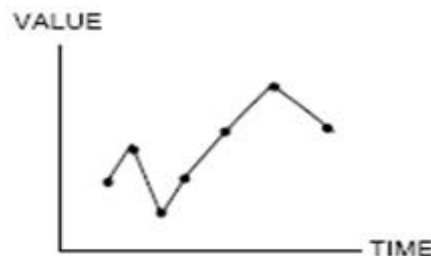
Pareto Chart



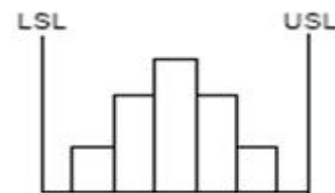
Fishbone Diagram



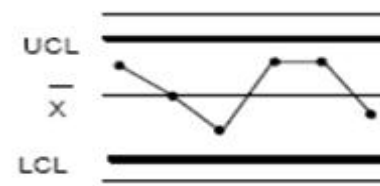
Scatter Diagram



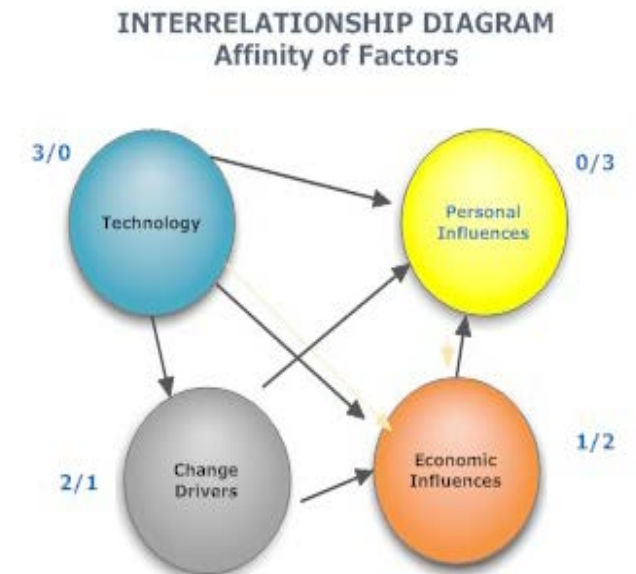
Run Chart



Histogram



Control Charts



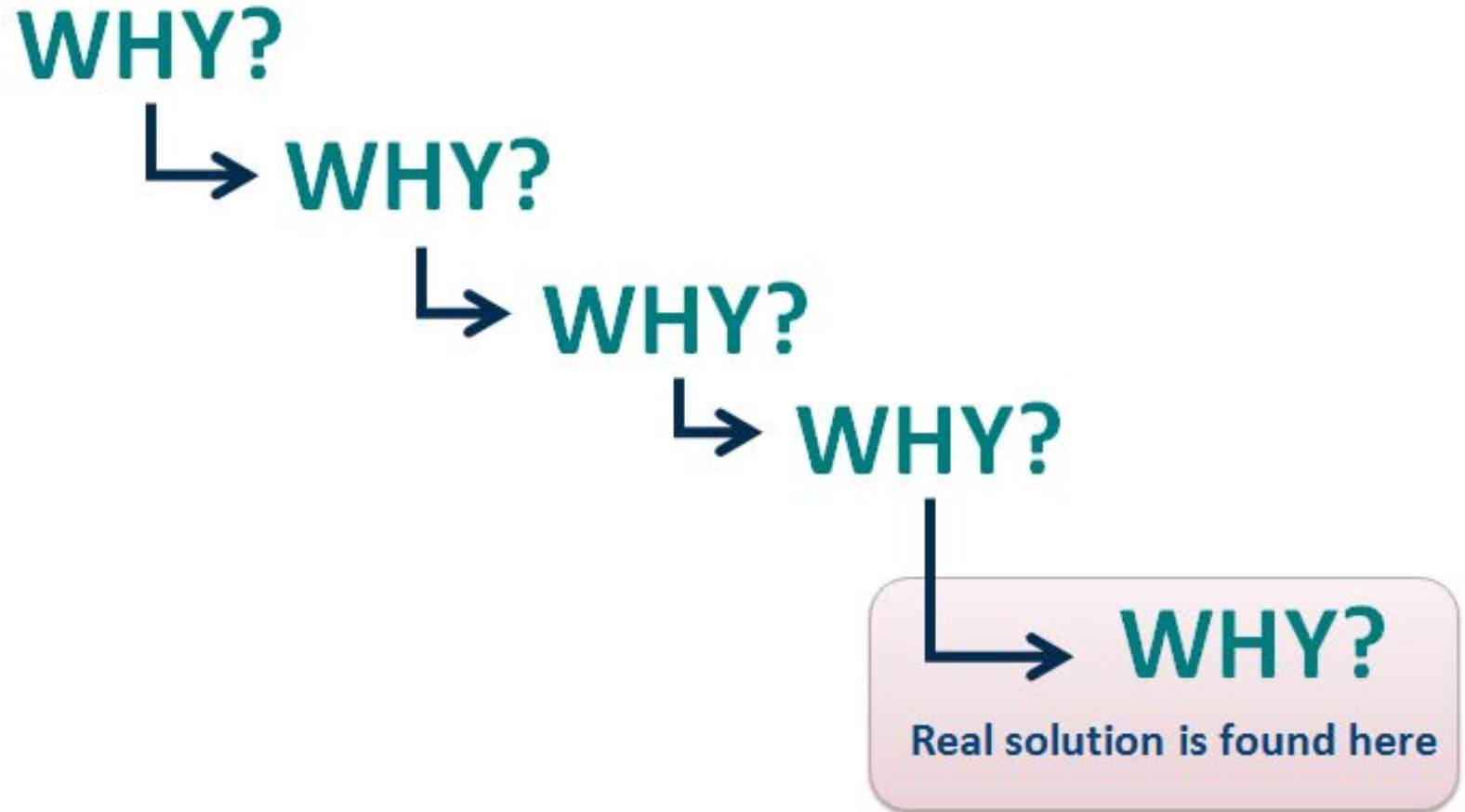
Let's start with perhaps the simplest tool for
RCA....

‘The 5 Whys’

Five Whys



- The simplest method to determine root cause/s
- Drills deeper into problems until a root cause is identified



Why did the chicken cross the road?

Criteria: Chickens should not be on roads.

Condition: Chickens are crossing roads.

Impact: There is an increased risk of chickens being struck by moving vehicles thereby reducing available chicken inventories, increasing chicken costs, and increasing reputation risk caused by adverse publicity from the public's perception of potentially poor poultry placement.

Let us now practice asking the five whys:



Why did the chicken cross the road?



Let us try another example:

1. Why did the chicken cross the road?

To get to the other side.

2. Why did the chicken want to get to the other side?

Because that was where dinner was being served.

3. Why was dinner served on the other side of the road?

Because that was where the permanent feeding trays were built.

4. Why were permanent feeding trays built on the other side of the road?

Because the project designer did not visit the site before completing designs.

5. Why did the designer not visit the site?

Because unreasonable time and £ budget constraints were established for the agricultural project.

Final Conclusion: Hungry chickens are susceptible to the increased risk of being run over while crossing roads because of poor budgeting processes.

5 Why's – A simple but perhaps more serious example...

Problem: Car won't start.



5 Why's – A Simple Example

Problem: Car won't start.

Why 1? – Dead Battery



5 Why's – A Simple Example

Problem: Car won't start.

Why 1? – Dead Battery

Why 2 ? – Alternator not charging



5 Why's – A Simple Example

Problem: Car won't start.

Why 1? – Dead Battery

Why 2 ? – Alternator not charging

Why 3 ? – Alternator belt broken



5 Why's – A Simple Example

Problem: Car won't start.

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Why 4 ? – Belt used beyond
useful life



5 Why's – A Simple Example

Problem: Car won't start.

Why 1? – Dead Battery

Why 2 ? – Alternator not charging

Why 3 ? – Alternator belt broken

Why 4 ? – Belt used beyond useful life

Why 5? – Recommend maintenance not performed

Are there more whys?

[illegible]

5 Why: Case Study: Large Marina

- Attendants at a large US West Coast marina had been complaining about the time-consuming nature of the process for collecting fees for short-term moorage (i.e., parking for boats) – it took time away from other activities that were potentially more profitable for the marina.
- Through the marina's strategic planning, this process was targeted for improvement.



5 Why: Case Study: Large Marina



Originally the daily process for collecting short-term moorage fees took 12 hours and included four major steps:

- 1. Boaters write the boat name, number and moorage space number on a marina-provided envelope, enclose the fees, and drop it in a deposit box.**
- 2. A moorage attendant picks up all of the envelopes twice a day. The counter attendant processes the contents and inputs all envelope data into the payment system. This step takes approximately two hours per day.**
- 3. Twice a day, an attendant walks the docks and writes down all of the boat names, numbers and moorage space numbers on a form and takes the form to the counter attendant for input into the payment system. This step takes approximately 10 hours per day.**
- 4. Invoices are automatically sent to boaters for collection discrepancies in moorage usage fees on a monthly basis.**

5 Why: Case Study: Large Marina

- The moorage attendants informed marina management that there was a lot of data entry duplication – the same data is recorded on paper and then entered into a payment system.
- They learned that other marinas equipped their attendants with a handheld device for inputting all boat information, which is then uploaded by the office attendant into the payment system.
- Marina management budgeted \$100,000 for the implementation of this automated system and engaged a third-party company to:
 - 1) document the as-is and to-be processes,
 - 2) write a business case to justify the investment and
 - 3) produce a business-requirements document for the implementation.

5 Why: Case Study: Large Marina

Current State

- When the consulting company began to document the current state, the activity of sending invoices to boaters (Step 4) for short-term moorage stood out.
- This type of activity is not normally seen in the similar situation of short-term parking for cars.
- The consultant suggested that exploring this approach to invoicing would be worthwhile before moving forward with the technological solution.
- The client agreed; the consultants partnered with the attendants to learn more about this process.

Why Send Invoices

- The project team used the **5 Whys** to discover why the activity of sending invoices to boaters was performed in the first place.
- **The situation:** Monthly invoices are automatically sent to boaters for collection of any discrepancies in moorage usage fees.

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Why	Answer
Why #1	
Why #2	
Why #3	
Why #4	
Why #5	

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Why		Answer
Why #1	Why are the boaters sent a monthly bill for moorage usage-fee collection discrepancies?	
Why #2		
Why #3		
Why #4		
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Why		Answer
Why #1	Why are the boaters sent a monthly bill for moorage usage-fee collection discrepancies?	The boaters used the facility so they need to pay for their use of the facility.
Why #2		
Why #3		
Why #4		
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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Why #3		
Why #4		
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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Why #1	Why are the boaters sent a monthly bill for moorage usage-fee collection discrepancies?	The boaters used the facility so they need to pay for their use of the facility.
Why #2	Why does the marina need to ensure boaters pay for usage?	The marina is a public facility and all usage fees must be collected on behalf of taxpayers.
Why #3		
Why #4		
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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Why #3	Why does the marina need to ensure the collection of all usage fees on behalf of taxpayers?	Because if the marina does not collect the fees, the boaters will use the facility without paying for it.
Why #4		
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Why		Answer
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Why #3	Why does the marina need to ensure the collection of all usage fees on behalf of taxpayers?	Because if the marina does not collect the fees, the boaters will use the facility without paying for it.
Why #4	Why would the boaters use the marina and not pay?	
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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Why #4	Why would the boaters use the marina and not pay?	There is no incentive for them to pay if they can get away with using the facility without paying.
Why #5		

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

	Why	Answer
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Why #4	Why would the boaters use the marina and not pay?	There is no incentive for them to pay if they can get away with using the facility without paying.
Why #5	Why would the boaters not pay even if they can get away without paying?	

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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Why #4	Why would the boaters use the marina and not pay?	There is no incentive for them to pay if they can get away with using the facility without paying.
Why #5	Why would the boaters not pay even if they can get away without paying?	The boaters cannot be trusted. This is why in comparable situations, there are train conductors walking around collecting tickets and parking lot attendants checking payments in payment boxes against cars in the parking lot spaces.

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Validating the Assumption

The underlying assumption is that boaters cannot be trusted and that given the opportunity, the short-term moorage users will either purposely not pay or underpay their daily moorage fees.

- Many of the activities within the fee collection process were established to ensure that all of the fees were collected.
- The consultants asked the operational team to test this assumption with data and created a standard form for them to use.
- The marina team went back through its records for the past two years and discovered that 99.5 percent of moorage customers voluntarily paid their moorage fees; the average underpaid amount was 54 cents.
- The team also learned that customers often overpaid because they did not have exact change.
- The team concluded that it was not cost effective to spend \$300 a day to chase an average of \$2.60 a day.

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Table 3: Moorage Fee Collection Process – Before and After			
Step	Before	After	Savings
1	Boaters write the boat name, number and moorage space number on a marina-provided envelope, enclose the fees and drop it in a deposit box.	No change	N/A
2			
3			
4			

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Table 3: Moorage Fee Collection Process – Before and After			
Step	Before	After	Savings
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The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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3	Twice a day, an attendant walks the docks and writes down all of the boat names, numbers and moorage space numbers on a form and takes the form to the counter attendant for input into the payment system. This step takes approximately 10 hours per day.	Eliminated	\$290/day (hourly rate x 10 hours)
4			

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

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4	Invoices are automatically sent to boaters for moorage usage-fee collection discrepancies on a monthly basis.	Eliminated	\$10/day (average 10 mailings/day x \$1 per mailing)

The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Results

- For a \$5,000 investment of consulting and staff time, the return on investment was outstanding.
- The marina redirected 10 hours per day to customer valued activities that were previously performed with staff overtime.
- The marina withdrew the decision to make a \$100,000 capital investment on a technological solution.
- The marina eliminated the mailing of monthly invoices.
- These simple changes led to a total hard savings of \$200,000 in the first year and \$100,000 in the following years. The soft saving was a much happier moorage staff.

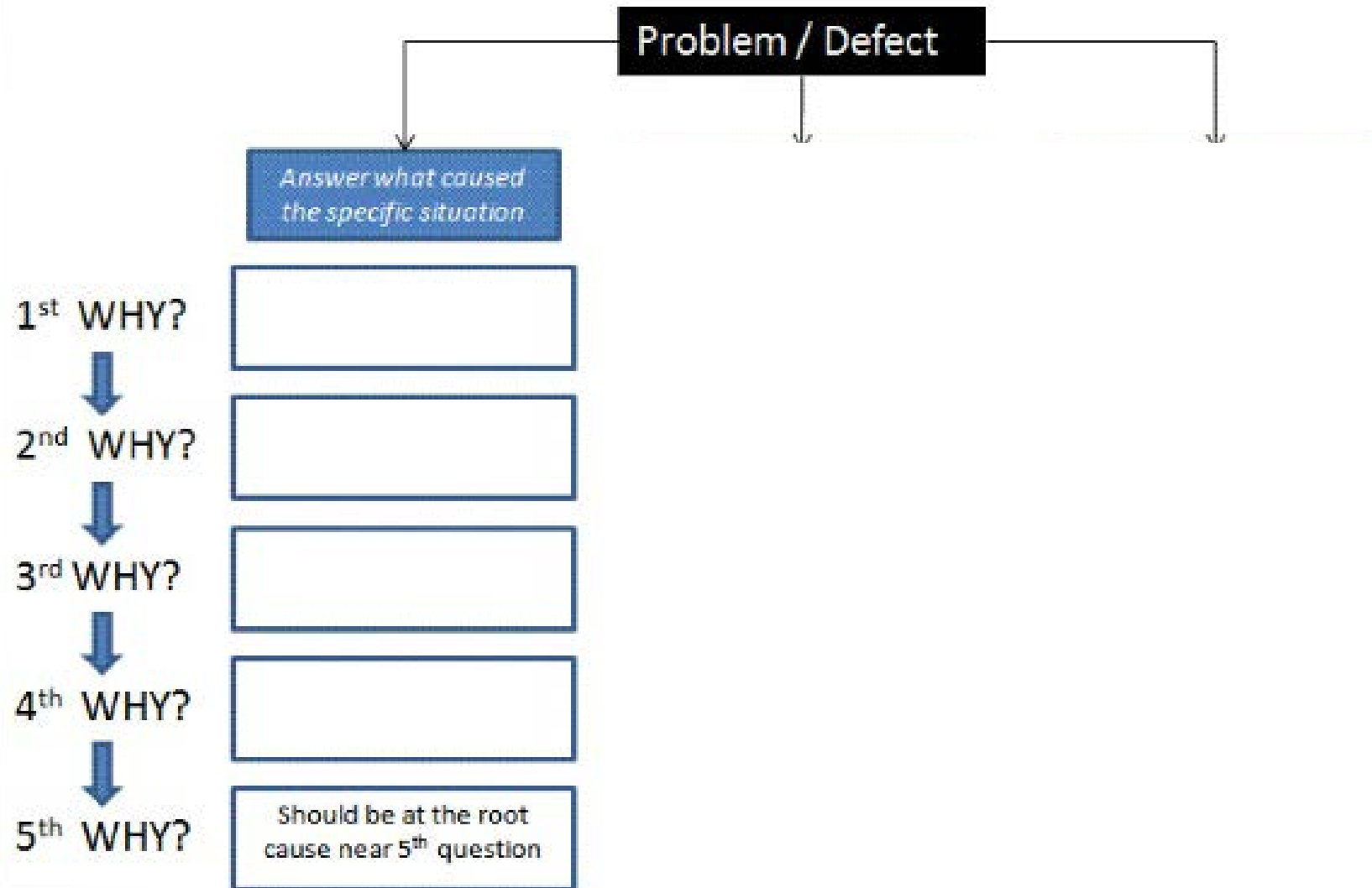
The 5 Whys – Sending Automatic Invoices for Fee Discrepancies

Will These Results Last?

- A question surfaced during the improvement process:
- Two years of data showed that 99.5 percent of moorage customers voluntarily paid their moorage fee and the average underpaid situation was 54 cents – but how can the marina be certain that this situation will continue? That the results will be sustained?
- The consulting company facilitated a solution in which the marina established a monthly audit to verify that the numbers continued to meet expectations.
- Attendants will randomly pick 20 boats and confirm whether those 20 boats made their fee payments. If there is an increase in the number of “no payments” or “underpayments,” then a reassessment will be undertaken.

The '5 Whys' can be a very simple technique or can be structured to consider multiple causes

5-WHY ANALYSIS TEMPLATE



5-WHY ANALYSIS TEMPLATE

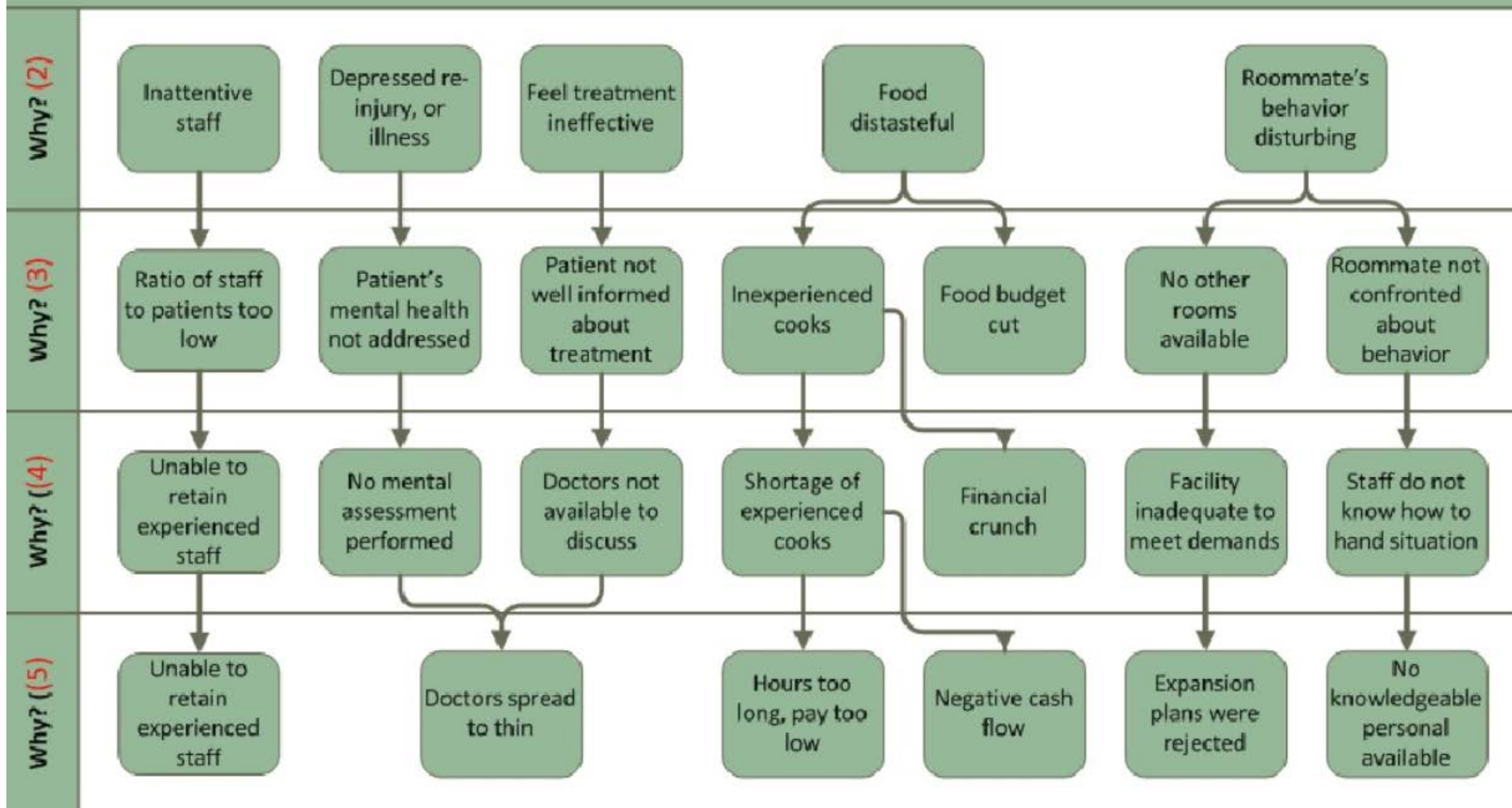
	Problem / Defect	
	<i>Answer what caused the specific situation</i>	<i>Answer why the problem wasn't detected</i>
1 st WHY?		
↓		
2 nd WHY?		
↓		
3 rd WHY?		
↓		
4 th WHY?		
↓		
5 th WHY?	Should be at the root cause near 5 th question	

5-WHY ANALYSIS TEMPLATE

	Problem / Defect	Answer what caused the specific situation	Answer why the problem wasn't detected	Answer what system(s) failed
1 st WHY?				
↓				
2 nd WHY?				
↓				
3 rd WHY?				
↓				
4 th WHY?				
↓				
5 th WHY?		Should be at the root cause near 5 th question		

Why are patients dissatisfied? (1)

(Westcott, 2006)



Let's look at another, more structured tool for RCA....

Cause & Effect Analysis

AKA – Ishikawa Diagram

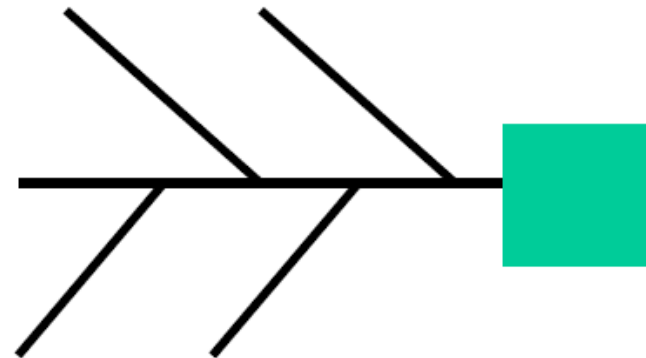
AKA – Fishbone Diagram

- Fishbone Diagram

- ❑ Identifies and organizes the potential causes of a business problem.
- ❑ Uses an easy and understandable format.
- ❑ Used to identify the sources of process variation.
- ❑ It is also called **Ishikawa Diagram** and **Cause and Effect Diagram**.

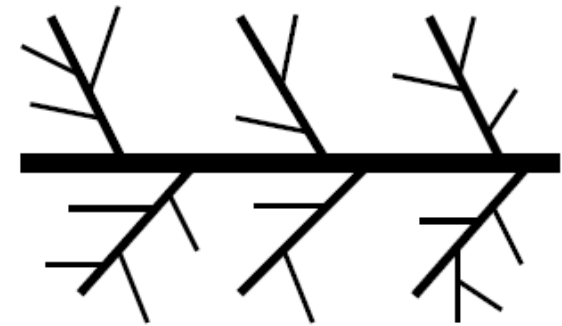


Kaoru
Ishikawa
(1915 – 1989)



- Fishbone Diagram

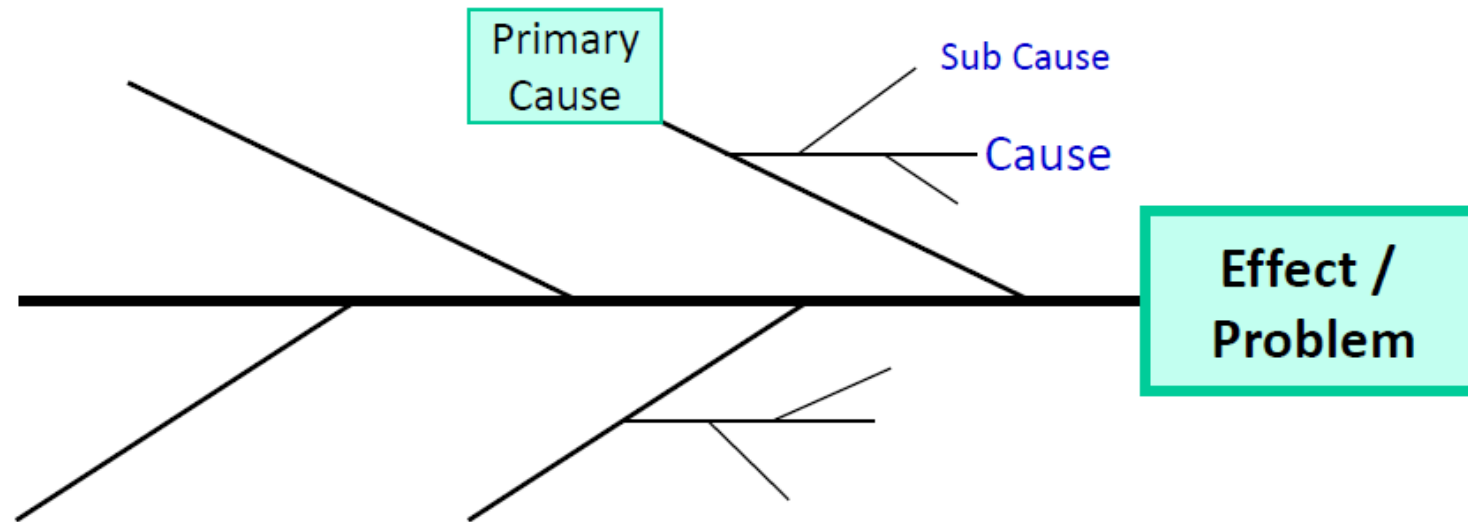
- ❑ Identifies the causes of an undesirable effect of a problem.
- ❑ It is also possible to identify the hierarchy of causes including the possible root causes.
- ❑ Brings attention to the primary factors affecting the quality of a product or service.
- ❑ These factors need to be optimized in order to reduce the amount of process variation.
- ❑ The outcome can provide initial information to later problem solving tools.



- Fishbone Diagram

Root Causes are Normally:

- ❑ Those at the ends of chains of causes.
- ❑ They do not have any sub-causes.



- Fishbone Diagram

- ❑ Often used during **brainstorming sessions**.
- ❑ Everyone gains insight into the cause and effect
- ❑ This makes the solution easier to find later on.



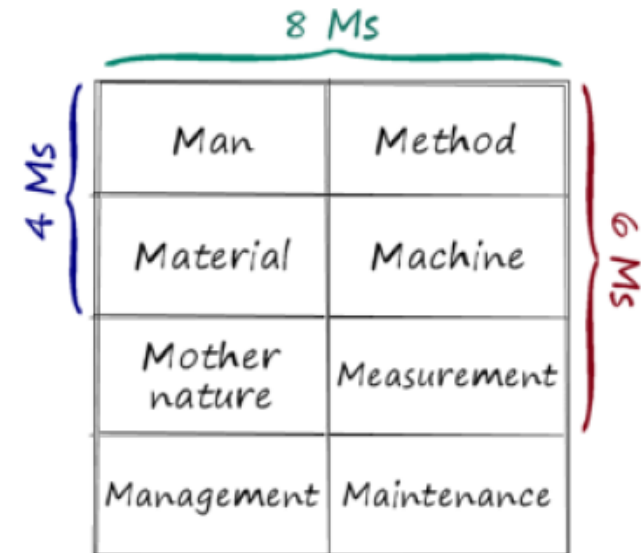
- Fishbone Diagram

- ❑ Helps to create ideas about the possible causes of a problem before it happens.
- ❑ An effective cause prevention tool.
- ❑ Helps to identify the potential factors causing an effect to prevent future problems.
- ❑ Can also be used in product design and to plan new processes.



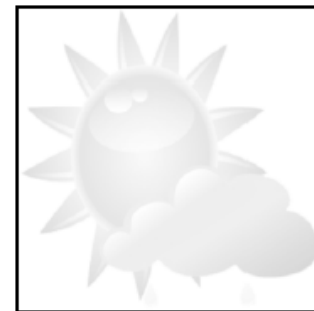
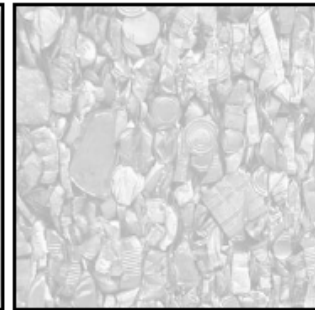
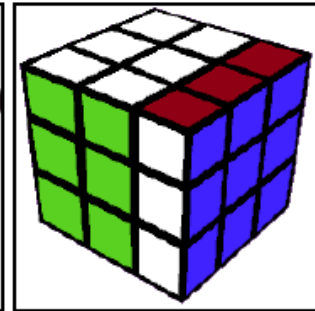
- Fishbone Diagram

- ❑ Potential causes are sometimes called the **process input variables**.
- ❑ They are normally grouped into categories for easier sharing and reference.
- ❑ These are often called the **6 Ms**.



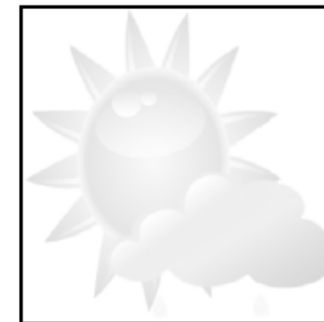
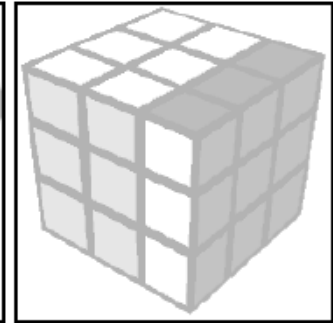
- Fishbone Diagram

- ❑ **Man** – anyone involved with the process and contributes to the effect.
- ❑ **Methods** – how the process is performed and the specific requirements for doing it, such as:
 - Policies.
 - Procedures.
 - Rules.
 - Common practices.



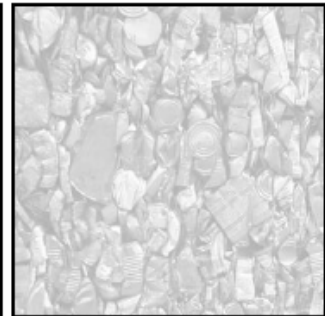
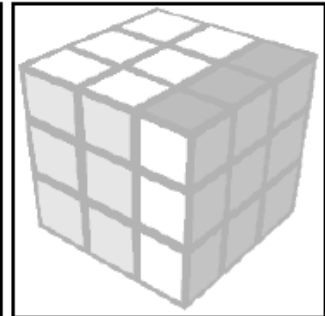
- Fishbone Diagram

- ❑ **Machines** – including the equipment and tools required to do the process.
- ❑ **Materials** – The material needed to produce the product or provide the service, including:
 - Raw materials.
 - Parts.
 - Papers.
 - Packing.
 - Consumables.



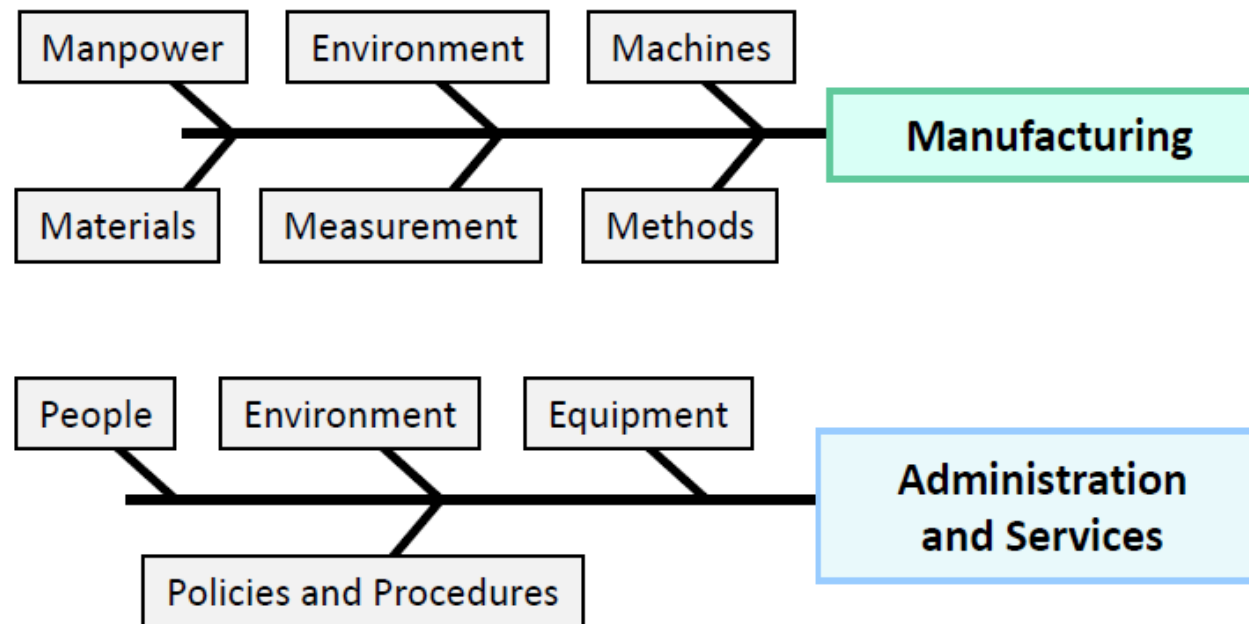
- Fishbone Diagram

- ❑ **Environment** (or Mother Nature) – the conditions in which the process operates such as:
 - Location.
 - Time.
 - Temperature.
 - Culture.
- ❑ **Measurements** – including the data that are used to evaluate the performance of the process.



- Fishbone Diagram

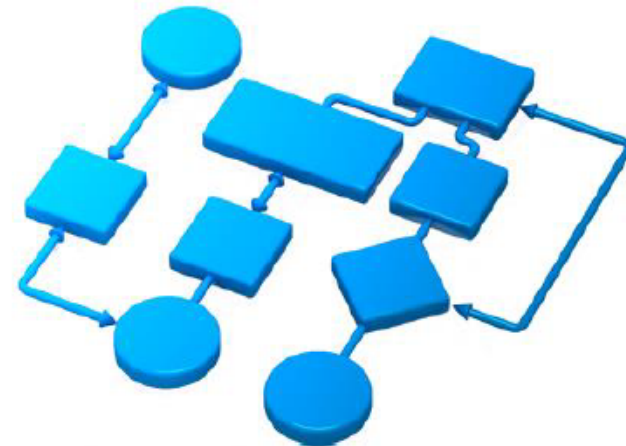
- Typical Fishbone Diagrams for Manufacturing and Non-manufacturing Processes:



- Fishbone Diagram

How to Construct a Fishbone Diagram:

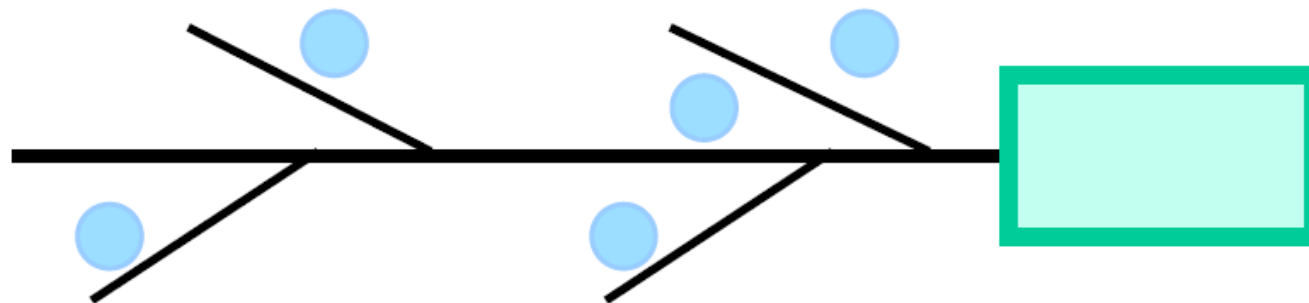
- ❑ Clearly define the effect of the problem.
- ❑ Write it down at the center right of a large piece of paper.
- ❑ Determine the major categories of causes.
- ❑ Write them on the branches of the diagram.
- ❑ Use brainstorming to log all possible causes under the appropriate branches.
- ❑ Use **5 Whys** to search for root causes then add them to the diagram.



- Fishbone Diagram

How to Construct a Fishbone Diagram:

- ❑ Take time to ensure the appropriateness of the recorded information.
- ❑ Update the chart as new causes become apparent.
- ❑ Mark or assign numbers near to the key causes to show their relative priority.
- ❑ Collect data and investigate to verify the key causes are actual.
- ❑ Plan and implement actions to address the key causes.



- Fishbone Diagram

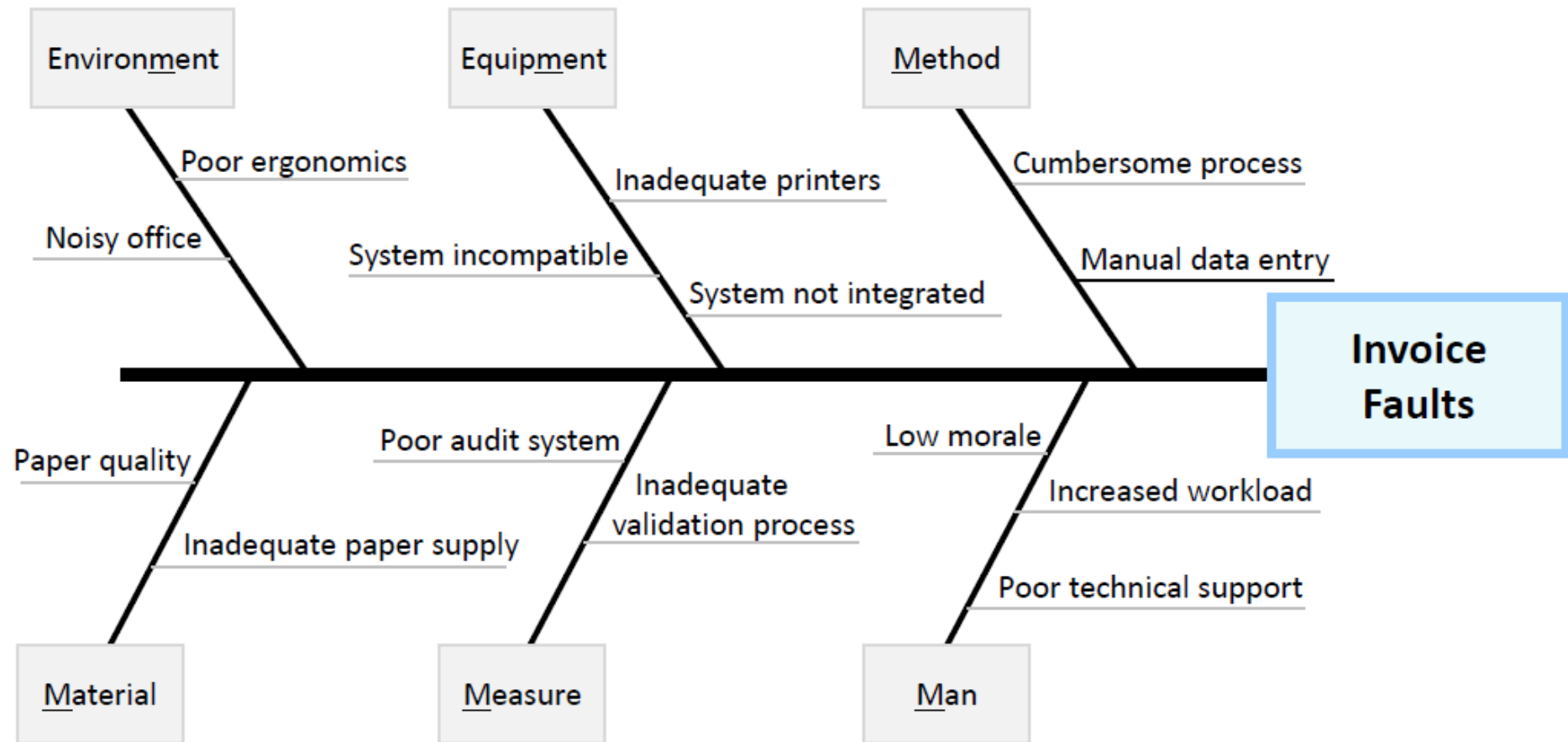
Ways of Finding More Causes:

- ❑ Keep asking **questions** to encourage everyone to participate.
- ❑ **Involve** other people, especially those who have experience in the process.
- ❑ **Leave** the chart on the wall for few days and encourage passers-by to contribute.
- ❑ Take a **break** or do something to take the team's mind off the current thoughts.



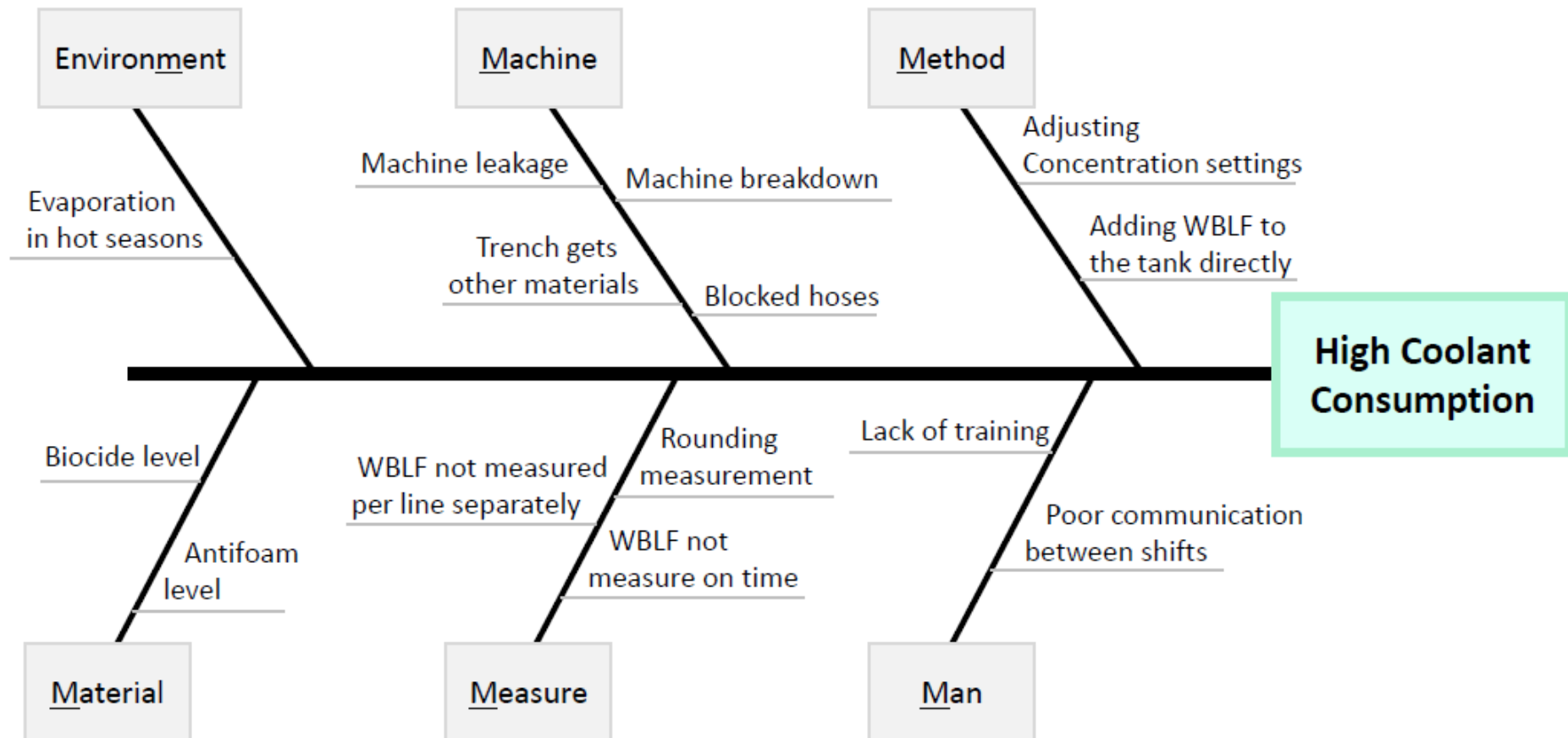
- Fishbone Diagram

Example – The Increased Invoice Errors for a Company:



- Fishbone Diagram

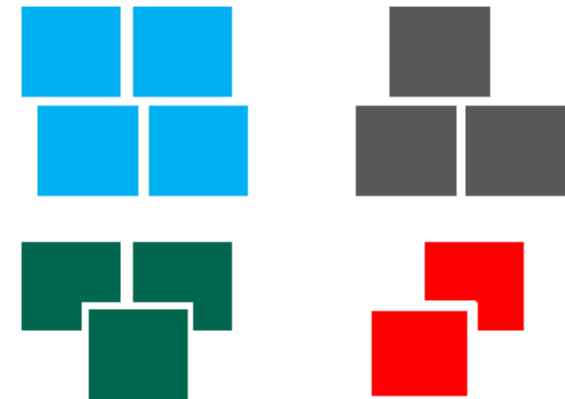
Example – The Increased Coolant Consumption in a Factory:



- Fishbone Diagram

Further Information:

- ❑ Different names may be used for the same category.
 - **Procedures** could be used instead of **Methods**.
 - **Equipment** could be used instead of **Machines**.
- ❑ You may even create your own branches that suit your needs.
- ❑ An **affinity diagram** could be used to create the branches of the diagram from the titles of the affinity sets.
- ❑ Don't overload categories.
 - Establish another category if needed.



- Fishbone Diagram

Further Information:

- ❑ You could also create sub categories under the main categories.
- ❑ For example, under **Man** there might be:
 - Poor Communication
 - Absenteeism
 - Lack of Training
 - ...
- ❑ You should, however, avoid writing real names of persons.

- Fishbone Diagram

Further Information:

- ❑ Beware of adding causes which are actually solutions.
- ❑ A **Cause and Effect Matrix** could be used to prioritize the causes of the problem.
- ❑ Prioritizing and selecting the key causes will minimize the need for more statistical evaluation of inputs that are unlikely to have an impact on the output.

	Y1	Y2	Y3	Y4
X1		○		○
X2	○			
X3	○	○		
X4			○	○

- Fishbone Diagram

Further Information:

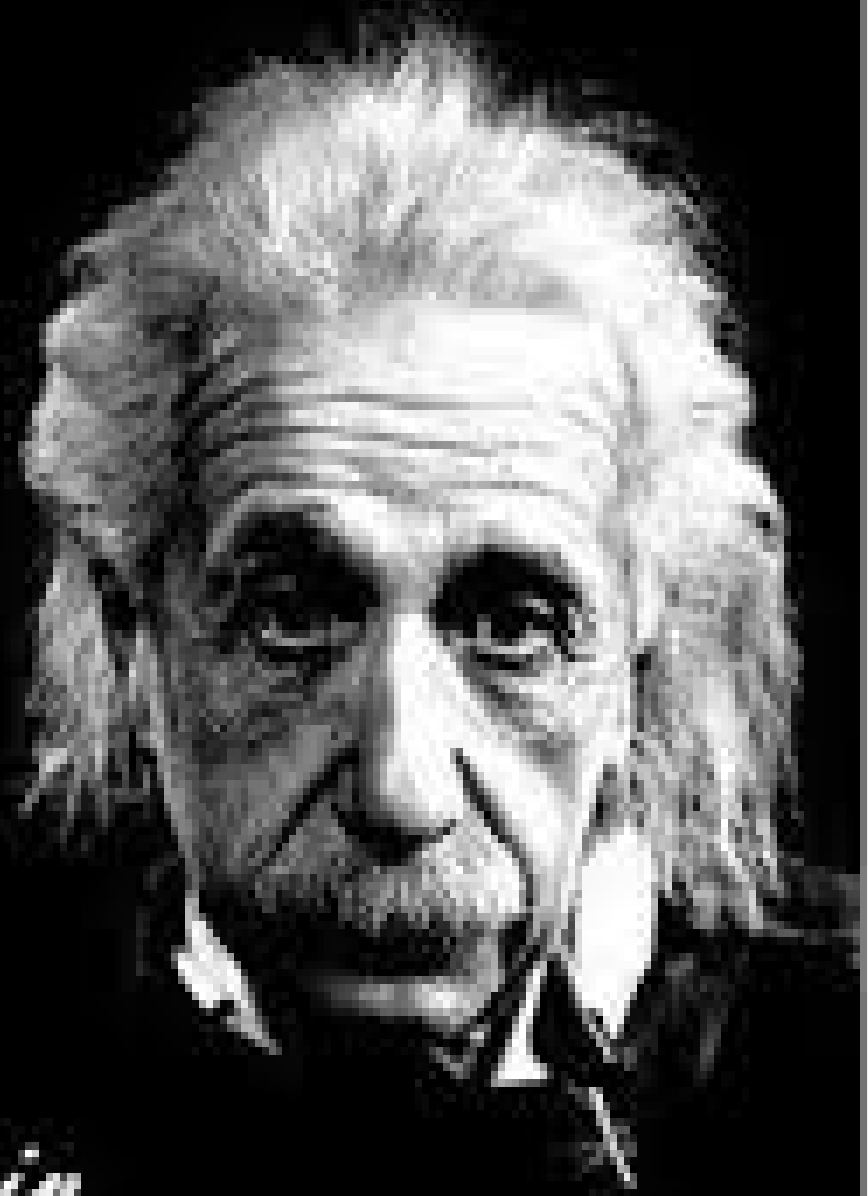
Example – Making Tea Cause and Effect Matrix:

Cause / Effect	Taste	Volume	Temperature	
The boil kettle		○	○	6
Adding water	△	○	⊙	13
Adding tea	⊙			9
Adding sugar	○			3
Adding milk	⊙	△	△	11
Stirring	○			3
	25	7	13	

Symbol	⊙	○	△
Value	9	3	1
Relationship	Strong	Medium	Weak

we cannot solve
our problems with
the same thinking
we used when
we created them

~ Albert Einstein



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